

## What Is Tungsten Alloy Wafer

中钨智造科技有限公司

CTIA GROUP LTD

CTIA GROUP LTD

Global Leader in Intelligent Manufacturing for Tungsten, Molybdenum, and Rare Earth Industries

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## INTRODUCTION TO CTIA GROUP

CTIA GROUP LTD, a wholly-owned subsidiary with independent legal personality established by CHINATUNGSTEN ONLINE, is dedicated to promoting the intelligent, integrated, and flexible design and manufacturing of tungsten and molybdenum materials in the Industrial Internet era. CHINATUNGSTEN ONLINE, founded in 1997 with [www.chinatungsten.com](http://www.chinatungsten.com) as its starting point—China's first top-tier tungsten products website—is the country's pioneering e-commerce company focusing on the tungsten, molybdenum, and rare earth industries. Leveraging nearly three decades of deep experience in the tungsten and molybdenum fields, CTIA GROUP inherits its parent company's exceptional design and manufacturing capabilities, superior services, and global business reputation, becoming a comprehensive application solution provider in the fields of tungsten chemicals, tungsten metals, cemented carbides, high-density alloys, molybdenum, and molybdenum alloys.

Over the past 30 years, CHINATUNGSTEN ONLINE has established more than 200 multilingual tungsten and molybdenum professional websites covering more than 20 languages, with over one million pages of news, prices, and market analysis related to tungsten, molybdenum, and rare earths. Since 2013, its WeChat official account "CHINATUNGSTEN ONLINE" has published over 40,000 pieces of information, serving nearly 100,000 followers and providing free information daily to hundreds of thousands of industry professionals worldwide. With cumulative visits to its website cluster and official account reaching billions of times, it has become a recognized global and authoritative information hub for the tungsten, molybdenum, and rare earth industries, providing 24/7 multilingual news, product performance, market prices, and market trend services.

Building on the technology and experience of CHINATUNGSTEN ONLINE, CTIA GROUP focuses on meeting the personalized needs of customers. Utilizing AI technology, it collaboratively designs and produces tungsten and molybdenum products with specific chemical compositions and physical properties (such as particle size, density, hardness, strength, dimensions, and tolerances) with customers. It offers full-process integrated services ranging from mold opening, trial production, to finishing, packaging, and logistics. Over the past 30 years, CHINATUNGSTEN ONLINE has provided R&D, design, and production services for over 500,000 types of tungsten and molybdenum products to more than 130,000 customers worldwide, laying the foundation for customized, flexible, and intelligent manufacturing. Relying on this foundation, CTIA GROUP further deepens the intelligent manufacturing and integrated innovation of tungsten and molybdenum materials in the Industrial Internet era.

Dr. Hanns and his team at CTIA GROUP, based on their more than 30 years of industry experience, have also written and publicly released knowledge, technology, tungsten price and market trend analysis related to tungsten, molybdenum, and rare earths, freely sharing it with the tungsten industry. Dr. Han, with over 30 years of experience since the 1990s in the e-commerce and international trade of tungsten and molybdenum products, as well as the design and manufacturing of cemented carbides and high-density alloys, is a renowned expert in tungsten and molybdenum products both domestically and internationally. Adhering to the principle of providing professional and high-quality information to the industry, CTIA GROUP's team continuously writes technical research papers, articles, and industry reports based on production practice and market customer needs, winning widespread praise in the industry. These achievements provide solid support for CTIA GROUP's technological innovation, product promotion, and industry exchanges, propelling it to become a leader in global tungsten and molybdenum product manufacturing and information services.



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## Table of Contents

### Chapter 1 Basic Knowledge of Tungsten Alloy Wafers

- 1.1 Tungsten Alloy Disc Performance Advantages
  - 1.1.1 Definition of Tungsten Alloy Disc
  - 1.1.2 Characteristics of Tungsten Alloy Wafers
- 1.2 Development History and Technological Evolution of Tungsten Alloy Wafers
  - 1.2.1 Early R&D and Initial Application
  - 1.2.2 Process Breakthroughs and Performance Improvements
  - 1.2.3 Intelligent Production and Diversified Applications

### Chapter 2 Classification System of Tungsten Alloy Discs

- 1.2 Tungsten Alloy Discs by Composition
  - 2.1.1 TungstenNickelIron Alloy Disc
  - 2.1.2 TungstenNickelCopper Alloy Disc
  - 2.1.3 TungstenCopper Alloy Disc
  - 2.1.4 TungstenSilver Alloy Disc
- 2.2 Tungsten Alloy Discs by Size
  - 2.2.1 MicroDiscs (Diameter < 10 mm)
  - 2.2.2 Conventional Wafers ( $10\text{ mm} \leq \text{Diameter} \leq 100\text{ mm}$ )
  - 2.2.3 Large Wafers (Diameter > 100 mm)
- 2.3 Classification of Tungsten Alloy Discs by Application Function
  - 2.3.1 Functional Tungsten Alloy Discs
    - 2.3.1.1 Tungsten Alloy Discs for Radiation Shielding
    - 2.3.1.2 Tungsten Alloy Discs for Electrical Conduction
    - 2.3.1.3 Tungsten Alloy Discs for Thermal Conductivity and Heat Dissipation
    - 2.3.1.4 Tungsten Alloy Discs for Wear and Corrosion Resistance
  - 2.3.2 Structural Tungsten Alloy Discs
    - 2.3.2.1 Tungsten Alloy Discs for Structural Support
    - 2.3.2.2 Tungsten Alloy Discs for Balance Weights
    - 2.3.2.3 Tungsten Alloy Discs for Connection and Fixing
    - 2.3.2.4 Tungsten Alloy Discs for Sealing and Isolation

### Chapter 3 Properties of Tungsten Alloy Discs

- 3.1 DensityRelated Properties of Tungsten Alloy Discs
  - 3.1.1 Density Range
  - 3.1.2 Density Uniformity Performance
  - 3.1.3 Effect of Density on the Application of Tungsten Alloy Discs
- 3.2 High Temperature Resistance of Tungsten Alloy Wafers
  - 3.2.1 Melting Point
  - 3.2.2 Stability in High Temperature Environment
  - 3.2.3 Thermal Shock Resistance

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- 3.3 Surface Properties of Tungsten Alloy Wafers
  - 3.3.1 Surface Roughness Parameters
  - 3.3.2 Flatness Accuracy
  - 3.3.3 Effect of Surface Finish on Use
- 3.4 Hardness and Wear Resistance of Tungsten Alloy Discs
  - 3.4.1 Hardness Index Range
  - 3.4.2 Wear Resistance Performance
  - 3.4.3 Relationship Between Hardness and Wear Resistance
- 3.5 Strength and Toughness of Tungsten Alloy Discs
  - 3.5.1 Tensile Strength Value
  - 3.5.2 Bending Strength Performance
  - 3.5.3 Impact Toughness Index
  - 3.5.4 Effect of Strength on the Application of Tungsten Alloy Discs
  - 3.5.5 Effect of Toughness on the Application of Tungsten Alloy Discs
- 3.6 Radiation Shielding Performance of Tungsten Alloy Discs
  - 3.6.1 Shielding Effect Against Gamma Rays
  - 3.6.2 XRay Shielding Capability
  - 3.6.3 Relationship Between Shielding Performance and Thickness
  - 3.6.4 Comparison With Lead Shielding Effectiveness
- 3.7 Electrical and Thermal Conductivity of Tungsten Alloy Discs
  - 3.7.1 Conductivity Parameters
  - 3.7.2 Thermal Conductivity Range
  - 3.7.3 Correlation Between Electrical Conductivity and Thermal Conductivity
  - 3.7.4 Factors Affecting the Electrical Conductivity of Tungsten Alloy Discs
  - 3.7.5 Factors Affecting Thermal Conductivity of Tungsten Alloy Discs
- 3.8 CTIA GROUP LTD Tungsten Alloy Wafer MSDS

## Chapter 4 Performance Test Methods of Tungsten Alloy Discs

- 4.1 Tungsten Alloy Disc Density Test Method
  - 4.1.1 Density Measurement by Drainage Method
  - 4.1.2 Radiographic Inspection of Density Uniformity
  - 4.1.3 Weighing Method Auxiliary Verification
- 4.2 Test Method for High Temperature Resistance of Tungsten Alloy Disc
  - 4.2.1 Melting Point Measurement by Differential Thermal Analysis
  - 4.2.2 High Temperature Endurance Strength Test
  - 4.2.3 Thermal Shock Test Method
- 4.3 Test Method of Tungsten Alloy Disc Surface Properties
  - 4.3.1 Measuring Surface Roughness With a Roughness Meter
  - 4.3.2 Flatness Testing Instrument Operation
  - 4.3.3 Gloss Meter to Measure Surface Finish
- 4.4 Test Methods for Hardness and Wear Resistance of Tungsten Alloy Discs
  - 4.4.1 Vickers Hardness Tester Hardness Measurement

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- 4.4.2 Wear Resistance Test Using a Wear Tester
- 4.4.3 Correlation Analysis Test Between Hardness and Wear Resistance
- 4.5 Test Methods for Strength and Toughness of Tungsten Alloy Discs
  - 4.5.1 Tensile Strength Measurement Using a Universal Testing Machine
  - 4.5.2 ThreePoint Bending Test to Measure Bending Strength
  - 4.5.3 Impact Toughness Testing Machine
- 4.6 Test Method for Radiation Shielding Performance of Tungsten Alloy Disc
  - 4.6.1 Use of  $\gamma$ Ray Shielding Effectiveness Detection Device
  - 4.6.2 XRay Attenuation Rate Test Steps
  - 4.6.3 Comparison of Shielding Performance of Tungsten Alloy Discs of Different Thicknesses
- 4.7 Electrical and Thermal Conductivity Test Methods
  - 4.7.1 Conductivity Measurement Using the FourProbe Method
  - 4.7.2 Thermal Conductivity Measurement Using the Hot Wire Method
  - 4.7.3 Correlation Test Between Electrical Conductivity and Thermal Conductivity

## Chapter 5 Production Process of Tungsten Alloy Discs

- 5.1 Raw Material Selection and Pretreatment of Tungsten Alloy Wafers
  - 5.1.1 Tungsten Powder Purity and Screening
  - 5.1.2 Material Composition Ratio and Mixing
- 5.2 Forming Process of Tungsten Alloy Disc
  - 5.2.1 Powder Pressing
  - 5.2.2 Sintering Process
- 5.3 Processing Technology of Tungsten Alloy Wafer
  - 5.3.1 Cutting and Grinding
  - 5.3.2 Surface Treatment
- 5.4 Quality Control and Inspection of Tungsten Alloy Discs
  - 5.4.1 Online Monitoring of the Molding Process
  - 5.4.2 Random Inspection of All Performance Items of Finished Products

## Chapter 6 Application Fields of Tungsten Alloy Wafers

- 6.1 Application of Tungsten Alloy Discs in Medical Equipment
  - 6.1.1 Radiation Shielding Discs for Radiotherapy Equipment
    - 6.1.1.1 Shielding Applications in Linear Accelerators
    - 6.1.1.2 Local Shielding Design of Gamma Knife Equipment
    - 6.1.1.3 Shielding Layout in Proton Therapy Devices
  - 6.1.2 Counterweight Discs for Medical Imaging Equipment
    - 6.1.2.1 Counterweight Balancing of Rotating Components of CT Machines
    - 6.1.2.2 Stable Counterweights for MRI Equipment
  - 6.1.3 Application of Tungsten Alloy Discs in Nuclear Medicine Equipment
    - 6.1.3.1 Shielding of Radiopharmaceutical Packaging Equipment
    - 6.1.3.2 Protective Components of Radioimmunoassay Instruments
- 6.2 Application of Tungsten Alloy Discs in Electronics and Semiconductors

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- 6.2.1 Chip Manufacturing Equipment Thermal Conductive Wafers
  - 6.2.1.1 Thermal Conductive Components of Ion Implanters
  - 6.2.1.2 Application of Heat Dissipation Wafers in Photolithography Machines
- 6.2.2 HighFrequency Device Electrode Wafers
  - 6.2.2.1 Electrode Structure of Microwave Communication Devices
  - 6.2.2.2 Conductive Discs for RF Power Devices
- 6.2.3 Application of Tungsten Alloy Wafers in Electronic Packaging
  - 6.2.3.1 HighPower Device Packaging Heat Sink
  - 6.2.3.2 Shielding and Packaging of Electronic Components
- 6.3 Application of Tungsten Alloy Discs in Aerospace
  - 6.3.1 Tungsten Alloy Discs for Spacecraft Attitude Control Weights
    - 6.3.1.1 Satellite Attitude Adjustment Counterweights
    - 6.3.1.2 Balancing Weights for Spacecraft Orbit Change Mechanisms
  - 6.3.2 HighTemperature Resistant Tungsten Alloy Discs for Engine Components
    - 6.3.2.1 HighTemperature Resistant Parts Near Rocket Engine Nozzles
    - 6.3.2.2 HeatResistant Wafers for Space Shuttle Propulsion Systems

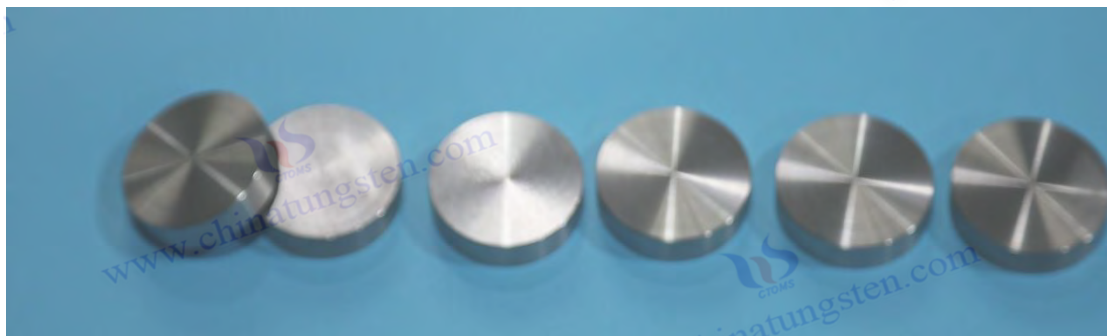
## Chapter 7 Storage, Transportation and Standards of Tungsten Alloy Discs

- 7.1 Storage Requirements for Tungsten Alloy Discs
  - 7.1.1 Storage Environment Conditions (Temperature, Humidity, Etc.)
  - 7.1.2 Packaging and Stacking Specifications
- 7.2 Transportation Requirements for Tungsten Alloy Discs
  - 7.2.1 Transportation Method Selection
  - 7.2.2 Protective Measures During Transportation
  - 7.2.3 Transport Safety Regulations and Labels
- 7.3 China Tungsten Alloy Disc Standard
- 7.4 International Tungsten Alloy Disc Standards
- 7.5 Tungsten Alloy Disc Standards in Europe, America, Japan, South Korea, Etc.

## Appendix

Tungsten Alloy Disc Terminology

References



CTIA GROUP LTD Tungsten Alloy Wafer

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## CTIA GROUP LTD

### High-Density Tungsten Alloy Customization Service

CTIA GROUP LTD, a customization expert in high-density tungsten alloy design and production with 30 years of experience.

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**Precision customization:** support high density (17-19 g/cm<sup>3</sup>), special performance, complex structure, super large and very small parts design and production.

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## Chapter 1 Basic Knowledge of Tungsten Alloy Wafers

Tungsten alloy discs play a vital role in modern industry and technology. Their unique physical and chemical properties enable them to excel in a wide range of applications, particularly those requiring high density, high temperature resistance, or high strength. The development and application of tungsten alloy discs demonstrates advancements in materials science. Through alloying and precision machining, tungsten alloy discs are able to meet complex requirements while maintaining excellent performance stability.

Tungsten alloy discs are not limited to traditional industrial fields but are also expanding into emerging technologies such as new energy, medical devices, and precision manufacturing. Their versatility and customizability enable them to adapt to the needs of diverse scenarios, making them a key material driving technological advancement. Optimizing the manufacturing process and performance of tungsten alloy discs is a key research area in materials science. Through continuous improvements in alloy formulations and processing techniques, the performance of tungsten alloy discs has been further enhanced, providing a reliable solution for modern industry.

Furthermore, the environmentally friendly nature of tungsten alloy discs makes them crucial for sustainable development. Compared to some traditional high-density materials, tungsten alloy discs are non-toxic, non-radioactive, and recyclable, meeting modern industry's demand for green materials. This characteristic not only reduces environmental impact but also provides companies with a high-performance material option while meeting environmental regulations. In short, as a versatile, high-performance material, a basic understanding of tungsten alloy discs is crucial for understanding their widespread industrial applications.

### 1.1 Definition and Characteristics of Tungsten Alloy Disc

Tungsten alloy discs are key to understanding their application value. The definition section will explain the material composition, shape characteristics, and manufacturing process of tungsten alloy discs, while the characteristics section will deeply analyze their physical and chemical properties and how these properties give them unique advantages in various scenarios.

#### 1.1.1 Definition of Tungsten Alloy Disc

Tungsten alloy wafers are circular, thin sheets primarily composed of tungsten, alloyed with other metal elements (such as nickel, iron, and copper) and processed using a specific process. Their definition extends beyond their circular geometry to encompass their unique physical and chemical properties, giving them broad potential for application in industry and technology. As a high-density, high-melting-point metal, tungsten possesses excellent high-temperature resistance and hardness in its pure form, but its brittleness and processing difficulty also limit its performance. Through alloying, tungsten alloy wafers retain the core advantages of tungsten while significantly improving its toughness and processing properties, making them suitable for a wide range of applications.

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Tungsten alloy discs are typically manufactured using powder metallurgy technology. This process involves mixing high-purity tungsten powder with other metal powders in a specific ratio, pressing and shaping, and sintering at high temperatures, ultimately forming circular discs with a uniform microstructure and excellent performance. The disc's shape design allows for high flexibility in practical applications. The circular structure facilitates processing and installation, meeting the shape and size requirements of various precision equipment. Its thickness can range from microns to several millimeters, and its diameter can be customized according to specific applications. For example, extremely thin discs may be required in precision instruments, while thicker discs may be required to provide sufficient mass and strength in heavy equipment.

Tungsten alloy discs is also closely related to their functionality. Due to their high density, discs are often used as counterweights or balancing components, especially in equipment that requires precise control of mass distribution, such as aerospace equipment or precision instruments. In addition, the high temperature resistance of tungsten alloy discs enables them to maintain stable physical properties in high temperature environments, which is especially important in heat treatment or high temperature processing scenarios. Different production processes, such as adjustments to sintering temperature, pressure, or alloy composition ratios, will directly affect the properties of the discs, such as hardness, toughness, or corrosion resistance, enabling them to meet the needs of specific scenarios.

Furthermore, the definition of tungsten alloy discs is also reflected in their versatility. Not only is it a structural material, but its unique physical properties also make it suitable for a variety of functional components. For example, in medical devices, tungsten alloy discs may be used as shielding materials to protect sensitive components; in industrial manufacturing, their high density and wear resistance make them ideal for mold or tool components. In short, the definition of tungsten alloy discs encompasses its material, shape, manufacturing process, and diverse functional properties, making it an indispensable high-performance material in modern industry.

### 1.1.2 Characteristics of Tungsten Alloy Discs

Tungsten alloy discs stand out from other materials due to their exceptional physical and chemical properties, making them an ideal choice for demanding applications. Their unique characteristics include high density, high-temperature resistance, excellent mechanical properties, corrosion resistance, and environmental friendliness, all contributing to their unique advantages in industry.

First, the high density of tungsten alloy discs is one of their most notable features. Tungsten's density is close to that of gold. Through alloying, the density of tungsten alloy discs can be increased to meet the needs of applications requiring increased weight or inertia. For example, in precision instruments or mechanical equipment, tungsten alloy discs can provide a stable balancing effect through their high density, thereby improving the operating accuracy and stability of the equipment. This high density gives them an irreplaceable advantage in applications requiring precise mass distribution.

Secondly, tungsten alloy discs offer exceptional high-temperature resistance. Their extremely high

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melting point enables them to maintain structural integrity and performance stability in extremely high-temperature environments. This characteristic is particularly important in aerospace, heat treatment equipment, or high-temperature processing environments. For example, in high-temperature furnaces or hot processing equipment, tungsten alloy discs can withstand thermal shock and prolonged high-temperature exposure without deformation or performance degradation.

Tungsten alloy discs are also a key feature. By alloying them with other metal elements (such as nickel and iron), the discs significantly improve their toughness while maintaining high hardness, overcoming the brittleness of pure tungsten. This improvement provides greater reliability when subjected to mechanical stress, vibration, or shock, making them suitable for use in high-intensity working environments. Furthermore, tungsten alloy discs exhibit excellent machinability and can be formed into highly complex shapes through processes such as turning, milling, or grinding, while maintaining excellent surface finish and dimensional accuracy, which is crucial in the field of precision manufacturing.

Corrosion resistance is another major advantage of tungsten alloy discs. They maintain stable chemical properties in acidic, alkaline, and other corrosive environments, resisting oxidation or corrosion. This property lends them broad application prospects in specialized environments such as the chemical industry and marine engineering. For example, in marine equipment, tungsten alloy discs can resist seawater corrosion, extending component life. Furthermore, while the thermal and electrical conductivity of tungsten alloy discs are inferior to those of some traditional conductive materials, their overall performance remains competitive in high-temperature or high-density environments, making them particularly suitable for applications requiring a balance between thermal conductivity and structural strength.

Tungsten alloy discs is also a key feature. As a non-toxic and non-radioactive material, tungsten alloy is more environmentally friendly than traditional high-density materials such as lead, meeting the sustainable development requirements of modern industry. This characteristic has led to their widespread application in fields such as medical devices and food processing equipment. For example, in medical devices, tungsten alloy discs can be used as shielding materials to protect sensitive components without worrying about toxicity. Furthermore, tungsten alloy discs are highly recyclable, allowing them to be reused through recycling and reprocessing, reducing resource waste. This sustainability further enhances their value in modern industry.

## 1.2 Development History and Technological Evolution of Tungsten Alloy Wafers

Tungsten alloy wafers are key to understanding their crucial role in modern industry. Early research and development laid the foundation for tungsten alloy wafers, while process breakthroughs have significantly improved their performance. Intelligent production has further broadened their applications.

### 1.2.1 Early R&D and Initial Application

Tungsten alloy discs stemmed from the exploration of the properties of tungsten metal. As a high-

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melting-point, high-density metal, tungsten's unique physical properties have attracted considerable attention in the industrial sector. However, the brittleness and difficulty of processing pure tungsten limited its direct application, so researchers began to experiment with improving its properties through alloying. Initial development of tungsten alloy discs focused on combining tungsten with other metal elements to create a material with high density, high-temperature resistance, and a certain degree of toughness. Early tungsten alloys were primarily composed of nickel, iron, or copper. These elements effectively enhanced tungsten's ductility and machinability, laying the foundation for the desired disc shape.

In terms of manufacturing, powder metallurgy became the core method for the early development of tungsten alloy discs. By mixing tungsten powder with other metal powders, pressing and shaping, and sintering at high temperatures, researchers were able to produce circular discs with uniform structure and preliminary properties. Although this process was relatively simple under the technological conditions at the time, it made possible the initial application of tungsten alloy discs. The disc's shape was designed for its ease of use in practical applications. The circular structure is not only easy to process, but also meets the shape and size requirements of various devices, such as counterweights or support components.

Tungsten alloy discs focused on industrial applications requiring high density or high-temperature resistance. For example, in early mechanical manufacturing, tungsten alloy discs were used as balancing components to improve equipment stability and operational precision. Their high density allows them to provide significant mass within a relatively small volume, which is particularly important in space-constrained equipment. Furthermore, their high-temperature resistance enables them to excel in high-temperature processing environments, such as supports or shielding components for heat treatment equipment. While limited in scope, these early applications laid a solid foundation for the further development of tungsten alloy discs.

At this stage, the development and application of tungsten alloy discs faced numerous challenges, such as high production costs, limited machining precision, and optimization of alloy composition. However, through continuous experimentation and refinement, researchers gradually mastered the basic manufacturing process for tungsten alloy discs and accumulated experience for their application in a wider range of fields. This early success not only demonstrated the feasibility of tungsten alloy discs as a high-performance material but also provided important technical reserves for subsequent process breakthroughs and technological innovations.

### 1.2.2 Process Breakthroughs and Performance Improvements

With advances in industrial technology, significant breakthroughs have been made in the manufacturing process of tungsten alloy discs, directly driving improvements in their performance and expanding their application range. The limitations of early powder metallurgy techniques were the uneven microstructure of the finished product and limited room for performance optimization. To address these issues, researchers have developed more advanced manufacturing techniques, such as plasma sintering, hot isostatic pressing, and precision forming. These new technologies have significantly improved the

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density, strength, and surface quality of tungsten alloy discs, enabling them to meet the needs of more demanding industrial applications.

The introduction of plasma sintering technology is a major breakthrough in tungsten alloy disc manufacturing. By rapidly heating the material with high-temperature plasma, researchers are able to achieve a denser microstructure in a shorter time, thereby improving the disc's mechanical properties and corrosion resistance. Hot isostatic pressing further optimizes the disc's internal structure. By uniformly compressing the material under high temperature and pressure, it eliminates internal defects and improves the disc's strength and toughness. These process breakthroughs enable tungsten alloy discs to maintain stable performance in even more demanding environments, such as those subjected to high temperature, high pressure, or severe corrosion.

Optimizing alloy composition was also a key advancement during this phase. By precisely controlling the ratios of elements such as nickel, iron, and copper, researchers were able to tailor the properties of the tungsten alloy discs to specific application requirements. For example, increasing the nickel content improves the disc's toughness and impact resistance, while adding copper improves its thermal conductivity. This customized composition design allows the tungsten alloy discs to better adapt to the needs of different scenarios, such as precision instruments requiring high density and low thermal expansion, while high-temperature equipment prioritizes heat resistance and structural stability.

Furthermore, advancements in processing technology have also supported the performance improvements of tungsten alloy discs. Advanced CNC machining techniques and surface treatment processes have significantly improved the dimensional accuracy and surface finish of the discs, which is particularly important in the field of precision manufacturing. For example, through laser cutting and precision grinding, tungsten alloy discs can be processed into complex shapes while maintaining high-precision dimensional control. These technological breakthroughs not only improve the quality of the discs but also reduce production costs, enabling their widespread application in more fields.

### 1.2.3 Intelligent Production and Diversified Applications

With the rise of smart manufacturing and industrial automation, the production of tungsten alloy discs has entered a new era. The application of intelligent production technologies has significantly improved production efficiency and product quality, while also promoting the application of tungsten alloy discs in a wide range of fields. By incorporating automated control, real-time monitoring, and data analysis technologies, smart manufacturing systems can precisely control every step of the production process, such as powder mixing, compacting, and sintering temperature. This high-precision production control ensures the consistent and reliable performance of tungsten alloy discs, ensuring their application in demanding applications.

Smart manufacturing also offers greater flexibility. Using computer-aided design and manufacturing systems, manufacturers can quickly adjust the size, shape, and composition of wafers to meet diverse customer needs. For example, in the aerospace sector, tungsten alloy wafers may require a specific

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thickness or surface treatment, while medical devices may require a higher surface finish and biocompatibility. The application of smart manufacturing technology makes this customized production more efficient, while reducing production costs and lead times.

Tungsten alloy discs are a significant achievement brought about by intelligent manufacturing. With improved performance and optimized production processes, the application of tungsten alloy discs has expanded beyond traditional mechanical manufacturing to emerging sectors such as new energy, medical equipment, and the electronics industry. For example, in the new energy sector, tungsten alloy discs are used as counterweights or support materials in battery components to improve device stability and efficiency. In medical devices, their high density and non-toxic properties make them ideal shielding materials for protecting sensitive instruments from external interference.

Furthermore, the environmentally friendly nature of tungsten alloy discs is further enhanced through intelligent production. Modern production processes prioritize efficient resource utilization and waste recycling. As a recyclable material, tungsten alloy discs are produced during a process that minimizes environmental impact. This green production model not only meets the sustainable development requirements of modern industry but also supports the application of tungsten alloy discs in environmentally sensitive areas.



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## Chapter 2 Classification System of Tungsten Alloy Discs

Tungsten alloy discs are crucial for a deeper understanding of their applications and performance optimization. Because tungsten alloy discs can be tailored to meet diverse industrial needs through adjustments in composition and manufacturing processes, their classification is typically based on the alloy's constituent elements, performance characteristics, or application scenarios. Compositional classification is the most fundamental and widely used method. By analyzing the combination of tungsten and other metal elements, different types of tungsten alloy discs can be clearly distinguished, and the unique advantages of each type in specific scenarios can be understood.

Tungsten alloy discs fully reflect the advancements in materials science and alloying technology. Different alloy compositions give the discs unique physical and chemical properties, such as density, toughness, corrosion resistance, and electrical conductivity, making them suitable for a wide range of applications, from precision instruments to heavy equipment. In actual production, the choice of composition is often closely related to the specific application. For example, some alloys are more suitable for high-temperature environments, while others are more suitable for applications requiring high conductivity.

Furthermore, the tungsten alloy disc classification system reflects modern industry's focus on environmental protection and sustainable development. Alloys of varying compositions exhibit varying environmental performance; for example, the non-toxic nature of some alloys makes them more suitable for medical or food processing applications. A comprehensive classification system helps companies balance performance requirements with environmental friendliness and resource recyclability, thereby promoting the application of tungsten alloy discs in a wider range of fields.

### Tungsten Alloy Discs by Composition

Compositional classification is the most common and fundamental method used in tungsten alloy disc classification. By analyzing the combination of tungsten and other metal elements, different types of tungsten alloy discs can be clearly distinguished. Each component combination endows the disc with specific performance characteristics, giving it unique advantages in different application scenarios. This classification method not only helps understand the characteristics of different tungsten alloy disc types but also provides an important reference for optimizing production processes and selecting application scenarios.

#### 2.1.1 Tungsten-nickel-iron alloy disc

Tungsten -nickel-iron alloy wafers are circular thin sheets made of tungsten as the main component, with nickel and iron added as alloying elements. This alloy significantly improves the brittleness and processing difficulty of pure tungsten by combining nickel and iron with tungsten, giving it better toughness and machinability while maintaining high density. The original intention of developing tungsten -nickel-iron alloy wafers was to meet industrial scenarios that require high density and high

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strength, such as counterweights or balancing components in aerospace, mechanical manufacturing, and precision instruments. The addition of nickel and iron not only enhances the ductility of the material, but also improves its impact resistance, enabling the wafer to maintain structural stability when subjected to mechanical stress or vibration.

Tungsten -nickel-iron alloy discs are typically manufactured using powder metallurgy technology. High-purity tungsten powder is mixed with nickel and iron powders in specific proportions, compacted, and sintered at high temperatures to form circular flakes with a uniform microstructure. Nickel acts as a binder, effectively connecting the tungsten particles and enhancing the alloy's overall strength, while the addition of iron further optimizes the disc's toughness and wear resistance. This combination of ingredients makes tungsten -nickel-iron alloy discs excellent for applications requiring high density and durability, such as balancing mass distribution in rotating equipment or serving as support components in high-temperature environments.

The corrosion resistance of tungsten -nickel-iron alloy wafers is also one of their important characteristics. The addition of nickel and iron enables them to maintain stable performance in a variety of chemical environments, especially in humid or mildly corrosive environments, effectively resisting oxidation and corrosion. This property gives them broad application prospects in certain special industrial scenarios, such as as key components in marine equipment or chemical processing equipment. In addition, the environmental friendliness of tungsten-nickel-iron alloy wafers is also worthy of attention. Despite containing nickel and iron, their overall non-toxic properties make them an ideal alternative to traditional high-density materials in many fields.

The flexibility of tungsten-nickel-iron alloy discs enables them to meet a wide range of application needs. By adjusting the ratio of nickel to iron, manufacturers can tailor the disc's properties, such as increasing the nickel content for improved toughness or the iron content for increased hardness. This customization capability makes tungsten -nickel-iron alloy discs valuable in a wide range of applications, from precision instruments to heavy machinery. Whether used as counterweights, support materials, or wear-resistant components, tungsten-nickel-iron alloy discs provide reliable support for industrial applications through their excellent comprehensive performance.

### 2.1.2 Tungsten-nickel-copper alloy disc

Tungsten -nickel-copper alloy wafers are circular, thin sheets primarily composed of tungsten, with nickel and copper added as alloying elements. Compared to tungsten-nickel-iron, this alloy prioritizes improved thermal conductivity and processing performance while maintaining high density and good mechanical properties. The addition of copper, a highly thermally conductive material, significantly improves the thermal conductivity of tungsten alloy wafers, giving them a distinct advantage in applications requiring efficient heat dissipation, such as electronic equipment or high-temperature processing environments. The addition of nickel enhances the alloy's toughness and structural stability, enabling the wafers to maintain reliable performance under complex operating conditions. tungsten -nickel-copper alloy discs is similar to that for tungsten-nickel-iron alloys, primarily utilizing powder

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metallurgy. By mixing tungsten powder, nickel powder, and copper powder, the mixture is pressed into shape and then sintered at high temperatures to form circular discs with a uniform structure and high performance. The addition of copper facilitates the formation of a dense microstructure during sintering, thereby improving the surface finish and dimensional accuracy of the discs. This characteristic makes them particularly suitable for applications requiring high-precision processing, such as heat dissipation components in the electronics industry or as support materials in precision instruments.

Tungsten -nickel-copper alloy wafers also offer excellent corrosion resistance, especially in environments exposed to moisture or chemicals. The addition of copper enhances the alloy's oxidation resistance, enabling it to maintain long-term performance stability. This property lends itself to broad application in fields such as the chemical industry and marine engineering. Furthermore, the combination of nickel and copper enhances the alloy's machinability, enabling the wafers to be processed into complex shapes while maintaining high-precision dimensional control. This machinability is particularly important in precision manufacturing, such as components in electronic devices that require high precision and reliability.

Tungsten -nickel-copper alloy wafers benefit from their balance of high density and excellent thermal conductivity. They are often used in applications where weight and heat dissipation must be balanced, such as aerospace components and high-performance electronic devices. Their non-toxic and environmentally friendly properties further expand their potential applications in areas such as medical devices. By adjusting the ratio of copper to nickel, manufacturers can further optimize the wafer's performance to meet specific application requirements, such as improving thermal conductivity or enhancing mechanical strength.

### 2.1.3 Tungsten-copper alloy disc

Tungsten-copper alloy discs are thin, circular sheets composed primarily of tungsten and copper, designed for applications requiring excellent thermal and electrical conductivity. The combination of copper's high thermal and electrical conductivity with tungsten's high density and high-temperature resistance gives tungsten-copper alloy discs unique advantages in the electronics, electrical, and thermal management sectors. By reducing the use of other elements like nickel, this alloy focuses on improving thermal and electrical conductivity while maintaining sufficient mechanical strength and corrosion resistance. Tungsten-copper alloy discs are typically manufactured using powder metallurgy technology. Tungsten and copper powders are mixed in a specific ratio, pressed into shape, and then sintered at high temperatures to form a thin, uniform disc with excellent performance. The copper ratio can be adjusted to optimize thermal and electrical conductivity according to specific application requirements, making it highly customizable. During the sintering process, copper fills the gaps between the tungsten particles, forming a dense microstructure that improves the disc's thermal stability and mechanical properties. This property enables it to maintain structural integrity in high-temperature environments.

Tungsten-copper alloy discs are widely used in applications requiring efficient heat dissipation, such as heat sinks in electronic devices and as electrode materials in electrical discharge machining (EDM). Their

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excellent electrical conductivity makes them suitable for use as electrical contacts or circuit components, effectively conducting current and minimizing energy loss. Furthermore, the low coefficient of thermal expansion of tungsten-copper alloy discs ensures dimensional stability in high-temperature environments, which is particularly important for precision applications, such as in electronic devices requiring high precision and stability.

Tungsten-copper alloy discs also makes them excellent performers in harsh environments. The addition of copper enhances the alloy's oxidation resistance, ensuring stable performance over extended use. This property holds great promise for applications in industrial furnaces, high-power electronic systems, and other fields. Its non-toxicity and recyclability, in line with modern environmental standards, make it an ideal choice for sensitive applications such as medical device manufacturing.

#### 2.1.4 Tungsten-silver alloy disc

Tungsten-silver alloy discs are thin, circular sheets composed primarily of tungsten and silver, designed for applications requiring high electrical conductivity and wear resistance. Silver, an excellent conductive material, significantly improves the conductivity of tungsten alloy discs, making them valuable for applications in the electrical and electronic fields. Furthermore, tungsten's high density and high-temperature resistance provide the discs with excellent structural stability and durability, enabling them to maintain performance in high-load or high-temperature environments.

Tungsten-silver alloy discs are also manufactured using powder metallurgy technology. By mixing tungsten and silver powders, pressing and shaping them, and then sintering them at high temperatures, they form circular discs with a uniform structure and high performance. The addition of silver improves the alloy's conductivity while maintaining tungsten's high density and mechanical strength. This combination of ingredients makes it particularly suitable for applications requiring high conductivity and durability, such as high-voltage electrical contacts or circuit breaker components. During the sintering process, the silver effectively fills the gaps between the tungsten particles, forming a dense structure and improving the disc's performance stability.

Tungsten silver alloy discs are particularly resistant to arc erosion, which is particularly important in electrical applications. In environments with high voltage or frequent switching operations, arcing can cause material loss. The excellent properties of tungsten silver alloy discs effectively resist arc erosion and extend component life. This characteristic makes them widely applicable in high-power electrical systems or industrial equipment. Furthermore, their high-temperature resistance ensures reliability in high-temperature environments, such as industrial furnaces or high-performance electronic systems.

The environmental friendliness and recyclability of tungsten-silver alloy discs are also key advantages. As a non-toxic material, they meet the environmental requirements of modern industry and are suitable for use in sensitive applications such as medical devices and food processing equipment. By adjusting the silver content, manufacturers can tailor the disc's conductivity and mechanical properties to meet the needs of various applications. This combination of flexibility and high performance makes tungsten-

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silver alloy discs irreplaceable in the electrical and electronic fields.

## 2.2 Tungsten Alloy Discs by Size

Classification by size is an intuitive and practical approach to tungsten alloy disc classification. By categorizing different diameter ranges, we can clearly understand the functions and advantages of discs in different application scenarios. Size directly affects the manufacturing process, performance, and application areas of the discs, making this classification method of tungsten alloy discs of great significance in industrial design and production. The following details the three main types of tungsten alloy discs: micro discs (diameter less than 10 mm), regular discs (diameters between 10 mm and 100 mm), and large discs (diameter greater than 100 mm).

### 2.2.1 Micro-discs (diameter < 10 mm)

Micro tungsten alloy discs are thin, circular sheets of material with a diameter less than 10 mm. Due to their compact size, they are primarily used in high-precision, miniaturized applications. These discs play a vital role in modern industry, particularly in precision instruments, electronic equipment, and medical devices. Their combination of small size and high performance enables them to meet the demands of space and precision. The development and production of micro discs require highly sophisticated manufacturing processes to ensure performance stability and structural integrity despite their tiny size.

Micro tungsten alloy discs are typically manufactured using advanced powder metallurgy techniques. Tungsten powder is mixed with other metal powders (such as nickel, iron, or copper), compacted, and sintered at high temperatures to form circular discs with a uniform microstructure. Due to their extremely small size, the production process requires extremely high precision control, such as precise control of powder particle size, sintering temperature, and pressure to avoid microscopic defects or dimensional deviations. Furthermore, the surface treatment of the micro discs is crucial. Through polishing or precision grinding, extremely high surface finish and dimensional accuracy can be achieved to meet the demands of precision applications.

Micro tungsten alloy discs are their high density and excellent physical properties. Despite their small size, their high density enables them to provide sufficient mass within limited spaces, enabling them to be used as counterweights or balancing components in micromechanical devices, improving operational stability and precision. Their high-temperature and corrosion resistance also make them excellent performers in microelectronic devices, for example, as micro heat sinks or shielding components, maintaining stable performance in high-temperature or chemical environments. Furthermore, the micro discs exhibit excellent machinability, allowing them to be fabricated into complex shapes through micromachining techniques to meet diverse design requirements.

In terms of applications, micro tungsten alloy discs are widely used in scenarios requiring high precision and miniaturization. For example, in the medical field, micro discs can be used to manufacture components for precision medical devices, such as shielding materials for micro sensors or implantable

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devices . In the electronics industry, their high density and thermal conductivity make them an ideal material for microcircuits or chips. Micro discs are also environmentally friendly. Their non-toxic and recyclable properties make them highly sought after in the medical and precision manufacturing fields. By optimizing the alloy composition and production process, micro tungsten alloy discs can achieve high performance in a tiny size, providing important support for the development of modern science and technology.

### 2.2.2 Conventional wafers ( $10\text{ mm} \leq \text{diameter} \leq 100\text{ mm}$ )

Conventional tungsten alloy wafers, thin circular sheets with diameters ranging from 10 mm to 100 mm, are the most widely used type of tungsten alloy wafer. Due to their moderate size, conventional wafers offer high flexibility and applicability in a wide range of industrial applications, from machinery manufacturing to electronics, aerospace, and medical devices. The range of conventional wafer sizes allows for a balance between performance and processing difficulty, enabling them to meet high-precision requirements while accommodating large-scale industrial applications.

conventional tungsten alloy discs is also based on powder metallurgy technology. By mixing tungsten powder with other metal powders, pressing and high-temperature sintering, circular thin discs with uniform structure and high performance are formed. Compared with micro discs, the manufacturing process of conventional discs has slightly relaxed precision requirements, but has higher requirements for the uniformity of material properties and structural stability. During the production process, the optimization of the sintering process is particularly important. For example, by adjusting the sintering temperature and pressure, the density and mechanical strength of the disc can be improved. In addition, the surface treatment process of conventional discs, such as grinding or polishing, can further improve its surface quality to meet the needs of different application scenarios.

Conventional tungsten alloy discs are distinguished by their balanced overall performance. Their high density enables them to be used as counterweights or balancing components in rotating equipment or precision instruments to improve operational stability and accuracy. Their high-temperature and corrosion resistance ensures stable performance in a variety of environments, such as when used as support or shielding components in high-temperature processing equipment or chemical environments. Furthermore, conventional discs possess excellent mechanical properties. Through alloying, their toughness and impact resistance are significantly enhanced, enabling them to withstand significant mechanical stress and vibration, making them suitable for use in high-intensity industrial applications.

In terms of application, the range of sizes available for conventional tungsten alloy wafers makes them widely adaptable. For example, in the aerospace sector, conventional wafers can be used to manufacture aircraft balancing components or high-temperature parts. In the electronics industry, their high density and thermal conductivity make them ideal for heat sinks or circuit support materials. In medical devices, their non-toxic and corrosion-resistant properties make them suitable for use as shielding or support components. The processing flexibility of conventional wafers enables them to be manufactured into various thicknesses and shapes to meet diverse design requirements. Their environmental friendliness

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and recyclability also make them more attractive in modern industry, enabling them to meet performance requirements while complying with sustainable development goals.

### 2.2.3 Large wafers (diameter > 100 mm)

Large tungsten alloy discs are thin, circular sheets with a diameter greater than 100 mm. They are primarily used in industrial applications requiring high strength, high mass, or large-scale components. Due to their large size, these discs are often used in heavy equipment, industrial machinery, or specialized engineering projects. Their high density and excellent mechanical properties enable them to meet stringent quality and durability requirements. The development and production of large discs presents significant manufacturing challenges, requiring the maintenance of uniform performance and structural stability despite their large size.

Large tungsten alloy discs is based on powder metallurgy technology, but requires more complex equipment and process control. Due to their large size, the production process requires extremely high precision in the powder mixing, pressing, and sintering processes to avoid internal defects or uneven performance. For example, the use of hot isostatic pressing technology can effectively improve the density and strength of large discs, eliminate microscopic pores, and ensure their reliability in high-load environments. In addition, the surface treatment and processing of large discs require the use of heavy equipment, such as large CNC machine tools, to achieve high-precision dimensional control and surface finish.

Large tungsten alloy discs are characterized by their exceptional high density and mechanical properties. Their high density gives them significant advantages in applications requiring high mass, such as counterweights or supporting components in heavy machinery or engineering equipment, providing sufficient inertia and stability. Their high-temperature and corrosion resistance enable them to maintain stable performance in extreme environments, such as in high-temperature furnaces or as critical components in chemical processing equipment. Furthermore, the mechanical strength and toughness of these large discs are optimized through alloying, enabling them to withstand high levels of mechanical stress and impact, making them suitable for use in demanding industrial applications.

In terms of applications, large tungsten alloy discs are primarily used in heavy industry and engineering. For example, in aerospace, their high density and high-temperature resistance make them ideal for balancing components or high-temperature parts in large aircraft. In the energy sector, large discs can be used to manufacture counterweights for wind turbines or nuclear power equipment. In industrial manufacturing, their wear and corrosion resistance make them suitable for use as large molds or tooling components. Large discs also offer environmental advantages. Their non-toxic and recyclable properties enable them to meet the sustainable development requirements of modern industry.

## 2.3 Classification of Tungsten Alloy Discs by Application Function

By application function is a practical application-oriented method in the tungsten alloy disc classification

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system. By analyzing the role of the disc in different functional scenarios, the types of functional tungsten alloy discs can be clearly divided. This classification method is directly related to the performance characteristics and application scenarios of the disc, such as radiation shielding, electrical conduction, heat dissipation, or wear and corrosion resistance.

### 2.3.1 Functional tungsten alloy discs

Functional tungsten alloy discs are circular, thin sheets designed for specific applications. Through optimized alloy composition and manufacturing processes, their performance can meet the stringent requirements of specific scenarios. These discs leverage tungsten alloy's high density, high-temperature resistance, and corrosion resistance. Through targeted design, they play a unique role in radiation shielding, electrical conductivity, heat dissipation, and wear and corrosion resistance. The core of functional classification lies in combining the performance of tungsten alloy discs with actual application requirements to maximize material performance.

Functional tungsten alloy discs are usually manufactured using powder metallurgy technology. By adjusting the ratio of tungsten to other metal elements, optimizing the sintering process and surface treatment, discs that meet specific functional requirements are produced. For example, in scenarios where high conductivity is required, the copper or silver content may be increased; in scenarios where wear resistance is required, the proportion of nickel or iron may be optimized. During the production process, precise process control and high-quality raw material selection are key to ensuring the stable performance of functional discs. In addition, the size and shape of functional discs can also be customized according to specific uses. For example, small-sized, high-precision discs are required in micro-devices, while larger-sized discs may be required in heavy equipment.

functional tungsten alloy discs embodies the deep integration of materials science and industrial applications. Through targeted alloy design and process optimization, these discs maintain excellent performance in a variety of complex environments, such as high temperature, high pressure, and corrosive environments. Their non-toxicity and recyclability also give them significant advantages in environmentally sensitive applications, such as medical and food processing equipment. The diverse applications of functional discs have promoted the widespread use of tungsten alloy materials in modern industry and provided important support for technological advancement.

#### 2.3.1.1 Tungsten alloy discs for radiation shielding

Tungsten alloy discs for radiation shielding are thin, circular sheets designed specifically to prevent radiation penetration and are widely used in the medical, scientific, and industrial fields. Their high density allows them to effectively absorb and block high-energy radiation, such as X-rays and gamma rays, thereby protecting equipment and personnel from the effects of radiation. The advantages of tungsten alloy discs as radiation shielding materials lie in their high density and non-toxicity. Compared to traditional shielding materials such as lead, tungsten alloy discs are more environmentally friendly and suitable for use in safety-critical applications.

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Tungsten alloy discs for radiation shielding are typically manufactured using powder metallurgy techniques. This involves mixing tungsten powder with other metal powders (such as nickel and iron), pressing and sintering the mixture at high temperatures to create circular discs with high density and uniform structure. To meet radiation shielding requirements, the disc's density and thickness must be precisely controlled to ensure the desired shielding effect. Surface treatments such as polishing or coating can further enhance the disc's performance, for example, by increasing its corrosion resistance or surface finish, thereby extending its service life.

The primary characteristic of tungsten alloy discs for radiation shielding is their exceptional radiation absorption capacity. Due to its high density, tungsten effectively blocks high-energy radiation, reducing the likelihood of radiation penetration. This property lends itself to widespread use in medical devices, such as shielding components in X-ray machines or CT scanners, protecting patients and medical personnel from radiation hazards. Furthermore, its high-temperature resistance and chemical stability enable it to maintain its performance in challenging environments, such as in scientific research equipment used to shield against high-energy particles.

In terms of applications, tungsten alloy discs for radiation shielding are not limited to the medical field; they are also widely used in industrial and scientific research scenarios. For example, in non-destructive testing equipment, tungsten alloy discs can be used to shield radiation, ensuring the safety of the testing process. In the nuclear energy field, its high density and corrosion resistance make it an ideal choice for radiation protection components. Its non-toxic and recyclable properties further enhance its applicability in environmentally sensitive fields, such as medical device manufacturing, where it can meet strict safety and environmental standards.

### 2.3.1.2 Tungsten alloy discs for electrical conduction

Tungsten alloy wafers for electrical conductivity are thin, circular sheets designed for applications requiring efficient electrical conductivity. Their conductivity is typically optimized by adding highly conductive metals such as silver or copper. These wafers play a vital role in the electrical and electronic fields, effectively conducting current and reducing energy loss while maintaining the high density and high-temperature resistance of tungsten alloy. The development of tungsten alloy wafers for electrical conductivity addresses the dual requirements of conductivity and durability for high-performance electrical devices.

Tungsten alloy discs for electrical conductivity are also manufactured using powder metallurgy technology. By mixing tungsten powder with silver or copper powder, pressing and shaping, and sintering at high temperatures, they form circular discs with high conductivity and uniform structure. The addition of silver or copper significantly improves the disc's electrical conductivity while maintaining tungsten's high density and mechanical strength. During production, precise control of the alloy composition and sintering process is key to ensuring conductive properties. For example, by adjusting the silver or copper ratio, the disc's electrical conductivity can be optimized to meet specific requirements. The key features of tungsten alloy discs for electrical conduction are their excellent conductivity and durability. The

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addition of silver or copper enables efficient current conduction in environments with high currents or frequent switching operations. Tungsten's high density and high-temperature resistance ensure the disc's structural stability under high loads. Furthermore, its arc erosion resistance excels in electrical applications, effectively resisting arc-induced material loss and extending service life. This property makes it particularly suitable for use in high-voltage electrical contacts, circuit breakers, or circuit components.

In terms of applications, tungsten alloy discs for electrical conduction are widely used in electrical and electronic equipment. For example, in high-voltage transmission systems, tungsten alloy discs can be used as electrical contacts to ensure efficient current conduction. In the electronics industry, their high conductivity and high-temperature resistance make them an ideal material for circuit boards or connectors. Their non-toxic and recyclable properties also give them advantages in areas with high environmental requirements, such as medical electronic equipment or precision instruments, where they can meet the dual requirements of safety and performance.

### **2.3.1.3 Tungsten alloy discs for thermal conductivity and heat dissipation**

Tungsten alloy wafers for thermal conductivity and heat dissipation are thin, circular sheets developed for applications requiring efficient thermal management. Their thermal conductivity is typically enhanced by adding a highly conductive metal, such as copper. These wafers play a vital role in electronic, aerospace, and industrial equipment, rapidly transferring heat from high-temperature areas to heat dissipation zones, thereby protecting the equipment from overheating. The high density and high-temperature resistance of tungsten alloy wafers give them unique advantages in thermal conductivity and heat dissipation scenarios.

Tungsten alloy discs for thermal conductivity and heat dissipation are manufactured using powder metallurgy technology. By mixing tungsten powder with copper powder, pressing and shaping, and sintering at high temperatures, they form circular discs with high thermal conductivity and uniform structure. The addition of copper significantly improves the disc's thermal conductivity, enabling it to conduct heat quickly, while tungsten's high density and high-temperature resistance ensure the disc's structural stability in high-temperature environments. During the production process, precise control of the copper ratio and sintering process are key to ensuring thermal conductivity. For example, by optimizing the sintering temperature, the disc's density and thermal conductivity can be improved.

The key features of tungsten alloy discs for heat dissipation and thermal stability are their excellent thermal conductivity and thermal stability. The addition of copper enables rapid heat dissipation in high-temperature environments, preventing equipment overheating. Tungsten's low coefficient of thermal expansion ensures dimensional stability despite temperature fluctuations. This makes it particularly suitable for use in high-performance electronic devices, such as heat sinks for processors or power modules. Furthermore, its corrosion resistance ensures stable performance in humid or chemical environments, extending its service life. In terms of applications, tungsten alloy discs for thermal conductivity and heat dissipation are widely used in scenarios requiring efficient thermal management.

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For example, in the electronics industry, their high thermal conductivity makes them ideal for heat sinks or heat pipes. In the aerospace field, their high-temperature resistance and thermal conductivity make them suitable for thermal management of high-temperature components. In industrial equipment, they can effectively dissipate heat, improving equipment efficiency and lifespan. Their non-toxic and recyclable properties make them promising for broad application in environmentally sensitive fields, such as medical electronics and new energy equipment.

#### 2.3.1.4 Tungsten alloy discs for wear and corrosion resistance

Tungsten alloy discs for wear and corrosion resistance are thin, circular sheets developed for applications requiring them to withstand wear and corrosion in harsh environments. These discs are typically optimized by adding elements such as nickel and iron. These discs play an important role in the chemical industry, marine engineering, and heavy machinery, maintaining stable performance in highly abrasive or corrosive environments. The high density and mechanical strength of tungsten alloy discs make them excellent performers in wear and corrosion-resistant applications.

Wear- and corrosion- resistant tungsten alloy discs are manufactured using powder metallurgy technology. Tungsten powder is mixed with nickel and iron powders, compacted, and then sintered at high temperatures to form circular discs with high wear and corrosion resistance. The addition of nickel and iron improves the disc's toughness and impact resistance, while also enhancing its chemical stability in corrosive environments. During production, optimizing the sintering process and surface treatment are key to ensuring wear and corrosion resistance. For example, polishing or coating processes can further enhance the disc's surface hardness and corrosion resistance.

for wear and corrosion resistance are their exceptional wear and corrosion resistance. Tungsten's high hardness and the addition of nickel and iron enable it to maintain surface integrity in high-wear environments, such as in wear-resistant components in machining or grinding equipment. Its corrosion resistance enables it to maintain stable performance in acidic, alkaline, or humid environments, such as in critical components in marine equipment or chemical reactors. Furthermore, its high density and mechanical strength enable it to withstand high mechanical stresses, making it suitable for heavy-duty industrial applications. In terms of applications, wear- resistant and corrosion-resistant tungsten alloy discs are widely used in scenarios requiring long-term durability. For example, in the chemical industry, their corrosion resistance makes them suitable as supporting components for reactors or pipelines; in marine engineering, they can resist seawater corrosion, extending equipment life; and in heavy machinery, their wear resistance makes them suitable for use as molds or tool components. Their non-toxic and recyclable properties give them advantages in areas with high environmental requirements, such as food processing equipment or medical devices, where they meet the dual requirements of safety and durability.

### 2.3 Classification of Tungsten Alloy Discs by Application Function

Functional classification is a purpose-based approach within the tungsten alloy disc classification system, clearly defining the disc's role in different functional scenarios. Structural tungsten alloy discs, a key

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functional classification category, focus on the material's application in mechanical structures, encompassing diverse functions such as support, counterweighting, connection, and sealing. Through targeted alloy design and manufacturing processes, these discs deliver exceptional performance in high-load, complex environments, meeting the diverse demands of modern industry.

### 2.3.2 Structural tungsten alloy discs

Structural tungsten alloy discs are thin, circular sheets designed to meet the needs of mechanical structures, leveraging tungsten alloy's high density, strength, and durability. These discs play a key role in structural support, counterweights, connections, and sealing. By optimizing alloy composition and manufacturing processes, they can meet the needs of a wide range of applications, from precision instruments to heavy equipment. The development of structural discs combines advances in materials science and engineering design, making them an indispensable structural material in modern industry.

Structural tungsten alloy discs are typically manufactured using powder metallurgy techniques. This involves mixing tungsten powder with other metal powders (such as nickel, iron, or copper), pressing and shaping, and then sintering at high temperatures to form circular discs with high strength and uniform structure. During production, precise control of process parameters is key to ensuring consistent disc performance. For example, adjusting the sintering temperature and pressure can optimize the disc's density and mechanical properties. Surface treatments such as grinding or polishing can further enhance the disc's dimensional accuracy and surface quality, meeting the requirements of diverse structural functions.

structural tungsten alloy discs lies in their ability to tailor their properties to specific applications. For example, where high strength is required, the disc might increase its nickel content to enhance toughness; where high density is desired, the tungsten ratio might be optimized to increase mass. Its non-toxic and recyclable properties offer significant advantages in environmentally sensitive applications, such as medical devices or food processing equipment, where it meets the dual requirements of safety and durability.

#### 2.3.2.1 Tungsten alloy discs for structural support

Tungsten alloy discs for structural support are thin, circular materials designed to provide mechanical structural support. They are widely used in industrial applications requiring high strength and stability. Leveraging the high density and mechanical strength of tungsten alloy, these discs provide reliable support for equipment under high loads or in complex environments, ensuring structural stability and durability. Their primary advantage lies in their ability to maintain performance under extreme conditions, such as high temperature, high pressure, or vibration, while maintaining structural integrity.

Tungsten alloy discs for structural support are manufactured using powder metallurgy technology. By mixing tungsten powder with metal powders such as nickel and iron, pressing and forming, and sintering at high temperatures, circular thin discs with high strength and uniform structure are formed. The addition

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of nickel and iron significantly improves the toughness and impact resistance of the discs, enabling them to withstand greater mechanical stress. During the production process, optimization of the sintering process is crucial. For example, hot isostatic pressing technology can eliminate internal defects and improve the density and strength of the discs. In addition, precise surface treatment processes can ensure the dimensional accuracy and surface finish of the discs, meeting the requirements of high-precision support components.

Tungsten alloy discs for structural support are characterized by their exceptional mechanical properties and stability. Tungsten's high density provides sufficient mass and strength within confined spaces, while alloying improves the brittleness of pure tungsten, enabling the discs to maintain structural integrity in vibration or shock environments. Their high-temperature and corrosion-resistant properties also allow them to excel in harsh environments, such as support components in high-temperature processing equipment or chemical environments. The discs' shape facilitates installation and integration, allowing them to be seamlessly embedded into various mechanical structures. Tungsten alloy discs for structural support are widely used in aerospace, industrial machinery, and energy equipment. For example, in aerospace equipment, their high strength and high-temperature resistance make them ideal for engine or fuselage support components. In industrial machinery, they can serve as support structures for high-load equipment, improving operational stability. Their environmental friendliness and recyclability also lend them potential for application in sensitive areas such as medical equipment, providing high-performance structural solutions for modern industry.

#### 2.3.2.2 Tungsten alloy discs for balance weights

Tungsten alloy discs for counterweights are thin, circular materials designed to adjust equipment mass distribution and improve operational stability. They are widely used in applications requiring precise balancing. Leveraging the high density of tungsten alloy, these discs provide a high mass within a small volume, thereby achieving balance and stability. Their design flexibility and high performance make them irreplaceable in rotating equipment, precision instruments, and heavy machinery.

The manufacture of tungsten alloy discs for counterweights also utilizes powder metallurgy technology. By mixing tungsten powder with metal powders such as nickel and iron, pressing and shaping the resulting discs, and then sintering them at high temperatures, the result is a circular disc with high density and uniform structure. The addition of nickel and iron improves the disc's toughness and processing properties, enabling it to be machined into precise sizes and shapes. During production, precise control of the disc's density and size is crucial to ensure it provides the desired counterweight effect. Additionally, surface treatments such as polishing or coating can enhance the disc's corrosion resistance and surface quality, extending its service life.

Tungsten alloy discs for counterweights are distinguished by their high density and processing flexibility. Tungsten's high density allows it to provide sufficient mass within a limited space, making it suitable for space-constrained applications such as micromotors or precision instruments. Its excellent mechanical properties allow it to withstand the stresses of rotation and vibration, ensuring long-term stability.

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Furthermore, its corrosion resistance allows it to maintain performance in humid or chemical environments, such as when used as counterweight components in marine equipment or chemical processing equipment.

In terms of applications, tungsten alloy discs for balance weights are widely used in aerospace, automotive, and precision manufacturing. For example, in aerospace, their high density makes them suitable for balancing components in aircraft or satellites, ensuring stability during high-speed operation. In the automotive industry, they are used to balance engines or wheels, improving vehicle smoothness. Their non-toxicity and recyclability also make them advantageous in environmentally sensitive applications, such as medical devices and food processing equipment, where they meet the dual requirements of safety and performance.

### 2.3.2.3 Tungsten alloy discs for connection and fixing

Tungsten alloy discs for connecting and fixing are thin, circular materials designed for mechanical connections and fixings. They are widely used in connection scenarios requiring high strength and stability. Leveraging the high density and mechanical strength of tungsten alloy, these discs can serve as connecting components or fixings, providing reliable structural support and ensuring the stability of equipment in high-load or vibration environments. Their circular design facilitates processing and installation, enabling seamless integration into various mechanical systems.

Tungsten alloy discs for connecting and fixing are manufactured using powder metallurgy technology. By mixing tungsten powder with metal powders such as nickel and iron, pressing and shaping them, and then sintering them at high temperatures, they form circular discs with high strength and uniform structure. The addition of nickel and iron improves the discs' toughness and impact resistance, enabling them to maintain performance in high-stress environments. Precise dimensional control and surface treatment are key during the production process. For example, precision grinding or polishing can achieve high-precision dimensions and surface finishes to meet the stringent requirements of connecting components.

Tungsten alloy discs for connectors and fixtures are distinguished by their high strength and precision processing. Tungsten's high density and alloying treatment allow it to withstand significant mechanical stress, making it suitable for use as connectors or fixtures. Its high-temperature and corrosion resistance enable it to maintain performance in demanding environments, such as high-temperature processing equipment or chemical environments. Furthermore, the disc's shape allows it to easily fit other components, enabling secure connections through bolts, rivets, and other methods.

Tungsten alloy discs for connection and fixturing are widely used in industrial machinery, aerospace, and energy equipment. For example, in industrial machinery, their high strength makes them ideal for connecting large components; in aerospace, their high-temperature resistance and stability make them suitable for connecting high-temperature components or high-load structures. Their environmental friendliness and recyclability also hold potential for application in sensitive areas such as medical

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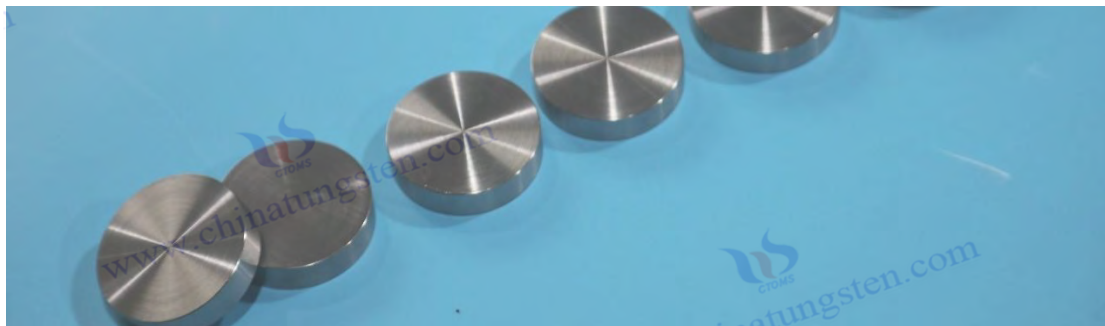
equipment, providing a reliable solution for connecting complex mechanical systems.

#### 2.3.2.4 Tungsten alloy discs for sealing and isolation

Tungsten alloy discs for sealing and isolation are thin, circular sheets designed for sealing or isolation functions. They are widely used in applications requiring protection from gases, liquids, or external factors. Leveraging tungsten alloy's high density, corrosion resistance, and low thermal expansion coefficient, these discs provide reliable sealing in high-pressure or harsh environments, ensuring equipment safety and operational efficiency. Their circular design and precision machining allow them to conform closely to sealing surfaces, meeting high-precision sealing requirements.

Tungsten alloy discs for sealing and isolation are manufactured using powder metallurgy technology. Tungsten powder is mixed with metal powders such as nickel and iron, compacted, and then sintered at high temperatures to form circular discs with high density and uniform structure. During production, surface treatment processes such as precision polishing or coating are crucial to ensuring sealing performance, enhancing the disc's surface finish and chemical stability. Furthermore, precise control of the disc's size and thickness is crucial to meeting sealing requirements, ensuring a perfect fit with the sealing surface.

Tungsten alloy discs for sealing and isolation applications are characterized by their excellent sealing properties and durability. Tungsten's high density and low coefficient of thermal expansion enable it to maintain dimensional stability in high-temperature or high-pressure environments, preventing seal failure. Its corrosion resistance enables it to maintain performance in acidic, alkaline, or humid environments, such as those used as sealing components in chemical reactors or marine equipment. Furthermore, its high strength and toughness enable it to withstand mechanical stress, ensuring long-term reliability. In terms of application, tungsten alloy discs for sealing and isolation are widely used in the chemical industry, energy equipment, and aerospace. For example, in the chemical industry, their corrosion resistance makes them suitable for sealing reactors or pipelines; in energy equipment, their high density and stability make them suitable for sealing high-pressure vessels; and in the aerospace field, their high-temperature resistance enables their use as high-temperature sealing components. Their non-toxic and recyclable properties also give them broad application potential in medical and food processing equipment, providing a highly efficient solution for demanding sealing scenarios.



CTIA GROUP LTD Tungsten Alloy Wafer

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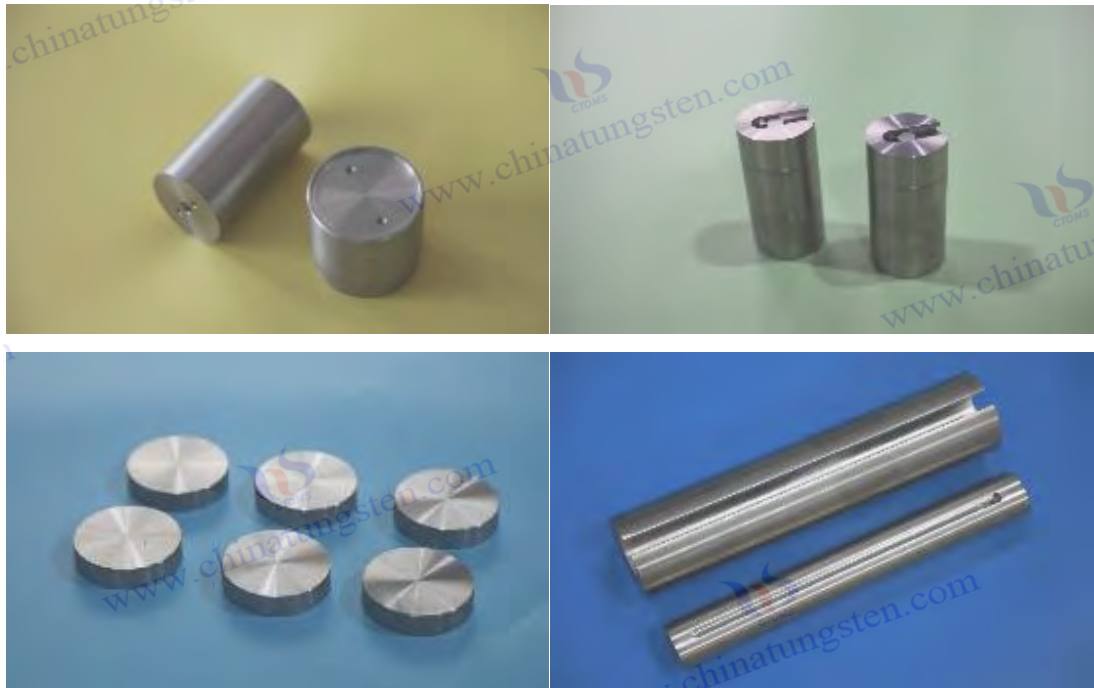
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## Chapter 3 Properties of Tungsten Alloy Discs

tungsten alloy discs is the core foundation of their widespread application in modern industry. Their unique physical and chemical properties enable them to excel in a variety of demanding scenarios. As a high-performance material, tungsten alloy discs possess a wide range of properties, including density, mechanical strength, high-temperature resistance, and corrosion resistance. Density-related properties are particularly critical, directly determining their effectiveness in applications such as counterweights, shielding, and structural support. This superior performance stems not only from the inherent properties of tungsten but also from advances in alloying and manufacturing techniques, enabling the discs to meet diverse demands, from precision instruments to heavy equipment.

Density, as one of the core properties of tungsten alloy discs, profoundly affects their functionality and application range. The high density property enables it to provide a large mass within a limited space, making it suitable for scenarios requiring precise mass distribution or shielding effects. The research and optimization of density-related properties is an important direction for the development of tungsten alloy discs. By adjusting the alloy composition and manufacturing process, the density can be precisely controlled and uniform, thereby improving the performance stability of the disc. In addition, the environmental friendliness and recyclability of tungsten alloy discs enable them to meet the requirements of modern industry for sustainable development while optimizing their performance, providing a guarantee for their application in fields such as medicine, aerospace, and electronics.

tungsten alloy discs also demonstrates the deep integration of materials science and engineering applications. Through systematic analysis of density, uniformity, and application impact, we can gain a clearer understanding of their performance in real-world scenarios, providing a scientific basis for material selection and process optimization.

### 3.1 Density-related properties of tungsten alloy discs

tungsten alloy discs are one of their most prominent characteristics, directly determining their performance in a variety of applications. Density not only affects the disc's weight and mass distribution but is also closely related to its mechanical properties, shielding effectiveness, and stability. By optimizing the alloy composition and manufacturing process, the density of tungsten alloy discs can be precisely controlled to meet the needs of different scenarios.

#### 3.1.1 Density range

The density range of tungsten alloy discs is a key performance indicator, making them an ideal choice for many industrial applications due to their high density. As a high-density metal, tungsten has a density far higher than that of common metals. By alloying it with other metal elements (such as nickel, iron, copper, or silver), the disc's properties can be tailored to suit different applications while maintaining high density. The density range of tungsten alloy discs is typically achieved through optimization of the alloy composition and manufacturing process, meeting a wide range of requirements, from high-density

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counterweights to precision shielding.

Tungsten alloy discs are typically manufactured using powder metallurgy technology. This involves mixing tungsten powder with other metal powders in specific proportions, pressing and shaping them, and then sintering them at high temperatures to form circular flakes with high density and uniform structure. The choice of alloy composition directly affects the density value. For example, adding nickel and iron can improve toughness while maintaining a high density; adding copper or silver may slightly reduce the density but improve thermal or electrical conductivity. During production, optimizing the sintering process is crucial to density control. For example, by adjusting the sintering temperature and pressure, higher density can be achieved while avoiding internal defects.

tungsten alloy discs gives them significant advantages in scenarios requiring greater mass. For example, in aerospace equipment, high-density discs can serve as counterweights, providing sufficient inertia to ensure the stability of the equipment. In medical equipment, their high density makes them an ideal material for radiation shielding, effectively absorbing high-energy radiation. The flexibility of the density range allows tungsten alloy discs to be customized according to specific needs. For example, in precision instruments, thinner discs with higher density may be required, while in heavy equipment, larger high-density discs may be required.

Furthermore, the density range of tungsten alloy discs is closely linked to their environmental friendliness. As a non-toxic material, tungsten alloy discs offer greater safety and recyclability than traditional high-density materials such as lead. This makes them highly sought after in sensitive fields such as healthcare and food processing. By optimizing the alloy composition and manufacturing process, tungsten alloy discs are able to maintain high density while meeting the dual requirements of environmental protection and performance, providing a reliable material solution for modern industry.

### 3.1.2 Density uniformity performance

Density uniformity is a critical aspect of tungsten alloy wafer performance, directly impacting its performance in high-precision and high-reliability applications. Density uniformity refers to the consistency of mass distribution across the wafer's microstructure, ensuring performance stability and structural reliability in applications. Density uniformity in tungsten alloy wafers is achieved through advanced manufacturing processes and rigorous quality control, enabling consistent performance in complex environments.

Achieving density uniformity relies on optimizing powder metallurgy technology. During the manufacturing process, the mixing of tungsten powder and other metal powders requires a highly uniform process to avoid local density variations. Pressing and high-temperature sintering are key steps influencing density uniformity. By precisely controlling pressure and temperature, a dense microstructure can be formed, eliminating internal porosity or defects. Furthermore, the introduction of advanced processes such as hot isostatic pressing further improves the wafer's density uniformity, enabling it to maintain stable performance in high-load or high-precision applications.

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Density uniformity has a significant impact on the performance of tungsten alloy discs. In applications requiring precise mass distribution, such as balancing components in aerospace equipment, density uniformity ensures consistent counterweighting across the disc, avoiding operational instability caused by local density differences. In radiation shielding applications, density uniformity directly impacts shielding reliability, as a uniform density distribution ensures consistent radiation absorption. Furthermore, density uniformity improves the disc's mechanical properties, such as impact and wear resistance, enabling it to maintain structural integrity in high-stress environments.

tungsten alloy wafers is also reflected in their processing performance. Their uniform microstructure enables them to be machined into highly precise shapes while maintaining surface finish and dimensional stability. This property lends them broad application prospects in precision manufacturing, such as key components in electronic devices and medical equipment. Optimizing density uniformity not only enhances wafer performance but also reduces scrap rates during production, improving resource efficiency and meeting the sustainable development requirements of modern industry.

### 3.1.3 Effect of Density on the Application of Tungsten Alloy Discs

Density profoundly impacts the application of tungsten alloy discs and is a key factor in determining their performance in a variety of scenarios. Its high density enables tungsten alloy discs to provide significant mass within a limited space, meeting requirements for counterweight, shielding, and structural support. Furthermore, the controllable and uniform density allows them to adapt to the performance requirements of diverse scenarios. Density influences not only the disc's physical properties but also its functional and economic benefits in practical applications.

The high density of tungsten alloy discs makes them ideal for counterweight applications. For example, in rotating equipment or precision instruments, high-density discs can provide sufficient inertia, reduce vibration, and improve operational stability. Their density advantage enables them to achieve a high mass within a small volume, making them particularly suitable for space-constrained applications such as aerospace equipment or micromotors. Furthermore, the controllable density allows manufacturers to adjust the disc's weight to specific needs, ensuring a perfect match with the equipment design.

In radiation shielding applications, density directly determines the shielding effectiveness of tungsten alloy discs. High density enables them to effectively absorb high-energy radiation, such as X-rays and gamma rays, thereby protecting equipment or personnel from the effects of radiation. Compared to traditional shielding materials, the density advantage of tungsten alloy discs enables them to achieve the same shielding effectiveness at a thinner thickness, reducing material usage and equipment weight. This characteristic is particularly important in medical devices, scientific research instruments, and industrial testing equipment, improving safety and efficiency.

In structural support and mechanical applications, density influences the strength and stability of tungsten alloy discs. High density, combined with an optimized alloy composition, enables the discs to provide reliable support in high-load environments, such as critical components in high-temperature processing

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equipment or heavy machinery. Density uniformity further ensures consistent performance, preventing structural failure due to localized density variations. Furthermore, high density improves the discs' wear and impact resistance, enabling long-term use in demanding environments.

tungsten alloy discs is also closely related to their environmental friendliness. As a non-toxic and recyclable material, its high density offers significant advantages when replacing traditional high-density materials, for example, in medical devices or food processing equipment, meeting both safety and environmental requirements. By optimizing density and manufacturing processes, tungsten alloy discs can meet high-performance requirements while maximizing resource efficiency, providing important support for the sustainable development of modern industry.

### 3.2 High temperature resistance of tungsten alloy discs

tungsten alloy wafers is their core advantage in high-temperature applications, directly determining their reliability in aerospace, industrial processing, and energy equipment. This high-temperature resistance encompasses multiple aspects, including melting point, stability in high-temperature environments, and resistance to thermal shock. These properties are achieved through optimized alloy composition and advanced manufacturing processes, enabling the wafers to maintain excellent performance under extreme high-temperature conditions.

#### 3.2.1 Melting point

tungsten alloy wafers is one of the fundamental indicators of their high-temperature resistance. Due to its extremely high melting point, it is an ideal choice for high-temperature applications. Tungsten itself is a high-melting-point metal. By alloying it with other metal elements (such as nickel, iron, copper, or silver), its toughness and processing properties can be improved while maintaining its high melting point, making the wafers suitable for a variety of high-temperature environments. The melting point characteristics of tungsten alloy wafers enable them to operate normally at temperatures approaching or exceeding the limits of many traditional materials, providing reliable material support for high-temperature processing and extreme environments.

Tungsten alloy discs are typically manufactured using powder metallurgy technology. This involves mixing tungsten powder with other metal powders in specific proportions, pressing the mixture into a compact shape, and sintering it at high temperatures to create circular flakes with a high melting point and uniform structure. The choice of alloy composition has a certain impact on the melting point. For example, the addition of nickel and iron can improve toughness but may slightly lower the melting point; the addition of copper or silver may further adjust the melting point to balance thermal or electrical conductivity. During production, optimizing the sintering process is crucial to maintaining high-temperature performance. For example, precise control of the sintering temperature and pressure can ensure a dense microstructure of the disc, thereby maintaining performance stability in high-temperature environments. tungsten alloy discs gives them significant advantages in applications requiring extreme temperatures. For example, in aerospace, high-melting-point discs can be used as high-temperature

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components in engines or high-temperature cabins. In industrial processing, they can withstand the extreme conditions of high-temperature furnaces or heat treatment equipment while maintaining structural integrity. The controllable melting point allows manufacturers to adjust the performance of the discs according to specific application requirements. For example, in some scenarios, a higher melting point is required to cope with extreme temperatures, while in other scenarios, it may be necessary to balance the melting point with other properties such as thermal conductivity.

Furthermore, the melting point characteristics of tungsten alloy discs are closely linked to their environmental friendliness. As a non-toxic and recyclable material, tungsten alloy discs not only offer excellent performance in high-temperature applications but also meet safety requirements in fields such as healthcare and food processing. By optimizing alloy composition and manufacturing processes, tungsten alloy discs can deliver reliable performance in high-temperature environments while maintaining environmental friendliness and sustainability, providing significant support for high-temperature applications in modern industry.

### 3.2.2 Stability in high temperature environment

High-temperature stability is a key aspect of a tungsten alloy disc's high-temperature resistance, referring to its ability to maintain its physical and chemical properties under sustained high temperatures or extreme thermal conditions. Through alloying and precision manufacturing processes, tungsten alloy discs maintain their structural integrity, mechanical properties, and chemical stability in high-temperature environments, avoiding deformation, softening, or performance degradation caused by high temperatures. This characteristic makes them critical components in aerospace, energy equipment, and industrial processing.

Achieving high-temperature stability relies on optimizing powder metallurgy technology. During the manufacturing process, uniform mixing of tungsten powder and other metal powders is essential for ensuring high-temperature stability. The choice of alloy composition directly impacts the wafer's performance in high-temperature environments. For example, the addition of nickel and iron can improve the wafer's toughness and oxidation resistance, thereby enhancing its stability in high-temperature environments. Optimizing the sintering process is key. For example, hot isostatic pressing (HIP) can eliminate internal porosity, improve the wafer's density and structural uniformity, and thus maintain stable performance under high-temperature conditions.

Tungsten alloy discs' stability in high-temperature environments enables them to excel in a variety of extreme scenarios. For example, in aerospace equipment, they can serve as support or shielding components in high-temperature engines or combustion chambers, maintaining structural integrity. In energy equipment, they can operate for long periods in high-temperature reactors or power generation equipment, resisting performance degradation caused by thermal stress. Furthermore, their corrosion resistance enables them to remain stable in high-temperature, chemically active environments, such as in critical components of chemical processing equipment. Another advantage of high-temperature stability is its support for machining accuracy. The stable microstructure enables it to maintain

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dimensional accuracy even in high-temperature environments, preventing dimensional changes caused by thermal expansion or deformation. This property makes it widely applicable in precision manufacturing, such as as a key component in high-temperature electronic equipment or medical devices. Optimized high-temperature stability also increases the wafer's service life and reduces material degradation caused by high temperatures, providing a long-term, reliable solution for industrial applications.

### 3.2.3 Thermal shock resistance

Thermal shock resistance is a key aspect of a tungsten alloy wafer's high-temperature performance. It refers to its ability to resist cracking or deformation caused by thermal stresses in environments with rapid temperature changes or thermal cycling. Through alloying treatment and optimized manufacturing processes, tungsten alloy wafers are able to maintain structural integrity and performance stability under conditions of rapid transitions between high and low temperatures. This characteristic gives them a significant advantage in applications requiring frequent thermal cycling, such as aerospace, industrial furnaces, and electronic equipment. The realization of thermal shock resistance depends on the coordinated optimization of alloy composition and manufacturing process. During the powder metallurgy manufacturing process, the addition of elements such as nickel and iron can improve the toughness and thermal stress resistance of the wafer, thereby enhancing the thermal shock resistance. The optimization of the sintering process is crucial to the thermal shock resistance. For example, by controlling the sintering temperature and pressure, a dense microstructure can be formed, reducing internal defects, thereby improving the reliability of the wafer in thermal cycling. In addition, surface treatment processes such as polishing or coating can further enhance the thermal shock resistance of the wafer and reduce the occurrence of surface cracks.

Tungsten alloy discs enables them to excel in extreme thermal cycling environments. For example, in aerospace, they maintain structural integrity during the rapid heating and cooling of engines or high-temperature cabins. In industrial furnaces, they can withstand frequent heating and cooling cycles without cracking or deformation caused by thermal stress. Their low coefficient of thermal expansion is key to their thermal shock resistance, enabling the discs to maintain dimensional stability during temperature fluctuations and reducing deformation caused by thermal stress. In terms of applications, tungsten alloy wafers' resistance to thermal shock holds broad promise for high-performance applications. For example, in electronic devices, they can serve as heat sinks, withstanding the thermal stresses of rapid temperature changes. In energy equipment, they can withstand long-term operation in high-temperature reactors or power generation equipment, resisting performance degradation caused by thermal cycling. Their non-toxicity and recyclability lend them potential for use in sensitive applications such as medical devices, where they offer reliable performance in high-temperature environments while meeting environmental requirements.

### 3.3 Surface properties of tungsten alloy wafers

Tungsten alloy wafers are a crucial component of their performance, directly impacting their performance

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in precision machining and functional applications. Surface properties encompass key indicators such as roughness, flatness, and smoothness, achieved through precision manufacturing processes and surface treatment technologies. These excellent surface properties enable tungsten alloy wafers to excel in high-precision, high-reliability applications, such as electronics, medical devices, and aerospace.

### 3.3.1 Surface roughness parameters

Surface roughness is a core performance indicator of tungsten alloy discs. It refers to the deviation in the surface's microscopic geometry, directly affecting its contact properties, friction characteristics, and aesthetics. The surface roughness of tungsten alloy discs is controlled through precise machining processes and surface treatment technologies, achieving extremely low roughness levels to meet the demands of high-precision applications. Optimizing roughness parameters is a crucial step in tungsten alloy disc manufacturing, directly impacting its performance in precision equipment.

Tungsten alloy discs is primarily achieved through powder metallurgy techniques and subsequent surface treatment. During the manufacturing process, tungsten powder is mixed with other metal powders (such as nickel, iron, or copper), compacted, and sintered at high temperatures to form circular discs with a uniform structure. Optimizing the sintering process has a significant impact on surface roughness. For example, controlling the sintering temperature and pressure can reduce surface microscopic defects and create a smoother surface. Subsequently, processes such as precision grinding, polishing, or electrochemical treatment further reduce surface roughness, achieving a highly smooth surface that meets the requirements of precision applications.

The superior surface roughness of tungsten alloy discs offers significant advantages in contact performance and friction characteristics. Low-roughness surfaces reduce frictional resistance and improve contact surface conformity, thereby enhancing the disc's performance in mechanical connections or sliding components. Furthermore, low-roughness surfaces contribute to improved corrosion resistance, as a smooth surface reduces the adhesion points for corrosive media, extending the disc's service life. Precise control of roughness parameters also enhances the disc's visual appeal, making it more attractive in applications requiring high aesthetics.

Optimizing surface roughness is also relevant to the sustainability of manufacturing processes. Through efficient surface treatment techniques, roughness can be reduced while simultaneously minimizing material waste and improving production efficiency. The non-toxic and recyclable properties of tungsten alloy discs offer advantages in environmentally sensitive applications. For example, in medical devices, low-roughness surfaces can reduce bacterial adhesion and improve safety. Research and optimization of surface roughness provide crucial support for improving the performance of tungsten alloy discs, driving their widespread application in high-precision applications.

### 3.3.2 Flatness accuracy

Flatness accuracy is another important indicator of tungsten alloy wafer surface performance. It refers to

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the degree of deviation of the wafer surface from an ideal plane and is a key parameter for measuring surface flatness. Flatness accuracy directly affects the wafer's performance in precision assembly, sealing, and contact applications, especially those requiring high-precision bonding. Through advanced manufacturing processes and precision machining techniques, tungsten alloy wafers can achieve extremely high flatness accuracy, meeting the needs of demanding applications.

Achieving accurate flatness relies on multiple optimizations during the manufacturing process of tungsten alloy wafers. In powder metallurgy manufacturing, the uniform mixing and compaction of tungsten powder and other metal powders is essential for ensuring uniform flatness. During high-temperature sintering, precise control of temperature and pressure reduces internal stress and deformation in the wafer, thereby improving surface flatness. Subsequent precision machining processes, such as CNC grinding or laser leveling, further optimize flatness, achieving high-precision wafer surfaces. Furthermore, the application of hot isostatic pressing (HIP) eliminates microscopic defects, further enhancing flatness accuracy.

Tungsten alloy discs with high flatness accuracy excel in a variety of applications. For example, in precision mechanical assembly, high flatness ensures a close fit between the disc and other components, reducing gaps and vibration, and improving equipment operational stability. In sealing applications, flatness accuracy directly impacts sealing effectiveness; a flat surface perfectly aligns with the sealing surface, preventing gas or liquid leakage. Furthermore, high flatness helps improve the contact performance of the disc, such as when used as a connector in electronic devices, ensuring stable electrical contact and signal transmission.

Optimizing flatness accuracy is also closely linked to manufacturing efficiency and environmental friendliness. Precision machining and quality control can reduce scrap due to insufficient flatness and improve production efficiency. The environmentally friendly nature of tungsten alloy wafers gives them advantages in the medical and food processing sectors. Highly flat surfaces reduce the risk of bacterial adhesion and corrosion, improving safety. Research and improvement in flatness accuracy provide technical support for the application of tungsten alloy wafers in high-precision applications.

### 3.3.3 Effect of surface finish on use

Surface finish is a crucial aspect of a tungsten alloy disc's surface performance. It refers to the smoothness and visual quality achieved after processing, directly impacting its functionality and durability. Surface finish not only affects the disc's appearance but also profoundly influences its friction, corrosion resistance, and contact properties. Through sophisticated surface treatment processes, tungsten alloy discs can achieve a high-quality surface finish, meeting the needs of a variety of demanding applications.

Achieving a smooth surface finish relies on the coordinated optimization of tungsten alloy wafer manufacturing and post-processing processes. During the powder metallurgy manufacturing process, the mixing and sintering of tungsten powder with other metal powders requires precise control to form a uniform microstructure, laying the foundation for subsequent surface treatment. Processes such as

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precision polishing, chemical polishing, or electrochemical treatment are key to improving surface finish, significantly reducing surface roughness to achieve a mirror-like effect. In addition, the application of surface coating technology can further enhance the finish while improving the corrosion and wear resistance of the wafer.

A high surface finish has a number of positive effects on the performance of tungsten alloy wafers. First, a high-quality surface can significantly reduce the coefficient of friction, reducing wear on the wafer in sliding or contact situations, thereby extending its service life. Second, a smooth surface reduces the number of adhesion points for corrosive media, enhancing the wafer's corrosion resistance and enabling it to maintain performance over time in humid or chemical environments. Furthermore, a high-quality surface can help improve contact performance. For example, when used as an electrical contact component in electronic devices, it can reduce contact resistance and improve signal transmission efficiency.

Optimizing surface finish also demonstrates advancements in tungsten alloy disc manufacturing. Through efficient surface treatment techniques, improved surface finish can be achieved while reducing material and energy consumption, thereby increasing production efficiency. The non-toxic and recyclable properties of tungsten alloy discs give them advantages in environmentally sensitive applications. Their high surface finish reduces the adhesion of pollutants, meeting the safety requirements of medical and food processing equipment. Surface finish research provides important support for the performance optimization and application expansion of tungsten alloy discs, promoting their development in high-precision and high-reliability scenarios.

### 3.4 Hardness and wear resistance of tungsten alloy discs

Tungsten alloy discs are key characteristics that enable them to excel in high-load and friction environments, directly impacting their application in mechanical structures, wear-resistant components, and industrial tools. Hardness determines the disc's ability to resist deformation and scratching, while wear resistance determines its durability under long-term friction. Through optimized alloy composition and advanced manufacturing processes, tungsten alloy discs achieve a combination of high hardness and excellent wear resistance, meeting the needs of a variety of demanding scenarios.

#### 3.4.1 Hardness index range

Hardness is a key performance indicator for tungsten alloy wafers, referring to their ability to resist deformation, scratching, or indentation due to external forces. It is a key parameter for measuring their mechanical strength. Tungsten itself possesses extremely high hardness, approaching the highest levels found in naturally occurring materials. By alloying it with other metal elements (such as nickel, iron, or copper), its toughness and processing properties can be improved while maintaining high hardness, making the wafers adaptable to a variety of applications. This flexible hardness range enables tungsten alloy wafers to meet diverse needs, from precision components to heavy-duty tools.

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Tungsten alloy discs is achieved through powder metallurgy. During the manufacturing process, tungsten powder is mixed with other metal powders in specific proportions, pressed into shape, and sintered at high temperatures to form circular discs with high hardness and uniform structure. The choice of alloy composition has a significant impact on hardness. For example, the addition of nickel can improve toughness while maintaining high hardness; the addition of iron further enhances hardness but may slightly reduce ductility. Optimizing the sintering process is crucial to hardness. For example, by controlling the sintering temperature and pressure, a dense microstructure can be formed, improving the hardness and deformation resistance of the disc.

Tungsten alloy discs makes them excellent for applications requiring resistance to mechanical stress. For example, in industrial processing, high-hardness discs can serve as mold or tool components, resisting deformation caused by cutting or impact. In mechanical structures, their high hardness ensures the disc's stability under high loads. The flexibility of the hardness index range allows manufacturers to adjust the disc's performance according to specific needs, such as increasing the tungsten content in applications requiring high hardness, or optimizing the nickel or iron ratio in applications requiring a balance between hardness and toughness.

Optimizing hardness is also related to the sustainability of the manufacturing process. Through efficient sintering and surface treatment techniques, hardness can be increased while reducing material waste and improving production efficiency. The non-toxic and recyclable properties of tungsten alloy discs give them advantages in environmentally sensitive applications. For example, in medical devices or food processing equipment, high-hardness discs can provide reliable performance while meeting safety requirements. Research on hardness provides important support for optimizing the performance of tungsten alloy discs and promotes their application in high-load scenarios.

#### 3.4.2 Wear resistance performance

Wear resistance is the ability of a tungsten alloy disc to maintain its performance in friction and wear environments, referring to its surface's ability to resist wear, scratching, or material loss. The wear resistance of tungsten alloy discs stems from their high hardness and optimized microstructure, enabling them to maintain surface integrity over time in high-friction, high-load environments. This superior wear resistance holds promise for a wide range of applications in industrial tools, mechanical components, and wear-resistant coatings.

Achieving wear resistance relies on multiple optimizations during the manufacturing process of tungsten alloy discs. In powder metallurgy manufacturing, the uniform mixing of tungsten powder with other metal powders (such as nickel and iron) and high-temperature sintering are fundamental to ensuring wear resistance. The addition of nickel and iron improves the toughness and impact resistance of the discs and reduces the microcracks that may occur during friction. Optimizing the sintering process is crucial to wear resistance. For example, hot isostatic pressing (HIP) can eliminate internal porosity and form a dense microstructure, thereby improving the disc's wear resistance. Surface treatments such as polishing or coating can further enhance wear resistance and reduce surface wear.

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Tungsten alloy discs enables them to excel in high-friction environments. For example, in industrial processing, they can be used as components of molds or cutting tools to resist wear caused by high-speed cutting or friction. In mechanical equipment, they can serve as sliding components to reduce material loss caused by long-term friction. Their corrosion resistance also supports their wear resistance, allowing the discs to maintain surface integrity in humid or chemical environments, avoiding wear accelerated by corrosion.

Optimizing wear resistance also reflects its integration with manufacturing efficiency. Through efficient surface treatment and quality control, wear resistance can be improved while reducing production costs. The non-toxic and recyclable properties of tungsten alloy discs give them advantages in environmentally sensitive fields. For example, in medical devices or food processing equipment, high-wear-resistant discs can reduce maintenance frequency and extend equipment life.

### 3.4.3 Relationship between hardness and wear resistance

Hardness and wear resistance are two closely related aspects of tungsten alloy disc performance. Hardness directly affects wear resistance, while wear resistance further reflects the effectiveness of hardness in actual use. Hardness, as a material's ability to resist deformation and scratching, is the foundation of wear resistance. Higher hardness generally means greater wear resistance. However, the relationship between hardness and wear resistance is not a simple linear relationship and is also affected by alloy composition, microstructure, and surface treatment. By optimizing these factors, tungsten alloy discs can achieve an ideal balance between hardness and wear resistance.

The relationship between hardness and wear resistance is reflected in the manufacturing process. In powder metallurgy manufacturing, the high hardness of tungsten provides the basis for wear resistance, while the addition of elements such as nickel and iron can improve toughness and prevent brittleness caused by high hardness, thereby enhancing wear resistance. The optimization of the sintering process is crucial to the relationship between the two. For example, by precisely controlling the sintering temperature, a dense microstructure can be formed, the hardness can be increased, and the microcracks that may occur during friction can be reduced. Surface treatment processes such as polishing or hard coating can further enhance the synergistic effect of hardness and wear resistance, making the wafer surface more wear-resistant.

High hardness provides a solid foundation for the wear resistance of tungsten alloy discs. For example, in high-hardness discs, the surface effectively resists scratches and wear, maintaining integrity over long-term use. However, excessive hardness can lead to insufficient toughness, making the disc susceptible to cracking in high-impact or vibration environments. Therefore, optimizing the balance between hardness and toughness through alloying treatments is key. For example, increasing the nickel content can improve toughness, thereby enhancing wear resistance while maintaining high hardness. This relationship enables tungsten alloy discs to perform well in a variety of friction environments.

The connection between hardness and wear resistance is also reflected in its integration with

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environmental protection. The non-toxic and recyclable properties of tungsten alloy discs give them advantages in the medical and food processing fields. The combination of high hardness and wear resistance can reduce the frequency of component replacement and reduce resource consumption. By optimizing the manufacturing process, it is possible to improve hardness and wear resistance while reducing energy waste and improving production efficiency.

### 3.5 Strength and Toughness of Tungsten Alloy Discs

Tungsten alloy discs are central to their mechanical properties, directly impacting their performance in high-load and dynamic environments. Strength, encompassing both tensile and flexural strengths, reflects the disc's ability to resist stretching and bending deformation; toughness, reflected in impact toughness, determines the disc's resistance to fracture under shock or vibration. Through optimized alloy composition and advanced manufacturing processes, tungsten alloy discs achieve an ideal balance of strength and toughness, meeting diverse requirements from precision components to heavy-duty structures.

#### 3.5.1 Tensile strength value

Tensile strength is a key mechanical property of tungsten alloy discs, defining their ability to resist fracture under tensile loads and serving as a key parameter for measuring their strength and reliability. While tungsten inherently possesses exceptional strength, its brittleness limits its direct applications. By alloying tungsten alloy discs with other metal elements (such as nickel, iron, or copper), they can maintain high tensile strength while improving toughness and processing properties, making them suitable for a variety of high-load scenarios. A wide range of tensile strength values is achieved through optimized alloy composition and manufacturing processes, meeting diverse requirements from precision instruments to heavy equipment.

Tungsten alloy discs is achieved through powder metallurgy. During the manufacturing process, tungsten powder and other metal powders are mixed in specific proportions, pressed into shape, and sintered at high temperatures to form circular discs with high strength and uniform structure. The choice of alloy composition has a significant impact on tensile strength. For example, the addition of nickel can improve toughness and enhance tensile strength, while the addition of iron further increases strength but may slightly reduce ductility. Optimizing the sintering process is crucial to tensile strength. For example, hot isostatic pressing can eliminate internal defects and form a dense microstructure, thereby improving the tensile strength of the disc.

Tungsten alloy discs with high tensile strength excel in applications requiring tensile loads. For example, in mechanical structures, they can serve as supporting components, resisting tensile stress and ensuring structural stability. In aerospace, their high tensile strength enables them to serve as connecting components, withstanding tensile forces in high-load environments. The controllable tensile strength allows manufacturers to tailor the disc's performance to specific needs, such as increasing the tungsten content for applications requiring high strength, or optimizing the nickel or iron ratio for applications

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requiring a balance between strength and toughness.

Optimizing tensile strength is also related to the sustainability of the manufacturing process. Through efficient sintering and processing techniques, it is possible to increase tensile strength while reducing material waste and improving production efficiency. The non-toxic and recyclable properties of tungsten alloy discs give them advantages in environmentally sensitive fields. For example, in medical devices or food processing equipment, high tensile strength discs can provide reliable performance while meeting safety requirements.

### 3.5.2 Bending strength performance

Flexural strength, the ability of a tungsten alloy disc to resist deformation and fracture under bending loads, is a key indicator of its mechanical properties and directly impacts its performance in complex stress environments. Through alloying and manufacturing process optimization, tungsten alloy discs are able to maintain high flexural strength while improving their toughness, thus preventing brittle fracture caused by bending stress. This flexural strength gives them a significant advantage in applications requiring bending loads, such as mechanical structures, aerospace, and industrial tooling.

The realization of flexural strength depends on the optimization of powder metallurgy technology. During the manufacturing process, the uniform mixing of tungsten powder and other metal powders (such as nickel and iron) and high-temperature sintering are the basis for ensuring flexural strength. The addition of nickel and iron improves the toughness and crack resistance of the wafer and reduces the possibility of fracture under bending stress. The optimization of the sintering process is crucial to flexural strength. For example, by controlling the sintering temperature and pressure, a dense microstructure can be formed, which improves the bending resistance of the wafer. In addition, surface treatment processes such as polishing or coating can further enhance the flexural strength and reduce stress concentration caused by surface defects.

Tungsten alloy discs enables them to excel in complex stress environments. For example, in industrial machinery, they can serve as supports or connectors, resisting bending stresses and ensuring structural stability. In aerospace, their high flexural strength enables them to withstand the complex stresses generated by high-speed aircraft. Their high temperature and corrosion resistance further enhance their flexural strength, enabling the discs to maintain stable performance in high-temperature or chemical environments, avoiding strength degradation caused by environmental factors.

The optimization of flexural strength also demonstrates advancements in manufacturing efficiency for tungsten alloy discs. Through efficient processing and quality control techniques, flexural strength can be increased while reducing production costs. The non-toxic and recyclable properties of tungsten alloy discs offer advantages in environmentally sensitive applications, such as medical devices or food processing equipment. High flexural strength discs provide reliable performance while meeting safety and environmental requirements.

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### 3.5.3 Impact toughness index

Impact toughness is a tungsten alloy disc's ability to resist fracture under impact or vibration loads. It is a key indicator of its toughness performance and directly impacts its reliability in dynamic environments. Tungsten inherently possesses high hardness but relatively low toughness. By alloying it with other metal elements (such as nickel and iron), tungsten alloy discs can significantly improve their impact toughness, preventing brittle fracture caused by shock or vibration. This impact toughness is achieved through optimization of the alloy composition and manufacturing process, enabling the disc to maintain stable performance in high-impact scenarios.

Achieving impact toughness relies on multiple optimizations during the powder metallurgy manufacturing process. The addition of nickel and iron is key to improving impact toughness, enhancing the ductility and crack resistance of the disc and reducing potential fractures under impact loads. Optimizing the sintering process is crucial for impact toughness. For example, hot isostatic pressing (HIP) can create a dense microstructure and eliminate internal porosity, thereby improving the disc's impact resistance. Furthermore, surface treatments such as polishing or hard coating can reduce surface defects and improve the disc's durability in impact environments.

Tungsten alloy discs enables them to excel in dynamic environments. For example, in mechanical equipment, they can act as sliding or rotating components, withstanding vibration and shock loads to maintain structural integrity. In aerospace, they can serve as connecting or supporting components, resisting the impact forces of aircraft operation. Their high temperature and corrosion resistance further enhance their impact toughness, allowing the discs to maintain their toughness in high-temperature or chemical environments, preventing performance degradation caused by environmental factors.

Optimizing impact toughness is also related to the environmental friendliness of tungsten alloy wafers. Their non-toxic and recyclable properties make them advantageous in the medical and food processing fields. High-impact toughness wafers can reduce component replacement frequency and resource consumption. Through efficient manufacturing processes, improved impact toughness can be achieved while reducing energy waste and improving production efficiency.

### 3.5.4 Effect of Strength on the Application of Tungsten Alloy Discs

Strength is a core mechanical property of tungsten alloy discs, encompassing tensile strength, flexural strength, and other attributes, directly impacting their performance in high-load environments. Strength determines the disc's ability to resist deformation, fracture, and stress, enabling it to play a key role in applications requiring high mechanical performance. Through alloying processes, such as the addition of elements like nickel and iron, tungsten alloy discs maintain high strength while improving toughness, thereby maintaining structural stability in complex stress environments.

The influence of strength on the application of tungsten alloy discs is reflected in many aspects. First, high strength enables the discs to withstand greater mechanical stress, making them suitable for use as

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supporting or connecting components in mechanical structures. For example, in aerospace equipment, high-strength discs can serve as engine or fuselage components, resisting the tensile and bending stresses during high-speed operation and ensuring the reliability of the equipment. Secondly, strength also affects the durability of the discs. High-strength discs can resist fatigue and deformation during long-term use, extending their service life. In addition, strength is related to processing performance. High-strength discs can maintain dimensional accuracy through precision processing, meeting the needs of high-precision applications.

During the manufacturing process, optimizing strength relies on precise control of powder metallurgy technology. The blending of tungsten powder with other metal powders and the high-temperature sintering process create a dense microstructure, enhancing the wafer's tensile and bending resistance. Advanced processes such as hot isostatic pressing further improve strength uniformity, reduce internal defects, and ensure the wafer's reliability in high-load environments. Adjusting the alloy composition is also crucial. For example, increasing the nickel content can balance strength and toughness to meet the needs of different scenarios.

The strength of tungsten alloy wafers is also related to their environmental friendliness. High-strength wafers reduce component replacement frequency, lower resource consumption, and meet sustainable development requirements. Their non-toxic nature gives them advantages in the medical and food processing fields, enabling reliable performance in high-load environments while meeting safety standards. Optimized strength provides a solid foundation for the application of tungsten alloy wafers in high-stress scenarios, driving their widespread development in modern industry.

### 3.5.5 Effect of toughness on the application of tungsten alloy wafers

Toughness is the ability of a tungsten alloy disc to resist fracture in dynamic environments, particularly under shock or vibration conditions, preventing brittle fracture and maintaining structural integrity. Tungsten inherently possesses high hardness but relatively low toughness. Through alloying processes, such as the addition of elements like nickel and iron, tungsten alloy discs significantly improve their impact toughness, enabling them to excel in complex dynamic environments. Toughness has a profound impact on the disc's application, determining its reliability in scenarios characterized by high vibration, shock, or cyclic loading.

The impact of toughness on the application of tungsten alloy discs is mainly reflected in their fracture resistance and long-term durability. High toughness enables the disc to resist the initiation and expansion of cracks in shock or vibration environments. For example, as a sliding or rotating component in mechanical equipment, it can withstand frequent dynamic loads and maintain stable performance. In the aerospace field, high-toughness discs can serve as connecting or supporting components to resist the impact forces during aircraft operation and ensure structural integrity. In addition, toughness also affects the processing performance of the disc. High-toughness discs can be processed into complex shapes through processes such as turning and milling while maintaining structural stability. During the manufacturing process, optimizing toughness relies on the synergistic effect of alloy composition and

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processing. The addition of nickel and iron significantly improves the wafer's ductility and crack resistance, while high-temperature sintering and hot isostatic pressing (HIP) create a dense microstructure, reduce internal defects, and improve impact toughness. Surface treatments such as polishing or coating can also enhance toughness and reduce the occurrence of surface cracks. Precise control of alloy composition enables the wafer to achieve a balance between toughness and strength to meet the needs of different application scenarios.

Optimizing toughness also demonstrates the environmental advantages of tungsten alloy wafers. Highly tough wafers can reduce component failures due to shock or vibration, reduce maintenance and replacement frequency, and minimize resource waste. Their non-toxic and recyclable properties offer broad application prospects in the medical and food processing sectors, enabling reliable performance in dynamic environments while meeting safety and environmental requirements. Toughness research provides technical support for the application of tungsten alloy wafers in highly dynamic scenarios, laying the foundation for their development in modern industry.

### 3.6 Radiation Shielding Performance of Tungsten Alloy Discs

Tungsten alloy discs are a key characteristic in specialized applications. Due to their high density and high atomic number, they effectively absorb and block high-energy radiation, such as X-rays and gamma rays. This property makes them irreplaceable in the medical, scientific, and industrial fields, serving as shielding components to protect equipment or personnel from radiation hazards. The radiation shielding properties of tungsten alloy discs are achieved through optimized alloy composition and improved manufacturing processes, enabling them to provide reliable protection in high-radiation environments.

Achieving radiation shielding performance relies on the high density and uniform microstructure of tungsten alloy discs. During the powder metallurgy manufacturing process, tungsten powder is mixed with other metal powders (such as nickel and iron), compacted, and sintered at high temperatures to form circular discs with high density and uniform structure. High density is central to shielding performance, enabling the discs to effectively absorb high-energy radiation and reduce the likelihood of penetration. Optimizing the alloy composition has a significant impact on shielding performance. For example, the addition of nickel and iron improves toughness and ensures structural stability in high-radiation environments. Optimizing the sintering process, such as hot isostatic pressing, can eliminate internal porosity and improve density uniformity, thereby enhancing shielding effectiveness.

Tungsten alloy discs make them widely used in medical devices. For example, they can serve as shielding components in X-ray machines or CT scanners, protecting patients and medical staff from radiation hazards. In the nuclear energy sector, their high density and corrosion resistance make them an ideal choice for radiation protection components. Compared to traditional shielding materials such as lead, tungsten alloy discs are non-toxic and recyclable, and can achieve the same shielding effect at a thinner thickness, reducing material usage and equipment weight.

Optimizing radiation shielding performance is also related to manufacturing efficiency and

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environmental friendliness. Efficient sintering and processing techniques can improve shielding performance while reducing material waste and increasing production efficiency. Its non-toxic nature makes it highly sought after in the medical and scientific research fields, meeting stringent safety and environmental standards. Research on radiation shielding properties provides a scientific basis for the application of tungsten alloy wafers in high-radiation environments, promoting their widespread development in the medical, scientific, and industrial fields.

### 3.6.1 Shielding effect against gamma rays

Tungsten alloy discs against gamma rays is a key indicator of their radiation shielding performance. This is due to their high density and high atomic number, which effectively absorb high-energy gamma rays and reduce their penetration potential. Gamma rays are highly penetrating electromagnetic radiation, often encountered in nuclear power facilities, medical radiotherapy, and scientific research experiments, requiring shielding materials with extremely high density and stability. Tungsten alloy discs undergo alloying treatments, such as the addition of elements such as nickel and iron, to maintain their high density while also improving their toughness and structural stability, resulting in excellent gamma ray shielding performance.

Tungsten alloy discs are manufactured using powder metallurgy techniques. Tungsten powder is mixed with other metal powders, compacted, and then sintered at high temperatures to form circular discs with high density and uniform structure. Optimizing the alloy composition is crucial to gamma-ray shielding effectiveness. For example, the addition of nickel improves the disc's toughness, preventing stress-induced cracking in high-radiation environments. Optimizing the sintering process, such as hot isostatic pressing, eliminates internal porosity and improves density uniformity, thereby enhancing the disc's gamma-ray absorption capacity. Surface treatments such as polishing can also reduce surface defects and ensure consistent shielding effectiveness.

Tungsten alloy discs' shielding effectiveness against gamma rays gives them significant advantages in high-radiation environments. For example, in the medical field, they can serve as shielding components for radiotherapy equipment, protecting patients and medical staff from the harmful effects of gamma rays. In nuclear power facilities, their high density and stability make them ideal shielding materials for reactors or waste disposal equipment. Their non-toxic properties make them more environmentally friendly than traditional shielding materials such as lead, making them suitable for use in medical and scientific research. The high density of tungsten alloy discs also enables them to achieve excellent shielding effectiveness at a relatively thin thickness, reducing equipment weight and increasing design flexibility.

Optimizing gamma-ray shielding also improves manufacturing efficiency and environmental friendliness. Efficient sintering and processing techniques improve shielding performance while reducing material waste. Its recyclability offers advantages in resource recycling, meeting the sustainable development requirements of modern industry. The gamma-ray shielding effectiveness of tungsten alloy wafers provides a reliable protection solution for high-radiation scenarios, driving their widespread application

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in medical and scientific research.

### 3.6.2 X-ray shielding capability

Tungsten alloy discs' X-ray shielding ability is another key aspect of their radiation shielding performance. Due to their high density and high atomic number, they effectively absorb and block X-rays, reducing the risk of X-ray penetration to equipment or personnel. X-rays are widely used in medical diagnosis, industrial testing, and scientific research, requiring shielding materials with high density and excellent structural stability. Through alloying technology and precision manufacturing processes, tungsten alloy discs provide excellent X-ray shielding performance, meeting the requirements of high precision and safety.

During the manufacturing process, tungsten alloy discs are manufactured using powder metallurgy technology. By mixing tungsten powder with other metal powders (such as nickel, iron, or copper), pressing and forming, and then sintering at high temperature, they form circular discs with high density and uniform structure. The choice of alloy composition has a significant impact on X-ray shielding capabilities. For example, the addition of nickel and iron can improve the toughness and crack resistance of the disc, ensuring structural integrity in high-radiation environments. Optimizing the sintering process, such as controlling the sintering temperature and pressure, can increase the density and uniformity of the disc, enhancing its X-ray absorption capacity. Surface treatment processes such as polishing or coating further improve the performance stability of the disc.

Tungsten alloy discs' X-ray shielding capabilities make them widely used in the medical and industrial fields. For example, they can serve as shielding components in X-ray machines or CT scanners, protecting operators and patients from radiation hazards. In industrial non-destructive testing, their high density effectively blocks X-rays, ensuring the safety of the inspection process. Their non-toxicity and recyclability give them advantages in environmentally sensitive applications, such as medical equipment, where they can meet stringent safety and environmental standards. The high density of tungsten alloy discs also enables efficient shielding at relatively thin thicknesses, optimizing device design.

Optimizing X-ray shielding capabilities is also related to manufacturing efficiency. Efficient processing and quality control techniques can improve shielding performance while reducing production costs. Its recyclability offers advantages in resource utilization and reduces environmental impact. Tungsten alloy wafers' X-ray shielding capabilities provide reliable support for their applications in medical diagnostics and industrial testing, driving their development in high-precision applications.

### 3.6.3 Relationship between shielding performance and thickness

Tungsten alloy discs is closely related to their thickness, which directly affects their ability to absorb high-energy radiation such as gamma rays and X-rays. High density is the core of a tungsten alloy disc's shielding performance, while thickness determines the degree of radiation attenuation. By adjusting the disc's thickness, varying degrees of shielding effectiveness can be achieved, meeting requirements

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ranging from low-intensity to high-intensity radiation protection. This relationship provides tungsten alloy discs with a high degree of flexibility in design and application, allowing for optimized shielding performance based on specific scenarios.

During the manufacturing process, the thickness of tungsten alloy discs is precisely controlled through powder metallurgy techniques and processing. Tungsten powder is mixed with other metal powders, compacted, and sintered at high temperatures to form circular discs with high density and uniform structure. Controlling thickness requires a comprehensive consideration of the alloy composition and sintering process. For example, hot isostatic pressing (HIP) can improve the uniformity of disc density, ensuring consistent shielding effectiveness across different thicknesses. Subsequent processing techniques such as grinding or turning can precisely adjust the disc thickness to meet specific shielding requirements.

The relationship between shielding performance and thickness is reflected in its ability to attenuate radiation. Thicker discs absorb more radiation energy and are suitable for high-intensity radiation environments, such as nuclear power facilities or radiotherapy equipment; thinner discs are suitable for low-intensity radiation scenarios, such as medical diagnostic equipment. The flexibility of tungsten alloy disc thickness allows it to achieve optimal shielding effectiveness in different scenarios while optimizing material usage and device weight. Its high density allows it to achieve shielding effectiveness comparable to traditional materials at a thinner thickness, improving design efficiency.

Optimizing thickness is also related to environmental performance and manufacturing efficiency. Precisely controlling thickness can meet shielding requirements while reducing material waste and improving resource utilization. The non-toxic and recyclable properties of tungsten alloy discs give them advantages in medical and scientific research, meeting safety and environmental requirements. Research on the relationship between shielding performance and thickness provides a scientific basis for the design and application of tungsten alloy discs, promoting their widespread use in high-radiation scenarios.

#### 3.6.4 Comparison with lead shielding effectiveness

Tungsten alloy discs offer significant shielding advantages over traditional lead shielding materials, particularly in terms of high density, environmental friendliness, and application flexibility. Lead, a traditional shielding material, is widely used in radiation protection due to its high density and low cost, but its toxicity and environmental impact limit its application in certain areas. Tungsten alloy discs, with their high density, non-toxicity, and recyclability, are an ideal alternative to lead, providing safer and more effective shielding in medical, scientific, and industrial applications.

Tungsten alloy discs is achieved through their high density and high atomic number, effectively absorbing gamma rays and X-rays. Compared to lead, tungsten alloy discs generally offer higher shielding efficiency at the same thickness, enabling the same protective effect at thinner thicknesses, reducing material usage and equipment weight. They are manufactured using powder metallurgy techniques. By mixing tungsten powder with other metal powders, pressing and forming, and then

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sintering at high temperatures, they form circular discs with high density and uniform structure. Optimizing the alloy composition, such as adding nickel or iron, can improve the disc's toughness and stability, further enhancing its shielding effectiveness.

Compared to lead, tungsten alloy discs' environmental friendliness is one of their greatest advantages. Lead is toxic and potentially harmful to the environment and human health, while tungsten alloy discs are non-toxic and recyclable, making them suitable for use in sensitive applications such as medical devices and food processing equipment. Furthermore, tungsten alloy discs possess superior mechanical properties to lead. Their high strength and toughness enable them to maintain structural stability in high-load or dynamic environments, preventing deformation or cracking due to stress.

Tungsten alloy discs offer superior manufacturing and application flexibility compared to lead. Through precision machining and surface treatment, they achieve high precision and smoothness, meeting complex design requirements. Their recyclability also reduces resource waste, aligning with sustainable development. Comparative studies of their shielding effectiveness with lead provide theoretical support for their application in high-radiation scenarios, promoting their widespread development in medical, scientific, and industrial fields.

### 3.7 Electrical and Thermal Conductivity of Tungsten Alloy Discs

Tungsten alloy wafers are key characteristics for their applications in electronics, electrical engineering, and thermal management, directly impacting their performance in high-performance devices. Electrical conductivity determines the wafer's efficiency in conducting current, while thermal conductivity determines its ability to transfer and dissipate heat. Through alloying technology and precision manufacturing processes, tungsten alloy wafers can achieve an optimal balance between electrical conductivity and thermal conductivity, meeting diverse requirements from precision electronics to high-temperature equipment.

#### 3.7.1 Conductivity parameters

Electrical conductivity is a key performance indicator for tungsten alloy discs, referring to their ability to conduct electrical current and a key parameter for evaluating their effectiveness in electrical and electronic applications. Tungsten itself has a high resistivity and relatively low conductivity, but by alloying it with other highly conductive metals, such as copper or silver, the conductivity of tungsten alloy discs can be significantly improved, enabling them to meet the demands of high-performance electrical devices. Optimizing conductivity parameters is achieved through precise control of alloy composition and manufacturing processes, enabling them to adapt to a wide range of applications, from low-power to high-power.

Tungsten alloy discs is achieved through powder metallurgy. During the manufacturing process, tungsten powder is mixed with highly conductive metal powders (such as copper or silver) in a specific ratio, pressed into shape, and sintered at high temperature to form circular discs with uniform structure and

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excellent electrical conductivity. The choice of alloy composition has a direct impact on conductivity. For example, the addition of copper can significantly improve conductivity while maintaining high mechanical strength; the addition of silver further enhances conductivity, making it suitable for high-precision electrical applications. Optimizing the sintering process is crucial to conductivity. For example, by controlling the sintering temperature and pressure, a dense microstructure can be formed, reducing resistance and improving current conduction efficiency.

Tungsten alloy discs with high conductivity offer significant advantages in the electrical and electronic fields. For example, in high-voltage electrical systems, they can serve as contacts or connectors, ensuring efficient current conduction and reducing energy loss. In electronic devices, their high conductivity makes them an ideal material for circuit boards or connectors, improving signal transmission efficiency. Their high-temperature resistance and arc erosion resistance further enhance their conductivity, enabling the discs to maintain stable performance in high-load environments and avoid performance degradation caused by overheating or arcing.

Optimizing conductivity parameters is also related to manufacturing efficiency and environmental friendliness. Through efficient sintering and processing technologies, conductivity can be improved while reducing material waste and increasing production efficiency. The non-toxic and recyclable properties of tungsten alloy wafers give them advantages in environmentally sensitive fields. For example, in medical electronic devices, high-conductivity wafers can provide reliable performance while meeting safety and environmental requirements. Conductivity research provides technical support for the application of tungsten alloy wafers in the electrical field and promotes their development in high-performance scenarios.

### 3.7.2 Thermal conductivity range

Thermal conductivity is a key performance indicator of tungsten alloy wafers in the field of thermal management. It refers to their ability to conduct heat and is a key parameter for measuring their heat dissipation effectiveness. While tungsten itself has low thermal conductivity, alloying it with high-conductivity metals can significantly improve the thermal conductivity of tungsten alloy wafers, making them excellent performers in applications requiring efficient heat dissipation. This flexibility in thermal conductivity is achieved through optimization of alloy composition and manufacturing processes, meeting diverse requirements from electronic devices to high-temperature industrial applications.

The achievement of thermal conductivity relies on the optimization of powder metallurgy technology. During the manufacturing process, tungsten powder is mixed with high thermal conductivity metal powders such as copper powder, pressed into shape, and sintered at high temperature to form circular flakes with high thermal conductivity and uniform structure. The addition of copper is key to improving thermal conductivity. Its high thermal conductivity can significantly enhance the thermal conductivity of the disc, while the high density and high temperature resistance of tungsten ensure the structural stability of the disc in high-temperature environments. Optimization of the sintering process is crucial to thermal conductivity. For example, through hot isostatic pressing technology, a dense microstructure can be

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formed, reducing thermal resistance and improving heat conduction efficiency.

Tungsten alloy discs with high thermal conductivity have a wide range of applications in thermal management. For example, in electronic devices, they can serve as heat sinks or heat pipes, quickly transferring heat from high-temperature areas to dissipated areas to prevent overheating. In aerospace, their high thermal conductivity and high-temperature resistance make them suitable for thermal management of high-temperature components, ensuring equipment reliability in extreme environments. Their low coefficient of thermal expansion further enhances thermal conductivity, allowing the disc to maintain dimensional stability during temperature fluctuations and avoid deformation caused by thermal stress.

The optimization of the thermal conductivity range also reflects the advancement in manufacturing efficiency of tungsten alloy discs. Through efficient processing and quality control techniques, thermal conductivity can be improved while reducing production costs. The non-toxic and recyclable properties of tungsten alloy discs give them advantages in environmentally sensitive fields. For example, in medical electronic equipment or new energy equipment, high thermal conductivity discs can provide efficient heat dissipation while meeting safety and environmental requirements. The study of thermal conductivity provides a scientific basis for the application of tungsten alloy discs in thermal management scenarios, promoting their development in modern industry.

### 3.7.3 Correlation between electrical conductivity and thermal conductivity

Electrical conductivity and thermal conductivity are two closely related indicators of the electrical and thermal conductivity of tungsten alloy wafers, jointly influencing their performance in electrical and thermal management. Electrical conductivity reflects the wafer's ability to conduct current, while thermal conductivity reflects its ability to conduct heat. Both share a similar physical basis in material microstructure and alloy composition. By optimizing the alloy composition and manufacturing process, tungsten alloy wafers can achieve a synergistic improvement in both electrical and thermal conductivity, meeting the demands of high-performance devices.

The correlation between electrical and thermal conductivity stems primarily from the movement of free electrons within the material. Adding highly conductive and thermally conductive metals, such as copper or silver, to tungsten alloy discs increases the density and mobility of free electrons, thereby improving both electrical and thermal conductivity. During the powder metallurgy manufacturing process, the uniform mixing of tungsten powder and copper or silver powders and high-temperature sintering form a dense microstructure, reducing the scattering of electrons and heat and improving conduction efficiency. Optimizing the sintering process, such as controlling temperature and pressure, can further enhance the synergistic effect of electrical and thermal conductivity.

The correlation between electrical and thermal conductivity gives tungsten alloy wafers unique advantages in scenarios requiring efficient simultaneous conduction of both current and heat. For example, in high-performance electronic devices, high electrical conductivity ensures efficient current

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conduction, while high thermal conductivity rapidly dissipates heat, preventing overheating. In electrical systems, they can serve as contacts or connecting components, simultaneously conducting current and managing heat, avoiding performance degradation caused by overheating. Their high-temperature resistance and corrosion resistance further enhance the stability of their electrical and thermal conductivity, enabling the wafers to maintain performance in harsh environments.

Optimizing electrical and thermal conductivity is also related to environmental protection and manufacturing efficiency. The non-toxic and recyclable properties of tungsten alloy wafers give them advantages in the medical and new energy fields. They can provide reliable performance in high electrical and thermal conductivity scenarios while meeting environmental requirements. Through efficient manufacturing processes, electrical and thermal conductivity can be improved while reducing energy consumption and improving production efficiency. Research on the correlation between electrical and thermal conductivity provides theoretical support for the application of tungsten alloy wafers in the electrical and thermal management fields, promoting their widespread development in high-performance scenarios.

#### 3.7.4 Factors Affecting the Electrical Conductivity of Tungsten Alloy Discs

tungsten alloy wafers is a crucial property for their applications in electrical and electronic applications. This property is influenced by a variety of factors, including alloy composition, microstructure, manufacturing process, and environmental conditions. Conductivity determines how efficiently the wafer conducts current, directly impacting its performance in contacts, connectors, or circuit components. By optimizing these factors, tungsten alloy wafers can achieve efficient current conduction, meeting the demands of high-performance devices.

Alloy composition is the primary factor affecting conductivity. Tungsten itself has high resistivity and low conductivity, but by adding highly conductive metals such as copper or silver, the wafer's conductivity can be significantly improved. For example, tungsten-copper alloy (W-Cu) compensates for tungsten's shortcomings with copper's high conductivity, enabling the wafer to excel in high-current scenarios. However, the alloy ratios must be precisely controlled. Excessive tungsten content can lead to decreased conductivity, while excessive copper content can reduce the wafer's mechanical strength and high-temperature resistance.

Microstructure significantly influences electrical conductivity. The microstructure of tungsten alloy wafers is formed through powder metallurgy. The uniform grain distribution and dense structure reduce electron scattering and improve conductivity. Internal porosity, impurities, or grain boundary defects increase resistance and reduce conductive efficiency. Therefore, high-temperature sintering and hot isostatic pressing (HIP) are crucial in the manufacturing process, eliminating microdefects and creating a dense structure, thereby optimizing conductivity.

The manufacturing process directly impacts conductivity. During the powder metallurgy process, the uniformity of the mixture of tungsten powder and copper or silver powder, the pressing pressure, and the

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sintering temperature all influence the wafer's conductivity. For example, high-temperature sintering promotes the bonding of metal particles and reduces grain boundary resistance, while hot isostatic pressing further increases structural density and reduces resistance. Furthermore, surface treatments such as polishing can reduce surface defects and improve contact conductivity.

Environmental conditions such as temperature and corrosive environments can also affect conductivity. High temperatures can reduce electron mobility, leading to decreased conductivity. However, the high heat resistance of tungsten alloy wafers allows them to maintain relatively stable conductivity in high-temperature environments. Corrosive environments can cause surface oxidation and increase contact resistance, so the addition of corrosion-resistant alloying components (such as nickel) can enhance the long-term conductivity stability of the wafer.

By optimizing the alloy composition, microstructure, and manufacturing process, the conductivity of tungsten alloy discs can be significantly improved, meeting the demands of electrical and electronic equipment. Their non-toxicity and recyclability make them advantageous in environmentally sensitive applications, such as medical electronics, where they provide efficient electrical conductivity while meeting safety requirements. Research into conductivity factors provides scientific support for the discs' application in high-performance scenarios.

### 3.7.5 Factors Affecting Thermal Conductivity of Tungsten Alloy Discs

The thermal conductivity of tungsten alloy wafers is a crucial property in thermal management applications. This property is influenced by a variety of factors, including alloy composition, microstructure, manufacturing process, and environmental conditions. Thermal conductivity determines the wafer's efficiency in heat transfer and dissipation, directly impacting its performance in electronic equipment, aerospace, and industrial thermal management. By optimizing these factors, tungsten alloy wafers can achieve efficient heat conduction and meet high-performance heat dissipation requirements.

Alloy composition is a key factor influencing thermal conductivity. Tungsten itself has a low thermal conductivity (approximately  $173 \text{ W/m}\cdot\text{K}$ ), but the thermal conductivity of a tungsten alloy disc can be significantly improved by adding a high-conductivity metal such as copper (approximately  $401 \text{ W/m}\cdot\text{K}$ ). For example, tungsten-copper alloys utilize copper's high thermal conductivity to enhance the disc's thermal conductivity, making them suitable for use in heat sinks or heat pipes. Controlling the alloy ratio is crucial: excessive tungsten content can reduce thermal conductivity, while excessive copper content can compromise high-temperature resistance or mechanical strength.

Microstructure has a significant impact on thermal conductivity. A uniform grain distribution and dense microstructure reduce heat dissipation and improve thermal conductivity. Internal porosity, impurities, or grain boundary defects increase thermal resistance and reduce thermal conductivity. Therefore, during the powder metallurgy manufacturing process, the uniform mixing of tungsten and copper powders and high-temperature sintering create a dense structure that optimizes thermal conductivity. Hot isostatic pressing further eliminates microscopic defects and improves thermal conductivity.

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Manufacturing processes directly impact thermal conductivity. During powder metallurgy, pressing pressure, sintering temperature, and cooling rate all influence the wafer's thermal conductivity. High-temperature sintering promotes the bonding of metal particles and reduces grain boundary thermal resistance, while hot isostatic pressing (HIP) creates a high-density structure, reducing resistance to heat transfer. Surface treatments such as polishing can reduce surface roughness, improve thermal contact efficiency, and thus enhance thermal conductivity.

Environmental conditions such as temperature and corrosive environments can also affect thermal conductivity. High temperatures can reduce thermal conductivity, but the high heat resistance of tungsten alloy wafers allows them to maintain stable thermal conductivity in high-temperature environments. Corrosive environments can cause surface oxidation, increasing thermal resistance, so the addition of corrosion-resistant alloying elements (such as nickel) can enhance the long-term thermal stability of the wafer. Furthermore, rapid temperature changes can cause thermal stresses that affect thermal conductivity, and the low thermal expansion coefficient of tungsten alloy wafers helps minimize this effect.

By optimizing the alloy composition, microstructure, and manufacturing process, the thermal conductivity of tungsten alloy wafers can be significantly improved, meeting the heat dissipation requirements of electronic devices and high-temperature industrial applications. Their non-toxic and recyclable properties make them advantageous in the medical and new energy sectors, providing efficient thermal conductivity while complying with environmental requirements. Research into thermal conductivity factors provides technical support for the wafer's application in thermal management scenarios.

### 3.8 CTIA GROUP LTD Tungsten Alloy Wafer MSDS

The Material Safety Data Sheet (MSDS) provides detailed guidance for the safe use, storage, and handling of CTIA GROUP LTD's tungsten alloy discs, covering their chemical composition, physical properties, potential hazards, and safety measures. Tungsten alloy discs are typically made primarily of tungsten (W) with additives such as nickel (Ni), iron (Fe), or copper (Cu). They offer high density, high-temperature resistance, and non-toxic properties, making them widely used in the medical, aerospace, and industrial sectors.

#### 1. Hazard identification

- **Health Hazards:** Tungsten alloy wafers are non-toxic in themselves, but metal dust may be generated during cutting, grinding or polishing. Inhalation may cause respiratory irritation or lung fibrosis similar to silicosis.
- **Physical Hazards:** No explosion or flammability risk, but high density may cause injury during handling.
- **Environmental hazards:** non-toxic, recyclable, and no significant harm to the environment.

#### 2. Firefighting measures

- **Combustion characteristics:** Tungsten alloy discs are non-flammable.

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- Fire extinguishing method: Use dry powder or carbon dioxide fire extinguisher, do not use water.

### 3. Emergency treatment of leaks

- Leakage risk: Solid wafers have no leakage risk.

### 4. Operation and storage

- Handling Precautions: Use appropriate tools to handle high-density wafers to avoid injury.
- Storage conditions: Store in a dry, ventilated environment, avoid moisture or contact with corrosive substances.

### 5. Exposure Control and Personal Protection

- Engineering Controls: Use local exhaust ventilation or dust collection system during processing.
- Personal protective equipment: Wear dust mask, safety glasses and gloves.

### 6. Physical and chemical properties

- Appearance: Silver-grey metal disc with smooth surface.
- Density: 15-18.5 g/cm<sup>3</sup>.
- Melting point: about 3000-3400°C.
- Solubility: Insoluble in water, resistant to acid and alkali corrosion, but soluble in a mixture of hydrofluoric acid and concentrated nitric acid.

### 7. Stability and reactivity

- Stability: stable at room temperature and resistant to oxidation at high temperature.
- Reactivity: Does not react with water, acids or bases, but may react with strong oxidants at elevated temperatures.

### 8. Ecological information

- Environmental impact: non-toxic, recyclable, and has no significant impact on the environment.
- Bioaccumulation: No risk of bioaccumulation.

### 9. Disposal

- Disposal method: Treat as recyclable metal and send to professional recycling facilities to avoid random discarding.

### 10. Shipping Information

- Transport classification: non-dangerous goods. During transport, please be careful to prevent physical damage due to high density.
- Packaging requirements: Use sturdy packaging to avoid damage during transportation.

### 11. Regulatory Information

- Complies with international material safety standards such as OSHA (Occupational Safety and Health Administration) and REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals).

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## Chapter 4 Performance Test Methods of Tungsten Alloy Discs

Tungsten alloy discs are critical for ensuring their quality and application effectiveness, encompassing multiple evaluation techniques, including density, strength, electrical conductivity, and thermal conductivity. Scientific and precise testing methods accurately measure disc performance parameters, providing a reliable basis for material selection, process optimization, and application design. Tungsten alloy discs, due to their high density, strength, and high-temperature resistance, are widely used in aerospace, medical, electronics, and industrial fields. Performance testing requires high-precision equipment and standardized operating procedures to ensure accurate and consistent results.

Density, a core property of tungsten alloy discs, directly impacts their effectiveness in applications such as counterweights, shielding, and structural support. Density testing methods assess whether a disc meets design requirements by measuring its volume, mass, and density distribution. These testing methods not only verify the disc's physical properties but also provide a valuable reference for quality control during production. The environmental friendliness and recyclability of tungsten alloy discs necessitate careful attention to safe operation and environmental impact control during testing.

### 4.1 Tungsten Alloy Disc Density Test Method

Tungsten alloy wafers is a crucial step in performance evaluation, directly impacting their performance in high-density applications such as counterweights, radiation shielding, and structural support. Density testing methods measure the wafer's volume, mass, and density distribution to assess whether it meets design requirements. The accuracy and reliability of testing methods are crucial to ensuring wafer quality, and multiple techniques are often combined to enhance testing precision.

#### 4.1.1 Density measurement by drainage method

The displacement method is a classic density test method that determines the volume and density of a tungsten alloy disc by measuring the change in its buoyancy when immersed in a liquid. This method, based on the principle that an object displaces liquid when submerged, is suitable for regularly shaped discs and offers advantages such as simplicity, low cost, and high accuracy. Widely used for density testing of tungsten alloy discs, the displacement method quickly provides reliable density data, providing a basis for quality control and performance evaluation.

**Principle :** The displacement method determines density by measuring the difference between the dry weight of a disc and its weight when immersed in a liquid. The volume of the liquid displaced is calculated using a liquid of known density (such as deionized water). The volume of the disc is calculated based on the change in buoyancy, and the density is then calculated based on the mass.

#### Test steps :

1. Use a high-precision electronic balance to measure the dry weight of the tungsten alloy disc and record the mass value. The accuracy is usually required to be one thousandth of a gram.

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2. Suspend the disc with a thin wire and immerse it in a liquid of known density (such as deionized water), ensuring that the disc is completely submerged and does not touch the wall of the container.
3. Use an electronic balance to measure the weight of the disc in the liquid and calculate the weight difference to determine the buoyancy.
4. Calculate the volume of the disc based on its buoyancy.
5. The density of the disc was calculated by combining the dry weight and volume.
6. Repeat the measurement multiple times and take the average value to improve the accuracy.

**Advantages and Limitations :** The displacement method is simple to use and requires minimal equipment, making it suitable for both laboratory and industrial applications. Its accuracy depends on the balance resolution and the purity of the liquid, but is generally quite high. However, for irregularly shaped discs or samples with microporous surfaces, the liquid may seep into the pores, leading to volume measurement errors. Therefore, ensure that the disc surface is smooth and free of visible pores before testing.

**Optimization Measures :** To improve test accuracy, use deionized water or alcohol as the test liquid to avoid air bubble interference. Also, use a thermostat to control the liquid temperature to ensure a stable density value. Density data from the water displacement test provides a reliable basis for quality control of tungsten alloy wafers, and is particularly suitable for performance verification in counterweight and shielding applications.

#### 4.1.2 Radiographic inspection of density uniformity

Radiographic testing is a non-destructive testing method used to assess the density uniformity of tungsten alloy discs. By analyzing the intensity change after the radiation penetrates the disc, the density distribution within the disc can be determined. Density uniformity directly impacts the performance stability of the disc. For example, in radiation shielding or counterweight applications, uneven density can lead to insufficient shielding effectiveness or uneven mass distribution. Radiographic testing, with its high precision and non-destructive nature, is widely used to test the density uniformity of tungsten alloy discs.

**Testing Principle :** Radiographic testing utilizes the penetrating power of X-rays or gamma rays. By measuring the change in radiation intensity after penetrating a wafer, the density distribution is analyzed. High-density areas absorb radiation more strongly, resulting in lower transmission intensity; low-density areas transmit higher intensity. By scanning different areas of the wafer, a density distribution image is generated, allowing assessment of uniformity.

#### Test steps :

1. Place the tungsten alloy disc on the test platform of the radiographic testing equipment (such as an X-ray CT scanner) to ensure that the disc is fixed and the surface is clean.
2. Select an appropriate radiation source (such as an X-ray tube or a gamma-ray source) and adjust

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the radiation energy and intensity to suit the thickness and density of the wafer.

3. Scan different areas of the wafer, record the intensity data after the radiation penetrates, and generate a density distribution image.
4. Image analysis software was used to process the data, calculate the density values of different areas, and evaluate the density uniformity.
5. Perform statistical analysis on the results to determine whether the density deviation is within the allowable range, which is usually required to be less than  $\pm 1\%$ .

**Advantages and Limitations :** X-ray testing offers the advantages of being non-destructive and highly accurate, enabling precise detection of density distribution within wafers. It is particularly well-suited for high-precision applications, such as radiation shielding components. However, the equipment is expensive, requires specialized personnel, and requires strict radiation protection. Test accuracy is limited by the radiation energy and equipment resolution, and test parameters may need to be adjusted for extremely thin or thick wafers.

**Optimization measures :** To improve detection accuracy, high-resolution X-ray CT equipment can be used, combined with multi-angle scanning technology, to generate three-dimensional density distribution images. At the same time, the X-ray source and detector should be calibrated to ensure data accuracy. Density uniformity data from X-ray testing provides an important basis for quality control of tungsten alloy wafers, especially in the aerospace and medical fields.

#### 4.1.3 Weighing method auxiliary verification

Gravimetric testing is a simple and direct density test method. It determines density by measuring the dry weight of a tungsten alloy disc and calculating its volume based on known geometric dimensions. Gravimetric testing is often used as a supplementary verification method for water displacement testing or radiographic testing, for rapid verification of density data, or as the primary testing method when laboratory conditions are limited. Its simplicity and low cost make it suitable for preliminary evaluation and quality control.

**Test Principle :** The gravimetric method calculates density by measuring the mass and volume of a disc. Volume is typically calculated by measuring the disc's geometric dimensions (such as diameter and thickness) and is suitable for discs with regular shapes.

##### Test steps :

1. Use a high-precision electronic balance to measure the dry weight of the tungsten alloy disc and record the mass value. The accuracy is usually required to be one thousandth of a gram.
2. Use a high-precision measuring tool (such as a micrometer or laser rangefinder) to measure the diameter and thickness of the disc and calculate the volume.
3. The density of the disc was calculated by combining the dry weight and volume.
4. Repeat the measurement multiple times and take the average value to improve the accuracy.
5. Compare the results with water displacement or radiographic data to verify the accuracy of the

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density values.

**Advantages and Limitations :** The gravimetric method is simple to operate and requires minimal equipment, making it suitable for rapid testing and on-site application. Its accuracy relies on the accuracy of geometric measurements and the regularity of the wafer shape. Volume calculations may be inaccurate for irregularly shaped or uneven wafers. Furthermore, the gravimetric method cannot directly assess density uniformity and is only suitable for preliminary verification of overall density.

**Optimization measures :** To improve test accuracy, high-precision measurement tools (such as laser scanners) can be used to measure geometric dimensions and ensure accurate volume calculations. At the same time, cross-validation can be combined with water displacement or radiographic testing to reduce errors. Weighing, as an auxiliary verification method, provides simple and reliable support for density testing of tungsten alloy discs, especially for rapid quality control during the production process.

## 4.2 Test method for high temperature resistance of tungsten alloy disc

Tungsten alloy wafers is a crucial step in evaluating their performance in high-temperature environments, directly impacting their applications in aerospace, industrial processing, and energy equipment. High-temperature resistance includes key indicators such as melting point, high-temperature endurance strength, and thermal shock resistance. Scientific testing methods can comprehensively assess the wafer's performance stability under high-temperature conditions.

### 4.2.1 Melting point measurement by differential thermal analysis

Differential thermal analysis (DTA) is a commonly used high-temperature performance test method for measuring the melting point of tungsten alloy discs. By analyzing the temperature difference between the sample and a reference during heating, the phase transition temperature is determined. Melting point is a core indicator of the high-temperature resistance of tungsten alloy discs and directly affects their application range in high-temperature environments. Due to its high precision and sensitivity, DTA is widely used for melting point testing of tungsten alloy discs, providing accurate melting point data and providing a basis for high-temperature application design.

**Testing Principle :** Differential thermal analysis (DTA) involves simultaneously heating a tungsten alloy disc sample and a reference material (such as aluminum oxide) and measuring the temperature difference between the two. When the disc undergoes a phase transition, such as melting, it absorbs or releases heat, causing a temperature difference with the reference material to change, generating a characteristic peak, which allows the melting point to be determined. Testing is typically performed under an inert gas (such as argon) to prevent oxidation.

#### Test steps :

1. Prepare the tungsten alloy disc sample by cutting it into small pieces (usually a few milligrams) and ensure the surface is clean and free of impurities.

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2. The sample and reference material are placed in the crucible of the differential thermal analyzer and placed in a high-temperature furnace.
3. Under inert gas protection, heat the sample at a constant rate (such as 10°C/min) and record the temperature changes of the sample and reference material.
4. Analyze the differential thermal curve, identify the endothermic peak caused by melting, and determine the melting point temperature.
5. Repeat the test several times, take the average value to improve the accuracy, and compare it with the standard value for verification.

**Advantages and Limitations :** Differential thermal analysis offers high precision and sensitivity, enabling accurate melting point determination and making it suitable for laboratory environments. However, the testing equipment is expensive and requires a small sample size, making it difficult to directly test large wafers. Furthermore, high temperatures can cause the sample to react with the crucible material, necessitating the selection of an appropriate crucible material (such as alumina or graphite).

**Optimization measures :** To improve test accuracy, use high-purity inert gas protection to prevent oxidation; calibrate the instrument to ensure accurate temperature measurement; and combine simultaneous testing with thermogravimetric analysis (TGA) to eliminate the interference of mass loss on the results. Melting point data measured by differential thermal analysis provides a reliable basis for evaluating the performance of tungsten alloy discs in high-temperature applications, particularly in aerospace and industrial furnaces.

#### 4.2.2 High temperature endurance strength test

High-temperature endurance strength testing is a method for evaluating the ability of tungsten alloy discs to resist deformation and fracture under sustained high temperature and high stress environments, reflecting their mechanical stability under long-term high-temperature loads. Due to their high melting point and high strength, tungsten alloy discs are often used in structural components in high-temperature environments. High-temperature endurance strength testing can verify their reliability in aerospace engines or high-temperature industrial equipment.

**Test Principle :** High-temperature endurance strength testing assesses mechanical properties at high temperatures by applying a constant stress to a disc sample and measuring its deformation or fracture time within a specified period. The test is typically conducted in a high-temperature furnace, using a precision loading device and displacement sensor to record the sample's strain behavior.

##### Test steps :

1. Prepare tungsten alloy disc samples and process them into standard specimens (such as cylinders or thin sheets) to ensure the surface is smooth and free of defects.
2. Install the specimen in a high-temperature endurance testing machine and set the test temperature (usually above 1000°C, depending on the alloy composition).
3. In an inert gas or vacuum environment, a constant tensile or compressive stress is applied and

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the deformation or fracture time of the specimen is recorded.

4. Analyze the strain-time curve to determine the high-temperature endurance strength and endurance time.
5. Repeated testing under different stress and temperature conditions to comprehensively evaluate the performance stability of the wafer.

**Advantages and Limitations :** High-temperature endurance strength testing can simulate actual high-temperature operating environments and evaluate the long-term performance of wafers, making it suitable for aerospace and industrial applications. However, the test cycle is long, the equipment requirements are high, the operation is complex, and the high-temperature environment may cause sample oxidation, requiring controlled test atmosphere. Optimization Measures: To improve test accuracy, high-purity inert gas or a vacuum environment can be used to prevent oxidation; high-precision displacement sensors can be used to record deformation; and finite element analysis can be combined to predict the performance of wafers in complex stress environments. High-temperature endurance strength testing provides important data for verifying the performance of tungsten alloy wafers in high-temperature structural applications.

#### 4.2.3 Thermal shock test method

Thermal shock testing is a method for evaluating the crack resistance and performance stability of tungsten alloy discs in environments with rapid temperature changes, reflecting their ability to withstand thermal shock. Tungsten alloy discs are often used in high-temperature and rapid thermal cycling environments, such as aerospace engines or electronic equipment heat dissipation components. Thermal shock testing can verify their reliability under drastic temperature fluctuations.

**Test Principle :** Thermal shock testing involves rapidly cycling wafer samples between high and low temperatures to observe cracks, deformation, or performance degradation under thermal stress. The test typically involves alternating exposure to a heating furnace and a cold medium (such as water or liquid nitrogen) to assess the sample's resistance to thermal shock.

##### Test steps :

1. Prepare tungsten alloy disc samples, process them into standard sizes, and ensure that there are no cracks or defects on the surface.
2. Place the sample in a high-temperature furnace and heat it to a specified temperature (e.g., above 1000°C) and keep it at that temperature for a certain time (e.g., 10 minutes).
3. Quickly transfer the sample to a cold medium (such as room temperature water or liquid nitrogen) to cool it down, completing a thermal shock cycle.
4. Repeat multiple thermal shock cycles and inspect the surface and interior of the sample for cracks, deformation, or property changes, using microscopy or ultrasonic testing for analysis.
5. The number of thermal shock cycles and sample failure conditions were recorded to evaluate their thermal shock resistance.

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**Advantages and Limitations :** Thermal shock testing can simulate actual thermal cycling environments, assessing a wafer's thermal shock resistance and making it suitable for high-temperature dynamic applications. However, the testing conditions are demanding, the equipment requirements are high, and rapid cooling of the sample can cause stress concentration, leading to distorted results.

**Optimization measures :** To improve test accuracy, optimize thermal shock cycle parameters (such as temperature difference and number of cycles), use non-destructive testing techniques to analyze internal defects, and select an appropriate cooling medium to reduce stress damage. Thermal shock testing provides a reliable basis for evaluating the performance of tungsten alloy wafers in high-temperature dynamic environments, particularly in the aerospace and electronics fields.

### 4.3 Test methods for surface properties of tungsten alloy discs

Tungsten alloy wafers is a crucial step in evaluating their surface quality, directly impacting their effectiveness in high-precision and demanding applications such as precision machinery, electronic connections, and sealing components. Surface performance includes key indicators such as roughness, flatness, and smoothness. Scientific testing methods enable a comprehensive assessment of a wafer's surface characteristics. The accuracy and reliability of testing methods are crucial to ensuring wafer quality, and multiple techniques are often combined to enhance testing accuracy. The following will detail the testing methods and their significance for tungsten alloy wafer surface performance , focusing on measuring surface roughness with a roughness meter, operating a flatness test instrument, and measuring surface smoothness with a gloss meter .

#### 4.3.1 Measuring surface roughness with a roughness meter

Surface roughness is a key indicator of tungsten alloy wafer surface performance, reflecting deviations in its microscopic geometry and directly impacting contact performance, friction characteristics, and sealing effectiveness. Roughness meter measurement is a commonly used testing method. Using contact or non-contact instruments, roughness parameters are measured on wafer surfaces, providing highly accurate surface quality data. Roughness meters, with their high sensitivity and standardized operation, are widely used for surface roughness testing of tungsten alloy wafers, providing a basis for quality control and performance evaluation.

**Testing Principle :** A roughness tester scans the surface of a wafer using a probe or laser, recording minute variations in surface height and generating roughness parameters such as Ra (arithmetic mean roughness) or Rz (maximum height difference). Contact roughness testers use a probe to directly contact the surface to measure height variations; non-contact roughness testers analyze surface topography through light beam reflection.

#### Test steps :

1. Prepare the tungsten alloy disc sample and ensure that the surface is clean and free of oil, dirt, or impurities.

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2. Fix the disc on the test platform of the roughness tester to ensure that the sample is stable and free from vibration.
3. Based on the wafer size and surface characteristics, select the appropriate roughness tester (such as contact or non-contact) and probe type.
4. Set measurement parameters (such as scanning length and speed) and scan along the wafer surface in multiple directions (such as radial and circumferential directions).
5. Record roughness parameters (such as Ra, Rz), analyze the data and calculate the average value.
6. Repeat the measurement in different areas to verify the consistency of the results and ensure the accuracy of the roughness data.

**Advantages and Limitations :** Roughness meters offer high accuracy and repeatability, making them suitable for both laboratory and industrial use, and they provide standardized roughness parameters. Contact instruments are less expensive but may leave tiny scratches on soft surfaces. Non-contact instruments offer higher accuracy but are more expensive. Test results are affected by surface cleanliness and instrument calibration, requiring strict control of testing conditions.

**Optimization measures :** To improve test accuracy, use a non-contact laser roughness tester to minimize damage to the wafer surface. Regularly calibrate the instrument to ensure measurement consistency. Clean the wafer surface before testing to avoid interference from impurities. Roughness tester measurement results provide reliable evidence for the surface quality of tungsten alloy wafers used in precision assembly and sealing applications.

#### 4.3.2 Flatness testing instrument operation

Flatness is a key indicator of tungsten alloy wafer surface performance, reflecting the degree of surface deviation from an ideal plane and directly impacting the fit in precision assembly and sealing applications. Flatness testing instruments measure the flatness of wafer surfaces using contact or non-contact methods, providing highly accurate flatness data. With its high precision and standardized operation, flatness testing is widely used to test the surface properties of tungsten alloy wafers, ensuring they meet the demands of high-precision applications.

**Testing Principle :** Flatness testing instruments generate flatness data by measuring the height deviation of each point on the wafer surface relative to a reference plane. Contact instruments (such as coordinate measuring machines) scan the surface with a probe and record height changes. Non-contact instruments (such as laser interferometers or optical flatness meters) analyze the surface topography by reflecting a light beam and calculate the deviation.

##### Test steps :

1. Prepare the tungsten alloy disc sample and ensure that the surface is clean and free of oil, dirt, or particles.
2. Fix the wafer on the test platform of the flatness tester to ensure that the sample is stable and without tilt.

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3. Select appropriate testing equipment (such as a three-coordinate measuring machine or laser interferometer) based on the wafer size and accuracy requirements.
4. Set the measurement parameters, perform a full scan along the wafer surface, and record the height data of each point.
5. Use analysis software to process the data, generate a flatness deviation map, and calculate the flatness value.
6. Repeat measurements in different areas to verify the consistency of results and ensure data accuracy.

**Advantages and Limitations :** Flatness testing instruments offer high accuracy and repeatability, enabling precise assessment of wafer surface flatness. They are suitable for high-precision applications such as sealing components or electronic connectors. Non-contact instruments avoid surface damage but are more expensive . Contact instruments are less expensive but may be affected by probe wear. Test results are affected by sample fixation and environmental vibration, requiring strict control of test conditions.

**Optimization measures :** To improve test accuracy, a high-resolution laser interferometer can be used to obtain more detailed flatness data; an anti-vibration platform can be used during testing to reduce environmental interference; and the instrument should be calibrated regularly to ensure measurement accuracy. The results of flatness testing provide important support for verifying the performance of tungsten alloy wafers in precision assembly and sealing applications.

#### 4.3.3 Gloss meter to measure surface finish

Surface finish is a key indicator of the surface performance of tungsten alloy discs. It reflects the smoothness and visual quality of the surface, directly affecting its friction performance, corrosion resistance, and aesthetics. Gloss meter measurement is a common testing method that assesses the surface finish level by measuring the intensity of light reflected from the disc surface. Gloss meters are widely used for surface finish testing of tungsten alloy discs due to their simplicity and speed, providing a basis for quality control and performance evaluation.

**Testing Principle :** A gloss meter shines a fixed-angle beam of light onto a wafer surface and measures the intensity of the reflected light to generate a gloss value (usually expressed in gloss units (GU)). A smoother surface reflects light more strongly, resulting in a higher gloss value; a rougher surface scatters light, resulting in a lower gloss value. Testing is typically performed at a standard angle (such as 20°, 60°, or 85°).

##### Test steps :

1. Prepare the tungsten alloy disc sample and ensure the surface is clean and free of oil, fingerprints, or particles.
2. Place the disc on the testing platform of the gloss meter , making sure the sample is stable and not tilted.

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3. Select an appropriate test angle (e.g. 60° is a common angle) and calibrate the gloss meter to ensure accuracy.
4. Aim the gloss meter probe at the wafer surface, emit a light beam and record the reflected light intensity to generate the gloss value.
5. Repeat the measurement on different areas of the wafer surface and take the average value to improve the accuracy.
6. Analyze gloss data, compare with standard values, and evaluate whether the surface finish meets the requirements.

**Advantages and Limitations :** Gloss meters are simple to use and provide intuitive results, making them suitable for quickly evaluating the surface finish of wafers and widely used in industrial settings and laboratories. However, test results are affected by surface cleanliness and ambient light, requiring strict control of test conditions. Furthermore, gloss values only reflect surface smoothness and cannot directly assess other surface properties such as roughness or flatness.

**Optimization measures :** To improve test accuracy, perform the test in a dark room or in a darkened environment to avoid ambient light interference. Use a multi-angle gloss meter to comprehensively evaluate the finish at different angles. Thoroughly clean the wafer surface before testing to ensure accurate results. Gloss meter measurement results provide important evidence for evaluating the tribological and aesthetic properties of tungsten alloy wafers, particularly in the electronics and medical fields.

#### 4.4 Test methods for hardness and wear resistance of tungsten alloy discs

Tungsten alloy discs are crucial for evaluating their performance in high-load and friction environments, directly impacting their application in industrial tools, mechanical structures, and wear-resistant components. Hardness reflects the disc's ability to resist deformation and scratching, while wear resistance determines its durability under long-term friction. The accuracy and reliability of testing methods are crucial to ensuring disc quality, and multiple techniques are often combined to enhance testing accuracy. The following will detail the testing methods and significance of tungsten alloy disc hardness and wear resistance, focusing on three aspects: measuring hardness with a Vickers hardness tester, testing wear resistance with a wear testing machine, and analyzing the correlation between hardness and wear resistance.

##### 4.4.1 Vickers hardness tester hardness measurement

Vickers hardness testing is a commonly used hardness testing method. It assesses the hardness of a tungsten alloy disc by applying a specific load to its surface and measuring the size of the indentation. With its high accuracy and wide applicability, the Vickers hardness test is ideal for measuring the high hardness characteristics of tungsten alloy discs. It provides reliable hardness data, providing a basis for quality control and performance evaluation. Hardness directly affects the disc's resistance to deformation and wear, particularly in industrial tools and mechanical components.

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**Test Principle :** A Vickers hardness tester uses a diamond quadrangular pyramid indenter to apply a specific load to the surface of a wafer, creating an indentation. The hardness value is calculated by measuring the diagonal length of the indentation. The Vickers hardness test is applicable to a wide range of hardness and features a regular indentation shape, making it suitable for high-hardness materials such as tungsten alloys.

**Test steps :**

1. Prepare tungsten alloy disc samples. The surface should be polished to be smooth without oil stains, scratches or oxide layers.
2. Fix the disc on the test platform of the Vickers hardness tester to ensure that the sample is stable and not tilted.
3. Select an appropriate test load (usually 1-10 kg, depending on the hardness of the disc) and loading time (10-15 seconds).
4. A diamond indenter was used to apply a load on the surface of the wafer to form an indentation, and the diagonal length of the indentation was recorded.
5. The Vickers hardness value (HV) is calculated based on the indentation size. Repeat the test on multiple areas and take the average value.
6. Analyze the data, compare it with the standard hardness value, and evaluate whether the hardness of the wafer meets the requirements.

**Advantages and Limitations :** The Vickers hardness test offers high precision and a small indentation, making it suitable for testing high-hardness materials and thin wafers. It is widely used in laboratories and industrial settings. However, test results are affected by surface quality and load selection; rough or uneven surfaces can lead to errors. Furthermore, the test equipment requires regular calibration to ensure accuracy.

**Optimization measures :** To improve test accuracy, the wafer surface can be finely polished to ensure a smooth and defect-free surface; an appropriate load can be selected to avoid indentations that are too deep or too shallow; and the indentation size can be measured using a high-resolution microscope. Hardness data measured with a Vickers hardness tester provides a reliable basis for verifying the performance of tungsten alloy wafers in high-load environments, particularly in the fields of industrial tools and wear-resistant components.

#### 4.4.2 Wear resistance test using a wear tester

Wear testing is the primary method for evaluating the wear resistance of tungsten alloy discs. By simulating friction and wear, the wear tester measures the material loss or surface changes of the disc under specific conditions. Wear resistance directly impacts the disc's service life in high-friction environments, such as those found in mechanical sliding parts or cutting tools. Due to its controllable and standardized operation, wear testing machines are widely used to test the wear resistance of tungsten alloy discs, providing critical data for performance evaluation.

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**Test Principle :** A wear tester applies a specific load and friction conditions (such as sliding or grinding) to a disc surface, measuring the sample's mass loss, volume loss, or surface topography change to assess its wear resistance. Common testing methods include pin-on-disc wear testing and grinding wheel wear testing, which simulate actual friction environments.

**Test steps :**

1. Prepare tungsten alloy disc samples. The surface must be cleaned and polished to the specified roughness.
2. Fix the disc on the test platform of the wear tester, select the appropriate friction couple (such as steel ball or grinding wheel) and test conditions (such as load, speed, time).
3. Start the testing machine, apply a constant load to perform the friction test, and record the test time and friction distance.
4. After the test, the mass loss of the disc is measured (using a high-precision balance) or the surface wear scar size is measured (using a microscope or profilometer).
5. Calculate the wear rate (such as mass loss rate or volume loss rate), repeat the test in different areas, and take the average value.
6. Analyze the data, compare it with the standard wear resistance requirements, and evaluate the wear resistance of the wafer.

**Advantages and Limitations :** Wear testers can simulate actual friction environments, providing reliable wear resistance data and suitable for testing a variety of wear scenarios. However, test results are affected by friction conditions, environmental factors (such as humidity), and the material of the mating pair, requiring strict control of test parameters. Furthermore, the equipment is expensive and testing cycles are lengthy.

**Optimization measures :** To improve test accuracy, standardize test conditions (such as constant temperature and humidity); select friction pairs similar to those used in actual applications; and use high-precision measurement equipment to analyze wear. Wear resistance data from wear testers provides important support for verifying the performance of tungsten alloy discs in high-friction environments, particularly in the manufacturing of mechanical components and tools.

#### 4.4.3 Correlation analysis test between hardness and wear resistance

The Hardness and Wear Resistance Correlation Analysis test investigates the relationship between hardness and wear resistance in tungsten alloy discs. By integrating data from hardness and wear tests, the authors analyze how the two influence each other. While hardness is fundamental to wear resistance, the correlation is not linear. Factors such as toughness, microstructure, and surface treatment also influence this relationship. This test provides a scientific basis for optimizing disc design and manufacturing processes, particularly in applications requiring high wear resistance.

**Test Principle :** This hardness and wear resistance correlation test combines Vickers hardness testing with wear testing to measure the wear resistance of discs with varying hardness levels and analyze the

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effect of hardness on wear rate. By manipulating alloy composition, heat treatment, or surface treatment, disc samples of varying hardness are prepared and their wear resistance is compared to reveal the relationship between the two.

**Test steps :**

1. Prepare multiple sets of tungsten alloy disc samples and obtain different hardness levels by adjusting the alloy composition (such as nickel and iron content) or heat treatment process.
2. Use a Vickers hardness tester to measure the hardness value of each group of samples and record the data to ensure consistent testing conditions.
3. Wear tests were performed on each group of samples using a wear tester, controlling the same friction conditions (such as load, speed, and time) to measure the mass loss or wear scar size.
4. Organize hardness and wear data, draw a curve of the relationship between hardness and wear rate, and analyze the correlation.
5. Statistical analysis software (e.g., regression analysis) was used to evaluate the correlation coefficient between hardness and wear resistance and identify key influencing factors.
6. Combined with microstructural analysis (such as scanning electron microscopy observation), the microscopic mechanisms of hardness and wear resistance are explored.

**Advantages and Limitations :** Correlation analysis tests can reveal the intrinsic relationship between hardness and wear resistance, providing a scientific basis for material optimization and suitable for the design of high-wear-resistant applications. However, the test requires the preparation of multiple sets of samples, which is costly. Moreover, the results are affected by alloy composition, microstructure, and testing conditions, requiring comprehensive analysis of multiple factors.

**Optimization measures :** To improve test accuracy, the number of sample groups can be increased to cover a wider hardness range; standardization of test conditions can be used to ensure data comparability; and in-depth research on the mechanisms of hardness and wear resistance can be conducted in combination with microstructural analysis.

#### 4.5 Test Methods for Strength and Toughness of Tungsten Alloy Discs

tungsten alloy wafers is crucial for evaluating their performance in high-load and dynamic environments, directly impacting their application in mechanical structures, aerospace, and industrial tools. Strength, encompassing tensile and flexural strength, reflects the wafer's ability to resist stretching and bending deformation. Toughness, measured through impact toughness, determines the wafer's resistance to fracture under shock or vibration. Accurate and reliable testing methods are crucial to ensuring wafer quality, and multiple techniques are often combined to enhance testing accuracy.

##### 4.5.1 Tensile strength measurement using a universal testing machine

Tensile strength is a key mechanical property of tungsten alloy discs, reflecting their ability to resist fracture under tensile loads and serving as a critical parameter for measuring their strength and reliability.

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A universal testing machine is a versatile testing device that applies a tensile load to a disc sample, measuring its maximum stress and deformation behavior before fracture to assess tensile strength. With its high precision, flexibility, and standardized operation, universal testing machines are widely used for tensile strength testing of tungsten alloy discs, providing reliable data for performance verification of mechanical structures and aerospace components.

**Testing Principle :** A universal testing machine applies a gradually increasing tensile load to a disc sample, recording the stress and strain changes until the sample breaks. Tensile strength is defined as the maximum stress a sample can withstand before breaking, typically measured in megapascals (MPa).

**Test steps :**

1. Prepare tungsten alloy disc samples and process them into standard tensile specimens (such as dumbbell or cylindrical shapes), ensuring the surface is smooth, free of cracks or defects, and in compliance with international standards (such as ASTM E8).
2. Fix the specimen in the clamp of the universal testing machine, ensuring that it is clamped securely and the axis of the specimen is aligned with the loading direction.
3. Set the test parameters, including the loading rate (typically 1-5 mm/min), data acquisition frequency, and environmental conditions (e.g., room temperature or elevated temperature).
4. Start the testing machine, apply tensile load, and record the load-displacement curve until the specimen breaks.
5. Analyze test data and calculate tensile strength (maximum load divided by specimen cross-sectional area), elongation at break, and elastic modulus.
6. Repeat the test on different areas or multiple groups of samples, take the average value to improve accuracy, and compare with the standard value for verification.
7. Examine the fracture surface (using a microscope or scanning electron microscope) and analyze the fracture type (ductile or brittle) to evaluate the material properties.

**Advantages and Limitations :** Universal testing machines offer high test accuracy, are suitable for a wide range of materials and testing conditions, and provide comprehensive tensile performance data, making them suitable for both laboratory and industrial use. However, test results are affected by the quality of specimen preparation and fixture alignment. Irregularly shaped discs must be processed into standard specimens, increasing testing costs. Furthermore, high-temperature testing requires specialized high-temperature fixtures and environmental control equipment, making operation complex.

**Optimization measures :** To improve test accuracy, high-precision displacement sensors and load cells can be used to ensure accurate data. Specimens should be finely polished to eliminate surface defects. A computer control system should be used to record real-time data to reduce human error. During high-temperature testing, inert gas protection can be used to prevent oxidation.

#### 4.5.2 Three-point bending test to measure bending strength

Bending strength is the ability of a tungsten alloy disc to resist deformation and fracture under bending

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loads. It is a key indicator of its mechanical properties and directly affects its performance in complex stress environments. The three-point bend test is a commonly used testing method that applies a concentrated load to a disc sample and measures its performance under bending stress to assess its bending strength. Due to its simplicity, reliability, and standardized operation, the three-point bend test is widely used to test the bending strength of tungsten alloy discs, providing critical data for performance verification of mechanical structures and industrial tools.

**Test Principle :** The three-point bending test uses support points at each end of the specimen and applies a concentrated load in the center, causing the specimen to bend. Flexural strength is calculated by measuring the maximum load and the specimen's geometric dimensions, reflecting the disc's ability to resist bending and fracture. The test also records the specimen's deflection and fracture behavior, providing a comprehensive assessment of its strength and toughness.

**Test steps :**

1. Prepare tungsten alloy disc samples and process them into standard rectangular or circular thin slices with dimensions that meet international standards (such as ASTM E290). The surface must be smooth and free of defects.
2. Place the specimen on the two support points of the three-point bending tester, ensuring that the specimen is level and the support points are spaced appropriately (usually 4-5 times the specimen length).
3. Set the test parameters, including loading rate (typically 0.5-2 mm/min), support point spacing, and data acquisition frequency.
4. Use the loading head of the testing machine to apply a gradually increasing load in the middle of the specimen and record the load-deflection curve until the specimen breaks or reaches the maximum deflection.
5. Analyze test data, calculate flexural strength, and evaluate performance based on specimen dimensions and fracture behavior.
6. Repeat the test on multiple groups of samples, take the average value to improve accuracy, and compare and verify with the standard value.
7. Examine the fracture surface using a microscope or scanning electron microscope to analyze the fracture mechanism (e.g., ductile or brittle fracture).

**Advantages and Limitations :** The three-point bending test is simple to use and provides intuitive results, making it suitable for evaluating the bending properties of wafers and widely used in laboratories and industrial settings. However, test results are affected by specimen size, support point spacing, and loading rate, requiring strict control of test conditions.

**Optimization measures :** To improve test accuracy, high-precision load cells and displacement sensors can be used to ensure accurate data; sample preparation processes can be optimized to eliminate surface defects; and support point spacing and loading rates can be standardized to reduce test errors. The flexural strength data measured in the three-point bending test provides important support for verifying the performance of tungsten alloy discs in complex stress environments, particularly in the aerospace and

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mechanical component fields.

#### 4.5.3 Impact toughness testing machine

Impact toughness is the ability of a tungsten alloy disc to resist fracture under shock or vibration loads. It is a key indicator of its toughness performance and directly impacts its reliability in dynamic environments. Impact testing is a common method for assessing impact toughness by applying a transient impact load to a disc sample and measuring the absorbed energy and fracture behavior. Due to their high efficiency and standardized operation, impact testing machines are widely used for impact toughness testing of tungsten alloy discs, providing critical data for dynamic performance verification in aerospace and mechanical equipment.

**Testing Principle :** An impact testing machine applies a momentary impact load to a specimen using a pendulum or drop weight. The energy absorbed at fracture is measured, reflecting the specimen's impact toughness. Common testing methods include the Charpy impact test and the drop weight impact test, which are suitable for evaluating the impact resistance of wafers. Test results are expressed as absorbed energy (joules) or fracture characteristics.

#### Test steps :

1. Prepare tungsten alloy disc samples and process them into standard impact specimens ( such as Charpy V-notch specimens). The dimensions must comply with international standards (such as ASTM E23) and the surface must be smooth and free of defects.
2. Fix the specimen to the support frame of the impact tester, ensuring that the notch position is aligned with the impact direction (for Charpy testing).
3. Set the test parameters, including pendulum energy (typically 50-300 J), impact velocity, and ambient temperature (e.g., room temperature or cryogenic).
4. Release the pendulum or drop weight to apply impact load to the specimen, and record the absorbed energy and fracture conditions.
5. Examine the fracture surface (using a microscope or scanning electron microscope) and analyze the fracture type (ductile or brittle).
6. Repeat the test on multiple groups of samples, take the average value to improve accuracy, and compare and verify with the standard value.
7. Tests can be performed at different temperatures to evaluate the change in impact toughness of the wafer in low or high temperature environments.

**Advantages and Limitations :** Impact testing can quickly assess a wafer's impact resistance, simulating real-world dynamic environments and making it suitable for aerospace and mechanical applications. However, test results are affected by specimen notch quality, temperature, and impact energy, requiring strict control of testing conditions. Tungsten alloy wafers, due to their high hardness, may exhibit low toughness, so the possibility of brittle fracture should be considered during testing.

**Optimization measures :** To improve test accuracy, a high-precision energy measurement system can

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be used to record the exact absorbed energy; the specimen notch processing process can be optimized to ensure consistent notch shape; and different temperature conditions can be tested to comprehensively evaluate the wafer's toughness performance. The impact toughness data measured by the impact testing machine provides a reliable basis for verifying the performance of tungsten alloy wafers in dynamic environments, especially in the aerospace and mechanical equipment fields.

#### 4.6 Test Method for Radiation Shielding Performance of Tungsten Alloy Discs

Tungsten alloy wafers is a crucial step in evaluating their ability to protect against high-radiation environments, directly impacting their effectiveness in medical, scientific, and nuclear applications. Radiation shielding performance includes gamma-ray and X-ray absorption, as well as its relationship to thickness. Scientific testing methods can comprehensively assess a wafer's shielding effectiveness. The accuracy and reliability of testing methods are crucial to ensuring wafer quality, and multiple techniques are often combined to enhance testing accuracy.

##### 4.6.1 Use of $\gamma$ -ray shielding effectiveness detection device

Gamma-ray shielding effectiveness testing is an important method for evaluating the absorption capacity of tungsten alloy discs against highly penetrating gamma rays. It is widely used in nuclear power facilities, medical radiotherapy, and scientific research experiments. Gamma-ray detection devices evaluate the shielding performance of a disc by measuring its attenuation of gamma rays. Tungsten alloy discs, due to their high density and high atomic number, effectively absorb gamma rays, reducing their penetration potential. With its high precision and safety, the test device is ideal for evaluating the shielding effectiveness of discs, providing reliable data for applications in high-radiation environments.

**Test Principle :** A gamma-ray shielding effectiveness tester uses a radioactive source (such as cobalt-60 or cesium-137) to emit gamma rays. After passing through a wafer, the intensity of the transmitted rays is measured to assess shielding effectiveness. High-density wafers absorb more gamma rays, resulting in lower transmitted intensity. Testing is typically conducted in a controlled environment, with detectors recording the intensity and analyzing the attenuation rate.

##### Test steps :

1. Prepare the tungsten alloy disc sample, ensuring that the surface is clean and defect-free, and the size meets the test requirements (e.g., 50 mm diameter, 5-20 mm thickness).
2. Fix the wafer on the test platform of the gamma ray detection device to ensure alignment with the ray source and detector.
3. Select a suitable gamma-ray source (such as cobalt-60, energy approximately 1.17-1.33 MeV), and set the ray intensity and irradiation time.
4. In the absence of a disc, the initial radiation intensity is measured as a reference value.
5. The disc is placed in the ray path, the intensity of the transmitted ray is measured, and the attenuation data is recorded.
6. Repeat the test on different areas or multiple groups of samples and take the average to improve

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accuracy.

7. Analyze the attenuation rate data and compare it with standard shielding requirements to evaluate the gamma ray shielding performance of the wafer.
8. Use protective measures (such as lead shielding rooms) to ensure operator safety and comply with radiation safety regulations.

**Advantages and Limitations** :  $\gamma$ -ray shielding effectiveness testing devices provide highly accurate attenuation data, making them suitable for evaluating wafer performance in high-radiation environments. Test results are intuitive and can be directly compared with standard values. However, testing requires specialized radiation protection equipment and qualifications, is complex, and is costly. Furthermore, the matching of radiation source energy and wafer thickness can affect test accuracy, necessitating appropriate test parameters tailored to the application scenario.

**Optimization measures** : To improve test accuracy, use high-resolution detectors (such as high-purity germanium detectors) to record radiation intensity; calibrate the radiation source and detector to ensure data accuracy; and test multiple sets of samples, covering different thicknesses or alloy compositions, to comprehensively evaluate shielding performance. Gamma-ray shielding effectiveness testing provides a reliable basis for the application of tungsten alloy discs in nuclear energy and medical fields, ensuring their protection capabilities in high-radiation environments.

#### 4.6.2 X-ray attenuation rate test steps

X-ray attenuation testing is an important method for evaluating the X-ray absorption capacity of tungsten alloy discs. It is widely used in medical diagnostic equipment (such as X-ray machines and CT scanners) and industrial non-destructive testing. Due to its high density and high atomic number, tungsten alloy discs can effectively block X-rays, reducing the risk of X-ray penetration to equipment or personnel. X-ray attenuation testing measures the disc's attenuation of X-rays to evaluate its shielding performance, providing critical data for high-precision applications.

**Test Principle** : The X-ray attenuation rate test uses an X-ray source to emit X-rays of a specific energy. After passing through a wafer, the intensity of the transmitted rays is measured and the attenuation rate is calculated. High-density wafers absorb more X-rays, resulting in lower transmitted intensity. The test is typically conducted in a laboratory setting, using an X-ray detector to record intensity changes.

##### Test steps :

1. Prepare tungsten alloy disc samples. The surface must be clean and free of defects, and the size must meet the test requirements (e.g., 50 mm diameter, 2-10 mm thickness).
2. Fix the disc on the sample holder of the X-ray testing device, ensuring alignment with the X-ray source and detector.
3. Select a suitable X-ray source (e.g., X-ray tube, energy range 50-150 kVp ), set the tube voltage and current, and adjust the irradiation time.
4. In the absence of a disk, the initial X-ray intensity was measured as a reference value.

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5. The disc is placed in the X-ray path, the intensity of the transmitted radiation is measured, and the attenuation data is recorded.
6. Repeat the test at different energy levels (e.g., 80 kVp , 120 kVp ) to evaluate the shielding performance of the wafer at different X-ray energies.
7. Analyze the attenuation rate data, calculate the transmittance (the ratio of transmitted intensity to initial intensity), and compare it with the standard shielding requirements.
8. Repeat the test on multiple groups of samples or different areas and take the average value to improve accuracy.
9. Comply with radiation safety regulations and use protective shielding to ensure operator safety.

**Advantages and Limitations :** X-ray attenuation rate testing accurately assesses a wafer's X-ray shielding performance, making it suitable for performance verification in medical and industrial applications. Testing equipment is relatively readily available and simple to operate. However, test results are affected by X-ray energy, wafer thickness, and detector sensitivity, requiring strict control of test conditions. Furthermore, testing with high-energy X-rays requires more stringent protective measures.

**Optimization measures :** To improve test accuracy, high-resolution X-ray detectors can be used to ensure accurate intensity measurements; multiple X-ray energies can be tested to cover the actual application range; and X-ray sources and detectors can be calibrated to reduce errors. X-ray attenuation rate testing provides reliable support for verifying the shielding performance of tungsten alloy discs in medical diagnosis and industrial testing, ensuring their effectiveness in high-precision applications.

#### 4.6.3 Comparison of Shielding Performance of Tungsten Alloy Discs of Different Thicknesses

Tungsten alloy discs of varying thicknesses aims to assess the impact of thickness on gamma-ray and X-ray shielding effectiveness, providing a basis for optimizing disc design and application. Thickness is a key factor influencing shielding performance. Thicker discs absorb more radiation energy and are suitable for high-intensity radiation environments, while thinner discs are more suitable for low-intensity radiation scenarios. The test reveals the relationship between thickness and shielding performance by comparing the attenuation rates of discs of varying thicknesses.

**Test Principle :** The relationship between shielding performance and thickness is based on the exponential attenuation of radiation in materials. Testing measures the transmission intensity of gamma rays or X-rays through discs of varying thicknesses, comparing the attenuation rates and evaluating the impact of thickness on shielding effectiveness. Testing is typically conducted using a combination of gamma ray and X-ray detection equipment to cover different radiation types.

##### Test steps :

1. Prepare multiple sets of tungsten alloy disc samples with thicknesses covering typical application scenarios (e.g., 1 mm, 5 mm, 10 mm, 20 mm), ensuring that each set of samples is made of consistent material.
2. Fix the discs one by one on the sample holder of the radiation testing device, ensuring alignment

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with the radiation source and detector.

3. Select a suitable radiation source (such as cobalt-60 gamma rays or X-ray tube), set the radiation energy and intensity, and record the initial radiation intensity.
4. Each set of thickness discs is tested, the intensity of the transmitted rays is measured, and the attenuation data is recorded.
5. Repeat the test at different energy levels (e.g. 1.25 MeV for gamma rays, 80-120 kVp for X-rays ) to evaluate the effect of thickness on shielding performance.
6. Analyze the data, draw a curve of the relationship between thickness and attenuation rate, and compare the shielding effects of wafers with different thicknesses.
7. Statistical analysis software was used to calculate the difference in attenuation rates and determine the optimal thickness range.
8. Ensure that radiation safety regulations are followed during testing and use protective shielding to protect operators.

**Advantages and Limitations :** Thickness comparison testing can intuitively reveal the impact of thickness on shielding performance, providing a scientific basis for optimizing wafer design and suitable for medical, scientific, and industrial applications. However, testing requires multiple sets of samples, which is costly, and the results are affected by radiation energy and alloy composition, requiring comprehensive consideration of multiple factors. Testing thick wafers can result in weak detector signals due to high attenuation, necessitating the use of a highly sensitive detector.

**Optimization measures :** To improve test accuracy, additional thickness test points can be added to cover a wider thickness range; a high-resolution detector can be used to accurately record low-intensity transmission signals; and microstructural analysis can be combined to evaluate the impact of thickness variations on material density. Comparative shielding performance testing of discs of varying thicknesses provides key data for optimizing the design of tungsten alloy discs for high-radiation environments, promoting their application in the medical and nuclear energy sectors.

#### 4.7 Test Methods for Electrical and Thermal Conductivity of Tungsten Alloy Discs

Tungsten alloy wafers is a crucial step in evaluating their effectiveness in electronics, electrical engineering, and thermal management applications. These performance directly impacts their performance in current conduction and heat transfer. Electrical conductivity reflects the wafer's efficiency in conducting current, while thermal conductivity determines its ability to dissipate heat and manage heat. Accurate and reliable testing methods are crucial to ensuring wafer quality, and multiple techniques are often combined to enhance testing accuracy.

##### 4.7.1 Conductivity Measurement Using the Four-Probe Method

The four-probe method is a highly accurate conductivity test method. By applying a constant current to the surface of a tungsten alloy wafer and measuring the voltage drop, the resistivity and conductivity of the wafer are calculated. The four-probe method is widely used for conductivity testing of tungsten alloy

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wafers due to its high accuracy, low contact resistance, and wide applicability. It provides reliable electrical performance data, providing a basis for performance verification in electronic and electrical applications. Conductivity directly affects the performance of the wafer in contacts, connectors, and circuit components.

**Test Principle :** The four-probe method uses four equally spaced probes in contact with the wafer surface. The outer two probes apply a constant current, while the inner two probes measure the voltage drop, thereby calculating the resistivity. Conductivity, the inverse of resistivity, reflects the wafer's ability to conduct current. This method improves test accuracy by separating the current and voltage measurement paths, eliminating the influence of contact resistance.

**Test steps :**

1. Prepare the tungsten alloy disc sample. The surface must be polished to a smooth surface without oil stains, oxide layer or impurities to ensure good contact.
2. Fix the wafer on the platform of the four-probe test device to ensure that the sample is stable and vibration-free.
3. Adjust the four-probe assembly to ensure that the four probes are in perpendicular contact with the wafer surface and the probe spacing is uniform.
4. Set the test parameters, including the constant current value (typically 1-100 mA) and the voltage measurement range, using a high-precision current source and voltmeter.
5. A constant current is applied, the voltage drop is measured across the inner probe, and the data is recorded.
6. Repeat the measurement at different areas of the wafer surface (such as the center and the edge) and take the average to improve accuracy.
7. The resistivity is calculated based on the voltage drop and current value, then converted into conductivity and compared with the standard value for verification.
8. Check the surface condition of the sample and observe the contact points with a microscope if necessary to ensure there is no damage or contamination.

**Advantages and Limitations :** The four-probe method offers high accuracy and low contact resistance, making it suitable for testing highly conductive materials such as tungsten-copper alloy wafers. It is widely used in laboratories and industrial settings. However, test results are affected by surface quality and probe contact, ensuring smooth surfaces and probe alignment. The test equipment requires regular calibration, and special fixtures may be required for thin or irregularly shaped wafers.

**Optimization measures :** To improve test accuracy, use a high-precision current source and voltmeter to ensure accurate data; finely polish the wafer surface to reduce contact resistance; test multiple sets of samples covering different alloy compositions ( such as tungsten-copper or tungsten-silver) to comprehensively evaluate conductivity. Conductivity data measured using the four-probe method provides a reliable basis for verifying the performance of tungsten alloy wafers in electrical and electronic applications, especially in circuit connection and contact applications.

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#### 4.7.2 Thermal conductivity measurement using the hot wire method

The hot wire method is a commonly used thermal conductivity test method. It calculates the thermal conductivity by applying a heat pulse to a tungsten alloy disc and measuring the temperature response. Due to its high accuracy, rapidity, and applicability, the hot wire method is widely used to test the thermal conductivity of tungsten alloy discs. It provides reliable thermal performance data, providing a basis for performance verification in thermal management applications. Thermal conductivity directly impacts the disc's performance in heat sinks, heat pipes, and high-temperature equipment.

**Testing Principle :** The hot wire method embeds a thin hot wire (such as a nickel-chromium wire) in a wafer sample, applies a constant-power heat pulse, and measures the temperature change over time near the hot wire. The thermal conductivity is calculated based on the temperature response rate and reflects the wafer's ability to conduct heat. Testing is typically performed in a controlled temperature environment to minimize external interference.

##### Test steps :

1. Prepare tungsten alloy disc samples and process them into standard sizes (such as rectangular or round slices). The surface must be clean and free of defects.
2. Embed a thin heating wire in the wafer or attach the heating wire to the surface, ensuring good contact between the heating wire and the sample.
3. Place the sample in a constant temperature environment of a hot wire test device and connect the hot wire to the power supply and temperature sensor.
4. Set the test parameters, including heat pulse power (typically 0.1-1 W), heating time (several seconds to tens of seconds), and temperature measurement frequency.
5. A heat pulse is applied and the temperature change near the hot line with time is recorded to generate a temperature-time curve.
6. Analyze the temperature response data, calculate the thermal conductivity, repeat the test in different areas, and take the average value.
7. Compare with the standard thermal conductivity value to verify whether the thermal conductivity of the wafer meets the requirements.
8. conductive adhesive to enhance the contact if necessary .

**Advantages and limitations :** The hot wire method has the advantages of high precision and rapidity. It is suitable for testing high thermal conductivity materials such as tungsten-copper alloy discs and can simulate actual thermal management environments. However, the test results are affected by the contact quality of the hot wire and the ambient temperature, and the test conditions need to be strictly controlled. For thin discs, hot wire embedding may be difficult, and surface attachment is required. Optimization measures: To improve test accuracy, high-precision temperature sensors and constant temperature environments can be used to reduce external interference; optimize the contact method between the hot wire and the sample to ensure heat transfer efficiency; test multiple groups of samples, covering different alloy compositions and thicknesses, and comprehensively evaluate thermal conductivity. The thermal conductivity data measured by the hot wire method provides important support for the performance

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verification of tungsten alloy discs in the field of thermal management , especially in electronic equipment and aerospace applications.

#### 4.7.3 Correlation test between electrical conductivity and thermal conductivity

The electrical conductivity and thermal conductivity correlation test investigates the relationship between the electrical and thermal conductivities of tungsten alloy wafers. By comprehensively measuring the performance data of both, the inherent correlation is analyzed, providing a basis for optimizing material design. Electrical and thermal conductivity are often correlated in metallic materials because both rely on the movement of free electrons. This test reveals the underlying mechanism by comparing electrical and thermal conductivity under different alloy compositions or processing conditions.

**Test Principle :** The electrical and thermal conductivity correlation test combines the four-probe method for measuring electrical conductivity and the hot wire method for measuring thermal conductivity. Multiple wafer samples with varying alloy compositions or process conditions are prepared, and their electrical and thermal conductivity values are measured to analyze the relationship between the two. This test is typically based on the Wiedemann-Franz law, which states that thermal conductivity is proportional to electrical conductivity under certain conditions.

##### Test steps :

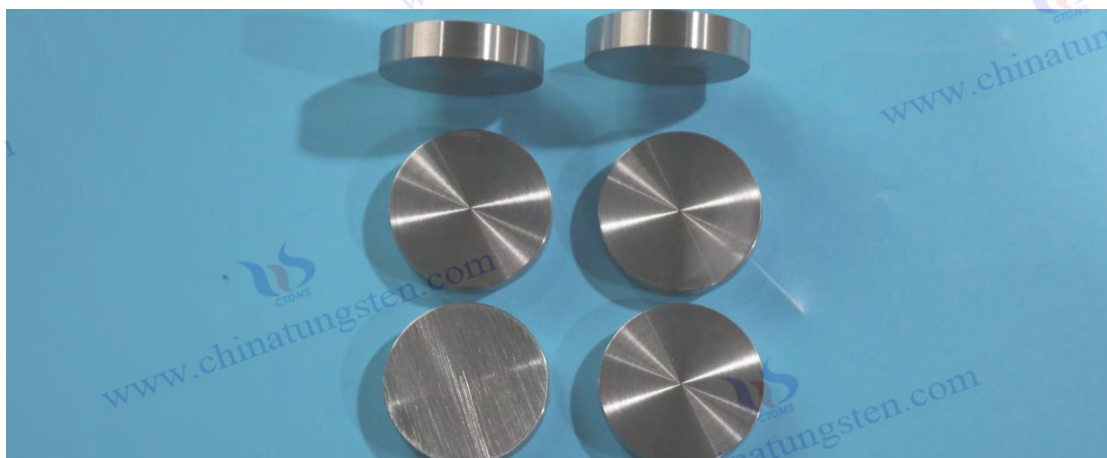
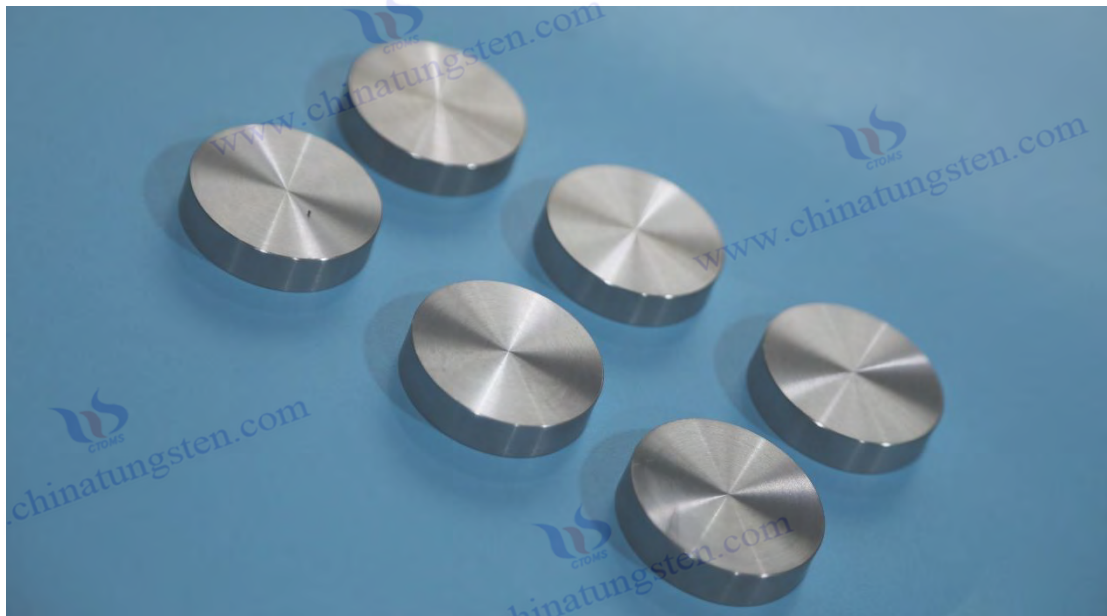
1. Prepare multiple sets of tungsten alloy disc samples, and obtain samples with different electrical and thermal conductivities by adjusting the alloy composition ( such as tungsten-copper ratio , nickel content) or manufacturing process (such as sintering temperature).
2. The conductivity of each group of samples was measured using the four-probe method, and the resistivity and conductivity data were recorded to ensure consistent test conditions.
3. The thermal conductivity of each group of samples was measured using the hot wire method, the temperature response data was recorded, and the thermal conductivity was calculated.
4. Organize the electrical conductivity and thermal conductivity data, draw the relationship curve between the two, and analyze the correlation.
5. Statistical analysis software (e.g., regression analysis) was used to calculate the correlation coefficient between electrical conductivity and thermal conductivity and to evaluate the strength of the correlation.
6. Combined with microstructural analysis (such as scanning electron microscopy observation of grain structure), the microscopic mechanisms of electrical and thermal conductivity are explored.
7. Repeat the test on multiple groups of samples to ensure the reliability of the data and compare and verify it with the theoretical model.
8. Analyze test results to identify key factors influencing correlation, such as alloy composition or microstructure.

**Advantages and Limitations :** Correlation testing can reveal the inherent relationship between electrical and thermal conductivity, providing a scientific basis for optimizing wafer design and suitable for

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material development for electronics and thermal management applications. However, testing requires multiple sets of samples, which is costly, and the results are affected by alloy composition, microstructure, and testing conditions, requiring comprehensive analysis of multiple factors. Furthermore, the Wiedemann-Franz law may exhibit deviations in high-hardness tungsten alloys, requiring correction based on experimental data.

**Optimization measures :** To improve test accuracy, the number of sample groups can be increased to cover a wider range of alloy compositions and process conditions; standardization of test conditions can ensure comparable electrical and thermal conductivity data; and in-depth research on the correlation mechanism can be conducted in conjunction with microstructural analysis. The correlation between electrical and thermal conductivity provides theoretical support for optimizing the performance of tungsten alloy wafers, promoting their application in applications requiring efficient simultaneous conduction of current and heat, such as electronic devices and electrical systems.



CTIA GROUP LTD Tungsten Alloy Wafer

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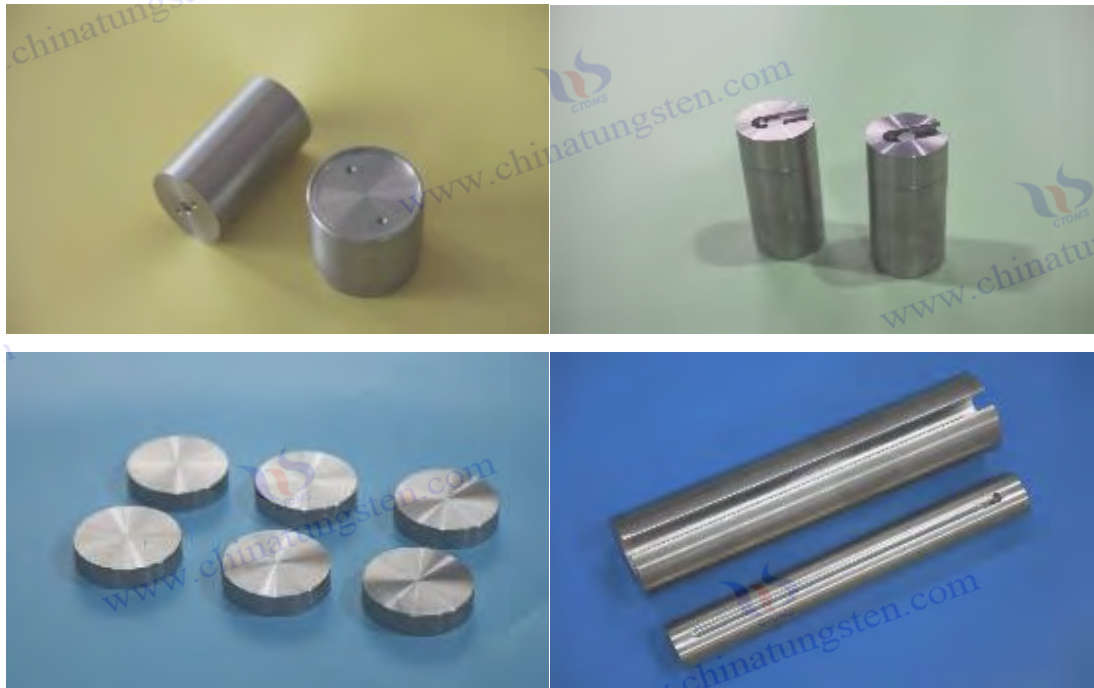
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## Chapter 5 Production Process of Tungsten Alloy Discs

Tungsten alloy discs is a key step in ensuring their high quality and performance, involving multiple steps including raw material selection, pretreatment, forming, sintering, and post-processing. Scientific and precise production techniques optimize the physical and mechanical properties of the discs, meeting the stringent requirements of aerospace, medical, electronics, and industrial sectors. Due to their high density, strength, high-temperature resistance, and radiation shielding properties, tungsten alloy discs are widely used in applications such as counterweights, shielding components, electrical contacts, and thermal management components. The production process requires strict quality control and standardized operations to ensure consistent and reliable product performance.

Raw material selection and pretreatment are fundamental to tungsten alloy disc production, directly impacting its ultimate performance. The quality and proportion of the raw materials determine the disc's density, strength, electrical conductivity, and thermal conductivity, while pretreatment ensures the uniformity and purity of the raw materials, laying the foundation for subsequent forming and sintering. The environmental friendliness and recyclability of tungsten alloy discs necessitate a focus on resource efficiency and environmental impact control during production.

### 5.1 Raw Material Selection and Pretreatment of Tungsten Alloy Discs

Tungsten alloy wafers are the starting point of the production process, directly determining the wafer's microstructure and performance. Raw materials primarily consist of high-purity tungsten powder and other alloying elements (such as nickel, iron, copper, or silver). Scientific screening and pretreatment ensure that the raw materials meet the production requirements for high-performance wafers. Pretreatment involves powder screening, cleaning, and mixing, aiming to improve the raw material's purity, particle size, and uniformity, providing a high-quality foundation for subsequent powder metallurgy processes.

#### 5.1.1 Tungsten powder purity and screening

Tungsten powder is the primary raw material for tungsten alloy wafers. Its purity and particle size directly impact the wafer's density, strength, and microstructural uniformity. High-purity tungsten powder can reduce the negative impact of impurities on performance, while a proper particle size distribution helps improve powder flowability and molding properties. Tungsten powder purity and screening are key steps in raw material pretreatment. Strict quality control ensures that the tungsten powder meets the production requirements for high-performance wafers.

**Process Principle :** Tungsten powder purity and screening are designed to remove impurities (such as oxides, carbon, or sulfur) and control particle size distribution to meet the requirements of powder metallurgy processes. High-purity tungsten powder (typically  $\geq 99.9\%$ ) reduces microscopic defects and improves wafer density and mechanical properties. Screening uses a vibrating screen or airflow classifier to remove oversized and undersized particles, ensuring a uniform particle size distribution (typically

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within the 1-10  $\mu\text{m}$  range), thereby optimizing powder flowability and compaction properties.

**Process steps :** The screening and purity control of high-purity tungsten powder begins with selecting raw materials that meet ASTM B777 standards (purity  $\geq 99.9\%$ ). Impurity levels ( e.g., oxygen  $\leq 0.05\%$ ) are confirmed using chemical analysis reports provided by the supplier. The tungsten powder is then placed in an ultrasonic cleaning system and cleaned with deionized water or ethanol to remove surface oxides and organic impurities. After cleaning, it is dried in a vacuum or inert gas atmosphere. Next, the powder is screened using a high-precision vibrating screen or air classifier to control the particle size within the 1-5  $\mu\text{m}$  or 5-10  $\mu\text{m}$  range, removing oversized particles (which affect uniformity) or fine particles (which tend to agglomerate). The particle size distribution is then measured using a laser particle size analyzer, with the median particle size (D50) and distribution range recorded to ensure compliance with process requirements. Purity testing is performed using inductively coupled plasma mass spectrometry (ICP-MS) or X-ray fluorescence spectroscopy (XRF) to confirm that impurity levels are below standard limits. The screened tungsten powder is stored in sealed containers in a dry, dust-free environment to prevent oxidation and contamination. Each batch of tungsten powder is sampled and tested to ensure purity and particle size consistency, and the data is recorded for traceability.

**Advantages and Limitations :** High-purity tungsten powder and uniform particle size distribution significantly improve wafer density and performance consistency, making it suitable for high-precision applications. However, high-purity tungsten powder is expensive, and the screening process requires sophisticated equipment, increasing production costs. Furthermore, fine particles may agglomerate during screening or storage, requiring strict environmental control.

**Optimization measures :** To improve process efficiency, automated screening equipment can be used to reduce manual errors; high-purity inert gas (such as argon) can be used to protect the tungsten powder from oxidation ; and a multi-stage screening process can be combined to optimize particle size distribution. Tungsten powder purity and screening processes provide a solid foundation for the high-performance production of tungsten alloy wafers, especially in radiation shielding and counterweight applications.

### 5.1.2 Material composition ratio and mixing

Material composition ratio and mixing are key steps in tungsten alloy disc production. By precisely controlling the ratio and uniformity of tungsten powder and other alloying elements, the disc's mechanical properties, electrical conductivity, and thermal conductivity are optimized. A reasonable ratio balances strength, toughness, and other properties, while uniform mixing ensures a uniform microstructure and minimizes performance variations.

**Process Principle :** The material composition ratio is determined based on the wafer application requirements. For example, high-density counterweights require a high tungsten content (90-95 wt %), while high-conductivity applications require increased copper or silver content. The mixing process uses mechanical mixing or ball milling equipment to evenly disperse the tungsten powder with the other metal

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powders to form a uniform powder mixture, providing high-quality raw materials for subsequent pressing and sintering. This uniform mixing reduces microsegregation and improves the performance stability of the wafer.

**Process Steps :** Material Component Ratio and Mixing: First, design the alloy ratio based on application requirements. For example, a tungsten-nickel-iron (W-Ni-Fe) alloy for high-density counterweights has a ratio of 90:7:3, while a tungsten-copper (W-Cu) alloy for conductive applications has a ratio of 70:30. Use a high-precision electronic balance (accuracy  $\geq 0.001$  g) to weigh the tungsten, nickel, iron, or copper powders to ensure accurate mixing ratios. Place the weighed powders in a V-type mixer, planetary ball mill, or three-dimensional blender. Add an appropriate amount of additive (such as ethanol or polyvinyl alcohol) to improve flowability. Set the mixing time to 2-8 hours at a speed of 100-300 rpm. Mix under an inert atmosphere (such as nitrogen or argon) to prevent oxidation. After mixing, sample the powder for elemental distribution analysis using scanning electron microscopy (SEM) or energy dispersive spectroscopy (EDS) to confirm uniformity (element distribution deviation  $\leq \pm 1\%$ ). Immediately seal and store the mixed powder in a dry environment to avoid oxidation and contamination. Each batch of mixed powder is sampled and tested to analyze the chemical composition and particle size distribution to ensure that it meets the ratio design and process requirements.

**Advantages and Limitations :** Precise ingredient ratios and uniform mixing optimize wafer performance, meet diverse application requirements, and are suitable for high-precision production. However, the mixing process can lead to unevenness due to equipment performance or improper operation, affecting wafer quality. Furthermore, high-conductivity alloys (such as W-Cu) require a high proportion of copper powder, which increases cost and may reduce density.

**Optimization measures :** To improve mixing uniformity, use a high-efficiency three-dimensional mixer or extend the mixing time; use grinding aids to reduce powder agglomeration; and ensure uniform element distribution through multi-point sampling and analysis. The material composition ratio and mixing process provide key guarantees for the high-performance production of tungsten alloy wafers, promoting their widespread application in electronics, medical, and aerospace fields.

## 5.2 Forming process of tungsten alloy disc

Tungsten alloy discs is a core step in the production process. Pre-processed powder material is transformed into circular discs with high density and excellent performance through pressing and sintering. The forming process consists of two main steps: powder pressing and sintering, responsible for forming the initial shape and achieving material densification, respectively. Precise forming ensures the discs' dimensional accuracy, density uniformity, and mechanical properties required for high-performance applications.

### 5.2.1 Powder pressing

Powder pressing is the first step in forming tungsten alloy discs. By pressing a uniformly mixed tungsten

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alloy powder into a die to form a disc blank with a preliminary shape and density, it provides a foundation for subsequent sintering. The powder pressing process is widely used in the production of tungsten alloy discs due to its high efficiency and precision, ensuring the dimensional consistency and structural stability of the disc blank.

**Process Principle :** Powder pressing uses hydraulic or mechanical pressure to compress tungsten alloy powder (such as tungsten-nickel-iron or tungsten-copper) into a billet with a specific strength and shape. During the pressing process, the powder particles undergo plastic deformation and particle rearrangement under high pressure, forming a dense billet structure. The pressing process requires controlling pressure, die design, and powder flowability to ensure the billet's density and shape meet the requirements.

**Process steps :** The powder pressing process begins by loading pre-treated tungsten alloy powder (screened for purity and uniformly mixed) into a high-precision circular mold. The mold surface is ensured to be smooth and free of contamination to prevent defects. The powder is weighed using a high-precision electronic balance to ensure a consistent charge each time, thereby ensuring uniform density in the blank. The mold is then placed in a hydraulic or mechanical press, where appropriate pressure is applied to form a circular blank with initial strength. Pressure and displacement are monitored during the pressing process to ensure consistent blank thickness. After pressing, the blank is carefully removed and inspected for surface quality and dimensions, using an optical microscope or profilometer to detect any cracks or deformation. The blank is then stored in a dry, dust-free environment pending sintering. The entire process must be carried out in a cleanroom to avoid powder contamination, and pressing parameters (such as pressure and time) are recorded for each batch of blanks for quality traceability.

**Advantages and Limitations :** The powder compaction process is efficient, low-cost, and can quickly produce high-precision disc blanks, making it suitable for large-scale production. However, uneven pressure or insufficient powder flowability during the compaction process can lead to density deviations, affecting blank quality. Furthermore, the high hardness of tungsten powder can cause wear on the mold, necessitating the use of high-strength mold materials.

**Optimization measures :** To improve pressing quality, isostatic pressing techniques (such as cold isostatic pressing) can be used to ensure uniform density; mold design can be optimized to reduce demolding resistance; and press aids (such as polyvinyl alcohol) can be used to improve powder fluidity. Powder pressing provides a reliable foundation for high-precision molding of tungsten alloy discs, especially in the production of counterweights and shielding components.

### 5.2.2 Sintering process

The sintering process is a key step in the production of tungsten alloy discs. High-temperature treatment binds the powder particles in the pressed blank, forming a high-density, high-strength disc. The sintering process eliminates porosity in the blank, improving the material's density and mechanical properties, ensuring the disc's ultimate performance. The sintering process is widely used in the production of tungsten alloy discs due to its high efficiency and performance optimization capabilities.

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**Process Principle :** The sintering process heats and compacts the blank at high temperatures (typically 1300-1600°C), allowing the powder particles to form a dense structure through diffusion, surface bonding, and grain growth. Tungsten alloy discs are typically sintered using liquid phase sintering. Added low-melting-point metals (such as nickel and copper) melt at the sintering temperature, promoting particle bonding and increasing density and strength. The sintering process must be performed in an inert atmosphere or vacuum to prevent oxidation.

**Process steps :** The sintering process begins by placing the pressed disc blanks in a high-temperature sintering furnace (such as a vacuum furnace or a hydrogen-protected furnace). High-purity ceramic or graphite crucibles are used to hold the blanks and ensure contamination-free conditions. The sintering temperature is set, with a controlled ramp rate of 5-10°C/min to avoid thermal stress. The blanks are held at the sintering temperature for 2-6 hours to promote liquid-phase sintering and particle bonding. An inert gas (such as argon) or hydrogen is introduced to prevent oxidation. Subsequently, the blanks are cooled to room temperature at a controlled rate to avoid cracking caused by rapid cooling. After sintering, the discs' density is measured using a high-precision electronic balance, and X-ray nondestructive testing is performed to inspect for internal porosity or defects. If necessary, the disc surfaces are polished to remove any oxide layer or surface defects formed during sintering. Sintering parameters (such as temperature, holding time, and atmosphere) are recorded for each batch of sintered discs for quality traceability.

**Advantages and Limitations :** The sintering process can significantly improve the density and mechanical properties of wafers, making it suitable for high-performance applications. However, high-temperature sintering consumes a lot of energy and requires strict equipment. In addition, improper temperature control can lead to oversized grains or residual porosity, compromising performance. Furthermore, liquid-phase sintering can cause compositional deviations due to volatilization of low-melting -point metals, necessitating precise control of sintering conditions.

**Optimization measures :** To improve sintering quality, hot isostatic pressing (HIP) can be used to further eliminate porosity; the sintering temperature profile can be optimized to reduce thermal stress; and high-purity shielding gas can be used to ensure oxidation-free conditions. The sintering process provides a key guarantee for the high-density and high-performance production of tungsten alloy wafers, driving their widespread application in aerospace, medical, and electronics fields.

### 5.3 Processing Technology of Tungsten Alloy Discs

Tungsten alloy discs is a critical step in the production process. Sintered blanks are processed through cutting, grinding, and surface treatment to create discs with high precision and excellent surface quality. This process ensures the discs' dimensional accuracy, surface finish, and mechanical properties, meeting the high-performance component requirements of aerospace, medical, and electronics industries. Tungsten alloy's high hardness and density make it challenging to process, requiring high-precision equipment and process parameter control to avoid defects and material waste. The following details the steps and applications of tungsten alloy disc processing , focusing on cutting, grinding, and surface treatment .

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### 5.3.1 Cutting and grinding

Cutting and grinding are the core steps in tungsten alloy disc processing. Machining removes excess material and shapes the disc to its precise size and shape, ensuring it meets the requirements of high-precision applications. Tungsten alloy's high hardness and density make it challenging to cut and grind, requiring high-performance cutting tools and precision equipment to achieve high-quality processing.

**Process Principle :** Cutting and grinding utilize high-speed rotating tools or abrasives to remove material from the sintered tungsten alloy blank to achieve the target size and surface quality. Cutting is primarily used for roughing, removing larger excesses and initially forming the disc shape; grinding is used for finishing, further improving dimensional accuracy and surface finish. The high hardness of tungsten alloy requires the use of diamond or cubic boron nitride (CBN) tools and abrasives to ensure efficient and high-quality processing.

**Process Steps :** The cutting and grinding process for tungsten alloy discs begins with preparing the sintered blank, ensuring that the surface is free of visible defects. Ultrasonic cleaning is then used to remove oil and impurities. The blank is secured in a fixture on a CNC lathe or machining center using a high-precision clamping device to ensure stability and prevent vibration during machining. During the cutting phase, diamond or CBN tools are selected, and appropriate cutting parameters are set. Excess material is removed through turning or milling to form the initial disc shape. After cutting, dimensional accuracy is checked using a laser rangefinder or micrometer to ensure compliance with design requirements. The grinding phase then begins, using a precision grinder and diamond grinding wheel at a low feed rate and a coolant spray to fine-tune the surface and edges of the disc, achieving optimal surface finish and dimensional accuracy. During machining, tool and grinding wheel wear should be regularly inspected and replaced to prevent defects. After machining, the disc is ultrasonically cleaned to remove cutting fluid and metal chips, and a profilometer is used to inspect the surface quality and dimensional consistency. Cutting and grinding parameters (such as speed, feed rate, and processing time) must be recorded for each batch of processed wafers for quality traceability.

**Advantages and Limitations :** Cutting and grinding processes can achieve high-precision dimensions and surface quality, meeting the stringent wafer requirements of the aerospace and electronics sectors. However, the high hardness of tungsten alloys leads to rapid tool wear, resulting in high processing costs. Furthermore, microcracks may form during cutting, necessitating strict control of processing parameters. Furthermore, the use of coolant during grinding can increase environmental disposal costs.

**Optimization measures :** To improve processing efficiency and quality, CNC machining centers and automated fixtures can be used to reduce manual errors; high-performance diamond cutting tools and abrasives can be used to extend tool life; and optimized coolant formulations can be used to reduce environmental impact and improve processing stability. Cutting and grinding processes provide a reliable foundation for high-precision machining of tungsten alloy wafers, especially in demanding applications such as medical devices and electronics.

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### 5.3.2 Surface treatment

Surface treatment is a crucial step in tungsten alloy wafer processing. Through processes such as polishing, coating, or chemical treatment, the surface finish, corrosion resistance, and functional performance of the wafer are enhanced to meet the needs of specific application scenarios. Surface treatment not only improves the appearance and performance of the wafer, but also enhances its durability in complex environments.

**Process Principle :** Surface treatment modifies the surface of tungsten alloy discs through mechanical, chemical, or physical methods to remove machining defects, improve finish, or add functional coatings to enhance wear resistance, corrosion resistance, and electrical conductivity. Due to the high hardness and chemical stability of tungsten alloy, surface treatment requires specialized equipment and processes to ensure treatment effectiveness and material performance stability.

**Process steps :** The surface treatment of tungsten alloy wafers begins with inspection of the wafers after cutting and grinding to ensure the surface is free of cracks, scratches, or residual stress. Ultrasonic cleaning is then used to remove surface oil and particles. During the polishing phase, a precision polisher using diamond polishing paste is used at low speed and moderate pressure to polish the wafer surface to a mirror finish, enhancing both smoothness and appearance. After polishing, the surface quality is inspected using a profilometer and a microscope to ensure the absence of microscopic defects. For wafers requiring enhanced corrosion resistance or conductivity, electroless plating or physical vapor deposition (PVD) processes can be used to deposit nickel, gold, or silver coatings to improve conductivity and corrosion resistance. Coating is performed in a vacuum environment, with the deposition temperature and rate controlled to ensure uniform coating and strong adhesion. After surface treatment, X-ray fluorescence (XRF) analysis is used to analyze the coating composition and thickness to verify compliance with design requirements. Chemical cleaning is performed, if necessary, to remove residual chemicals, and the wafers are rinsed with deionized water to ensure a clean surface. Polishing and coating parameters (such as polishing time, coating thickness, and deposition conditions) are recorded for each batch of surface-treated wafers for quality traceability.

**Advantages and Limitations :** Surface treatment can significantly improve wafer surface quality and functional performance, meeting the stringent requirements of the electronics, medical, and aerospace sectors. However, polishing and coating processes require high-precision equipment, increasing production costs. Furthermore, improper coating techniques can lead to poor adhesion, necessitating strict control of process parameters. Furthermore, chemical treatments can generate wastewater, which must be properly handled to minimize environmental impact.

**Optimization measures :** To improve surface treatment efficiency and quality, automated polishing equipment and online monitoring systems can be used to reduce manual errors; coating process parameters can be optimized to ensure coating uniformity and adhesion; and environmentally friendly cleaning agents and waste liquid treatment systems can be used to reduce environmental impact. Surface treatment processes provide a key guarantee for the high-performance application of tungsten alloy

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wafers, promoting their widespread use in high-precision and complex environments.

## 5.4 Quality Control and Inspection of Tungsten Alloy Discs

Tungsten alloy wafers are critical components of the production process, ensuring they meet high standards for density, strength, surface properties, and radiation shielding performance. Quality control utilizes online monitoring and spot checks of finished products to track key parameters during the production process in real time, promptly identifying and correcting deviations. Testing utilizes systematic testing methods to verify that wafer performance meets application requirements. These processes improve production efficiency, reduce defective product rates, and provide reliable support for applications in aerospace, medical, and electronics. The following details the processes and applications of tungsten alloy wafer quality control and testing, focusing on online monitoring of the molding process and spot checks of all finished product properties.

### 5.4.1 Online Monitoring of the Molding Process

Online monitoring of the forming process is a real-time quality control method used in tungsten alloy disc production. By monitoring key parameters during the powder compaction and sintering processes, the dimensional accuracy, density, and structural uniformity of the blank and sintered discs are ensured. With its high efficiency and real-time performance, online monitoring can promptly detect production deviations and reduce defective products. It is widely used in the high-precision production of tungsten alloy discs.

**Process Principle :** Online monitoring of the forming process utilizes sensors, control systems, and data analysis equipment to collect real-time parameters during the pressing and sintering process (such as pressure, temperature, and density distribution). These parameters are then compared with reference values to determine process stability. The monitoring system can detect density deviations in the pressed blank, temperature fluctuations during sintering, or porosity formation, ensuring wafer quality meets requirements.

**Process Steps :** Online monitoring of the molding process begins at the powder pressing stage. High-precision pressure sensors and displacement sensors monitor the pressing machine's pressure and die displacement, recording the force-displacement curve in real time during the pressing process to ensure consistent billet thickness and crack-free production. After pressing, a laser rangefinder or ultrasonic detector rapidly scans the billet's surface and dimensions to check for deformation or surface defects. During the sintering stage, high-temperature sensors and infrared thermometers monitor the temperature in the sintering furnace in real time to ensure stable heating rates and holding times, avoiding thermal stress and abnormal grain growth. During sintering, online X-ray density measurement or ultrasonic flaw detectors monitor the wafer's density distribution (target density  $\geq 95\%$  of theoretical density) to detect internal porosity or segregation. Monitoring data is analyzed in real time by a computer control system and compared with standard parameters. If deviations are detected (such as pressure exceeding limits or temperature fluctuations), equipment parameters are automatically adjusted or an alarm is issued. All

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monitoring data is recorded in the quality management system for process optimization and quality traceability.

**Advantages and Limitations :** Online monitoring can detect production deviations in real time, improving production efficiency and product qualification rates, making it suitable for high-precision and large-scale production. However, monitoring systems require high-precision sensors and complex data analysis software, resulting in high equipment investment and maintenance costs. Furthermore, monitoring results may be affected by environmental interference, necessitating strict control of the production environment.

**Optimization measures :** To improve monitoring accuracy, a multi-point sensor system can be used to comprehensively cover the key parameters of the pressing and sintering processes; use artificial intelligence algorithms to analyze monitoring data and predict potential defects; and regularly calibrate sensors to ensure data accuracy.

#### 5.4.2 Random inspection of all performance items of finished products

Finished product full-performance spot checks are a post-production quality verification step for tungsten alloy wafers. Through systematic testing of the finished wafers' density, dimensions, mechanical properties, surface quality, and radiation shielding performance, we ensure they meet design and application requirements. With their comprehensiveness and representativeness, spot checks verify the consistency of production batches and provide a basis for product quality certification.

**Process Principle :** Full-scale performance inspections of finished products are conducted through random sampling tests to evaluate the physical and mechanical properties of wafers, including key indicators such as density, hardness, tensile strength, surface roughness, and flatness. These inspections utilize standardized testing methods (such as ASTM standards) and high-precision instrumentation to verify that wafers meet technical specifications and analyze performance consistency across batches.

**Process steps :** Full performance inspection of finished products begins with random sampling. Samples (typically 5-10%) are randomly selected from each batch of wafers according to statistical sampling standards (such as ISO 2859) to ensure representativeness. Samples are first measured for mass using a high-precision electronic balance, and dimensions are measured with a laser rangefinder or micrometer to calculate density to ensure they meet target values. Hardness is then tested using a Vickers hardness tester, and the hardness value (HV) is recorded to verify compliance with standards. Mechanical testing includes tensile strength using a universal testing machine (compliant with ASTM E8) and flexural strength using a three-point bend test (compliant with ASTM E290) to assess the wafer's strength and toughness. Surface quality is measured using a roughness meter and flatness using a flatness tester to ensure that it meets precision assembly requirements. Radiation shielding performance is assessed using gamma-ray or X-ray attenuation tests to measure the wafer's radiation absorption capacity. All test data is recorded in a quality report and compared to technical specifications to determine the batch acceptance rate. Batches that fail random inspections require full inspection or rework, and the cause is analyzed to

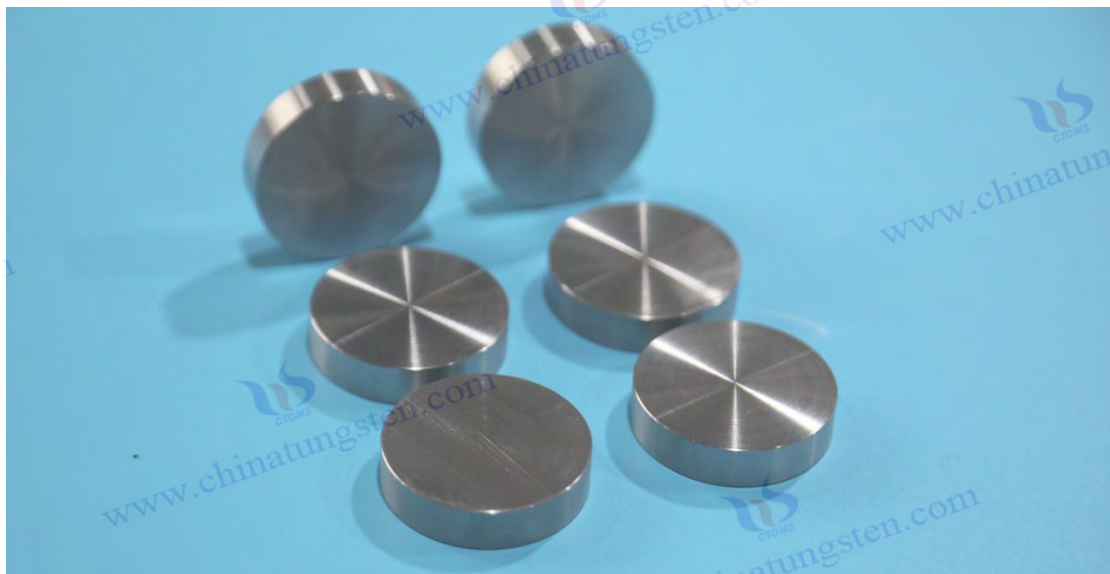
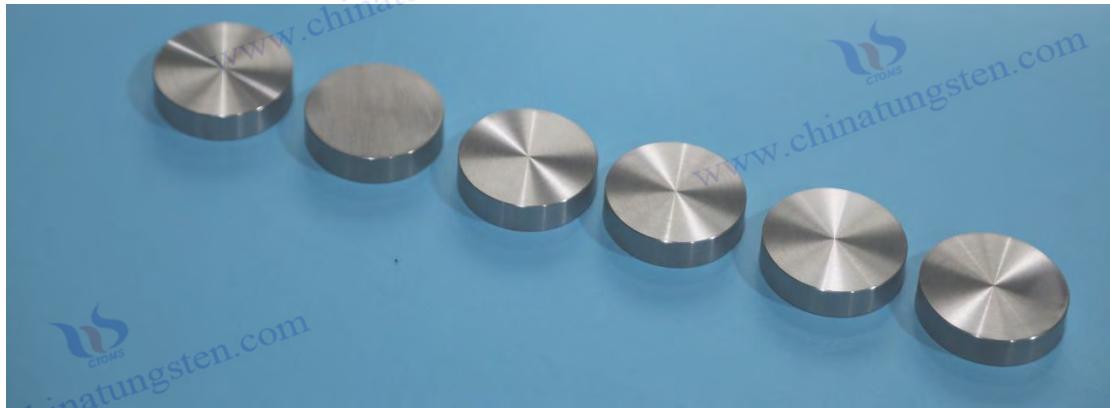
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optimize the process.

**Advantages and Limitations :** Full-scale performance sampling of finished products comprehensively evaluates wafer performance, ensuring it meets diverse application requirements and is suitable for quality certification and customer acceptance. However, sampling coverage is limited, potentially missing individual defects, and testing cycles are lengthy, increasing production costs. Furthermore, high-precision testing equipment requires regular calibration, placing high demands on operational efficiency.

**Optimization measures :** To improve sampling efficiency, automated testing equipment can be used to shorten testing cycles; sampling ratios can be increased to cover more performance parameters; and non-destructive testing techniques (such as X-ray CT) can be combined to conduct in-depth analysis of internal structures. Full performance sampling of finished products provides systematic support for the quality verification of tungsten alloy wafers, promoting their reliable application in the medical, aerospace, and electronics fields.



CTIA GROUP LTD Tungsten Alloy Wafer

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## Chapter 6 Application Fields of Tungsten Alloy Wafers

Tungsten alloy discs, with their high density, excellent mechanical properties, high-temperature resistance, and superior radiation shielding capabilities, have demonstrated widespread application value in multiple high-tech fields. Their unique physical and chemical properties make them an indispensable material in aerospace, medical, electronic, industrial, and scientific research. Through precision production processes, tungsten alloy discs can meet demanding application requirements, such as counterweights in high-load environments, shielding in high-radiation environments, and structural stability under high-temperature conditions. Their non-toxicity and recyclability further enhance their appeal in environmentally sensitive areas, meeting modern industry's requirements for sustainable development and safety. In fields such as medical devices, aerospace components, electronic connectors, and industrial tools, tungsten alloy discs, with their diverse performance, provide critical support for high precision and reliability.

### 6.1 Application of Tungsten Alloy Discs in Medical Equipment

Tungsten alloy discs in medical devices is primarily due to their high density and high atomic number, making them an ideal material for radiation shielding. Their mechanical strength and corrosion resistance also make them suitable for complex medical environments. In the medical field, tungsten alloy discs are widely used in radiotherapy equipment, diagnostic instruments, and protective devices, providing safe and effective radiation protection for patients and medical staff. Their high density effectively absorbs and blocks high-energy radiation, such as X-rays and gamma rays, while maintaining a compact size, making them suitable for the design requirements of precision medical equipment. Tungsten alloy discs have excellent processability and can be manufactured in various shapes and sizes through powder metallurgy and precision machining processes to meet the requirements of different medical devices. Furthermore, their non-toxicity and recyclability make them both safe and environmentally friendly in medical applications, especially in applications with strict biocompatibility and environmental impact requirements. The use of tungsten alloy discs in medical devices not only improves device performance but also promotes advancements in radiotherapy and diagnostic technologies, providing important support for the development of modern medicine.

In radiotherapy equipment, tungsten alloy discs are primarily used to shield high-energy radiation, ensuring treatment accuracy and safety. For example, in linear accelerators, gamma knife devices, and proton therapy devices, tungsten alloy discs are used as shielding components, effectively reducing radiation leakage and protecting surrounding personnel and equipment. Their high-temperature resistance and mechanical stability enable them to maintain performance in high-intensity radiation and complex stress environments, ensuring the long-term reliability of the equipment. Furthermore, the surface finish and dimensional accuracy of tungsten alloy discs make them easy to integrate with other components, meeting the high-precision assembly requirements of medical equipment. In diagnostic equipment such as CT scanners and X-ray machines, tungsten alloy discs are used in collimators and shielding covers to optimize the focusing and protection of radiation beams. These properties make tungsten alloy discs irreplaceable in the medical equipment field, providing a key guarantee for

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improving treatment effectiveness and patient safety.

### 6.1.1 Radiation shielding discs for radiotherapy equipment

Radiation shielding discs in radiotherapy equipment are a key medical application of tungsten alloy discs. They are designed to block and absorb high-energy radiation, protecting patients, medical staff, and equipment from unnecessary radiation exposure. Due to their high density and high atomic number, tungsten alloy discs efficiently absorb gamma rays and X-rays, reducing radiation penetration. Their compact size also makes them suitable for use in space-constrained radiotherapy equipment. Their mechanical strength and corrosion resistance ensure structural stability in high-radiation and high-stress environments, extending the life of the equipment. Tungsten alloy discs offer excellent processability, allowing them to be formed into shielding components with complex shapes, meeting the precision and reliability requirements of radiotherapy equipment. Furthermore, their non-toxicity ensures safety in contact with the human body and meets the strict biocompatibility standards of medical devices. In radiotherapy equipment, tungsten alloy discs are widely used in the shielding design of devices such as linear accelerators, gamma knives, and proton therapy devices. By optimizing the radiation beam path and reducing scattered radiation, they improve treatment precision and safety.

Tungsten alloy wafers in radiotherapy equipment also reflect a focus on environmental protection and sustainability. Their recyclability reduces environmental impact during production and disposal, while their high performance reduces the frequency of equipment maintenance and replacement, reducing resource consumption. In the design of radiotherapy equipment, tungsten alloy wafers are often combined with other materials (such as lead or stainless steel) to form a multi-layer shielding structure to further enhance the protective effect. Their surface finish and dimensional accuracy enable seamless integration into the equipment's precision components, such as collimators, shields, and protective plates, ensuring precise control of the radiation beam and minimizing leakage. These properties of tungsten alloy wafers make them an indispensable component of radiotherapy equipment, providing important support for the development of modern radiotherapy technology and promoting advances in cancer treatment and other disease management.

#### 6.1.1.1 Shielding Applications in Linear Accelerators

In linear accelerators (LINACs), tungsten alloy discs are widely used as radiation shielding components to control high-energy X-ray and electron beams, ensuring the precision and safety of radiotherapy. Linear accelerators are the core equipment of modern radiotherapy, generating high-energy radiation by accelerating electrons for the treatment of diseases such as cancer. Due to their high density and high atomic number, tungsten alloy discs can effectively absorb and block the high-energy X-rays generated by the accelerator, reducing radiation leakage and protecting non-target tissues of patients and surrounding medical staff. Their compact size makes them suitable for integration into the compact structures of accelerators, such as collimators, shields, and protective plates, for precise control of the shape and direction of radiation beams. The mechanical strength and high-temperature resistance of tungsten alloy discs enable them to maintain stable performance in high-radiation and high-heat

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environments, avoiding deformation or performance degradation caused by long-term use.

In the shielding design of linear accelerators, tungsten alloy discs are usually processed into thin sheets or disc shapes for key components of multi-leaf collimators (MLCs) or fixed collimators. These components adjust the shape and intensity of the radiation beam to achieve precise irradiation of the tumor area while minimizing damage to healthy tissue. The surface finish and high dimensional accuracy of the tungsten alloy discs ensure smooth movement and accurate positioning of the collimator, improving the accuracy of treatment. In addition, its corrosion resistance and non-toxicity make it suitable for long-term use in medical environments without contaminating patients or equipment. The processing technology of tungsten alloy discs, such as powder metallurgy and precision grinding, enables it to meet the accelerator's requirements for complex shapes and strict tolerances, such as achieving high-precision radiation beam modulation in dynamic intensity-modulated radiotherapy (IMRT).

Tungsten alloy discs in linear accelerators is also reflected in their synergistic effect with multi-layer shielding structures. The discs are often combined with other materials (such as lead or steel) to form composite shielding layers, enhancing overall protection while optimizing equipment weight and volume. Their recyclability and environmentally friendly nature reduce the environmental impact of waste disposal, meeting the medical industry's requirements for sustainable development. In practical applications, the shielding performance of tungsten alloy discs is verified through regular testing (such as X-ray attenuation rate testing) to ensure their reliability in high-intensity radiation environments. These advantages make tungsten alloy discs an ideal shielding material for linear accelerators, providing efficient and safe support for cancer treatment and promoting the advancement of modern radiotherapy technology.

#### 6.1.1.2 Local Shielding Design of Gamma Knife Equipment

In gamma knife devices, tungsten alloy discs are used in local shielding designs to precisely control the radiation path of gamma rays and protect non-targeted tissue and the surrounding environment. The gamma knife is a non-invasive radiotherapy device that focuses gamma rays emitted by multiple cobalt-60 sources on the tumor area, enabling precise treatment. Tungsten alloy discs, with their high density and high absorption capacity, effectively block gamma rays, reduce scattered radiation, and ensure the accuracy and safety of the treatment area. Their small size and high machining precision make them suitable for the compact design of gamma knife devices, especially in key components such as collimators and shielding covers. The mechanical strength and corrosion resistance of tungsten alloy discs enable them to maintain long-term performance stability in high-radiation environments, preventing performance degradation due to radiation damage.

In the local shielding design of the Gamma Knife, tungsten alloy discs are processed into thin sheets or complex geometric shapes for the manufacture of collimators and shielding plates. These components precisely control the focus and direction of gamma rays, ensuring that the radiation beam is concentrated on the tumor area while reducing radiation exposure to surrounding healthy tissue. The surface finish and dimensional accuracy of the tungsten alloy discs enable seamless integration into the Gamma Knife

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's precision system, supporting the implementation of high-precision treatment plans. Its non-toxicity ensures safe contact with patients and medical staff, meeting the biocompatibility requirements of medical devices. In addition, the high-temperature resistance of the tungsten alloy discs enables it to maintain structural stability in the local high-temperature environment generated by the operation of the Gamma Knife device, avoiding deformation or performance loss.

Tungsten alloy discs in gamma knife equipment is also reflected in their integration into multi-layer shielding structures. The discs are often used in conjunction with other shielding materials to form a composite shielding system, optimizing protection effectiveness and device weight. Their recyclability reduces the environmental impact of production and disposal, aligning with the medical industry's environmental concerns. In practical applications, the shielding performance of tungsten alloy discs is verified through gamma-ray attenuation rate testing, ensuring their reliability in high-energy radiation environments. These properties of tungsten alloy discs make them crucial in the local shielding design of gamma knife equipment, providing important support for the precision treatment of brain tumors and other neurological diseases, and promoting the development of radiosurgery technology.

#### 6.1.1.3 Shielding Layout in Proton Therapy Devices

In proton therapy devices, tungsten alloy discs are used in shielding arrangements to control the proton beam and the accompanying secondary radiation, ensuring safe and precise treatment. Proton therapy is an advanced radiotherapy technique that uses accelerated proton beams to precisely irradiate tumors while minimizing damage to healthy tissue. Tungsten alloy discs, due to their high density and high atomic number, effectively absorb the secondary radiation generated by the proton beam. Their compact size and processability make them suitable for integration into the complex structures of proton therapy devices. The mechanical strength and corrosion resistance of tungsten alloy discs ensure stable performance in high-energy radiation environments, extending the life of the device.

In the shielding layout of proton therapy devices, tungsten alloy wafers are processed into thin sheets, discs, or customized shapes for the manufacture of collimators, shields, and protective plates. These components achieve high-precision irradiation of the tumor area by precisely controlling the path and intensity of the proton beam, while blocking secondary radiation and protecting the patient's non-target tissue and medical staff. The surface finish and high dimensional accuracy of the tungsten alloy wafers ensure smooth movement and accurate positioning of the collimator and shielding components, improving the accuracy of treatment. Its non-toxicity makes it suitable for use in medical environments and will not contaminate patients or equipment. In addition, the high-temperature resistance of the tungsten alloy wafers enables it to maintain structural stability in the high-temperature environment generated by the operation of the proton therapy device, avoiding deformation caused by thermal stress.

Tungsten alloy discs in proton therapy devices is also reflected in their synergy with composite shielding systems. Discs are often combined with other materials (such as borides or concrete) to form a multi-layer shielding structure, enhancing the absorption of neutrons and gamma rays while optimizing equipment weight and space usage. Their recyclability reduces the environmental impact of production

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and disposal, meeting the medical industry's requirements for sustainable development. In practical applications, the shielding performance of tungsten alloy discs is verified through radiation attenuation testing and neutron dose measurements, ensuring reliable protection in high-energy proton environments. These advantages of tungsten alloy discs enable them to play a key role in the shielding layout of proton therapy devices, providing efficient and safe support for the precision treatment of cancer and other diseases, and promoting the development of proton therapy technology.

### 6.1.2 Counterweight discs for medical imaging equipment

Tungsten alloy discs as counterweights in medical imaging equipment is one of its important functions. With their high density and excellent mechanical properties, they provide key support for the stable operation of the equipment and imaging accuracy. Medical imaging equipment, such as CT machines and MRI equipment, often contains components that rotate at high speed or move with precision, requiring precise counterweights to ensure dynamic balance and structural stability. Due to their high density, tungsten alloy discs can provide sufficient weight in a small volume. Compared with traditional counterweight materials (such as lead or steel), they occupy less space and are suitable for the compact design requirements of medical equipment. Their mechanical strength and corrosion resistance enable them to maintain stable performance under high loads and complex environments, avoiding deformation or performance degradation caused by long-term use. In addition, tungsten alloy discs have excellent processing properties and can be made into high-precision round or customized shapes through powder metallurgy and precision machining processes to meet the equipment's strict requirements for counterweight components.

In medical imaging equipment, tungsten alloy discs serve primarily as counterweights, balancing rotating components and optimizing overall device stability. For example, in the rotating gantry of a CT machine, tungsten alloy discs are used as counterweights to ensure dynamic balance during high-speed rotation and reduce the impact of vibration on image quality. In MRI equipment, tungsten alloy discs are used as fixed or adjustable counterweights to enhance device stability in strong magnetic fields, ensuring magnetic field uniformity and imaging accuracy. Their non-toxicity makes them suitable for use in medical environments, posing no health risks to patients or medical staff. The surface finish and dimensional accuracy of tungsten alloy discs enable seamless integration into the device's precision systems, supporting high-precision motion and long-term operational reliability. Their recyclability further reduces environmental impact, aligning with the medical industry's focus on environmental protection and sustainable development. The use of tungsten alloy discs in counterweights for medical imaging equipment not only improves device performance but also promotes advances in diagnostic technology, providing patients with safer and more accurate medical care.

#### 6.1.2.1 Counterweight Balancing of Rotating Components of CT Machines

Tungsten alloy discs play a vital role in balancing the rotating components of CT machines, ensuring the equipment maintains dynamic balance during high-speed rotation, thereby improving imaging accuracy and device stability. CT machines (computed tomography scanners) are core equipment in the field of

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medical imaging, generating detailed cross-sectional images of human tissue through the rapid rotation of X-ray sources and detectors. The rotating frame is a key component of CT machines, containing X-ray tubes, detectors, and other precision components, which must rotate at high speeds to achieve rapid scanning. Due to its high density, tungsten alloy discs can provide sufficient weight within a small volume to balance the weight distribution of the rotating frame, reduce vibration and noise caused by imbalance, and ensure smooth operation and image quality.

In the rotating components of CT machines, tungsten alloy discs are usually processed into precise circular or sector-shaped counterweights and installed at specific positions on the rotating frame to offset the unbalanced forces of heavy components such as X-ray tubes and detectors. Their high density enables the counterweights to achieve efficient counterweighting in a limited space, optimize the structural design of the rotating frame, and reduce the overall weight and volume. The mechanical strength and corrosion resistance of tungsten alloy discs enable them to withstand the centrifugal force generated by high-speed rotation and the environmental stress during long-term operation, avoiding deformation or performance degradation. It has excellent processing performance and can achieve high dimensional accuracy through precision grinding and CNC machining, ensuring the perfect match between the counterweight and the rotating frame, and supporting dynamic balance during high-speed rotation. In addition, the high surface finish of the tungsten alloy discs reduces the friction resistance when in contact with rotating parts, improving the smoothness of movement and the life of the equipment.

Tungsten alloy discs as counterweights in CT scanners also reflects a focus on safety and environmental protection. Their non-toxicity ensures safe contact with patients and medical staff, meeting biocompatibility requirements for medical devices. Their recyclability reduces the environmental impact of disposal and minimizes resource waste. In practical applications, the counterweight performance of tungsten alloy discs is verified through dynamic balance testing and vibration analysis to ensure the stability of the rotating frame during high-speed operation. Tungsten alloy discs are often combined with other materials (such as aluminum or steel) to form composite counterweight systems to further optimize weight distribution and device performance.

#### 6.1.2.2 Stable counterweights for MRI equipment

Tungsten alloy discs play an important role in stabilizing the weight of magnetic resonance imaging (MRI) equipment. By providing high-density weights, they ensure the structural stability and operational accuracy of the equipment in strong magnetic field environments. MRI equipment is a key technology in the field of medical imaging. It uses strong magnetic fields and radio frequency pulses to generate detailed images of human tissue and is used to diagnose a variety of diseases. MRI equipment contains heavy components such as large magnets, gradient coils, and radio frequency coils, which require precise weights to maintain overall stability and prevent displacement or vibration during operation. Due to its high density, tungsten alloy discs can provide sufficient weight in a small volume, which is suitable for the compact and precise design requirements of MRI equipment. Its mechanical strength and corrosion resistance enable it to maintain stable performance in strong magnetic fields and complex environments, avoiding performance degradation caused by long-term use.

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In the design of stable counterweights for MRI equipment, tungsten alloy discs are typically processed into round, rectangular, or custom-shaped counterweights, which are installed around the equipment's base, support structure, or gradient coils to optimize weight distribution and enhance overall stability. Their high density enables the counterweights to provide sufficient mass within a limited space, reducing the volume of the equipment base and optimizing space utilization. Tungsten alloy discs offer excellent machinability, achieving high dimensional accuracy through powder metallurgy and precision machining processes, ensuring a precise fit between the counterweight and the equipment structure. Their high surface finish reduces frictional resistance during contact with the equipment and improves ease of installation and adjustment. Furthermore, the non-magnetic properties of tungsten alloy discs prevent them from interfering with the strong magnetic field of the MRI equipment, ensuring magnetic field uniformity and imaging quality.

Tungsten alloy discs as counterweights in MRI equipment also demonstrates a commitment to safety and environmental protection. Their non-toxicity ensures safe contact with patients and medical staff, meeting the stringent standards for medical devices. Their recyclability reduces the environmental impact of production and disposal, meeting the medical industry's requirements for sustainable development. In practical applications, the counterweight performance of tungsten alloy discs is verified through vibration testing and stability analysis to ensure that the equipment does not move or vibrate during operation. Tungsten alloy discs are often combined with other non-magnetic materials to form composite counterweight systems, further optimizing the equipment's weight distribution and structural stability. Their use in MRI equipment not only improves imaging accuracy and equipment reliability, but also reduces operating noise and maintenance requirements, providing patients with a safer and more comfortable diagnostic experience and promoting the development of MRI technology.

### 6.1.3 Application of Tungsten Alloy Discs in Nuclear Medicine Equipment

Tungsten alloy discs in nuclear medicine equipment is primarily due to their excellent radiation shielding capabilities. They are widely used to protect operators, patients, and equipment from the high-energy radiation released by radioactive isotopes. Nuclear medicine equipment involves the preparation, packaging, and testing of radiopharmaceuticals, such as single-photon emission computed tomography (SPECT), positron emission tomography (PET), and radioimmunoassay analyzers. These devices require highly effective shielding materials to block gamma and beta rays. Tungsten alloy discs, due to their high density and high atomic number, effectively absorb and block these high-energy radiation. Their compact size also makes them suitable for integration into the compact structures of nuclear medicine equipment. Their mechanical strength and corrosion resistance ensure stable performance in high-radiation and chemically corrosive environments, preventing deformation or performance degradation due to long-term use. Tungsten alloy discs offer excellent processability and can be precision-machined into thin sheets, discs, or custom shapes to meet the stringent shielding requirements of these equipment.

In nuclear medicine equipment, the shielding effect of tungsten alloy discs not only improves operational safety but also optimizes equipment performance. For example, in radiopharmaceutical packaging equipment, tungsten alloy discs are used as shielding containers and protective covers to minimize

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radiation leakage from radioisotopes during the packaging process. In radioimmunoassay instruments, tungsten alloy discs are used to protect detectors and key components, reduce radiation background noise, and improve detection sensitivity and accuracy. Their non-toxicity ensures safety during contact with the human body and meets the biocompatibility standards of medical devices. In addition, the surface finish and high dimensional accuracy of tungsten alloy discs enable seamless integration into the precision systems of the equipment, supporting high-precision operation and long-term operational reliability. Their recyclability reduces environmental impact and reduces waste disposal costs, which is in line with the medical industry's focus on environmental protection and sustainable development.

#### 6.1.3.1 Shielding of radiopharmaceutical packaging equipment

Tungsten alloy discs in radiopharmaceutical dispensing equipment is a significant advancement in nuclear medicine. They are primarily used to block high-energy gamma and beta rays emitted by radioisotopes, protecting operators and the environment. Radiopharmaceutical dispensing equipment prepares and dispenses radioisotopes (such as technetium-99m, iodine-131, and fluorine-18) for diagnostic and therapeutic purposes. These isotopes release high-energy radiation during the dispensing process, requiring efficient shielding materials to prevent radiation leakage. Tungsten alloy discs, due to their high density and high atomic number, effectively absorb and block this radiation, reducing the likelihood of radiation penetration. Their compact size also makes them suitable for compact dispensing equipment designs. Their mechanical strength and corrosion resistance ensure stable performance in high-radiation and chemically corrosive environments, preventing deformation or degradation from long-term use. Tungsten alloy discs offer excellent processability and can be formed into thin sheets, discs, or custom-shaped shielding covers, meeting the high-precision shielding requirements of dispensing equipment.

In radiopharmaceutical packaging equipment, tungsten alloy discs are typically processed into shielding containers, protective covers, or linings for packaging tanks to isolate radioactive isotopes and prevent radiation leakage into the operating area. Their high density enables them to provide sufficient shielding effect within a smaller thickness, optimizing the design space of the equipment and reducing the overall weight. The surface finish and high dimensional accuracy of the tungsten alloy discs ensure a perfect match with other components of the packaging equipment, supporting the smooth operation of the automated packaging system. Their non-toxicity makes them suitable for use in medical environments and will not contaminate drugs or operators. In addition, the high temperature resistance and chemical stability of the tungsten alloy discs enable them to withstand local high temperatures or chemical corrosion that may occur during the packaging process, ensuring long-term reliability. In actual applications, the shielding performance of tungsten alloy discs is verified by gamma-ray attenuation rate testing to ensure that they can effectively reduce radiation doses and protect the safety of operators.

Tungsten alloy discs in radiopharmaceutical packaging equipment also reflects a focus on environmental sustainability. Their recyclability reduces environmental impact during production and disposal, meeting the medical industry's commitment to sustainable development. Tungsten alloy discs are often combined with other shielding materials (such as lead glass or stainless steel) to form composite shielding systems,

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further enhancing protection while optimizing equipment weight and cost. During packaging equipment operation, the shielding effect of tungsten alloy discs significantly reduces radiation exposure risks, improving the safety and efficiency of drug preparation.

#### 6.1.3.2 Protective components of radioimmunoassay instruments

Tungsten alloy discs as protective components in radioimmunoassay instruments is another important application in nuclear medicine. They are primarily used to shield radiation emitted by radioisotopes, protect detectors and key components, and ensure detection accuracy and equipment safety. Radioimmunoassay instruments detect specific molecules (such as hormones or proteins) in biological samples using radioactive markers (such as iodine-125 or technetium-99m) for high-sensitivity analysis. These markers emit low-energy gamma or beta radiation, requiring efficient shielding materials to reduce background noise and improve detection sensitivity. Tungsten alloy discs, due to their high density and high atomic number, effectively absorb these radiations. Their compact size and processability make them suitable for integration into sophisticated instrument detection systems. Their mechanical strength and corrosion resistance ensure stable performance in high-radiation environments, preventing performance degradation from long-term use.

In radioimmunoassay instruments, tungsten alloy discs are usually processed into thin sheets, discs or custom-shaped protective plates, which are installed around detectors, sample chambers or radiation sources to shield radiation and reduce background noise. Its high density enables it to provide sufficient shielding effect within a smaller thickness, optimize the spatial design of the instrument, and reduce the overall volume. The surface finish and high dimensional accuracy of the tungsten alloy disc ensure precise matching with other components of the instrument, supporting the stable operation of the detection system. Its non-toxicity makes it suitable for use in medical environments and will not contaminate biological samples or operators. In addition, the corrosion resistance of the tungsten alloy disc enables it to withstand corrosion from chemical reagents or moisture that may occur inside the instrument, ensuring long-term reliability. In actual applications, the shielding performance of the tungsten alloy disc is verified by radiation background measurement and attenuation rate testing to ensure that it can effectively reduce detection interference and improve analysis accuracy.

Tungsten alloy discs in radioimmunoassay instruments also reflects a focus on environmental sustainability. Their recyclability reduces the environmental impact of production and disposal, meeting the medical industry's requirements for green manufacturing. Tungsten alloy discs are often combined with other non-magnetic materials (such as plastic or stainless steel) to form composite shielding systems, further optimizing shielding effectiveness and instrument weight. In radioimmunoassays, the protective effect of tungsten alloy discs significantly improves detection sensitivity and accuracy, providing reliable support for disease diagnosis.

#### 6.2 Application of Tungsten Alloy Discs in Electronics and Semiconductors

Tungsten alloy wafers in the electronics and semiconductor fields is primarily due to their excellent

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thermal conductivity, high density, and mechanical strength, making them an ideal material for heat sinks, structural supports, and electrical connections. In chip manufacturing equipment, tungsten alloy wafers are widely used in heat conduction and heat dissipation components, ensuring efficient thermal management during high-power operation and maintaining the stability of precision processes. Their high thermal conductivity enables rapid heat transfer, preventing equipment overheating and extending its service life. The mechanical strength and corrosion resistance of tungsten alloy wafers enable them to maintain stable performance in high vacuum, high temperature, and chemically corrosive environments, making them suitable for the demanding conditions of semiconductor manufacturing. Their excellent processability allows them to be formed into high-precision round or custom shapes through powder metallurgy and precision machining processes, meeting the dimensional accuracy and surface quality requirements of chip manufacturing equipment. Furthermore, their non-toxicity and recyclability align with the electronics industry's focus on environmental protection and sustainable development. The application of tungsten alloy wafers in the electronics and semiconductor fields has promoted advancements in chip manufacturing technology and provided critical support for the development of high-performance electronic devices and integrated circuits.

In chip manufacturing equipment, tungsten alloy wafers are primarily used as heat-conducting and heat-dissipating components in key equipment such as ion implanters, photolithography machines, and chemical vapor deposition equipment. For example, in ion implanters, tungsten alloy wafers serve as thermally conductive substrates, rapidly transferring heat generated during the process and ensuring uniform wafer temperature. In photolithography machines, tungsten alloy wafers are used as heat sinks to maintain the thermal stability of the optical system and wafer platform, improving photolithography accuracy. Their high density also allows them to function as counterweights, optimizing equipment operational stability.

### 6.2.1 Chip Manufacturing Equipment Thermal Conductive Wafers

Tungsten alloy wafers as thermal conductors in chip manufacturing equipment is a key application in the electronics and semiconductor fields. They are primarily used for heat dissipation and thermal management, ensuring stable operation during high-power and high-precision processes. Chip manufacturing involves numerous high-precision processes, such as ion implantation, photolithography, and chemical vapor deposition. These processes generate significant amounts of heat. Failure to dissipate this heat can lead to equipment overheating, wafer deformation, or decreased process precision. Tungsten alloy wafers, particularly tungsten-copper alloys, possess high thermal conductivity (approximately 150-200 W/ m·K ) and excellent mechanical properties, enabling rapid heat transfer and maintaining stable temperatures in equipment and wafers. Their high density allows them to provide sufficient heat capacity within a compact footprint, making them ideal for the compact design of chip manufacturing equipment. The high-temperature and corrosion resistance of tungsten alloy wafers ensures stable performance in high vacuum and chemically corrosive environments, preventing performance degradation over time.

In chip manufacturing equipment, tungsten alloy wafers are typically processed into thin sheets, discs, or custom-shaped thermally conductive substrates or heat sinks, which are then installed near key heat-

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generating components, such as the wafer stage of an ion implanter or the optical system of a photolithography machine. Their surface finish and high dimensional accuracy (error  $\leq 0.01$  mm) ensure precise matching with other equipment components, supporting the stable operation of high-precision processes. Tungsten alloy wafers have excellent processing performance and can achieve complex shapes and high tolerances through powder metallurgy and precision grinding processes, meeting the needs of chip manufacturing for high-precision components. Their non-toxicity makes them suitable for use in cleanroom environments and will not contaminate wafers or equipment. In addition, the recyclability of tungsten alloy wafers reduces the environmental impact of production and waste disposal, meeting the semiconductor industry's requirements for environmental protection and sustainable development.

#### 6.2.1.1 Thermal Conductive Components of Ion Implanters

Tungsten alloy wafers as thermally conductive components in ion implanters is a key feature of chip manufacturing equipment. They are primarily used to rapidly transfer heat generated during the process, ensuring wafer temperature uniformity and equipment operational stability. Ion implanters, critical equipment in chip manufacturing, use accelerated ion beams to implant dopants into wafers, forming specific semiconductor structures. This process generates significant heat, which, particularly at high implant doses, can lead to wafer overheating or elevated temperatures in equipment components, compromising doping accuracy and wafer quality. Tungsten alloy wafers, with their high thermal conductivity and density, efficiently absorb and transfer heat, maintaining stable temperatures on the wafer stage and surrounding components. Their mechanical strength and high-temperature resistance enable them to maintain stable performance in high vacuum environments and high-energy ion beams, preventing deformation caused by thermal stress or long-term use. Tungsten alloy wafers offer excellent processing properties and can be fabricated into high-precision thermally conductive substrates or heat sinks, meeting the stringent thermal management requirements of ion implanters.

In the thermal conductivity components of ion implanters, tungsten alloy wafers are usually processed into circular or rectangular thin sheets and installed in the heat dissipation system near the wafer stage or ion beam path to absorb and transfer the heat generated by the wafer and equipment. Its high thermal conductivity ensures that heat is quickly transferred from the hot area to the heat dissipation device, preventing wafer deformation or uneven doping caused by local overheating. The surface finish and high dimensional accuracy of the tungsten alloy wafer enable it to fit tightly with the wafer stage, improving heat transfer efficiency while supporting high-speed rotation and precise positioning of the wafer stage. Its corrosion resistance enables it to withstand the chemical gas or plasma environment that may be exposed during the ion implantation process, ensuring long-term reliability. In actual applications, the thermal conductivity of the tungsten alloy wafer is verified through temperature distribution testing and thermal imaging analysis to ensure that it can effectively maintain the uniformity of the process temperature.

Tungsten alloy wafers for thermal conductivity in ion implanters also reflects a focus on environmental protection and sustainability. Their non-toxicity ensures they will not contaminate wafers when used in cleanroom environments, meeting the stringent standards of semiconductor manufacturing. Their

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recyclability reduces the environmental impact of production and disposal, minimizing resource waste. Tungsten alloy wafers are often combined with other thermally conductive materials, such as graphite or aluminum, to form composite heat dissipation systems, further optimizing thermal management efficiency and device performance.

#### 6.2.1.2 Application of Heat Dissipation Wafers in Photolithography Machines

Tungsten alloy wafers are another important application in chip manufacturing equipment as heat sinks in lithography machines. They are primarily used to maintain the thermal stability of the optical system and wafer platform, ensuring high precision and consistency in the lithography process. Lithography machines are core equipment in chip manufacturing, transferring circuit patterns onto wafers using ultraviolet or extreme ultraviolet (EUV) light. Their optical systems and wafer platforms require strict temperature control during high-power operation to prevent thermal expansion and optical distortion. Tungsten alloy wafers, with their high thermal conductivity and high density, can quickly transfer heat generated during the lithography process, preventing overheating of optical components or wafers and ensuring accurate pattern transfer. Their mechanical strength and high-temperature resistance enable them to maintain stable performance in high vacuum environments and under intense light radiation, preventing deformation caused by thermal stress. Tungsten alloy wafers offer excellent processing properties and can be manufactured into high-precision heat sinks or thermally conductive substrates, meeting the precision requirements of lithography machines.

In the cooling system of photolithography machines, tungsten alloy wafers are typically processed into thin discs or custom-shaped heat sinks and installed near optical lens arrays, reflectors, or wafer stages to absorb and transfer heat generated by the light source and laser system. Their high thermal conductivity ensures rapid heat transfer from hot areas to the heat sink, maintaining temperature stability in the optical system and wafer, and preventing optical distortion or misalignment caused by temperature fluctuations. The tungsten alloy wafer's smooth surface finish and high dimensional accuracy enable seamless integration with the precision components of the photolithography machine, supporting high-precision positioning and stable operation. Its corrosion resistance allows it to withstand the chemical cleaning agents and high vacuum environments encountered during the photolithography process, ensuring long-term reliability. During application, the heat dissipation performance of the tungsten alloy wafer is verified through thermal imaging and temperature distribution testing to ensure its ability to effectively maintain thermal stability during the photolithography process.

The use of tungsten alloy wafers in photolithography machines for heat dissipation also reflects a focus on environmental protection and sustainability. Their non-toxicity ensures no contamination of wafers or optical components when used in cleanroom environments, meeting the high standards of semiconductor manufacturing. Their recyclability reduces the environmental impact of production and disposal, minimizing resource waste. Tungsten alloy wafers are usually combined with other thermally conductive materials to form a composite heat dissipation system to further optimize thermal management efficiency and equipment performance.

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## 6.2.2 High-frequency device electrode wafers

Tungsten alloy discs in high-frequency device electrodes is a key manifestation of its application in the electronics and semiconductor fields. They are primarily used to support high-frequency signal transmission and efficient current conduction, ensuring stable device performance during high-frequency oscillation and high-power operation. High-frequency devices, such as microwave communication devices and RF power devices, are widely used in applications such as radar, satellite communications, mobile communication base stations, and power amplifiers. They require materials with high conductivity and mechanical strength for their electrodes and conductive components. Tungsten alloy discs, particularly tungsten-copper or tungsten-silver alloys, offer stable current conduction and signal transmission in high-frequency environments due to their high conductivity (close to that of pure copper or silver) and excellent mechanical properties. Their high thermal conductivity enables rapid heat dissipation, preventing overheating caused by high-power operation and extending device life. The high-temperature and corrosion resistance of tungsten alloy discs ensures stable performance in high-frequency oscillation and chemically corrosive environments, preventing degradation of electrode materials over time.

In high-frequency devices, tungsten alloy wafers are typically processed into thin discs, wafers, or custom-shaped electrodes, which are installed in microwave circuits, RF amplifiers, or connectors to support current conduction and signal transmission. Their surface finish and high dimensional accuracy (error  $\leq 0.01$  mm) ensure precise matching with other components of the device, reduce contact resistance and signal loss, and support stable transmission of high-frequency signals. Tungsten alloy wafers have excellent processing performance and can achieve complex shapes and high tolerance requirements through powder metallurgy and precision grinding processes, meeting the strict requirements of high-frequency devices for electrode components. Their non-toxicity makes them suitable for use in cleanroom environments and will not pollute the device or manufacturing environment. In addition, the recyclability of tungsten alloy wafers reduces the environmental impact of production and waste disposal, meeting the electronics industry's requirements for green manufacturing.

### 6.2.2.1 Electrode Structure of Microwave Communication Devices

Tungsten alloy discs in the electrode structures of microwave communication devices is a key manifestation of their application in high-frequency devices. They are primarily used to support the stable transmission of high-frequency signals and efficient current conduction, ensuring stable device performance within the microwave frequency range. Microwave communication devices are widely used in radar, satellite communications, 5G base stations, and wireless network equipment, requiring electrode materials with high conductivity and low signal loss to maintain signal integrity and transmission efficiency. Tungsten alloy discs, particularly tungsten-copper or tungsten-silver alloys, due to their high conductivity and excellent mechanical strength, can provide reliable current conduction in high-frequency oscillation environments, reducing signal attenuation and electromagnetic interference. Their high thermal conductivity enables rapid heat dissipation, preventing overheating caused by high-power operation in microwave devices and maintaining electrode and circuit stability. The high-temperature

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and corrosion resistance of tungsten alloy discs enable them to maintain stable performance in the high-temperature and high-frequency oscillation environments of microwave devices, avoiding signal loss due to material degradation.

In the electrode structures of microwave communication devices, tungsten alloy discs are typically processed into thin discs, strip electrodes, or custom-shaped connectors, which are installed in microwave circuits, waveguides, or antenna systems to support high-frequency signal transmission and current conduction. Their high conductivity ensures low resistance loss, reduces signal attenuation, and improves communication efficiency. The tungsten alloy disc's smooth surface finish and high dimensional accuracy enable seamless connection with other components of microwave devices (such as ceramic substrates or gold electrodes), reducing contact resistance and electromagnetic interference, and supporting stable transmission of high-frequency signals. Their corrosion resistance enables them to withstand moisture and chemical gases that microwave devices may encounter during operation, ensuring long-term reliability. In practical applications, the electrical performance of tungsten alloy discs is verified through impedance testing and signal loss analysis to ensure they meet the high standards required for microwave communications.

Tungsten alloy wafers as electrodes in microwave communication devices also reflects a focus on environmental friendliness and sustainability. Their non-toxicity ensures they will not contaminate devices or the manufacturing environment when used in cleanroom environments, meeting the high standards of the electronics industry. Their recyclability reduces the environmental impact of production and disposal, minimizing resource waste. Tungsten alloy wafers are often combined with other conductive materials, such as gold or silver coatings, to form composite electrode structures, further optimizing conductivity and signal transmission efficiency.

#### 6.2.2.2 Conductive wafers for RF power devices

Tungsten alloy wafers as conductive wafers in RF power devices is another important manifestation of its application in high-frequency devices. They are mainly used to support the reliable conduction of high-power currents and heat management, ensuring the stability and efficiency of devices during high-power operation. RF power devices, such as RF power amplifiers and power transistors, are widely used in wireless communication base stations, broadcast equipment, and industrial RF systems. They require materials with high electrical and thermal conductivity to construct conductive components and electrodes. Tungsten alloy wafers, especially tungsten-copper alloys, can efficiently conduct large currents and quickly dissipate heat due to their high electrical and thermal conductivity, preventing overheating or performance degradation caused by high-power operation. Their high density and mechanical strength enable them to maintain structural stability in high-power and high-frequency oscillation environments, avoiding deformation caused by mechanical or thermal stress. The corrosion resistance of tungsten alloy wafers enables them to withstand the chemical environments that RF devices may be exposed to during operation, ensuring long-term reliability.

Among the conductive components of RF power devices, tungsten alloy wafers are usually processed

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into circular electrodes, conductive substrates or connecting pieces, which are installed in power amplifiers, transistors or heat dissipation systems to support the conduction of high-power current and heat management. Its high conductivity ensures low resistance loss, reduces energy waste, and improves power conversion efficiency. The high thermal conductivity of tungsten alloy wafers enables it to quickly transfer the heat generated by device operation to the heat dissipation device, maintain the stability of the operating temperature, and extend the life of the device. Its surface finish and high dimensional accuracy ensure precise matching with other components of the device, reduce contact resistance and thermal resistance, and support efficient current and heat transfer. In actual applications, the electrical and thermal conductivity of tungsten alloy wafers are verified through conductivity testing and thermal imaging analysis to ensure that they can meet the high standards of RF power devices.

Tungsten alloy wafers in RF power devices also reflects a focus on environmental protection and sustainability . Its non- toxicity ensures that it will not contaminate devices when used in cleanroom environments, meeting the high standards of the electronics industry. Its recyclability reduces the environmental impact of production and disposal, minimizing resource waste. Tungsten alloy wafers are often combined with other conductive or thermally conductive materials (such as copper or ceramics) to form composite conductive systems, further optimizing electrical and thermal performance.

### 6.2.3 Application of Tungsten Alloy Wafers in Electronic Packaging

Tungsten alloy wafers in electronic packaging is primarily due to their excellent thermal conductivity and electromagnetic shielding capabilities. They are widely used as heat sink substrates for high-power devices and as shielding packages for electronic components, ensuring stable performance in high-power operation and complex electromagnetic environments. Electronic packaging is the process of integrating chips, circuits, and other electronic components into a single module, which requires a balance between thermal management, electromagnetic compatibility, and mechanical stability. Tungsten alloy wafers, particularly tungsten-copper or tungsten-silver alloys, due to their high thermal conductivity and high density, can quickly transfer heat to prevent device overheating, while also providing effective electromagnetic shielding, protecting sensitive circuits from external interference. Their mechanical strength and corrosion resistance enable them to maintain stable performance in high vacuum, high temperature, and chemically corrosive environments, preventing performance degradation due to long-term use. Tungsten alloy wafers also have excellent processability and can be formed into thin discs, substrates, or custom shapes through powder metallurgy and precision machining processes, meeting the stringent requirements of high-precision components in electronic packaging. In electronic packaging, tungsten alloy wafers are commonly used as heat sink substrates, shielding covers, or package covers, mounted around high-power chips, power amplifiers, or sensitive electronic components. Its high thermal conductivity ensures rapid heat transfer from the heating element to the heat sink, maintaining device operating temperature stability and improving operational efficiency and lifespan. Its high density enables it to effectively block electromagnetic waves, reducing the impact of external electromagnetic interference on circuits, and improving signal integrity and device reliability. The tungsten alloy wafer's smooth surface finish and high dimensional accuracy enable seamless integration with other components of the package structure, supporting high-precision assembly and long-term operational reliability. Its

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non-toxicity makes it suitable for use in cleanroom environments, without contaminating the chip or manufacturing environment. Furthermore, the recyclability of tungsten alloy wafers reduces the environmental impact of production and disposal, meeting the electronics industry's requirements for green manufacturing.

#### 6.2.3.1 High-power device package heat sink

Tungsten alloy wafers play a key role in the application of packaging heat sinks for high-power devices. They are mainly used to quickly transfer the heat generated during device operation to ensure temperature stability and operational reliability. High-power devices, such as power amplifiers, laser diodes, and central processing units (CPUs), generate a large amount of heat during operation. If the heat is not dissipated in time, it may cause device overheating, performance degradation, or shortened life. Tungsten alloy wafers, especially tungsten-copper alloys, can efficiently absorb and transfer heat due to their high thermal conductivity and high density, maintaining the operating temperature of the device within a safe range. Their mechanical strength and high-temperature resistance enable them to maintain structural stability during high-power operation and high-temperature environments, avoiding deformation or cracking caused by thermal stress. Tungsten alloy wafers have excellent processing performance and can be made into high-precision heat sink wafers or substrates through powder metallurgy and precision grinding processes, meeting the strict requirements of high-power device packaging for dimensional accuracy and surface quality.

In the packaging of high-power devices, tungsten alloy wafers are usually processed into thin discs, heat dissipation substrates or heat sinks, which are installed under the chip or heating element to quickly transfer heat to external heat dissipation devices, such as heat pipes or air cooling systems. Its high thermal conductivity ensures efficient heat conduction from the heat-generating area, preventing device performance degradation caused by local overheating. The surface finish and high dimensional accuracy of the tungsten alloy wafer enable it to fit tightly with the chip or other packaged components, reducing thermal resistance and improving heat transfer efficiency. Its corrosion resistance enables it to withstand chemical cleaning agents or humid environments that it may be exposed to during the packaging process, ensuring long-term reliability. In actual applications, the heat dissipation performance of the tungsten alloy wafer is verified through thermal imaging and temperature distribution testing to ensure that it can effectively maintain the temperature stability of the device. Tungsten alloy wafers as heat sinks in high-power device packaging also reflects a focus on environmental sustainability. Their non-toxicity ensures they will not contaminate chips or the manufacturing environment when used in cleanroom environments, meeting the high standards of the electronics industry. Their recyclability reduces the environmental impact of production and disposal, minimizing resource waste. Tungsten alloy wafers are often combined with other thermally conductive materials, such as graphite or ceramics, to form composite heat sink systems, further optimizing thermal management efficiency and packaging performance.

#### 6.2.3.2 Shielding and packaging of electronic components

Tungsten alloy wafers play a vital role in the shielding and packaging of electronic components, primarily

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used to block external electromagnetic interference, protect sensitive circuits, and ensure signal integrity and reliability in complex electromagnetic environments. Electronic components such as integrated circuits, sensors, and high-frequency modules are widely used in communications, automotive electronics, and industrial control systems. They are susceptible to interference from external electromagnetic waves, resulting in signal distortion or performance degradation. Tungsten alloy wafers, due to their high density and high atomic number, effectively shield electromagnetic radiation, including radio frequency interference (RFI) and electromagnetic interference (EMI), protecting sensitive circuits from external influences. Their high conductivity enables them to quickly conduct interfering currents, reducing electromagnetic noise. Their mechanical strength and corrosion resistance enable them to maintain stable performance in environments with high humidity, chemical corrosion, or high temperatures, preventing shielding degradation due to long-term use.

In the shielding and packaging of electronic components, tungsten alloy discs are typically processed into thin discs, shielding covers, or package covers, which are installed around sensitive circuits or chips to form an electromagnetic shielding layer. Their high density enables them to provide sufficient shielding effect within a relatively small thickness, optimizing the space occupied by the package design and meeting the needs of compact electronic devices. The surface finish and high dimensional accuracy of the tungsten alloy discs ensure precise matching with other components of the package structure, reducing gaps or contact resistance and improving shielding efficiency. They have excellent processing properties and can be made into complex shapes through powder metallurgy and precision machining processes to meet the shielding requirements of different electronic components. In practical applications, the shielding performance of tungsten alloy discs is verified through electromagnetic compatibility testing and shielding effectiveness analysis to ensure that they can effectively reduce the impact of electromagnetic interference.

tungsten alloy discs in electronic component shielding and packaging also reflects a focus on environmental protection and sustainability . Their non- toxicity ensures no contamination of chips or circuits when used in cleanroom environments, meeting the high standards of the electronics industry. Their recyclability reduces the environmental impact of production and disposal, minimizing resource waste. Tungsten alloy discs are often combined with other shielding materials (such as conductive polymers or metal coatings) to form composite shielding systems, further optimizing shielding effectiveness and package weight. Their use in electronic component shielding and packaging significantly improves device signal integrity and reliability, providing critical support for advancements in communications, automotive electronics, and industrial control systems, and driving progress in electronic packaging technology.

### 6.3 Application of Tungsten Alloy Discs in Aerospace

Tungsten alloy discs in the aerospace industry is primarily due to their high density, excellent mechanical strength, and high-temperature resistance, making them an ideal material for counterweights, structural components, and high-temperature environments. In spacecraft, tungsten alloy discs are widely used for attitude control, counterweight balancing, and structural support, ensuring stable operation and precise

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control in the complex space environment. Their high density allows them to provide sufficient weight within a small volume, which is ideal for compact spacecraft designs and optimizes weight distribution and space utilization. The mechanical strength and corrosion resistance of tungsten alloy discs enable them to maintain stable performance in extreme temperatures, vacuum, and radiation environments, avoiding deformation or performance degradation caused by long-term use. Their excellent processability allows them to be formed into high-precision round or custom shapes through powder metallurgy and precision machining processes, meeting the stringent dimensional accuracy and surface quality requirements of aerospace equipment. Furthermore, their non-toxicity and recyclability align with the aerospace industry's focus on environmental protection and sustainable development. The application of tungsten alloy discs in aerospace has promoted advancements in spacecraft design and operation technologies, providing critical support for space exploration and satellite communications.

In spacecraft attitude control, tungsten alloy discs are primarily used as counterweights and balancing components to ensure spacecraft stability during orbital operation, attitude adjustment, and trajectory changes. For example, in satellite attitude adjustment systems, tungsten alloy discs are used as counterweights to optimize weight distribution and maintain the satellite's dynamic balance. In spacecraft trajectory change mechanisms, tungsten alloy discs are used as balancing weights to ensure stability during high-precision trajectory changes. Their high density and mechanical stability enable them to withstand the high stresses and vibrations of the space environment, maintaining the operational reliability of the spacecraft.

### 6.3.1 Tungsten Alloy Discs for Spacecraft Attitude Control Weights

Tungsten alloy discs in spacecraft attitude control counterweights is an important manifestation of its role in the aerospace field. It is mainly used to optimize the weight distribution of spacecraft and ensure the stability of attitude adjustment and orbital operation. Spacecraft, such as satellites, probes and space stations, require precise attitude control to maintain the correct direction and trajectory to perform communication, observation or navigation missions. Tungsten alloy discs, due to their high density, can provide sufficient weight in a smaller volume, which is suitable for the strict requirements of spacecraft for space and weight optimization. Their mechanical strength and high temperature resistance enable them to maintain stable performance in the extreme conditions of the space environment, avoiding deformation or performance degradation caused by long-term use. Tungsten alloy discs have excellent processing performance and can be made into high-precision round or customized shapes through powder metallurgy and precision machining processes to meet the strict size and quality requirements of attitude control systems for counterweight components.

In spacecraft attitude control systems, tungsten alloy discs are typically processed into discs, thin sheets, or custom-shaped counterweights, which are installed in rotating components, flywheels, or balancing mechanisms of spacecraft to adjust the center of gravity and optimize dynamic balance. Their high density enables efficient counterweighting in a smaller volume, reducing the overall weight of the spacecraft and lowering launch costs. The surface finish and high dimensional accuracy of tungsten alloy discs ensure seamless integration with other components of the attitude control system, supporting high-

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precision motion and long-term operational reliability. Their corrosion resistance enables them to withstand the effects of trace gases or radiation that may exist in the space environment, ensuring the long-term stability of the counterweight components. In actual applications, the counterweight performance of tungsten alloy discs is verified through dynamic balance tests and vibration analysis to ensure that they can meet the high standards required for spacecraft attitude control.

Tungsten alloy discs in spacecraft attitude control counterweights also reflects a focus on environmental friendliness and sustainability . Their non- toxicity ensures no contamination to the environment or equipment during spacecraft manufacturing and operation, meeting the high standards of the aerospace industry. Their recyclability reduces the environmental impact of production and disposal, minimizing resource waste. Tungsten alloy discs are often combined with other lightweight materials ( such as aluminum or carbon fiber) to form composite counterweight systems, further optimizing weight distribution and spacecraft performance. Their use in attitude control significantly improves spacecraft operational stability and precision, providing critical support for the successful execution of space missions and driving advancements in aerospace technology.

#### 6.3.1.1 Counterweights for Satellite Attitude Adjustment

Tungsten alloy discs play a key role in the application of counterweights for satellite attitude adjustment , primarily used to optimize the satellite's weight distribution and ensure its dynamic balance and attitude control accuracy during orbital operation. Satellites in space require attitude control systems (such as reaction wheels, control moment gyroscopes, or thrusters) to adjust their orientation to achieve missions such as communications, Earth observation, or scientific experiments. Tungsten alloy discs, due to their high density, can provide sufficient weight in a small volume, making them suitable for satellites' needs for compact design and weight optimization. Their mechanical strength and high-temperature resistance enable them to maintain stable performance in the extreme conditions of the space environment, avoiding deformation caused by thermal stress or radiation damage. Tungsten alloy discs have excellent processing properties and can be manufactured into high-precision round or custom-shaped counterweights through powder metallurgy and precision grinding processes, meeting the stringent requirements of satellite attitude control systems for dimensional accuracy and mass distribution.

In satellite attitude adjustment systems, tungsten alloy discs are typically processed into thin discs, counterweights, or custom shapes and installed in the satellite's reaction wheel, flywheel, or structural frame to adjust the center of gravity and maintain dynamic balance. Their high density enables them to provide sufficient counterweighting within limited space, optimizing the satellite's weight distribution and reducing fuel consumption and launch costs. The tungsten alloy discs' smooth surface finish and high dimensional accuracy ensure seamless integration with other attitude control system components (such as bearings or motors), supporting high-precision rotation and stability for attitude adjustment. Their corrosion resistance enables them to withstand trace gases or high-energy particle radiation that may be present in the space environment, ensuring the long-term reliability of the counterweight. In practical applications, the counterweight performance of tungsten alloy discs is verified through ground vibration testing and orbital operation analysis to ensure they meet the high-precision requirements of satellite

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attitude adjustment.

Tungsten alloy discs in satellite attitude control also reflects a focus on environmental protection and sustainability . Their non- toxicity ensures no contamination of equipment or the space environment during satellite manufacturing and operation, meeting the high standards of the aerospace industry. Their recyclability reduces the environmental impact of production and disposal, minimizing resource waste. Tungsten alloy discs are often combined with lightweight materials (such as titanium alloys or composites) to form composite counterweight systems, further optimizing satellite weight distribution and performance.

#### 6.3.1.2 Balancing Weights for Spacecraft Orbit Change Mechanisms

Tungsten alloy discs play a vital role in the use of counterweights in spacecraft trajectory adjustment mechanisms. They are primarily used to optimize the mechanism's weight distribution and ensure the spacecraft's stability and precision during orbital adjustments and maneuvers. Spacecraft trajectory adjustment mechanisms, such as propulsion systems or robotic arms, are used to adjust the spacecraft's orbital position or attitude to perform tasks such as orbital transfer, docking, or attitude correction. These mechanisms must operate under high precision and high stress conditions, requiring counterweights to optimize weight distribution and reduce vibration and deviation. Tungsten alloy discs, due to their high density, can provide sufficient weight within a small volume, making them ideal for the compact design of spacecraft trajectory adjustment mechanisms. Their mechanical strength and high-temperature resistance enable them to maintain stable performance in the extreme conditions of the space environment, avoiding deformation caused by mechanical or thermal stress. Tungsten alloy discs have excellent processing properties and can be manufactured into high-precision counterweight discs through powder metallurgy and precision machining processes, meeting the stringent requirements for dimensional accuracy and mass distribution in trajectory adjustment mechanisms.

In spacecraft trajectory change mechanisms, tungsten alloy discs are typically processed into round counterweights, thin sheets, or custom shapes and installed at specific locations on thrusters, robotic arms, or rotating components to balance the mechanism's center of gravity and reduce vibration and deviation during operation. Their high density enables efficient counterweighting in a smaller volume, optimizing the mechanism's weight distribution and improving the spacecraft's maneuverability and fuel efficiency. The tungsten alloy discs' surface finish and high dimensional accuracy ensure precise matching with other components of the trajectory change mechanism, supporting high-precision motion and long-term operational reliability. Their corrosion resistance enables them to withstand the effects of trace gases or radiation that may be present in the space environment, ensuring the long-term stability of the counterweight components.

Tungsten alloy discs in spacecraft trajectory maneuvers also reflects a focus on environmental protection and sustainability . Their non- toxicity ensures no contamination of equipment or the space environment during spacecraft manufacturing and operation, meeting the high standards of the aerospace industry. Their recyclability reduces the environmental impact of production and disposal, minimizing resource

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waste. Tungsten alloy discs are often combined with lightweight materials (such as aluminum alloy or carbon fiber) to form composite counterweight systems, further optimizing the mechanism's weight distribution and performance. Their use in trajectory maneuvers significantly improves spacecraft maneuverability and control precision, providing critical support for the success of orbit adjustment, space docking, and deep space exploration missions, and driving advancements in aerospace technology.

### 6.3.2 High-temperature resistant tungsten alloy discs for engine components

Tungsten alloy discs in aerospace engine components is a key manifestation of its application in the aerospace field. They are primarily designed to withstand extreme heat and thermal stress, ensuring the structural stability and performance reliability of the engine during high-power operation. Aerospace engines, such as rocket engines and space shuttle propulsion systems, generate extremely high temperatures (up to thousands of degrees Celsius) and intense thermal shock during operation, requiring high-temperature-resistant materials to maintain the integrity of critical components. Tungsten alloy discs, due to their high melting point, high density, and excellent mechanical strength, can maintain stable performance in high-temperature, high-pressure, and corrosive environments, preventing failure due to thermal stress or material degradation. Their corrosion resistance enables them to withstand the chemical composition of the high-temperature combustion gases in the combustion chamber, extending component life. Tungsten alloy discs also offer excellent processability and can be formed into high-precision round or custom shapes through powder metallurgy and precision machining processes, meeting the stringent dimensional accuracy and surface quality requirements of engine components.

In aerospace engines, tungsten alloy wafers are usually processed into high-temperature resistant discs, liners or protective plates, which are installed in key areas of nozzles, combustion chambers or propulsion systems to withstand the direct impact and thermal radiation of high-temperature gases. Its high thermal conductivity enables it to quickly disperse heat, reduce local overheating, and protect surrounding components from thermal damage. The surface finish and high dimensional accuracy of tungsten alloy wafers ensure seamless integration with other components of the engine system, supporting high-precision assembly and long-term operational reliability. Its non-toxicity makes it suitable for use in the aerospace manufacturing process and will not cause pollution to equipment or the environment. In addition, the recyclability of tungsten alloy wafers reduces the environmental impact of production and waste disposal, meeting the aerospace industry's requirements for green manufacturing. The high-temperature resistant application of tungsten alloy wafers in engine components not only improves the operational reliability and safety of the system, but also promotes the advancement of aerospace propulsion technology, providing key support for deep space exploration and high-performance aviation.

#### 6.3.2.1 High-temperature resistant parts near rocket engine nozzles

Tungsten alloy discs play a key role in high-temperature resistant components near rocket engine nozzles. They are primarily designed to withstand the extreme thermal stresses of the high-temperature combustion chamber gases and the nozzle area, ensuring the engine's performance stability and structural integrity. Rocket engines are core components of spacecraft propulsion systems, burning propellant to

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generate high-temperature, high-pressure gases (temperatures reaching thousands of degrees Celsius) to propel spacecraft into orbit or perform deep-space missions. The area near the nozzle is directly exposed to high-temperature gases and intense thermal shock, requiring high-temperature resistant materials to maintain structural stability and functional reliability. Tungsten alloy discs, due to their high melting point and excellent heat resistance, can maintain mechanical strength and dimensional stability in extremely high-temperature environments, preventing failure due to thermal stress or material melting. Their corrosion resistance enables them to withstand erosion by oxidizing or corrosive gases in the combustion chamber, extending component life.

Among the high-temperature resistant components near rocket engine nozzles, tungsten alloy discs are typically processed into circular liners, protective plates, or heat-resistant layers on the inner wall of the nozzle. These discs are installed in the nozzle throat or exit area to protect the nozzle structure from direct impact from high-temperature gases and thermal radiation. Their high thermal conductivity enables them to quickly disperse heat in the nozzle area, reducing local temperature gradients and minimizing the risk of cracks or deformation caused by thermal stress. The tungsten alloy discs' surface finish and high dimensional accuracy ensure a precise fit with the nozzle structure, supporting efficient airflow guidance and thrust output. Their mechanical strength enables them to withstand the high pressure and vibrations experienced during nozzle operation, ensuring long-term operational reliability.

Tungsten alloy discs in rocket engine nozzles also reflects a focus on environmental protection and sustainability . Their non- toxicity ensures no contamination to equipment or the environment during manufacturing and operation, meeting the high standards of the aerospace industry. Their recyclability reduces the environmental impact of production and disposal, minimizing resource waste. Tungsten alloy discs are often combined with other high-temperature resistant materials (such as ceramics or molybdenum alloys) to form composite heat-resistant systems, further optimizing the nozzle's heat resistance and weight distribution.

#### 6.3.2.2 Heat-resistant discs for space shuttle propulsion systems

Tungsten alloy discs play a vital role in the application of heat-resistant discs in space shuttle propulsion systems, primarily used to protect critical components from high-temperature gases and thermal shock, ensuring the propulsion system's performance stability and safety during high-power operation. The space shuttle propulsion system generates high-temperature, high-pressure gases by burning propellant, propelling the shuttle into orbit or performing orbital adjustments. These systems generate extremely high temperatures and intense thermal shock during operation, requiring high-temperature-resistant materials to maintain the structural integrity and functional reliability of critical components. Tungsten alloy discs, due to their high melting point and excellent heat resistance, can maintain mechanical strength and dimensional stability in high-temperature environments, preventing failure due to thermal stress or material degradation. Their corrosion resistance enables them to withstand the corrosive gases or oxidizing environments found in propulsion systems, extending component life.

In space shuttle propulsion systems, tungsten alloy discs are typically processed into heat-resistant discs,

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protective plates, or liners, installed in critical areas of combustion chambers, nozzles, or heat exchangers to withstand the direct impact and thermal radiation of high-temperature gases. Their high thermal conductivity enables them to quickly dissipate heat, reducing the risk of localized overheating and protecting surrounding components from thermal damage. The tungsten alloy discs' smooth surface finish and high dimensional accuracy ( $\leq 0.01$  mm) ensure precise matching with other propulsion system components, supporting efficient airflow guidance and thrust output. Their mechanical strength enables them to withstand the high pressures, vibrations, and thermal shocks of propulsion system operation, ensuring long-term operational reliability.

Tungsten alloy discs in space shuttle propulsion systems also reflects a focus on environmental protection and sustainability . Their non- toxicity ensures no contamination to equipment or the environment during manufacturing and operation, meeting the high standards of the aerospace industry. Their recyclability reduces the environmental impact of production and disposal, minimizing resource waste. Tungsten alloy discs are often combined with other high-temperature resistant materials to form composite heat-resistant systems, further optimizing the propulsion system's thermal performance and weight distribution.



CTIA GROUP LTD Tungsten Alloy Wafer

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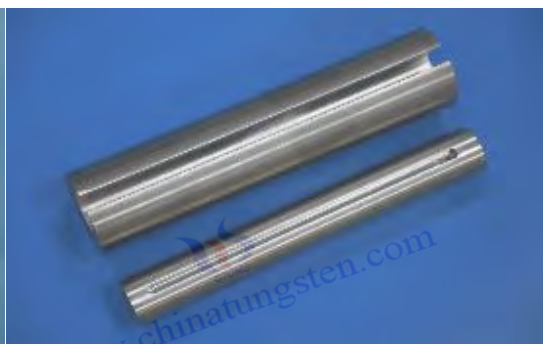
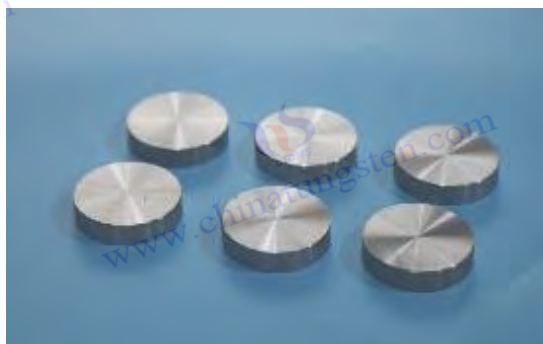
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## Chapter 7 Storage, Transportation and Standards of Tungsten Alloy Discs

Tungsten alloy discs have a wide range of applications in aerospace, medical, electronics, and industrial fields due to their high density, excellent mechanical properties, and high-temperature resistance. The storage and transportation links during the production and application process directly affect the quality and performance stability of the discs. To ensure that tungsten alloy discs are not affected by environmental factors or physical damage during storage and transportation, strict standards and specifications must be established, including storage environment conditions, packaging methods, and transportation requirements. These measures not only protect the physical and chemical properties of the discs, but also extend their service life and reduce material waste caused by improper storage or transportation. The environmental friendliness and recyclability of tungsten alloy discs require attention to resource utilization efficiency and environmental impact control during storage and transportation to meet the requirements of modern industry for sustainable development.

### 7.1 Storage Requirements for Tungsten Alloy Discs

Tungsten alloy wafers are an important link to ensure their stable performance and undamaged quality, which is directly related to their reliability in subsequent processing or applications. The high density and high hardness of tungsten alloy wafers make them more sensitive to environmental conditions, especially in humid, corrosive or high-temperature environments, prone to oxidation, surface contamination or physical damage. Therefore, during the storage process, it is necessary to strictly control environmental parameters and adopt scientific packaging and stacking methods to protect the surface quality and performance stability of the wafers. Storage requirements involve not only the control of environmental conditions, but also reasonable packaging design and stacking specifications to prevent the wafers from deformation, scratches or chemical changes during long-term storage.

#### 7.1.1 Storage environment conditions (temperature, humidity, etc.)

The storage environment of tungsten alloy wafers is a key factor in ensuring the stability of their physical and chemical properties. This involves strict control of parameters such as temperature, humidity, gas environment, and cleanliness. Although tungsten alloy wafers have excellent corrosion resistance, long-term exposure to high humidity or corrosive gas environments may cause surface oxidation or contamination, affecting their electrical and thermal conductivity and surface quality. Proper storage conditions can effectively extend the shelf life of the wafers and maintain their high performance in applications such as aerospace, medical, and electronics.

Controlled storage conditions are designed to prevent tungsten alloy discs from experiencing performance degradation due to environmental factors such as high temperature, high humidity, or corrosive gases. Appropriate temperature and humidity can reduce surface oxidation and chemical reactions, while a clean storage environment prevents dust or particle contamination, ensuring the disc's surface finish and performance stability. Tungsten alloy discs are typically stored in a controlled indoor environment, using an inert gas blanket or desiccant to further minimize environmental impact.

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### 7.1.2 Packaging and stacking specifications

Tungsten alloy discs are crucial for their storage. They aim to prevent physical damage, surface scratches, or deformation during storage and transportation, ensuring their performance and appearance are not affected. The high density and hardness of tungsten alloy discs make them sensitive to mechanical impact and friction, requiring scientific packaging design and stacking methods to protect their surface quality and dimensional accuracy.

Packaging and stacking specifications: Protect tungsten alloy discs from mechanical shock, vibration, and friction through the use of cushioning materials, separators, and sturdy packaging containers. Proper stacking design prevents disc deformation and surface damage caused by improper stacking while optimizing storage space utilization. Packaging materials must be moisture-proof, dust-proof, and antistatic to further protect the disc's performance stability.

Scientific packaging and stacking specifications can effectively preserve the surface quality and performance of tungsten alloy wafers, making them suitable for high-precision and long-term storage. However, customized packaging materials and separate trays increase production costs, and limited stacking heights can reduce storage space utilization. Furthermore, improper packaging can damage the wafers, necessitating strict adherence to these specifications.

To improve packaging efficiency, automated packaging equipment can be used to reduce manual errors; reusable packaging trays can be designed to reduce costs and environmental impact; and optimized stacking layouts, combined with lightweight, high-strength materials, can improve space utilization. Packaging methods and stacking specifications provide key guarantees for the safe storage of tungsten alloy wafers, promoting their reliable application in aerospace, medical, and electronics fields.

## 7.2 Transportation Requirements for Tungsten Alloy Discs

Tungsten alloy wafers are crucial for ensuring their quality and performance are maintained from production to use. Due to their high density, hardness, and sensitivity to surface quality, scientific transportation methods and protective measures are essential to prevent scratches, deformation, or contamination caused by vibration, collision, or environmental factors. Transportation requirements not only involve selecting the appropriate transportation method but also include the development of protective measures and safety regulations to ensure the safety and reliability of the wafers during transportation.

### 7.2.1 Transportation method selection

Choosing the right transportation method is crucial to ensuring that tungsten alloy wafers arrive safely and intact at their destination. The high density and high value of tungsten alloy wafers make them sensitive to vibration, shock, and environmental changes during transportation. Therefore, the appropriate transportation method must be selected based on the transportation distance, environmental

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conditions, and application requirements, ensuring a balance between efficiency and safety.

The choice of transportation method is based on the wafer's physical properties and application requirements. The goal is to optimize transportation tools and routes to minimize vibration, shock, and environmental impact, ensuring stable wafer performance. Common transportation methods include road, rail, air, and sea transport. Each method requires a trade-off based on transportation distance, time requirements, and environmental conditions to ensure wafer safety and transportation efficiency.

To improve transportation efficiency, multimodal transport can be adopted, combining the advantages of road, rail, and air transportation; using a logistics tracking system to monitor transportation status in real time; and collaborating with professional logistics companies to customize transportation plans. Scientific optimization of transportation mode selection provides reliable guarantees for the safe transportation of tungsten alloy wafers, especially under the strict requirements of the aerospace and medical fields.

### 7.2.2 Protective measures during transportation

Protective measures during transportation are crucial to ensure that tungsten alloy wafers are not physically damaged or affected by the environment during transportation. Due to the high density and hardness of the wafers, their surfaces are easily scratched by collisions or friction. Scientific packaging and protective measures are necessary to reduce these risks.

Protective measures during transportation include the use of high-strength packaging materials, shock absorbers, and environmental control measures to protect tungsten alloy wafers from vibration, shock, moisture, and temperature fluctuations. These protective measures should be combined with the transportation method and environmental conditions to optimize packaging design and loading methods to ensure the wafer's surface quality and performance stability.

### 7.2.3 Transport safety regulations and labels

Transportation safety regulations and labeling are crucial for ensuring the safety and traceability of tungsten alloy wafers during transportation. Clear regulations and labeling reduce transportation risks and ensure compliance and quality control. The high value and high precision of tungsten alloy wafers require strict safety standards during transportation to prevent loss or damage.

compliance during transportation through established operating procedures and standardized packaging labeling. These regulations cover loading and unloading operations, transportation condition controls, and emergency response measures. Labeling provides information on wafer properties, protective requirements, and safety warnings, facilitating proper handling by both transporters and recipients.

To improve safety and efficiency, electronic tags (such as RFID) can be used to achieve real-time tracking during transportation; unified international transportation regulations can be developed to simplify

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labeling requirements; and transportation personnel training can be strengthened to ensure compliance with regulations. Transportation safety regulations and labeling provide systematic guarantees for the safe transportation of tungsten alloy wafers, promoting their reliable application in aerospace, medical, and electronics fields.

### 7.3 China Tungsten Alloy Disc Standard

As the world's largest producer and consumer of tungsten resources, China has developed a series of national (GB/T) and industry standards for tungsten alloy wafers to regulate their production, quality control, and application. These standards, primarily issued by the Standardization Administration of China (SAC) and relevant industry associations, ensure the performance consistency and safety of tungsten alloy wafers in fields such as aerospace, electronics, and medical.

#### Standard Overview :

China's tungsten alloy wafer standards mainly cover material composition, mechanical properties, dimensional accuracy, surface quality and testing methods, and are applicable to the production and application of tungsten-based alloy wafers (such as tungsten-nickel-iron, tungsten-copper alloy, etc.). Common standards include:

- **GB/T 3875-2017 Tungsten and Tungsten Alloy Plates** : Although primarily aimed at plates, its regulations are applicable to raw materials for wafer processing. It specifies the chemical composition (e.g., tungsten content  $\geq 90\%$ ), density ( $17-18.5 \text{ g/cm}^3$ ), hardness (HB  $\geq 250$ ), and surface quality requirements ( $Ra \leq 0.8 \mu\text{m}$ ) of tungsten alloys.
- **GB/T 3459-2006 General Technical Specifications for Tungsten and Tungsten Alloy Products** : Specifies the manufacturing process, dimensional tolerance ( $\pm 0.01 \text{ mm}$ ), surface treatment and quality inspection methods for tungsten alloy products. It is applicable to the cutting, grinding and surface treatment of wafers.
- **YS/T 659-2007 Tungsten and Tungsten Alloy Processing Materials** : This standard specifies the test methods for the dimensional accuracy, surface finish, and mechanical properties of tungsten alloy processed products. It is suitable for electronic and aerospace applications.

#### Key requirements :

- **Chemical composition** : Tungsten content is usually between 90% and 97%, supplemented by elements such as nickel, copper or iron to ensure high density and mechanical strength.
- **Dimensional accuracy** : wafer diameter tolerance  $\leq \pm 0.01 \text{ mm}$ , thickness tolerance  $\leq \pm 0.005 \text{ mm}$ , meeting high-precision application requirements.
- **Surface quality** : surface roughness  $Ra \leq 0.4 \mu\text{m}$ , no cracks or oxidation marks, ensuring electrical and thermal conductivity.
- **Test Method** : X-ray fluorescence spectroscopy (XRF) is used to analyze composition, a durometer is used to test hardness, and a profilometer is used to test surface roughness to meet the quality requirements of the aerospace and electronics industries.

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- **Environmental protection requirements** : The standard requires that the production process reduce waste emissions, encourage the use of recyclable materials, and comply with environmental regulations.

#### 7.4 International Tungsten Alloy Disc Standards

International tungsten alloy disc standards, primarily developed by organizations such as the International Organization for Standardization (ISO) and the Society for Testing and Materials (ASTM), aim to provide unified technical specifications for the production, testing, and application of tungsten alloy discs worldwide. These standards are widely used in aerospace, electronics, and medical fields, ensuring the consistency and reliability of tungsten alloy discs throughout the global supply chain.

##### Standard Overview :

International standards mainly cover the material properties, processing requirements and quality inspection methods of tungsten alloy wafers, and are applicable to the production and application of tungsten-based alloys (such as tungsten-nickel-iron and tungsten-copper alloys ). Commonly used standards include:

- **ASTM B777-15 High-Density Tungsten-Based Alloy** : This standard specifies the chemical composition (e.g., tungsten content 90%-97%), density ( $16.5-19 \text{ g/cm}^3$ ), mechanical properties (tensile strength  $\geq 600 \text{ MPa}$ ), and processing requirements for tungsten alloy discs suitable for aerospace and electronics applications.
- **ISO 28319:2010 Tungsten and tungsten alloy products** : Specifies the manufacturing process, dimensional tolerance ( $\pm 0.01 \text{ mm}$ ) and surface quality ( $Ra \leq 0.4 \mu\text{m}$ ) of tungsten alloy products. It is suitable for cutting, grinding and surface treatment of wafers.
- **ASTM E696-07 Test Methods for Tungsten and Tungsten Alloys** : Provides chemical composition analysis, hardness testing, and microstructural examination of tungsten alloy discs to ensure consistent performance.

##### Key requirements :

- **Chemical composition** : 90%-97% tungsten , supplemented by elements such as nickel, copper or iron to ensure high density and corrosion resistance.
- **Dimensional accuracy** : diameter and thickness tolerance  $\leq \pm 0.01 \text{ mm}$ , parallelism  $\leq 0.005 \text{ mm}$ , meeting high-precision application requirements.
- **Surface quality** : surface roughness  $Ra \leq 0.4 \mu\text{m}$  , no scratches, cracks or oxides, ensuring conductivity and wear resistance.
- **Test method** : Use spectrum analyzer to detect composition, Brinell hardness tester to test hardness, and three-coordinate measuring machine to verify dimensional accuracy to ensure compliance with aerospace and electronics industry requirements.
- **Environmental protection and safety** : The standard requires that the production process reduce the emission of harmful substances, and the packaging must comply with international transportation regulations (such as IATA) to ensure safety and recyclability .

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## 7.5 Tungsten Alloy Disc Standards in Europe, America, Japan, South Korea, etc.

Countries like Europe, the US, Japan, and South Korea have developed their own standards for tungsten alloy wafers, regulating their production and application based on their respective industrial needs and environmental regulations. These standards are similar in terms of material properties, processing technology, and quality testing, but differ depending on the application areas and regulatory requirements.

### Standard Overview :

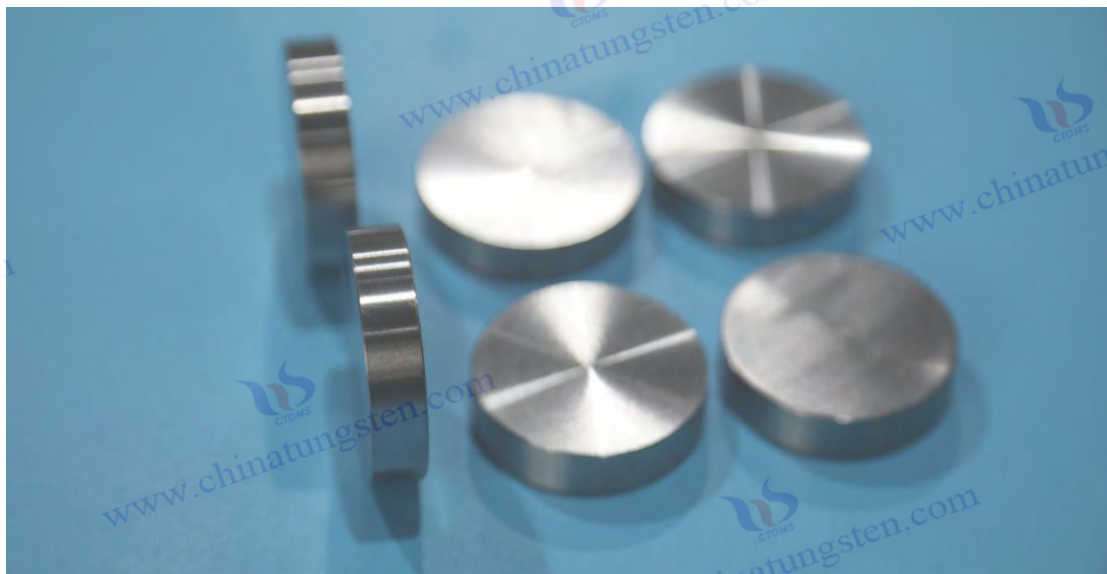
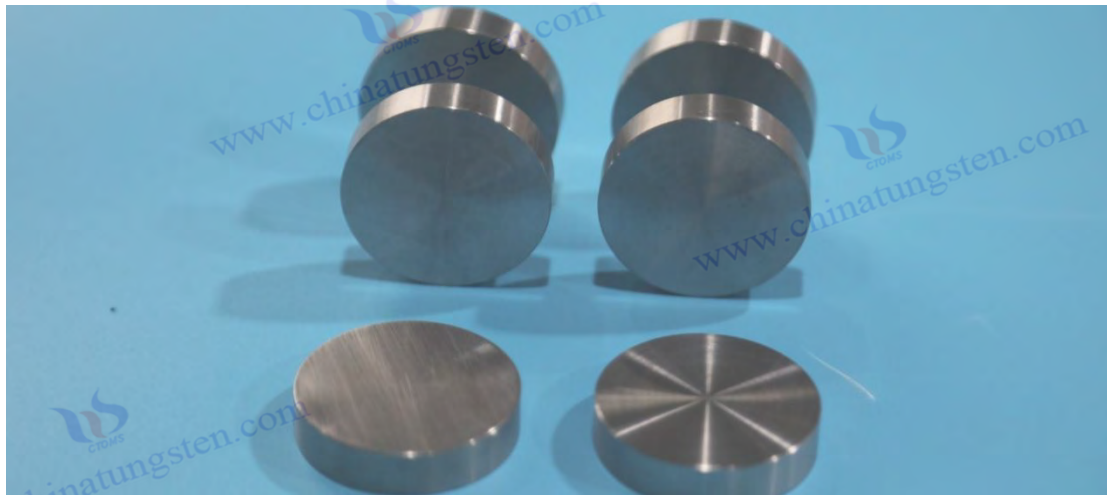
- **U.S :**
  - **ASTM B777-15 High-Density Tungsten-Based Alloy** : Applicable to tungsten - nickel-iron and tungsten-copper alloy wafers. Specified chemical composition (90%-97% tungsten), density (17-18.5 g/cm<sup>3</sup>), tensile strength ( $\geq 600$  MPa), and surface quality ( $Ra \leq 0.4 \mu m$  ). Widely used in aerospace counterweights and electronic cooling components.
  - **MIL-T-21014D tungsten alloy military standard** : Targeted at military applications, it specifies higher precision dimensional tolerances ( $\pm 0.005$  mm) and radiation resistance, making it suitable for nuclear reactor shielding and military counterweights.
- **Europe :**
  - **EN ISO 28319:2010 Tungsten and tungsten alloy products** : Specifies the composition, mechanical properties and processing requirements of tungsten alloy discs. It is suitable for the electronics and aerospace fields, emphasizing environmental protection and recyclability .
  - **EN 10204:2004 Metal Product Inspection Documents** : Requires a Material Test Report (MTR) for tungsten alloy discs, including composition, hardness, and dimensional test results, to ensure quality traceability.
- **Japan :**
  - **JIS H 4463:2006 Tungsten and tungsten alloy products** : Specifies the chemical composition (tungsten  $\geq 90\%$ ), density (17-19 g/cm<sup>3</sup>) and surface quality ( $Ra \leq 0.3 \mu m$  ) of tungsten alloy discs suitable for semiconductor and precision machinery applications.
  - **JIS Z 8801:2011 Tungsten Alloy Test Methods** : Provides composition analysis, hardness testing, and microstructure testing methods to ensure consistent wafer performance.
- **South Korea :**
  - **KS D 9501:2018 Tungsten and Tungsten Alloys** : Specifies the chemical composition, mechanical properties and processing requirements of tungsten alloy wafers, suitable for electronic and communication equipment, emphasizing high thermal conductivity and surface finish ( $Ra \leq 0.4 \mu m$  ).
  - **KS D 9502:2018 Tungsten Alloy Test Methods** : Provides composition testing, dimensional accuracy, and surface quality testing specifications to ensure compliance with high-precision application requirements.

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**Key requirements :**

- **Chemical composition** : All national standards require a tungsten content of  $\geq 90\%$ , supplemented by nickel, copper or iron. Some standards (such as MIL-T-21014D) require stricter impurity control.
- **Dimensional accuracy** : The tolerance range is usually  $\pm 0.005$  mm to  $\pm 0.01$  mm, and European and Japanese standards have higher requirements for surface finish ( $Ra \leq 0.3 \mu\text{m}$ ).
- **Testing method** : Use XRF, hardness tester and three-coordinate measuring machine and other equipment to ensure that the composition, mechanical properties and dimensional accuracy meet the standards.
- **Environmental protection and safety** : European and American standards emphasize environmentally friendly production and recyclability , while Japanese and Korean standards focus on clean room compatibility, and packaging must comply with international transportation regulations.



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## appendix

### Tungsten Alloy Disc Terminology

category	the term	definition	Application Background
Material properties	Tungsten Alloy	A composite material made mainly of tungsten (W) (90%-97%) with added elements such as nickel, iron, copper or silver through powder metallurgy. It has high density, high strength and high temperature resistance.	Aerospace counterweights, medical radiation shielding, electronic thermal conductive components.
	density	Mass per unit volume, typically 17-18.5 g/cm <sup>3</sup> .	Counterweight and shielding applications, such as satellite counterweights and radiotherapy equipment.
	hardness	The ability to resist deformation or scratches caused by external forces, typically $\geq 300$ HV.	Wear and impact resistance scenarios for electronic packaging and mechanical components.
	Thermal conductivity	The heat conduction capacity of tungsten copper alloy is about 150-200 W/ m·K .	Thermal management in chip manufacturing and electronic packaging.
	Electrical conductivity	The ability to conduct current of tungsten copper alloy is about 30%-50% IACS.	High-frequency device electrodes and electronic connectors.
Production process	Powder Metallurgy	Tungsten powder is mixed with other metal powders, pressed and sintered to produce discs.	Forming process of tungsten alloy discs.
	Liquid Phase Sintering	The low melting point metal melts, promoting the bonding of tungsten particles and increasing density and strength.	The wafers are sintered to ensure that the density is $\geq 95\%$ of the theoretical density.
	Cutting and Grinding	Excess material is removed by turning, milling and grinding to achieve target dimensions and surface quality.	Wafer precision machining, dimensional error $\leq 0.01$ mm, Ra $\leq 0.4$ $\mu$ m .
	Surface treatment	Improve surface finish, corrosion resistance and functionality through polishing, electroless plating or PVD.	Improve electrical conductivity and wear resistance, such as electronic heat dissipation discs.
	Isostatic pressing	The powder is pressed into billets using high and uniform pressure to ensure uniform density.	The disc is pressed to reduce internal porosity.
Quality Control	Dimensional accuracy	The dimensions must conform to the design specifications with a tolerance of $\leq \pm 0.01$ mm.	Inspect diameter, thickness, and parallelism to meet aerospace and electronics requirements.
	surface roughness	Surface micro-roughness, Ra $\leq 0.4$ $\mu$ m .	Profilometer inspection ensures smooth surface.
	Nondestructive Testing	Non-destructive inspection of wafers for internal defects, such as X-ray inspection or	Check for internal porosity, cracks or segregation.

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		ultrasonic inspection.	
	Chemical composition analysis	The elemental composition was determined by XRF or ICP-MS.	Ensure tungsten content $\geq 90\%$ and control impurities.
	Quality traceability	Record production, processing and testing data to ensure quality traceability.	Quality control in the aerospace and medical fields.
Storage and transportation	Constant temperature and humidity	Maintain the temperature between 15-25°C and the humidity $\leq 40\%$ to prevent oxidation or contamination.	Wafer storage to ensure surface quality and performance.
	Antistatic packaging	Use antistatic materials to prevent static electricity accumulation.	Transportation and storage in the electronics and semiconductor sectors .
	shock absorber	Use cushioning material or shock-absorbing trays to reduce vibration and shock.	Protect high-density wafers from scratches or deformation.
	Moisture-proof seal	Use moisture-proof sealing strips or desiccant to prevent moisture from penetrating.	Long distance transportation or sea transportation to protect surface quality.
	Transport Label	Marks product information, moisture-proof, shock-proof and operating requirements.	Guide transport personnel to comply with international transport regulations.
Standards and Applications	ASTM B777	An American standard that specifies the composition, density, and mechanical properties of high-density tungsten-based alloys .	Aerospace counterweights, medical radiation shielding.
	GB/T 3875	Chinese standard specifies the composition, density and surface quality of tungsten alloy plates.	Domestic aerospace and electronics wafer production.
	Radiation shielding	Use high density and high atomic number to block gamma rays or X-rays.	Medical radiotherapy equipment and nuclear medicine equipment.
	counterweight	Utilizes high density to optimize weight distribution and maintain dynamic balance.	Aerospace (satellite attitude control), medical imaging (CT machine).
	Cleanroom compatibility	Non-toxic and low volatility, suitable for clean room use.	Semiconductor manufacturing, medical equipment production.

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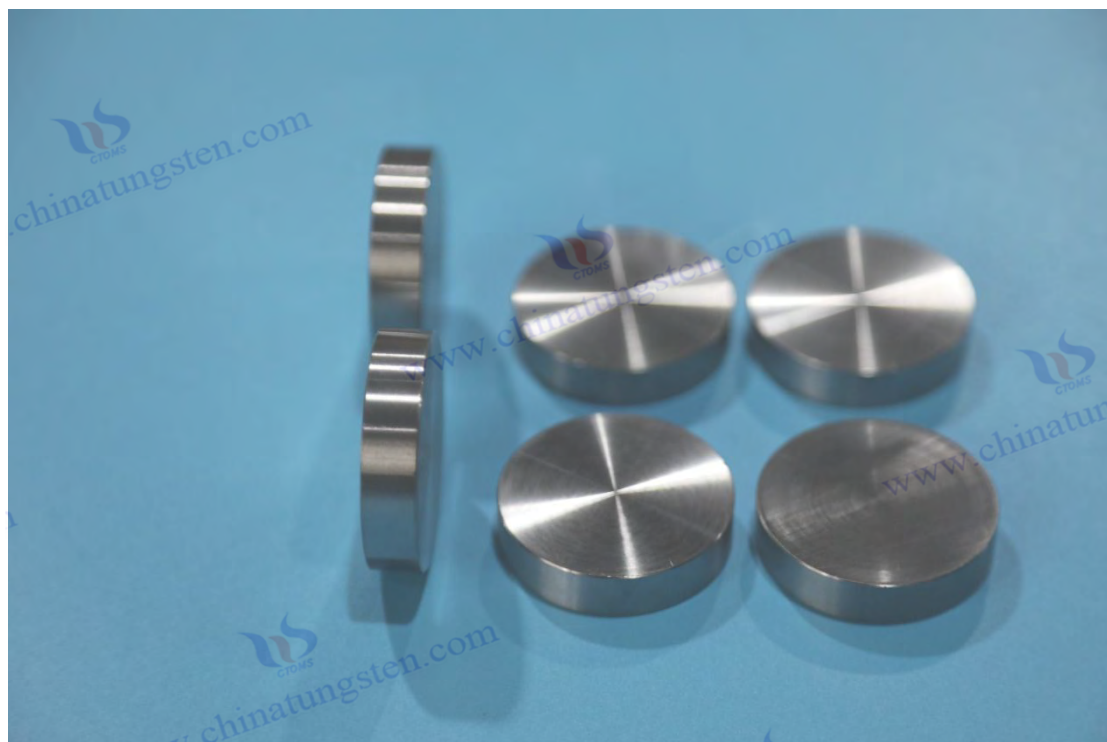
## References

### Chinese references

- [1] GB/T 3875-2017, Tungsten and tungsten alloy plates, Standardization Administration of the People's Republic of China, 2017.
- [2] GB/T 3459-2006, General technical requirements for tungsten and tungsten alloy products, Standardization Administration of the People's Republic of China, 2006.
- [3] YS/T 659-2007, Tungsten and tungsten alloy processed materials, China Nonferrous Metals Industry Association, 2007.

### English references

- [1] ASTM B777-15, Standard Specification for Tungsten Base, High-Density Metal, American Society for Testing and Materials, 2015.
- [2] ISO 28319:2010, Dentistry — Laser welding and filler materials, International Organization for Standardization, 2010.
- [3] ASTM E696-07, Standard Specification for Tungsten-Rhenium Alloy Thermocouple Wire, American Society for Testing and Materials, 2007.
- [4] JIS H 4463:2006, Tungsten and Tungsten Alloy Products, Japanese Industrial Standards, 2006.
- [5] KS D 9501:2018, Tungsten and Tungsten Alloys, Korean Industrial Standards, 2018.
- [6] KS D 9502:2018, Test Methods for Tungsten and Tungsten Alloys, Korean Industrial Standards, 2018.
- [7] EN 10204:2004, Metallic Products — Types of Inspection Documents, European Committee for Standardization, 2004.



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