Encyclopedia of Tungsten Copper Rod

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

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 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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Tungsten Copper Rod Introduction

1. Overview of Tungsten Copper Rod

Tungsten copper rod is composite materials produced by infiltrating high-purity tungsten powder with copper through a vacuum infiltration process. It possesses a unique microstructure that combines the high strength and high melting point of tungsten with the excellent electrical and thermal conductivity of copper. This results in a high-performance material with outstanding thermal stability, wear resistance, and electrical conductivity.

2. Characteristics of Tungsten Copper Rod

High Thermal Conductivity: The excellent thermal conductivity of copper ensures rapid heat dissipation, making it suitable for high-power devices and laser systems.

High Strength and High-Temperature Resistance: The stable mechanical properties of tungsten allow the material to remain reliable under extreme high-temperature conditions.

Resistance to Arc Erosion: The tungsten-copper composite structure provides exceptional resistance to arc erosion in electrical applications, significantly extending electrode service life.

Low Thermal Expansion Coefficient: Effectively reduces thermal stress and improves structural stability.

Excellent Machinability: Can be precisely fabricated into electrodes, heat sinks, or complex parts to meet diversified application requirements.

3. Performance Parameters of Tungsten Copper Rod

Product Name	Chemical Composition (%)		Physical and Mechanical Properties			
	Impurities ≤	W	Density (g/cm³)	Hardness (HB)	Resistivity (mΩ·cm)	Tensile Strength (MPa)
W50Cu	0.5	Balance	11.85	115	3.2	—
W60Cu	0.5	Balance	12.75	140	3.7	—
W70Cu	0.5	Balance	13.8	175	4.1	790
W80Cu	0.5	Balance	15.15	220	5	980
W90Cu	0.5	Balance	16.75	260	6.5	1160

4. Advantages of Tungsten Copper Rod

High-Performance Combination: A balanced integration of strength, electrical conductivity, thermal conductivity, and high-temperature resistance.

Customized Solutions: Tungsten-to-copper ratio and dimensions can be tailored to meet specific customer requirements.

Long Service Life and Stability: Significantly reduces maintenance and replacement costs.

5. Procurement Information

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Directory

Chapter 1 Overview of Tungsten Copper Rod

1.1 Definition and Basic Concepts of Tungsten Copper Rod

Tungsten copper rod is a metal-based composite material composed of tungsten (W) and copper (Cu), typically with tungsten as the matrix and copper as the secondary component, produced through a specific process. The copper content of tungsten copper rod is typically between 10% and 50%, with the specific ratio determined by the application requirements. This material combines the high melting point, high hardness, high density, and wear resistance of tungsten with the excellent electrical and thermal conductivity of copper, resulting in unique physical and chemical properties. Due to the significant difference in the melting points of tungsten and copper (tungsten melting point is approximately 3410°C, and copper melting point is approximately 1083°C) and the immiscibility of the two, tungsten copper rod cannot be produced through traditional casting methods. Instead, powder metallurgy technology is typically used, including mixing, pressing, sintering, and copper infiltration.

The basic properties of tungsten copper rod include:

High electrical and thermal conductivity: The high electrical and thermal conductivity of copper gives tungsten copper rods excellent electrical and thermal conductivity, making them widely used in electrical and electronic fields.

High temperature resistance: The high melting point and high temperature strength of tungsten enable tungsten copper rods to maintain structural stability in extremely high temperature environments. Especially above 3000℃, copper will liquefy and evaporate, absorbing a large amount of heat and lowering the surface temperature of the material. Therefore, tungsten copper rods are also called "metal sweating materials."

Low thermal expansion coefficient: The low thermal expansion property of tungsten makes tungsten copper rod have good dimensional stability in high temperature environment.

High hardness and wear resistance: The high hardness and wear resistance of tungsten give tungsten copper rods excellent mechanical properties, making them suitable for manufacturing wear-resistant parts and molds.

Good arc breaking performance: Tungsten copper rod performs well in high voltage arc environment and is suitable for use as electrical contact material and electrode.

Typical manufacturing processes for tungsten copper rods include powder metallurgy, hot isostatic pressing, and infiltration. Powder metallurgy involves mixing high-purity tungsten powder and high-purity copper powder in a specific ratio, followed by isostatic pressing, high-temperature sintering, and copper infiltration. This method ensures uniformity in the material's internal structure while optimizing its electrical, thermal, and mechanical properties.

1.2 Development History and Technological Evolution of Tungsten-Copper Composite Materials

The development of tungsten copper composite materials began in the early 20th century. As industry's demand for high-performance materials increased, tungsten copper alloys gradually attracted attention. The following are the main stages of its development history and technological evolution:

1.2.1 Early Exploration (Early 20th Century to 1950s)

The development of tungsten-copper composites stems from the need for high-performance electrical contact materials. In the early 20th century, the rapid development of the electrical and electronics industries placed higher demands on materials with high conductivity and high-temperature resistance. Since a single metal could not simultaneously meet these requirements, scientists began exploring tungsten-copper composites. Early tungsten-copper materials were primarily produced by mechanically mixing tungsten and copper powders, followed by pressing and sintering. However, due to process limitations, the material's uniformity and performance stability were poor.

1.2.2 Maturity of Powder Metallurgy Technology (1950s to 1980s)

In the mid-20th century, advances in powder metallurgy technology provided technical support for the development of tungsten-copper composites. Researchers optimized the mixing ratio of tungsten and copper powders, particle size, and sintering process, significantly improving the material's electrical conductivity and mechanical properties. The introduction of copper infiltration further improved the density and uniformity of tungsten-copper composites. During this period, tungsten-copper materials began to be used in electrical contacts, resistance welding electrodes, and aerospace components.

1.2.3 Introduction of new technologies (1980s to 2000s)

With the advancement of materials science, new preparation processes such as hot isostatic pressing, plasma sintering, and laser sintering have been introduced into the manufacture of tungsten-copper composites. These technologies have significantly improved the density and performance consistency of the materials. For example, hot isostatic pressing, by pressing tungsten-copper powder under high temperature and pressure, can produce high-density tungsten-copper rods suitable for high-precision electronic packaging and aerospace applications. Furthermore, the application of nanotechnology has further reduced the particle size of tungsten and copper powders, improving the material's microstructure and properties.

1.2.4 Modern Technology and Diversified Applications (2000s to Present)

Since the 21st century, the research and application of tungsten-copper composites has entered a new phase. With the rise of advanced manufacturing technologies (such as additive manufacturing and micro-nanofabrication), the performance of tungsten-copper rods has been further optimized, and their application areas have become more extensive. For example, the introduction of 3D printing technology has enabled the production of complex-shaped components from tungsten-copper composites to meet the specialized needs of the aerospace and nuclear industries. Furthermore, researchers have developed alloy systems with varying tungsten-copper ratios for different application scenarios. For example, high tungsten content (70%-90%) is used for applications requiring high hardness and wear resistance, while low tungsten content (50%-70%) is used for applications requiring higher electrical conductivity.

1.2.5 Future Development Trends

In the future, the development of tungsten copper composite materials will focus on the following aspects:

Green manufacturing: Develop low-energy, low-pollution preparation processes, such as cold spray technology and green powder metallurgy technology.
Performance optimization: By doping with rare earth elements or other trace elements, the mechanical properties and electrothermal properties of tungsten copper materials can be further improved.
Intelligent application: Combined with intelligent manufacturing technology, we develop tungsten-copper composite materials with adaptive properties to meet the needs of next-generation electronic devices and energy equipment.

1.3 The status and role of tungsten copper rod in the material system

In the modern material system, tungsten copper rod, as a high-performance composite material, occupies an important position. Its unique combination of properties makes it indispensable in many high-tech fields. Its main functions include:

1.3.1 Electrical and Electronics Field

Tungsten copper rods, due to their excellent electrical conductivity and wear resistance, are widely used in the manufacture of electrical contact materials, resistance welding electrodes, and electronic packaging materials. For example, in high-voltage switchgear, tungsten copper rods serve as electrical contacts, capable of withstanding high voltages and arc shocks, ensuring the stability and durability of the equipment. In the field of electronic packaging, tungsten copper rods' low thermal expansion coefficient and high thermal conductivity make them an ideal material for heat dissipation substrates in semiconductor devices.

1.3.2 Aerospace and Defense Industry

The high-temperature strength and wear resistance of tungsten copper rods make them important applications in the aerospace industry. For example, in aircraft engines and spacecraft, tungsten copper rods are used to manufacture high-temperature thermal conductive components and wear-resistant parts, capable of maintaining stable performance in extreme environments. Furthermore, the high density of tungsten copper rods makes them suitable for the manufacture of armor-piercing projectile cores and counterweight components in the defense industry.

1.3.3 Machining and mold manufacturing

The wear resistance and thermal conductivity of tungsten copper rod make it an ideal material for manufacturing cutting tools, stamping dies and die casting molds. For example, in aluminum alloy die casting molds, tungsten copper rod is used as core rod and nozzle, which can significantly extend the service life of the mold and improve product quality.

1.3.4 Nuclear Industry and Energy

In nuclear fusion reactors, tungsten copper rods are used as divertor heat sinks, capable of withstanding the heat loads and particle bombardment in high-temperature, high-pressure environments. Furthermore, tungsten copper rods are used in the manufacture of heat pipes and heat dissipation components, improving the efficiency and lifespan of nuclear power equipment and high-temperature industrial furnaces.

1.3.5 Other areas

Tungsten copper rods are also widely used in friction materials (such as brake pads), chemical equipment (such as corrosion-resistant heat-conducting components) and medical equipment (such as radiation shielding components). Its versatility and high performance make it an irreplaceable position in the material system.

1.4 Research and application status of tungsten copper materials at home and abroad

1.4.1 Current status of domestic research and application

China is the country with the richest tungsten resources in the world and has significant advantages in the research and production of tungsten-copper materials. In recent years, domestic research institutions and enterprises have made important progress in the field of tungsten-copper composite materials:

Research Progress: Domestic universities and research institutions (such as Tsinghua University, Central South University, and the Institute of Metal Research, Chinese Academy of Sciences) have conducted in-depth research on the preparation, performance optimization, and microstructural analysis of tungsten-copper materials. For example, doping with rare earth elements (such as lanthanum and cerium) has improved the mechanical properties and oxidation resistance of tungsten-copper materials. Furthermore, novel preparation techniques (such as plasma sintering and microwave sintering) have significantly improved the density and performance uniformity of tungsten-copper rods.

Application Status: Domestically, tungsten copper rods are widely used in the electrical power, electronics, aerospace, and machining sectors. For example, high-performance tungsten copper rods are used in electrical contact materials, resistance welding electrodes, and electronic packaging substrates. Various tungsten copper alloy grades (such as WCu10, WCu20, and WCu30) have also been developed in China to meet diverse application needs.

Industrial advantages: China has a complete tungsten industry chain, from tungsten ore mining to tungsten copper rod production, forming strong industrial competitiveness.

1.4.2 Current status of research and application abroad

Foreign countries started early in the research and application of tungsten copper materials, especially in Europe, America and Japan, where the relevant technologies are relatively mature:

Research Progress: The United States, Japan, and Germany lead the way in the preparation and performance optimization of tungsten-copper composite materials. For example, CBMM in the United States has developed high-performance tungsten-copper rods for use in aerospace and

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defense. Japan, through nanotechnology and precision sintering processes, has produced high-density tungsten-copper materials, which are widely used in semiconductor packaging. German research institutions are focusing on the application of tungsten-copper materials in nuclear fusion, developing tungsten-copper composite materials suitable for divertor heat sinks.

Application Status: Overseas, tungsten copper rods are primarily used in high-precision electronic devices, aerospace components, and nuclear industry equipment. For example, in the United States, tungsten copper rods are used to manufacture satellite radiators and missile components, while Japanese tungsten copper materials are used in high-end electronic packaging and resistance welding electrodes. In Europe, tungsten copper rods are widely used as heat sinks in nuclear fusion research, such as the ITER project.

Technical Features: Foreign companies are placing greater emphasis on the production of high-precision and complex-shaped components in the preparation of tungsten copper materials. For example, the application of additive manufacturing technology enables foreign companies to produce tungsten copper components with complex geometries. Furthermore, foreign companies have advantages in surface treatment technologies (such as gold and nickel plating), which improve the corrosion resistance and conductivity of tungsten copper rods.

1.4.3 Domestic and International Gap and Future Outlook

Although China leads in the production scale and resource advantages of tungsten copper materials, there is still a certain gap between China and foreign countries in high-precision preparation processes, complex component manufacturing, and high-end applications. For example, foreign countries are more advanced in the research and development of nano-scale tungsten copper materials and additive manufacturing technology. In the future, China needs to strengthen research in the following areas:

High-end manufacturing technology: Develop high-precision, complex-shaped tungsten copper component manufacturing technologies, such as 3D printing and laser sintering.
Performance optimization: The electrical conductivity, thermal conductivity and mechanical properties of tungsten copper materials are further improved through doping and new processes.
International cooperation: Strengthen cooperation with international scientific research institutions and enterprises, learn from foreign advanced technologies, and promote the application of tungsten copper materials in the global market.

Chapter 2 Main Types and Classifications of Tungsten Copper Rod

As a high-performance composite material, tungsten copper rods come in a variety of types and classifications, primarily based on the tungsten-to-copper ratio and application areas. The performance of tungsten copper rods varies depending on the ratio of tungsten to copper. Rods with different ratios are designed for specific industrial applications to meet varying requirements for electrical conductivity, thermal conductivity, mechanical strength, and high-temperature resistance. Furthermore, depending on their application areas, tungsten copper rods are further subdivided into categories such as electrical and electronics, heat dissipation and thermal management, military and aerospace, machinery and mold industry, and medical and scientific research. The following will discuss in detail the classification of tungsten copper rods and their specific applications in various fields.

2.1 Classification by tungsten-copper ratio

The performance of tungsten copper rods is closely related to the ratio of its tungsten to copper content. Rods with different ratios show significant differences in electrical conductivity, thermal conductivity, hardness, wear resistance, and high temperature resistance. The following is a classification of common tungsten copper ratios and their characteristics and applications.

2.1.1 W-Cu 50/50 Tungsten Copper Rod (Balanced Electrical and Thermal Conductivity)

W-Cu 50/50 tungsten copper rods contain 50% tungsten and 50% copper, representing a typical balance of electrical and thermal conductivity. Due to the high copper content, this type of tungsten copper rod has excellent electrical conductivity (approximately 50%-60% of pure copper) and thermal conductivity (approximately 200-250 W/m·K), while retaining a certain degree of mechanical strength and wear resistance. Its main characteristics include:

High conductivity: suitable for situations requiring fast electrical signal transmission.
Excellent thermal conductivity: can dissipate heat efficiently and is suitable for thermal management devices.
Moderate mechanical strength: Compared with materials with high tungsten content, its hardness and wear resistance are slightly lower, but its processing performance is better.

Applications: W-Cu 50/50 tungsten copper rod is widely used in electronic packaging materials, connectors, and low-voltage electrical contact components. For example, in the conductive substrates and connectors of integrated circuits, this material provides stable electrical signal transmission and excellent thermal management. It is also used to manufacture resistance welding electrodes and low-power arc contacts.

Preparation Characteristics: This type of tungsten copper rod is typically produced through powder metallurgy, using a mixture of high-purity tungsten powder and copper powder, followed by compaction and sintering. Some processes may include a copper infiltration step to increase material density. Due to the high copper content, the sintering temperature is relatively low (approximately 1200-1300°C), resulting in a low process cost.

2.1.2 W-Cu 70/30 Tungsten Copper Rod (Commonly used for electrodes and contacts)
W-Cu 70/30 tungsten copper rod contains 70% tungsten and 30% copper, one of the most commonly used tungsten-copper ratios in the electrical and electronic fields. This type of material achieves a good balance between electrical conductivity, thermal conductivity, and mechanical strength, making it suitable for use as electrodes and electrical contact materials. Its main characteristics include:

Higher hardness and wear resistance: The increased tungsten content makes it more suitable for withstanding mechanical wear.
Moderate conductivity: The electrical conductivity is approximately 30%-40% of pure copper, making it suitable for medium and high voltage electrical applications.
Good arc breaking performance: strong anti-ablation ability in arc environment.

Applications: W-Cu 70/30 tungsten copper rod is the preferred material for manufacturing high-voltage switch contacts, resistance welding electrodes, and electrical discharge machining (EDM) electrodes. For example, in medium- and high-voltage circuit breakers, this material can withstand frequent arc shocks and mechanical stress, extending the service life of the equipment. It is also used for spot welding electrodes in the automotive industry and electrical connectors in the aviation sector.

Preparation characteristics: This type of tungsten copper rod is usually produced by powder metallurgy combined with copper infiltration. Due to the high tungsten content, the sintering process requires higher temperatures (about 1300-1500℃) and stricter process control to ensure the uniformity and density of the material.

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Tungsten Copper Rod Introduction

1. Overview of Tungsten Copper Rod

Tungsten copper rod is composite materials produced by infiltrating high-purity tungsten powder with copper through a vacuum infiltration process. It possesses a unique microstructure that combines the high strength and high melting point of tungsten with the excellent electrical and thermal conductivity of copper. This results in a high-performance material with outstanding thermal stability, wear resistance, and electrical conductivity.

2. Characteristics of Tungsten Copper Rod

High Thermal Conductivity: The excellent thermal conductivity of copper ensures rapid heat dissipation, making it suitable for high-power devices and laser systems.
High Strength and High-Temperature Resistance: The stable mechanical properties of tungsten allow the material to remain reliable under extreme high-temperature conditions.
Resistance to Arc Erosion: The tungsten-copper composite structure provides exceptional resistance to arc erosion in electrical applications, significantly extending electrode service life.
Low Thermal Expansion Coefficient: Effectively reduces thermal stress and improves structural stability.
Excellent Machinability: Can be precisely fabricated into electrodes, heat sinks, or complex parts to meet diversified application requirements.

3. Performance Parameters of Tungsten Copper Rod

Product Name	Chemical Composition (%)		Physical and Mechanical Properties			
	Impurities ≤	W	Density (g/cm³)	Hardness (HB)	Resistivity (mΩ·cm)	Tensile Strength (MPa)
W50Cu	0.5	Balance	11.85	115	3.2	—
W60Cu	0.5	Balance	12.75	140	3.7	—
W70Cu	0.5	Balance	13.8	175	4.1	790
W80Cu	0.5	Balance	15.15	220	5	980
W90Cu	0.5	Balance	16.75	260	6.5	1160

4. Advantages of Tungsten Copper Rod

High-Performance Combination: A balanced integration of strength, electrical conductivity, thermal conductivity, and high-temperature resistance.
Customized Solutions: Tungsten-to-copper ratio and dimensions can be tailored to meet specific customer requirements.
Long Service Life and Stability: Significantly reduces maintenance and replacement costs.

5. Procurement Information

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2.1.3 W-Cu 75/25 Tungsten Copper Rod (Medium Thermal Conductivity and Strength Combination)

W-Cu 75/25 tungsten copper rod contains 75% tungsten and 25% copper, providing a better balance between thermal conductivity and mechanical strength. This type of material is suitable for applications that require both high strength and certain thermal conductivity. Its main characteristics include:

Higher mechanical strength: Hardness and wear resistance are better than W-Cu 70/30, suitable for high load environments.
Moderate thermal conductivity: The thermal conductivity is approximately 150-200 W/m·K, which is suitable for medium-power thermal management applications.
Low thermal expansion coefficient: The high tungsten content gives it good dimensional stability at high temperatures.

Applications: W-Cu 75/25 tungsten copper rod is widely used in the manufacture of heat sink substrates and electrical contact materials for medium-power electronic devices. For example, in power semiconductor devices such as IGBT modules, this material acts as a heat sink substrate, effectively dissipating heat while maintaining structural stability. It is also used in the manufacture of wear-resistant components and medium- and high-voltage electrical contacts in the aerospace industry.

Preparation Characteristics: The production process for this material is similar to that of W-Cu 70/30, but due to the increased tungsten content, the sintering temperature and pressure require further optimization. Some manufacturers use hot isostatic pressing (HIP) technology to improve the material's density and performance consistency.

2.1.4 W-Cu 80/20 Tungsten Copper Rod (for high strength and ablation resistance)

W-Cu 80/20 tungsten copper rod contains 80% tungsten and 20% copper, focusing on high strength and ablation resistance, suitable for high load and high temperature environment. Its main features include:

Extremely hard and wear-resistant: The high tungsten content makes it extremely resistant to mechanical wear.
Good ablation resistance: performs well in high temperature arc or plasma environments.
Lower electrical and thermal conductivity: electrical conductivity is about 20%-30% of pure copper, and thermal conductivity is about 120-150 W/m·K.

Applications: W-Cu 80/20 tungsten copper rod is primarily used in high-strength electrodes, high-temperature aerospace components, and military applications. For example, in plasma cutting machines and EDM equipment, this material is used as an electrode, capable of withstanding intense arc erosion. It is also used in the manufacture of rocket nozzle throat liners and high-temperature wear-resistant components.

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Preparation Characteristics: Due to the high tungsten content, the production process requires higher sintering temperatures (approximately 1500-1600°C) and more complex copper infiltration processes. Some advanced processes use plasma sintering or laser sintering technology to improve the uniformity of the material's microstructure.

2.1.5 W-Cu 85/15 tungsten copper rod (high temperature and high strength type, taking into account electrical conductivity)

W-Cu 85/15 tungsten copper rod contains 85% tungsten and 15% copper. It is a high-temperature, high-strength material while retaining a certain degree of conductivity. Its main characteristics include:

Extremely high temperature resistance: Able to maintain structural stability in extreme environments close to 3000℃.
Excellent mechanical strength: Hardness and wear resistance are further improved, suitable for extreme working conditions.
Lower conductivity: The electrical conductivity is about 15%-25% of pure copper, suitable for electrical applications requiring high strength.

Applications: W-Cu 85/15 tungsten copper rods are widely used in divertor heat sinks for nuclear fusion reactors, aerospace engine components, and high-voltage arc contacts. For example, in the International Thermonuclear Experimental Reactor (ITER) project, this material is used as a divertor heat sink, capable of withstanding high thermal loads and particle bombardment. It is also used in the manufacture of electrodes for high-energy lasers and plasmas.

Preparation Characteristics: This type of material is difficult to prepare, typically using hot isostatic pressing or plasma sintering to ensure high density and stable performance. The copper infiltration process requires precise control to avoid porosity or uneven performance within the material.

2.1.6 W-Cu 90/10 Tungsten Copper Rod (Ultra-High Strength and High Temperature Resistance)

W-Cu 90/10 type tungsten copper rod contains 90% tungsten and 10% copper. It is the type with the highest strength and high temperature resistance among tungsten copper rods and is suitable for extreme working conditions. Its main features include:

Ultra-high hardness and wear resistance: mechanical properties close to pure tungsten, suitable for extreme mechanical loads.
Extremely strong high temperature resistance: able to work for a long time in extremely high temperature and plasma environments.
Extremely low electrical and thermal conductivity: electrical conductivity is only 10%-15% of pure copper, and thermal conductivity is about 80-120 W/m·K.

Applications: W-Cu 90/10 tungsten copper rods are primarily used for high-temperature components in extreme environments and in the military industry. For example, in spacecraft

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propulsion systems (such as rocket nozzles), this material serves as a high-temperature, wear-resistant lining. It is also used to manufacture rails for electromagnetic guns and high-temperature components for nuclear fusion devices.

Preparation Characteristics: Due to the extremely high tungsten content, the production process requires extremely high sintering temperatures (approximately 1600-1700°C) and high pressure conditions. Hot isostatic pressing and plasma sintering are commonly used preparation techniques. Some processes also require the addition of trace additives (such as nickel or iron) to improve sintering properties.

2.1.7 Special Ratio Tungsten Copper Rod (Customized Alloy)

In addition to the standard ratios mentioned above, special ratios of tungsten copper rods can also be customized according to specific application requirements. For example, W-Cu 60/40, W-Cu 65/35 or alloys with higher copper content can be used in applications requiring higher conductivity, while alloys with ultra-high tungsten content (such as W-Cu 95/5) are used in extreme wear resistance and high temperature scenarios. The development of customized alloys usually involves the following aspects:

Doping modification: adding rare earth elements (such as lanthanum, cerium) or transition metals (such as nickel, cobalt) to improve specific properties.
Microstructure optimization: By controlling the particle size of tungsten powder and copper powder, the uniformity and density of the material are optimized.
Special processes: Additive manufacturing, microwave sintering or cold spraying technology are used to produce tungsten copper rods with complex shapes or high performance.

Applications: Custom alloys are widely used in cutting-edge scientific research, aerospace, and high-end electronic devices. For example, tungsten-copper rods with specific ratios are used to manufacture targets for high-energy physics experimental equipment and radiation shielding components for the nuclear industry.

2.2 Classification by application field

According to different application fields, tungsten copper rods can be divided into five categories: electrical and electronics, heat dissipation and thermal management, military and aerospace, machinery and mold industry, and medical and scientific research. The following will introduce the specific uses and performance requirements of various types of tungsten copper rods in detail.

2.2.1 Tungsten copper rod for electrical and electronic applications

Tungsten copper rod is widely used in the electrical and electronic fields. Its excellent conductivity, arc breaking performance and wear resistance make it the first choice for electrical contact materials and electrodes.

2.2.1.1 High-voltage switches and arc contacts

High-voltage switches and circuit breakers require materials that can withstand high voltages and arc shocks while maintaining long-term stability. W-Cu 70/30 and W-Cu 75/25 tungsten copper rods are widely used in arc contacts due to their excellent conductivity and ablation resistance. Their main advantages include:

High arc breaking performance: can quickly cut off the arc and reduce contact burning.
High temperature resistance: maintain structural integrity under high temperature of arc.
Long life: High hardness and wear resistance extend the service life of the contacts.

Application example: In high-voltage transmission systems and industrial circuit breakers, tungsten copper arc contacts are used in switchgear ranging from 10kV to 500kV and can withstand thousands of switching operations.

2.2.1.2 Discharge electrode and spark plug electrode

Electrospark machining (EDM) and spark plugs require electrode materials with high wear and erosion resistance. W-Cu 70/30 and W-Cu 80/20 tungsten copper rods are commonly used electrode materials. Their advantages include:

High-precision machining: The uniform microstructure of tungsten copper rod ensures machining accuracy.
Ablation resistance: Remains stable in high-frequency discharge environment.
Good electrical conductivity: ensures the efficiency and stability of the discharge process.

Application examples: In the automotive industry, tungsten copper rods are used to manufacture high-performance spark plug electrodes; in precision mold manufacturing, tungsten copper electrodes are used for electrospark machining of complex-shaped metal parts.

2.2.1.3 Semiconductor packaging and conductive connectors

In semiconductor packaging, tungsten copper rods are used as conductive substrates and connectors to provide electrical signal transmission and thermal management. W-Cu 50/50 and W-Cu 75/25 tungsten copper rods are widely used due to their high conductivity and low thermal expansion coefficient. Their advantages include:

Low coefficient of thermal expansion: matches silicon and ceramic substrates, reducing thermal stress.
High thermal conductivity: effectively dissipates heat and protects sensitive electronic components.
High reliability: Maintains stable performance in high temperature and high humidity environments.

Application Case: In power semiconductor devices (such as MOSFET and IGBT), tungsten copper rods are used as conductive substrates and heat dissipation base plates, and are widely used in new energy vehicles and industrial automation equipment.

2.2.2 Tungsten copper rod for heat dissipation and thermal management

The application of tungsten copper rod in the field of thermal management is due to its excellent thermal conductivity and low thermal expansion coefficient, which is suitable for the heat dissipation needs of high-power electronic devices and aerospace equipment.

2.2.2.1 Microelectronics and integrated circuit heat sinks

Microelectronics and integrated circuits require efficient heat dissipation materials to prevent overheating. W-Cu 75/25 and W-Cu 80/20 tungsten copper rods are widely used in heat sink manufacturing due to their high thermal conductivity and thermal expansion matching with silicon substrates. Their advantages include:

Efficient heat dissipation: thermal conductivity is as high as 150-200 W/m·K.
Dimensional stability: Low coefficient of thermal expansion ensures structural integrity in long-term operation.
High reliability: Maintains stable performance during high power operation.

Application Case: In the CPU/GPU modules of high-performance computers and servers, tungsten copper heat sinks are used to dissipate heat and ensure stable operation of the chip under high load.

2.2.2.2 Laser and high-power device heat dissipation substrates

High-power lasers and RF devices require an efficient heat sink to maintain performance. W-Cu 70/30 and W-Cu 75/25 tungsten copper rods are ideal heat sink materials. Their advantages include:

High thermal conductivity: quickly dissipates heat to prevent device overheating.
Good mechanical properties: able to withstand the mechanical stress during the operation of high-power devices.
Surface flatness: suitable for precision machining and surface coating.

Application example: In optical communication lasers and radar systems, tungsten copper heat sinks are used to support high-power laser diodes and RF amplifiers.

2.2.2.3 Aerospace cooling components

Aerospace equipment requires efficient heat dissipation in extreme environments. W-Cu 80/20 and W-Cu 85/15 tungsten copper rods are used in heat dissipation components due to their high strength and high temperature resistance. Their advantages include:

High temperature resistance: Ability to maintain performance in high temperature environments.
High density: provides sufficient mechanical strength and mass balance.
Thermal shock resistance: Remains stable during rapid temperature changes.

Application examples: In satellite thermal management systems and aircraft engines, tungsten copper heat dissipation components are used to manage high-temperature airflow and the heat load of electronic devices.

2.2.3 Tungsten copper rods for military and aerospace applications

The application of tungsten copper rods in the military and aerospace fields is due to their high density, high strength and high temperature resistance, making them suitable for manufacturing high-performance weapons and aerospace components.

2.2.3.1 Electromagnetic guns and protective armor materials

Electromagnetic guns and protective armor require materials with high density and wear resistance. W-Cu 90/10 tungsten copper rod is used to manufacture guide rails and armor components due to its high strength and high density. Its advantages include:

High density: provides sufficient kinetic energy and quality stability.
Wear resistance: Maintains performance under high-speed friction and impact.
High temperature resistance: Withstands the instantaneous high temperature during electromagnetic gun firing.

Application examples: In electromagnetic gun systems, tungsten copper rails are used to withstand the friction and arc impact of high-speed projectiles; in armor materials, tungsten copper rods are used to enhance protective performance.

2.2.3.2 Electrodes and components for high-energy weapons

High-energy weapons, such as lasers and plasma weapons, require electrode materials that are resistant to high temperatures and ablation. W-Cu 80/20 and W-Cu 85/15 tungsten copper rods are ideal choices, offering advantages such as:

Ablation resistance: Maintains structural integrity during high-energy discharge.
High conductivity: ensures efficient transmission of electrical energy.
Long life: Reduce replacement frequency and improve weapon reliability.

Application examples: In high-energy laser weapons, tungsten copper electrodes are used to support high-power discharge; in plasma weapons, tungsten copper components are used to withstand high-temperature plasma impact.

2.2.3.3 Rocket Nozzle and Propulsion System Components

Rocket nozzles and propulsion systems need to operate in high temperature and high pressure environments. W-Cu 85/15 and W-Cu 90/10 tungsten copper rods are used to manufacture nozzle throat liners and propulsion system components due to their high temperature resistance and high strength. Its advantages include:

Extremely high temperature resistance: withstands the high temperatures of rocket combustion chambers (>3000℃).
Thermal shock resistance: Remains stable during rapid temperature changes.
High density: provides structural strength and mass balance.

Application Case: In solid rocket engines and liquid rocket propulsion systems, tungsten copper rods are used to manufacture nozzle throat liners and high-temperature guide components.

2.2.4 Tungsten copper rods for machinery and mold industry

Tungsten copper rods are used in the machinery and mold industry due to their high hardness, wear resistance, excellent thermal conductivity, and ablation resistance, making them an ideal material for manufacturing high-precision machining tools and molds. In particular, in fields such as electrical discharge machining (EDM) and stamping dies, tungsten copper rods exhibit unique advantages, significantly improving machining efficiency and mold life.

2.2.4.1 Electrode for Electrical Discharge Machining (EDM)

Electrical discharge machining (EDM) is a precision machining technology that removes material through electrical spark discharge. It is widely used in mold manufacturing, aerospace parts processing, and metalworking of complex geometries. EDM electrodes require materials with high wear resistance, ablation resistance, and good electrical conductivity to ensure machining accuracy and electrode life. W-Cu 70/30 and W-Cu 80/20 tungsten copper rods are the preferred materials for EDM electrodes. Their main advantages include:

High wear resistance: The high hardness of tungsten enables the electrode to resist wear in high-frequency discharge and extend its service life.
Excellent ablation resistance: Under the instantaneous high temperature (up to 6000℃) generated by electric spark discharge, the tungsten copper rod can maintain its structural integrity and reduce electrode loss.
Good conductivity: The addition of copper ensures that the electrode has sufficient conductivity (the conductivity is about 20%-40% of pure copper), supporting efficient discharge machining.
High processing precision: The uniform microstructure and low thermal expansion coefficient of the tungsten copper rod ensure that the electrode maintains dimensional stability during processing, which helps to achieve high-precision processing.
Easy to process: Compared with pure tungsten, tungsten copper rod has better machinability, which is convenient for preparing electrodes with complex shapes.

Application Examples: In precision mold manufacturing, W-Cu 70/30 tungsten copper rods are widely used to process complex steel molds, such as automotive parts molds and electronic device housing molds. In the aerospace field, tungsten copper electrodes are used to process titanium alloy and high-temperature alloy components, ensuring high precision and surface quality. Furthermore, in the processing of micro-parts, tungsten copper electrodes can achieve micron-level processing accuracy, meeting the manufacturing requirements of MEMS (microelectromechanical systems) and precision instruments.

Manufacturing Characteristics: Tungsten-copper electrodes for EDM are typically produced using powder metallurgy, mixing high-purity tungsten and copper powders before compacting and sintering. To improve electrode density and performance uniformity, some processes incorporate copper infiltration or hot isostatic pressing (HIP). The electrode surface typically requires precision machining (such as grinding or polishing) to meet high-precision machining requirements.

Development Trends: As EDM technology advances into micro- and nano-machining, the fabrication process for tungsten-copper electrodes is continuously being optimized. For example, the use of nano-sized tungsten and copper powders can further improve the microstructural uniformity of the electrodes and reduce minor defects during discharge. Furthermore, surface modification techniques (such as nickel or gold plating) are being used to improve the electrodes' oxidation resistance and electrical conductivity, further extending their lifespan.

2.2.4.2 Stamping dies and wear-resistant parts

In the manufacture of stamping dies and wear-resistant parts, tungsten copper rods are widely used due to their high hardness, wear resistance, and excellent thermal conductivity. Stamping dies and wear-resistant parts are often required to work in high load, frequent impact, and high temperature environments. Tungsten copper rods can effectively meet these stringent requirements. W-Cu 75/25 and W-Cu 80/20 tungsten copper rods are commonly used in this field. Their main advantages include:

High hardness and wear resistance: The high hardness of tungsten (close to the Mohs hardness of pure tungsten at level 9) enables the tungsten copper rod to resist mechanical wear during the stamping process and extend the life of the mold.
Excellent thermal conductivity: The addition of copper makes the tungsten copper rod have a higher thermal conductivity (about 150-200 W/m·K), which can quickly dissipate heat and prevent the mold from deformation or failure due to overheating.
Low thermal expansion coefficient: Tungsten's low thermal expansion characteristics (approximately $4.5\text{-}5.5\times10^{-6}$ / K) ensure the dimensional stability of the mold at high temperatures and is suitable for high-precision stamping.
Fatigue resistance: Tungsten copper rods can maintain structural integrity under frequent impacts, reducing the risk of cracks and fatigue failure.

Application Examples: In the automotive industry, tungsten copper rods are used to manufacture stamping dies for producing body panels, engine components, and transmission parts. In die-casting dies for aluminum and magnesium alloys, tungsten copper rods serve as core rods and nozzles, capable of withstanding the impact and corrosion of high-temperature molten metal. Furthermore, in the stamping production of precision hardware and electronic connectors, tungsten copper dies are favored for their high wear resistance and long life.

Manufacturing Characteristics: Tungsten copper rods for stamping dies are typically produced using powder metallurgy combined with a copper infiltration process to ensure high material density and uniform performance. To meet the complex shape requirements of the mold, some processes use CNC machining or laser cutting technology to fine-tune the tungsten copper rods. In addition, surface hardening treatments (such as carburizing or nitriding) can further improve the mold's wear and corrosion resistance.

Development Trends: In the future, tungsten copper rods for stamping dies will develop towards higher performance and more complex shapes. For example, the application of additive manufacturing (3D printing) technology enables the design of complex internal cooling channels in tungsten copper dies, improving heat dissipation efficiency. In addition, doping with trace elements (such as nickel or rare earth elements) can further optimize the fatigue and wear resistance of tungsten copper rods, meeting the requirements of high-strength stamping.

2.2.5 Tungsten Copper Rods for Medical and Scientific Research Applications

Tungsten copper rods are used in medical and scientific research due to their high density, high temperature resistance, and biocompatibility. They are particularly suitable for manufacturing medical electrodes, specialized probes, and components for high-energy physics experiments. W-Cu 80/20 and W-Cu 85/15 tungsten copper rods are commonly used in this field, meeting the demands of high precision and extreme environments.

2.2.5.1 Medical electrodes and special probes

In the medical field, tungsten copper rods are used to manufacture high-precision electrodes and probes, which are widely used in nerve stimulation, radiofrequency ablation, and minimally invasive surgical devices. These applications require materials with high conductivity, corrosion resistance, and biocompatibility. W-Cu 70/30 and W-Cu 80/20 tungsten copper rods are widely used due to their excellent performance. Their main advantages include:

High conductivity: ensures accurate transmission of electrical signals, suitable for nerve stimulation and electrophysiological monitoring.
Corrosion resistance: Remains stable in physiological environments (such as blood or tissue fluid) and reduces material degradation.
High hardness and wear resistance: supports long-term use of the probe in high-precision operations.
Biocompatibility: After appropriate surface treatment (such as gold plating or silver plating), the tungsten copper rod can meet the biocompatibility requirements of medical devices.

Application Examples: In neurostimulation devices, tungsten-copper electrodes are used in deep brain stimulation (DBS) to treat Parkinson's disease and epilepsy, precisely delivering electrical pulses. In radiofrequency ablation procedures, tungsten-copper probes are used to treat heart lesions or tumors, maintaining stability in high temperatures and high-frequency electric fields. Furthermore, in minimally invasive surgery, tungsten-copper rods are processed into miniature probes for endoscopic examinations and tissue sampling.

Preparation Characteristics: Medical tungsten copper rods are typically produced using high-purity tungsten and copper powders through powder metallurgy and hot isostatic pressing to ensure high density and a non-porous structure. Surface treatment (such as electroplating or chemical passivation) is a key step to enhance the material's biocompatibility and corrosion resistance. Furthermore, micro-nanofabrication technologies are used to manufacture microelectrodes and probes to meet the demands of high-precision medical devices.

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Development Trends: With the advancement of minimally invasive medical technologies, tungsten-copper electrodes and probes will move toward smaller sizes and higher precision. For example, the development of nanoscale tungsten-copper composites can further improve the conductivity and mechanical properties of electrodes. Furthermore, combined with smart material technologies, future tungsten-copper probes may incorporate sensor functions for real-time monitoring of physiological signals.

2.2.5.2 High-energy physics experiments and nuclear industry applications

Tungsten copper rods are widely used in high-energy physics experiments and the nuclear industry due to their high density, high temperature resistance, and radiation resistance. W-Cu 85/15 and W-Cu 90/10 tungsten copper rods are the preferred materials in this field, capable of withstanding the high temperatures, high pressures, and particle bombardment found in extreme environments. Their key advantages include:

High density: The high density of tungsten (about 19.25 g/cm³) enables tungsten copper rods to effectively shield high-energy radiation, making them suitable for use in components of nuclear reactors and particle accelerators.
High temperature resistance: Maintains stable performance at extremely high temperatures (>3000℃) generated by nuclear fusion or high-energy particle collisions.
Radiation resistance: Tungsten copper rods can resist damage from neutron irradiation and gamma rays, extending component life.
Excellent thermal conductivity: Rapidly dissipates heat to prevent components from failing due to high temperatures.

Application Examples: In the International Thermonuclear Experimental Reactor (ITER) project, W-Cu 85/15 tungsten copper rods are used as divertor heat sinks, capable of withstanding high heat loads and plasma bombardment. In particle accelerators such as CERN's Large Hadron Collider, tungsten copper rods are used to manufacture targets and radiation shielding components, protecting equipment from high-energy particles. Furthermore, in the nuclear power industry, tungsten copper rods are used as high-temperature thermal conductors and radiation shielding materials to improve reactor safety and efficiency.

Preparation Characteristics: The production of tungsten copper rods for the nuclear industry requires extremely high material purity and density. Hot isostatic pressing or plasma sintering techniques are typically used to eliminate micropores and defects within the material. To enhance radiation resistance, some processes involve doping with rare earth elements (such as lanthanum or cerium) to optimize the material's microstructure. Additionally, surface coatings (such as molybdenum or ceramic coatings) are used to improve the material's corrosion resistance and high-temperature resistance.

Development Trends: In the future, tungsten copper rods for the nuclear industry will develop towards higher performance and more complex structures. For example, the application of additive manufacturing technology enables the fabrication of tungsten copper rods into heat sinks and shielding components with complex geometries, meeting the needs of next-generation nuclear fusion reactors . Furthermore, new doping and surface modification technologies will further enhance the radiation resistance and high-temperature resistance of tungsten copper rods, promoting their application in high-energy physics experiments and the nuclear industry.

Chapter 3 Preparation and Production Technology of Tungsten Copper Rod

Tungsten copper rod, a composite material combining the high strength and high-temperature resistance of tungsten with the excellent electrical and thermal conductivity of copper, plays an irreplaceable role in electronic devices, electrical contacts, thermal management components, and aerospace. Its preparation process is a delicate journey in materials science, blending traditional powder metallurgy techniques with innovative breakthroughs in modern technology. From meticulous raw material selection to precision machining of the final product, each step requires meticulous design to ensure material uniformity, density, and stable performance. The key lies in creating a porous tungsten skeleton and precisely infiltrating molten copper to achieve a perfect composite of the two phases. Traditional processes rely on pressing, sintering, and vacuum infiltration, while emerging technologies incorporate nanomaterials, additive manufacturing, and intelligent control to meet even higher performance demands. This chapter will provide a detailed narrative description, delving into every step from raw material preparation to the exploration of new processes. Focusing on process principles, operational details, challenges, and optimization strategies, it avoids overloading with technical data and instead uses vivid language to showcase the complexity and charm of the preparation process.

3.1 Raw material preparation

The preparation of raw materials is the starting point for the production of tungsten copper rods, much like preparing the instruments for a sophisticated symphony. Tungsten powder and electrolytic copper, as the primary raw materials, undergo rigorous screening and processing to ensure they work seamlessly together in subsequent processes to form a high-performance composite material. Controlling purity, particle size, and morphology not only influences forming and sintering results but also determines the thermal, electrical, and mechanical properties of the final product.

3.1.1 Preparation and quality requirements of tungsten powder

The preparation of tungsten powder is like transforming hard tungsten ore into a fine, artistic material. Hydrogen reduction is typically used. This is a mature industrial technique. Starting with tungsten ore (such as wolframite or scheelite), it is chemically purified to produce tungstates, which are then roasted to form tungsten trioxide. The subsequent reduction process takes place in a high-temperature furnace, where hydrogen, like a patient craftsman, gradually strips away the oxides, resulting in pure tungsten powder. Other methods, such as electrolysis or mechanical alloying, can produce finer particles, but are more expensive and suitable for specialized applications.

Tungsten powder quality requirements are exceptionally demanding: it requires extremely high purity to minimize impurities, a uniform particle shape to facilitate packing and bonding, and a tightly controlled oxygen content to prevent unwanted oxide formation at high temperatures. High-quality tungsten powder acts as a carefully selected seed, laying the foundation for subsequent processes. The addition of trace activators can enhance the powder's fusion during sintering, but caution is advised to avoid compromising the material's thermal conductivity. Tungsten powder should be stored in a dry, sealed environment to prevent moisture and oxygen from eroding its activity.

3.1.2 Preparation and Characteristics of Electrolytic Copper

The production of electrolytic copper is a journey of electrochemical refining. Crude copper is decomposed in an electrolyte, and copper ions, guided by an electric field, are deposited at the cathode, forming pure copper foil or powder. This process, like gold refining, requires precise control to remove impurities and ensure that the copper meets industry-leading quality standards.

Electrolytic copper, with its excellent electrical and thermal conductivity, serves as the "lubricant" in tungsten copper rods. Its low melting point allows it to flow easily during infiltration, filling the pores of the tungsten skeleton; its excellent plasticity ensures the toughness of the composite material. Copper comes in a variety of forms, from fine powder to solid blocks, to suit different process requirements. Within the tungsten copper rod, copper not only conducts current and heat but also connects the tungsten particles, forming a tough network. However, copper is sensitive to oxygen and requires extreme care during storage and handling to prevent oxidation that may affect its performance.

3.1.3 Effect of tungsten powder size, morphology and purity on the process

The particle size and shape of tungsten powder act like a sculptor's tools, directly shaping the material's structure. Fine particles combine more tightly, enhancing the skeleton's strength, but can prematurely close pores and hinder copper penetration. Larger particles foster an open pore network, but require more energy to fuse. Choosing the right particle size is like mixing the colors of a painting: finding a balance between strength and permeability.

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Tungsten Copper Rod Introduction

1. Overview of Tungsten Copper Rod

Tungsten copper rod is composite materials produced by infiltrating high-purity tungsten powder with copper through a vacuum infiltration process. It possesses a unique microstructure that combines the high strength and high melting point of tungsten with the excellent electrical and thermal conductivity of copper. This results in a high-performance material with outstanding thermal stability, wear resistance, and electrical conductivity.

2. Characteristics of Tungsten Copper Rod

High Thermal Conductivity: The excellent thermal conductivity of copper ensures rapid heat dissipation, making it suitable for high-power devices and laser systems.
High Strength and High-Temperature Resistance: The stable mechanical properties of tungsten allow the material to remain reliable under extreme high-temperature conditions.
Resistance to Arc Erosion: The tungsten-copper composite structure provides exceptional resistance to arc erosion in electrical applications, significantly extending electrode service life.
Low Thermal Expansion Coefficient: Effectively reduces thermal stress and improves structural stability.
Excellent Machinability: Can be precisely fabricated into electrodes, heat sinks, or complex parts to meet diversified application requirements.

3. Performance Parameters of Tungsten Copper Rod

Product Name	Chemical Composition (%)		Physical and Mechanical Properties			
	Impurities ≤	W	Density (g/cm³)	Hardness (HB)	Resistivity (mΩ·cm)	Tensile Strength (MPa)
W50Cu	0.5	Balance	11.85	115	3.2	—
W60Cu	0.5	Balance	12.75	140	3.7	—
W70Cu	0.5	Balance	13.8	175	4.1	790
W80Cu	0.5	Balance	15.15	220	5	980
W90Cu	0.5	Balance	16.75	260	6.5	1160

4. Advantages of Tungsten Copper Rod

High-Performance Combination: A balanced integration of strength, electrical conductivity, thermal conductivity, and high-temperature resistance.
Customized Solutions: Tungsten-to-copper ratio and dimensions can be tailored to meet specific customer requirements.
Long Service Life and Stability: Significantly reduces maintenance and replacement costs.

5. Procurement Information

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Particle morphology is also crucial: powders with a nearly spherical shape pack more densely, promoting a uniform structure; irregular particles increase contact points, potentially enhancing mechanical properties but also potentially leading to localized defects. Purity is the soul of a material, determining interfacial stability and performance reliability. High-purity powders minimize unwanted chemical reactions, ensuring a smooth composite process; low-purity powders can cause brittleness and compromise durability. Through careful screening and processing, these factors can be optimized, paving the way for subsequent processing.

3.2 Forming process of tungsten-based preform

Forming the tungsten preform is the "foundation-building" stage of the manufacturing process. The goal is to create a porous tungsten skeleton that provides ideal channels for copper infiltration. This process combines pressing and sintering techniques, like carving a microscopic city from the solid tungsten powder. Porosity and strength require a careful balance to avoid either an overly dense or overly loose structure.

3.2.1 Pressing (Uniaxial Pressing, Isostatic Pressing)

Uniaxial pressing is a simple and straightforward process, similar to compacting loose sand into bricks using a mold. Tungsten powder is loaded into a steel mold and compressed into a preliminary shape using a uniaxial force. A small amount of binder, like adding adhesive to clay, helps the powder form. This method is low-cost and suitable for small-scale production, but it can result in uneven density, with loose centers and dense edges.

Isostatic pressing, like giving the powder a full embrace, applies uniform pressure through a liquid or gaseous medium. Whether cold isostatic pressing or hot isostatic pressing combined with high temperature, it significantly improves the uniformity of the preform and is particularly suitable for large or complex tungsten copper rods. After pressing, the green body must be carefully dried to remove the binder and prepare it for subsequent sintering.

3.2.2 Sintering densification (vacuum or hydrogen atmosphere)

The sintering process is like welding loose particles into a solid framework. The pressed green body is then placed in a high-temperature furnace and heated under vacuum or hydrogen. The vacuum acts as a sterile chamber, preventing oxidation and facilitating the expulsion of gases. The hydrogen acts like a cleaner, reducing surface oxides and strengthening the particle bond.

During this process, the particles gradually connect through diffusion and neck growth, causing the green body to shrink and become denser. Adding trace amounts of activators can lower the required temperature, but caution is advised to avoid compromising the purity of the material. Sintering is a slow chemical dance, requiring a precise balance of temperature and time to ensure a strong skeleton while retaining sufficient porosity.

3.2.3 Control of porosity and connectivity of preforms

Porosity and connectivity are the preform's "breathing system," directly impacting the infiltration of molten copper. Excessive porosity can weaken the framework, while too little can hinder penetration. This requires careful control through powder ratio and process conditions. Adding temporary pore-forming agents is like embedding soluble particles in soil, which are then removed after sintering to create channels.

Checking the connectivity of pores is like inspecting a city's traffic network to ensure there are no dead ends. An optimized preform has a uniform pore distribution, providing a smooth path for melt infiltration while maintaining sufficient mechanical strength.

3.3 Vacuum infiltration process

Vacuum infiltration is the key step in the preparation of tungsten-copper rods. It's like injecting liquid copper into the microscopic veins of the tungsten skeleton, forming a dense composite material. This process is not only a technical challenge but also a symphony of physics and chemistry. Under vacuum, molten copper permeates the pores of the tungsten skeleton via capillary forces, filling every gap and ultimately forming a uniform composite structure. The key to success lies in controlling the temperature, vacuum level, and infiltration dynamics, while also avoiding copper volatilization, interfacial defects, and uneven distribution. The following will provide an in-depth description of the complexity and sophistication of this process, from the principles, equipment, and specific operations.

3.3.1 Basic principles of vacuum infiltration

The essence of vacuum infiltration is to utilize capillary action and vacuum to allow molten copper to flow naturally into the pore network of the tungsten skeleton. Imagine a drop of water being absorbed into a sponge: the molten copper becomes a flowing liquid at high temperatures, and with the help of the negative pressure of the vacuum, it penetrates the tungsten structure through tiny pore channels. Tungsten and copper do not react chemically, but rather bond through physical wetting. The size of the wetting angle determines whether the copper can flow spontaneously, and the vacuum environment eliminates gas resistance, allowing the copper to fill every corner more smoothly.

This process breathes life into the tungsten skeleton. The copper not only fills the pores but also, upon cooling, forms a conductive and heat-conducting network, forming a tough and efficient composite with the tungsten skeleton. The key is ensuring good wetting while avoiding copper volatilization due to excessive temperatures or incomplete penetration due to uneven porosity.

3.3.2 Infiltration furnace structure and working principle

The infiltration furnace is the "heart" of vacuum infiltration, and its design is as sophisticated as a precision operating room. The furnace body consists of a vacuum chamber, a heating system, a vacuum pump, and a cooling system. The vacuum chamber is usually made of high-temperature resistant materials such as stainless steel or quartz, and a graphite crucible is placed inside to hold the tungsten preform and copper block. The heating system can be resistance heating or induction heating, and like a precise chef, it controls the temperature above the melting point of copper. The vacuum pump acts like a ventilator, extracting air to create a high vacuum environment and reduce gas interference. The cooling system gradually lowers the temperature after infiltration is completed to prevent cracks caused by thermal stress.

During operation, a tungsten preform is placed in a crucible, with a copper block placed above or to the side. The furnace is first evacuated to remove air and moisture, then the temperature is slowly raised to melt the copper. Capillary forces and the vacuum in the crucible allow the molten copper to penetrate the preform, filling the pores before cooling and solidifying. The entire process is like a microscopic infusion molding process, requiring precise, accurate execution of every step.

3.3.3 Copper infiltration temperature, vacuum degree and infiltration dynamics

The copper infiltration temperature must be above the melting point of copper, but not too high to prevent evaporation of the copper or unwanted grain growth in the tungsten framework. Choosing the right temperature is like adjusting the heat in cooking; it must be just right. The degree of vacuum determines the smoothness of the infiltration process: a high vacuum environment is like a clear runway, allowing the copper liquid to flow unimpeded; insufficient vacuum allows residual gas to form bubbles, affecting the material's density.

Infiltration dynamics lie at the core of this process. The flow rate of the copper solution depends on pore size, wettability, and the effect of temperature on the viscosity of the copper solution. Smaller pores provide greater capillary forces but may increase flow resistance; larger pores have the opposite effect. Optimizing these factors requires experimentation and simulation to find the ideal combination of temperature, vacuum, and time for rapid and uniform infiltration.

3.3.4 Interface reaction and microstructure evolution during infiltration

During the infiltration process, the interface between the molten copper and the tungsten particles is like the contact surface of two dancers, requiring coordinated movement. Tungsten and copper are immiscible, and physical wetting, rather than chemical reaction, occurs at the interface. When the molten copper contacts the tungsten particles, a thin diffusion zone forms, strengthening the bond between the two. Adding small amounts of elements such as chromium or zirconium can improve wetting and reduce voids or microcracks at the interface.

The microstructure evolves from a porous tungsten skeleton to a dense copper-filled complex. The copper liquid first penetrates the larger pores, then gradually fills the smaller channels, ultimately forming a three-dimensional network. This process is like a city gradually filling up with streets and buildings from an empty framework. Upon cooling, the copper phase solidifies, forming a cohesive whole with the tungsten skeleton. Microscopic observation reveals an ideal microstructure with no visible cracks or unfilled areas, and the copper phase is evenly distributed, enhancing the material's performance.

3.3.5 Infiltration uniformity and quality control

Uniformity is the ultimate goal of the infiltration process. Any localized incomplete infiltration or copper pooling will weaken the material's performance. Uniformity depends on the uniformity of the tungsten skeleton's porosity and the stability of the infiltration conditions. The preform's porosity must be scientifically and rationally designed to avoid overly dense areas that block the copper solution or overly porous areas that result in insufficient strength.

Quality control is like a comprehensive physical examination of the finished product. Density measurement can determine the completeness of the fill, microscopic examination can check the uniformity of the microstructure, and non-destructive testing such as ultrasound or X-rays can reveal hidden defects. If uneven infiltration is found, correction can be made through multi-step infiltration or adjustment of the temperature profile. The ultimate goal is to ensure that the material is free of bubbles or cracks and that its performance meets the design requirements.

3.4 Post-processing and machining

Post-processing and machining are the processes of polishing tungsten copper rod from "rough" to "finely crafted" finished product. These steps not only eliminate residual problems in preparation, but also give the material precise dimensions and optimized surface properties.

3.4.1 Heat treatment and stress relief

Heat treatment is like a deep relaxation of the material, eliminating internal stresses accumulated during infiltration and cooling. Tungsten copper rods are heated in a protective atmosphere such as hydrogen or vacuum, gradually increasing the temperature and maintaining it, allowing the crystal structure to realign and enhance toughness. The cooling process is slow, allowing the material to "breathe" and avoid the generation of new stresses. This step can significantly improve the material's reliability and service life.

3.4.2 Precision machining and dimensional control

Precision machining is key to giving tungsten copper rod its final shape. Using high-precision lathes, milling machines, or grinders, combined with diamond tools, the material is carefully sculpted to the designed dimensions. The machining process resembles the work of a sculptor, requiring controlled cutting speeds and feeds to avoid overheating or surface damage. Dimensional accuracy is ensured through laser measurement and three-dimensional coordinate measurement, ensuring micron-level tolerances to meet the demands of high-precision applications.

3.4.3 Surface modification and coating technology

Surface modification is like applying a protective coating to a material. Polishing or chemical etching creates a mirror-smooth surface, reducing friction and wear. Coating technologies further enhance performance. For example, applying a nickel or gold layer through electroplating or physical vapor deposition (PVD) enhances corrosion resistance and electrical conductivity. The coating's thickness must be carefully controlled to provide protection without affecting the material's thermal conductivity.

3.5 Exploration of new processes

With the advancement of materials science, new processes have injected new vitality into the preparation of tungsten copper rods. These technologies are like explorers, exploring more efficient and precise preparation paths to meet the needs of future complex applications.

3.5.1 Nano-Tungsten Copper Preform and Ultrafine Copper Infiltration Technology

The use of nano-scale tungsten powder elevates manufacturing precision to the molecular level. Ultra-fine powders, produced through specialized methods, enable the creation of preforms with higher densities. Ultra-fine copper infiltration technology utilizes nano-copper powders to achieve infiltration at lower temperatures, reducing energy consumption while improving material uniformity. This approach, like painting a material structure with a finer brush, significantly improves performance.

3.5.2 Combination of Vacuum Infiltration and Additive Manufacturing

Additive manufacturing (3D printing) has opened up new possibilities for the fabrication of tungsten copper rods. By laser or electron beam printing a tungsten skeleton, combined with vacuum infiltration, complex geometries can be created. This method, like digitally sculpting the material, transcends the limitations of traditional processes and is suitable for customized production.

3.5.3 High Uniformity and Low Porosity Optimization Process

New optimized processes combine high-pressure-assisted infiltration, microwave sintering, or intelligent control technologies to achieve ultimate uniformity and low porosity. Intelligent systems act as conductors, adjusting process parameters in real time to ensure optimal performance at every step. These technologies elevate the performance of tungsten copper rods to a new level, meeting demanding applications.

Chapter 4 Physical and Chemical Properties of Tungsten Copper Rod

As a unique composite material, tungsten copper rods derive their physical and chemical properties from the perfect blend of tungsten's high heat and wear resistance and copper's excellent electrical and thermal conductivity. This material, reminiscent of nature's harmonious union of hard rock and gentle stream, not only plays a key role in electronic packaging, electrical contacts, and heat sinks, but also demonstrates remarkable adaptability in aerospace and high-voltage electrical equipment. These properties are not simply added together; rather, they form a holistic advantage through the ingenious design of the microstructure, allowing tungsten copper rods to maintain stability and high performance under extreme conditions. This chapter will begin with basic physical properties and gradually delve into mechanical properties, chemical properties, and microstructural characteristics. Through detailed description and analysis, it will reveal the underlying mechanisms, influencing factors, and practical applications of these properties, helping readers fully understand how tungsten copper rods have become a reliable partner in modern industry.

4.1 Basic physical properties of tungsten copper rod

The fundamental physical properties of tungsten copper rods form the foundation of their applications. These properties, like the material's inherent "physique," determine its performance in temperature, electric fields, and thermal environments. The addition of tungsten imparts greater stability and density, while copper provides excellent conductivity. The two complement each other to form a balanced and efficient system. These physical properties are often the primary consideration when designing and using tungsten copper rods, as they directly impact the material's durability and compatibility.

4.1.1 Density and specific gravity of tungsten copper rod

The density of tungsten copper rods is one of their most fundamental yet crucial physical properties, reflecting the compactness and weight distribution of the material's internal components. As the tungsten content increases, the density increases accordingly, making tungsten copper rods excellent for applications requiring high mass, such as counterbalance components in precision instruments or radiation shielding materials. This density allows the material to carry greater weight within a limited space, avoiding design issues that require excessive bulk. It also improves the material's stability, preventing it from shifting under vibration or high-speed motion. In practical applications, high-density tungsten copper rods are often used in counterweight systems in aviation, providing reliable inertial balance without sacrificing other material properties. Specific gravity, as a measure of density relative to water, further emphasizes this perceived heaviness and is particularly useful when calculating material usage or assessing shipping costs. Overall, the optimized density and specific gravity make tungsten copper rods an ideal choice for weight-sensitive applications that require high performance. By adjusting the tungsten-to-copper ratio, they can be flexibly adapted to meet diverse requirements, avoiding the processing difficulties associated with excessively high density or the insufficient strength associated with too low a density.

4.1.2 Melting Point and Thermal Stability of Tungsten Copper Rod

The melting point characteristics of tungsten copper rods inherit tungsten's extreme heat resistance,

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allowing the material to maintain its integrity in high-temperature environments, like a fortress withstanding the test of fire. Tungsten's high melting point significantly raises the upper limit of the overall material's heat resistance. Even at temperatures approaching the melting point of copper, the tungsten copper rod will not easily soften or deform. This thermal stability is particularly prominent in arc discharge or high-temperature welding applications, where it can withstand transient thermal shocks and prevent the material's internal structure from collapsing, thereby extending its service life. Under long-term high-temperature exposure, the thermal stability of tungsten copper rods is also reflected in the durability of their phase structure, without significant crystal transformation or thermal decomposition. This makes them suitable for applications involving sustained high temperatures, such as aircraft engine components or electronic heat sinks. Through sophisticated composite processes, this stability can be further enhanced, allowing the tungsten copper rod to operate with ease in extreme thermal environments, like a warrior unafraid of fire, protecting the normal operation of equipment.

4.1.3 Thermal Expansion Coefficient and Thermal Conductivity of Tungsten Copper Rod

The coefficient of thermal expansion (CTE) is a key regulator in tungsten copper rods' ability to withstand temperature fluctuations. Tungsten's low expansion dominates the material's overall performance, allowing it to maintain relative dimensional stability during thermal cycling, preventing stress concentration and crack formation caused by differential expansion. This characteristic, like the flexibility of a bridge during seasonal changes, is particularly suitable for applications involving ceramics, glass, or semiconductor materials. For example, in microelectronics packaging, tungsten copper rods perfectly match the chip, preventing failures caused by thermal stress. Thermal conductivity, primarily due to copper's excellent heat transfer capabilities, allows tungsten copper rods to act like efficient heat pipes, rapidly dissipating heat from the heat source to the surrounding environment, preventing localized overheating. In high-power laser devices or power semiconductors, this thermal conductivity ensures stable operating temperatures and reduces the risk of thermal failure. The synergistic effect of CTE and thermal conductivity makes tungsten copper rods unique in the field of thermal management. They not only withstand temperature fluctuations but also actively regulate heat flow, achieving efficient energy transfer and heat dissipation balance.

4.1.4 Conductivity and Resistivity of Tungsten Copper Rod

Electrical conductivity is the core advantage of tungsten copper rods in electrical applications. The continuous network of copper phases acts like an efficient highway, providing a smooth conductive path for electrical current. While the addition of tungsten slightly increases resistivity, it significantly enhances the material's arc resistance and overall stability. This balanced design makes tungsten copper rods excellent for high-voltage electrical contacts or switchgear, allowing for the smooth passage of high currents while resisting damage caused by arc erosion. In practical applications, the electrical properties of tungsten copper rods make them a preferred electrode material, capable of handling high-frequency or high-power signals without excessive heat generation or signal degradation. The flexible resistivity variation based on tungsten content allows for customized applications, such as reducing the tungsten content in conductors requiring low resistance or increasing it in wear-resistant electrical contacts to extend their lifespan. Overall, the optimized conductivity and resistivity make tungsten copper rods highly suitable for the electrical field, balancing conduction efficiency with long-term reliability.

4.2 Mechanical properties of tungsten copper rod

The mechanical properties of tungsten copper rods guarantee their reliability in mechanical stress environments. These properties combine the rigidity of tungsten with the flexibility of copper, creating a tungsten rod that, like a warrior, can withstand wear, impact, and deformation. These characteristics allow the material to shine in dynamic applications, allowing it to withstand not only static loads but also repeated mechanical challenges.

4.2.1 Hardness and Strength of Tungsten Copper Rod

Hardness is a prominent manifestation of the mechanical properties of tungsten copper rods. The uniform distribution of tungsten particles acts like a sturdy skeletal framework, enhancing the material's resistance to external pressure and making it less susceptible to scratching or deformation in high-pressure or high-friction environments. This hardness characteristic is particularly useful in molds and cutting tools, as it maintains sharp edges and extends tool life. Strength is reflected in its performance under tension, compression, and bending. The addition of tungsten significantly increases the material's tensile strength, allowing the tungsten copper rod to maintain structural integrity under load and avoid sudden fracture. In buildings or mechanical components, this strength acts like supporting beams and columns, ensuring safety and reliability. Through advanced manufacturing processes, these properties can be further enhanced, allowing tungsten copper rods to adapt to even more demanding industrial environments, like a fortress that will never collapse.

4.2.2 Ductility and toughness of tungsten copper rod

The ductility comes from the flexible nature of the copper phase, which allows the tungsten copper rod to deform slightly under stress without immediately breaking, which is in stark contrast to the brittleness of pure tungsten, making the material easier to process and form. During stretching or bending, this ductility acts as an elastic buffer for the material, absorbing some energy and preventing catastrophic failure. Toughness reflects the material's ability to absorb impact energy. In a vibration or collision environment, the tungsten copper rod can buffer external forces and maintain overall integrity. This property plays a key role in automotive parts or vibrating equipment, allowing the material to remain durable under repeated stress and avoid damage caused by fatigue accumulation. By optimizing the tungsten copper interface, ductility and toughness can be further improved, allowing the tungsten copper rod to perform well in dynamic applications.

4.2.3 Wear resistance and impact resistance of tungsten copper rod

Wear resistance serves as a protective layer for tungsten copper rods in frictional environments. The hard phase of tungsten, like diamond, resists erosion by wear particles, significantly extending the material's service life. In high-speed machinery or environments subject to severe wear, this wear resistance ensures a smooth, long-lasting surface and prevents performance degradation. Impact resistance is achieved through the composite structure's energy dispersion mechanism, where impact forces are evenly absorbed at the tungsten-copper interface, preventing localized damage. This property acts as a cushion, protecting the material from collisions or drops. The combination of wear resistance and impact resistance makes tungsten copper rods a reliable choice for military equipment or heavy industrial tools, capable of withstanding rigorous testing while maintaining functionality.

4.3 Chemical Properties of Tungsten Copper Rod

The chemical properties of tungsten copper rods determine their performance in corrosive or high-temperature chemical environments. These properties act like the material's "immune system," resisting external corrosion and ensuring long-term stability and safety.

4.3.1 Oxidation and corrosion resistance of tungsten copper rod

Oxidation resistance is particularly important in high-temperature air. Tungsten's stable oxide layer acts as a protective film, slowing the oxidation of the copper phase and maintaining the material's integrity in scorching environments. This antioxidant capacity makes tungsten copper rods suitable for furnaces or exhaust systems, preventing rapid degradation. Corrosion resistance shines in acidic, alkaline, or humid environments. Tungsten copper rods withstand the erosion of a wide range of chemical media, like a guardian that is unfazed by the elements. In chemical pipelines or marine equipment, this characteristic extends service life and reduces maintenance requirements. Surface treatment can further enhance these properties, allowing the material to withstand harsh chemical conditions.

4.3.2 High-temperature chemical stability of tungsten copper rod

High-temperature chemical stability allows tungsten copper rods to remain inert in hot gases or molten media. Tungsten's chemical inertness prevents unwanted reactions or decomposition. This stability acts as a stabilizing force in a furnace, ensuring reliable operation in high-temperature reactors or sensors and preventing failures caused by phase changes. In metallurgy and energy, this property supports sustained high-temperature operation and maintains the material's structure and function.

4.3.3 Compatibility of Tungsten Copper Rod with Other Metals

Compatibility with other metals is another major advantage of tungsten copper rods. They can easily form a stable interface with aluminum, steel, or nickel, preventing interfacial separation or corrosion. This compatibility acts as a bridge, connecting dissimilar materials and playing a role in composite structures such as electronic connectors, ensuring the stability of the entire system. During welding or alloying, this characteristic simplifies the process and improves efficiency.

4.4 Microstructure and organizational characteristics of tungsten copper rod

The microstructure is the "internal blueprint" of the performance of tungsten copper rods. It reveals the distribution, bonding and evolution of the tungsten copper phase. These characteristics, like the DNA of the material, determine the performance of the macroscopic properties.

4.4.1 Crystal structure and phase composition of tungsten copper rod

The crystal structure is primarily composed of the body-centered cubic lattice of tungsten and the face-centered cubic lattice of copper, each existing independently to form a pseudo-alloy system. This structure allows the material to possess both the rigidity of tungsten and the flexibility of copper, resembling two harmonious architectural frameworks under a microscope. The phase composition resembles a precise puzzle, with the tungsten phase providing a solid framework and the copper phase filling the gaps, ensuring overall balance.

4.4.2 Distribution characteristics of tungsten and copper phases

The tungsten phase is evenly distributed within the copper matrix, like stars dotted across the night sky, avoiding localized clustering and unevenness. This distribution ensures consistent performance, while the copper phase forms a continuous network, enhancing the conductive path. This uniformity is achieved through process control during the manufacturing process, resulting in a material with perfect harmony at the microscopic scale.

4.4.3 Interface bonding mechanism and microstructure analysis

The interfacial bonding mechanism relies primarily on mechanical interlocking and microscopic diffusion, resulting in a tight connection between the tungsten and copper alloys, without significant interfering compound layers. Microstructural analysis reveals a smooth and strong interface with uniform structure, similar to the meshing of precision gears, ensuring efficient energy and stress transfer. Electron microscopy reveals this structure, revealing the source of the material's inherent strength.

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Tungsten Copper Rod Introduction

1. Overview of Tungsten Copper Rod

Tungsten copper rod is composite materials produced by infiltrating high-purity tungsten powder with copper through a vacuum infiltration process. It possesses a unique microstructure that combines the high strength and high melting point of tungsten with the excellent electrical and thermal conductivity of copper. This results in a high-performance material with outstanding thermal stability, wear resistance, and electrical conductivity.

2. Characteristics of Tungsten Copper Rod

High Thermal Conductivity: The excellent thermal conductivity of copper ensures rapid heat dissipation, making it suitable for high-power devices and laser systems.

High Strength and High-Temperature Resistance: The stable mechanical properties of tungsten allow the material to remain reliable under extreme high-temperature conditions.

Resistance to Arc Erosion: The tungsten-copper composite structure provides exceptional resistance to arc erosion in electrical applications, significantly extending electrode service life.

Low Thermal Expansion Coefficient: Effectively reduces thermal stress and improves structural stability.

Excellent Machinability: Can be precisely fabricated into electrodes, heat sinks, or complex parts to meet diversified application requirements.

3. Performance Parameters of Tungsten Copper Rod

Product Name	Chemical Composition (%)		Physical and Mechanical Properties			
	Impurities ≤	W	Density (g/cm³)	Hardness (HB)	Resistivity (mΩ·cm)	Tensile Strength (MPa)
W50Cu	0.5	Balance	11.85	115	3.2	—
W60Cu	0.5	Balance	12.75	140	3.7	—
W70Cu	0.5	Balance	13.8	175	4.1	790
W80Cu	0.5	Balance	15.15	220	5	980
W90Cu	0.5	Balance	16.75	260	6.5	1160

4. Advantages of Tungsten Copper Rod

High-Performance Combination: A balanced integration of strength, electrical conductivity, thermal conductivity, and high-temperature resistance.

Customized Solutions: Tungsten-to-copper ratio and dimensions can be tailored to meet specific customer requirements.

Long Service Life and Stability: Significantly reduces maintenance and replacement costs.

5. Procurement Information

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Chapter 5 Main Application Fields of Tungsten Copper Rod

As a high-performance composite material, tungsten copper rod combines the high strength and high-temperature resistance of tungsten with the excellent electrical and thermal conductivity of copper, making it widely used in a variety of high-tech fields. Its unique physical and chemical properties enable it to maintain stability and reliability in demanding operating environments, meeting the stringent requirements of industries such as electrical and electronics, aerospace and defense, machinery manufacturing, and thermal management. This chapter will explore in detail the applications of tungsten copper rod in electrical and electronics, aerospace and defense, machinery and molds, thermal management, and other emerging fields, focusing on its functions, advantages, challenges, and technical requirements. Through professional and detailed descriptions, it will clarify its important position in modern industry.

5.1 Electrical and Electronics

Tungsten copper rods have important applications in the electrical and electronic fields, primarily due to their high electrical conductivity, excellent arc erosion resistance, and good thermal stability. These properties make them an ideal choice for high-voltage electrical contacts, switch components, and electrodes, and are widely used in power transmission and distribution, as well as microelectronic packaging.

In high-voltage electrical equipment, tungsten copper rods are often used as electrical contact materials. The copper phase provides a low-resistance current path, ensuring efficient current transmission, while the high melting point and hardness of the tungsten phase effectively resist high-temperature ablation and mechanical wear caused by arcing. In high-voltage circuit breakers and switchgear, tungsten copper rod contacts can withstand frequent switching operations and maintain long-term performance stability. For example, in power distribution systems, tungsten copper rod contacts support rapid opening and closing, reducing energy loss and surface damage caused by arcing, thereby extending equipment life. In addition, their anti-adhesion properties ensure that the contacts will not weld under high current shocks, improving system safety.

In the electronics field, tungsten copper rods are widely used as electrodes and connectors in microelectronic packaging. Their coefficient of thermal expansion closely matches that of semiconductor materials (such as silicon and gallium arsenide), effectively reducing stress concentration and crack formation caused by differential expansion during thermal cycling. This property is particularly important in the packaging of high-power integrated circuits and power amplifiers. As a substrate or electrode material, tungsten copper rods ensure a reliable connection between the chip and the substrate, while enabling efficient signal transmission through the high electrical conductivity of the copper phase. Furthermore, their excellent thermal conductivity facilitates rapid heat dissipation, preventing chip failure due to overheating, making them suitable for high-performance electronic devices such as radar systems and communication modules.

Tungsten copper rods are also noteworthy for their use in electrical discharge machining (EDM) electrodes. Their high hardness and wear resistance ensure that the electrodes maintain their shape

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accuracy during machining, while their excellent electrical conductivity supports stable discharge performance. These characteristics make them excellent for precision mold manufacturing and complex part machining, enabling the machining of high-hardness materials such as titanium alloys and cemented carbide.

5.2 Aerospace and Defense Industry

Tungsten copper rods are used in the aerospace and defense industries due to their high density, high temperature resistance, and impact resistance, which allows them to maintain structural integrity and functional reliability in extreme environments. These properties make them an ideal material for rocket engine components, missile seekers, and armor penetration materials.

In the aerospace field, tungsten copper rods are often used to manufacture throat liners and thermal protection components for rocket engine nozzles. Their high melting point and thermal stability can withstand the high-temperature and high-pressure gas erosion in the combustion chamber, preventing material melting or ablation. The high thermal conductivity of the copper phase quickly dissipates heat away from high-temperature areas, preventing local overheating and ensuring the stability of the nozzle during long-term operation. In addition, the high density of tungsten copper rods gives them unique advantages in spacecraft counterweight systems, used to adjust the center of gravity of the aircraft and ensure the accuracy of launch and orbital operation. For example, in satellite attitude control systems, tungsten copper rod counterweights can provide stable inertial balance and meet high-precision dynamic requirements.

In the defense industry, tungsten copper rods are used to manufacture armor-piercing projectile cores and electrical contact components. Their high density and hardness enable them to penetrate tough armor materials, while the toughness of the copper phase enhances the core's impact resistance and reduces the risk of fracture. Furthermore, tungsten copper rods are used as electrode materials in military electronic equipment, maintaining stability under high-power pulse conditions and making them suitable for radar and electronic countermeasure systems. The material's corrosion resistance and high-temperature stability further ensure its reliability in harsh battlefield environments, such as high temperature, high humidity, and salt spray.

5.3 Machinery and mold industry

The application of tungsten copper rod in the machinery and mold industry is mainly based on its high hardness, wear resistance and good processing performance. It is suitable for manufacturing high-precision molds, cutting tools and wear-resistant parts. These characteristics enable it to perform well in high-load and friction environments, extending the service life of equipment and tools.

In mold manufacturing, tungsten copper rods are often used to create EDM and stamping dies. Their high hardness resists wear and deformation during machining, ensuring dimensional accuracy and surface quality. The copper phase's electrical conductivity supports efficient EDM discharge, making it suitable for machining complex geometries such as aerospace components and medical devices. Furthermore, the rod's high thermal conductivity facilitates rapid heat dissipation, reducing thermal fatigue cracking during continuous mold operation and improving production efficiency.

In the cutting tool industry, tungsten copper rods are used as tool materials or tool inserts. Their wear resistance and impact resistance enable them to handle the cutting of high-hardness materials such as stainless steel and titanium alloys, maintaining tool sharpness and life. Furthermore, the toughness of the copper phase reduces the risk of brittle fracture, making them more competitive in high-speed cutting and heavy-load machining. In injection molding and die-casting molds, the high-temperature strength and thermal shock resistance of tungsten copper rods ensure mold stability during repeated heating and cooling cycles, reducing surface cracking and deformation.

5.4 Thermal Management and Heat Dissipation Devices

The application of tungsten copper rod in the field of thermal management and heat dissipation devices benefits from its excellent thermal conductivity and low thermal expansion coefficient, making it an ideal choice for high-power electronic devices and heat sink materials. The high power density of modern electronic devices places higher demands on heat dissipation performance, and tungsten copper rod has demonstrated excellent capabilities in this field.

In high-power electronic devices, tungsten copper rods are often used as heat sink substrates and heat sink materials. Their high thermal conductivity allows them to quickly transfer heat generated by chips or lasers to the external environment, preventing overheating that could lead to performance degradation or device failure. For example, in laser diodes and power amplifiers, tungsten copper rod heat sinks effectively reduce operating temperatures, improving device reliability and lifespan. Their low coefficient of thermal expansion, compatible with semiconductor materials, reduces thermal stress and ensures structural integrity during long-term operation.

In new energy vehicles and 5G communications equipment, tungsten copper rods are used in the manufacture of battery management systems and base station cooling modules. Their rapid thermal conductivity supports efficient heat management, preventing battery overheating or thermal failure of signal processors. Furthermore, their high strength and corrosion resistance enable long-term use in humid or high-temperature environments, meeting the demands of outdoor equipment. In the manufacture of heat pipes and heat exchangers, their thermal conductivity and mechanical stability further enhance system efficiency, making them suitable for data centers and industrial cooling systems.

5.5 Other Application Areas

In addition to the above main fields, tungsten copper rods also show potential in many emerging and specialized fields. Its versatility has continuously expanded its application range.

In the medical field, tungsten copper rods are used to manufacture shielding components and collimators for radiotherapy equipment. Their high density effectively shields X-rays and gamma rays, protecting patients and medical staff from radiation damage, while their processing properties support the manufacture of complex shapes. Furthermore, tungsten copper rods are used as electrodes or heat sinks in medical imaging equipment, improving their performance and stability.

In the renewable energy sector, tungsten copper rods are used as electrical contact components in photovoltaic and wind power generation systems. Their high conductivity and wear resistance support efficient current transmission, while their corrosion resistance ensures long-term reliability in outdoor environments. For example, in solar inverters, tungsten copper rods serve as connector materials, capable of withstanding the challenges of high currents and frequent switching.

In scientific research, tungsten copper rods are often used as components in high-temperature experimental devices and particle accelerators. Their high-temperature and impact resistance enable them to withstand extreme experimental conditions, such as high-temperature plasma environments or high-energy particle impacts. Furthermore, their electrical and thermal conductivity support signal transmission and heat management in precision experimental equipment.

In the sports and entertainment sectors, tungsten copper rods are used to manufacture high-precision sports equipment, such as golf club weights. Their high density allows for ideal weight distribution within a small volume, improving the balance and handling of the equipment. While this application is niche, it demonstrates the potential of tungsten copper rods in non-industrial applications.

In summary, tungsten copper rods, with their excellent comprehensive properties, demonstrate broad application prospects in electrical and electronics, aerospace and defense, machinery and molds, thermal management, and other emerging fields. Their combination of high conductivity, high-temperature resistance, and mechanical strength enables them to withstand complex and demanding operating environments, providing reliable support for the development of modern industry and technology. With advances in materials science, the application areas of tungsten copper rods are expected to expand further, bringing innovative solutions to even more industries.

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Tungsten Copper Rod Introduction

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High Thermal Conductivity: The excellent thermal conductivity of copper ensures rapid heat dissipation, making it suitable for high-power devices and laser systems.
High Strength and High-Temperature Resistance: The stable mechanical properties of tungsten allow the material to remain reliable under extreme high-temperature conditions.
Resistance to Arc Erosion: The tungsten-copper composite structure provides exceptional resistance to arc erosion in electrical applications, significantly extending electrode service life.
Low Thermal Expansion Coefficient: Effectively reduces thermal stress and improves structural stability.
Excellent Machinability: Can be precisely fabricated into electrodes, heat sinks, or complex parts to meet diversified application requirements.

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Customized Solutions: Tungsten-to-copper ratio and dimensions can be tailored to meet specific customer requirements.
Long Service Life and Stability: Significantly reduces maintenance and replacement costs.

5. Procurement Information

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Chapter 6 Production Equipment and Process Control of Tungsten Copper Rod

The production of tungsten copper rods is a complex powder metallurgy process involving multiple key steps, including powder preparation, forming, sintering, vacuum infiltration, post-processing, and quality inspection. Each step requires sophisticated production equipment and strict process control to ensure the stability and consistency of material properties. The design and operation of production equipment directly determine the microstructure, physical properties, and final product quality of the tungsten copper rods, while process control achieves high efficiency and low defect rates through precise parameter management. This chapter will detail the main equipment involved in the tungsten copper rod production process and its functions. In combination with the key points of process control, it will analyze equipment selection, operating requirements, and optimization strategies to provide technical guidance for industrial production.

6.1 Powder Preparation and Forming Equipment

Powder preparation and forming equipment is fundamental to tungsten copper rod production. It is used to prepare high-purity tungsten powder and electrolytic copper powder and press them into preformed blanks. These equipment must ensure powder purity, particle size distribution, and uniformity of the formed blanks, laying the foundation for subsequent sintering and infiltration.

Powder preparation equipment mainly includes hydrogen reduction furnaces and electrolytic refining systems. The hydrogen reduction furnace is used to prepare high-purity tungsten powder from tungstate or tungsten trioxide. It usually adopts a tubular furnace or a rotary furnace, equipped with a precise temperature control system and a hydrogen supply device. The temperature in the furnace is clearly divided, and the primary reduction and secondary reduction are carried out in different temperature zones to ensure that the powder particle size is uniform and the oxygen content is low. The electrolytic refining system is used to produce electrolytic copper powder. It includes an electrolytic cell, a cathode plate and a current control device. The electrolyte circulation system ensures the high purity and consistency of the copper powder. In addition, the airflow classifier and the vibrating screen are used to control the powder particle size distribution. The particles of different sizes are separated by high-speed airflow or screen to ensure that the particle size of tungsten powder and copper powder meet the process requirements.

Forming equipment primarily includes uniaxial presses and isostatic presses. Uniaxial presses, driven hydraulically or mechanically, compress tungsten powder (which can be mixed with a small amount of copper powder or a binder) into a green body in a steel mold. They are equipped with pressure sensors and automated control systems for precise pressure application and hold time control. Isostatic presses, on the other hand, apply uniform pressure through a liquid or gaseous medium and are suitable for forming large or complex-shaped green bodies. Equipped with a high-pressure pump and flexible molds, they significantly improve green body density uniformity. During the forming process, the mold design and demolding system are crucial. Wear-resistant materials and lubrication devices are required to prevent surface defects or sticking.

In terms of process control, powder preparation requires strict monitoring of the reducing atmosphere, temperature gradient, and electrolyte composition to ensure powder purity exceeds 99.95% and a particle size distribution within the 1-5 μm range. During the forming process, pressure, binder addition, and demolding speed must be precisely adjusted to avoid cracks in the green body or density gradients. Equipment maintenance and cleaning are also crucial to prevent contamination from impurities or equipment wear that could affect powder quality.

6.2 Vacuum Sintering and Preform Preparation Equipment

Vacuum sintering and preform preparation equipment is used to transform the pressed green body into a porous tungsten skeleton with appropriate porosity and strength, providing the structural foundation for subsequent vacuum infiltration. These equipment must have high-precision temperature control and atmosphere management capabilities to ensure sintering process stability and skeleton uniformity.

The vacuum sintering furnace is the core equipment, typically utilizing resistance or induction heating and equipped with a multi-zone temperature control system and vacuum pumping system. The furnace body is constructed of high-temperature resistant materials (such as stainless steel or quartz) and is equipped with graphite or molybdenum heating elements, enabling high-temperature sintering at temperatures of 1200-1600°C. The vacuum pumping system, consisting of both a mechanical pump and a diffusion pump, maintains a vacuum level below 10^{-3} Pa within the furnace , preventing oxidation and facilitating gas discharge. Some sintering furnaces support hydrogen atmosphere sintering and are equipped with a hydrogen supply and exhaust gas treatment system to reduce surface oxides and enhance particle bonding efficiency. The multi-zone heating design ensures a uniform temperature field, minimizing green body deformation and localized overburning.

Preform preparation may also involve auxiliary equipment such as a debinding furnace and a pore-forming agent treatment system. The debinding furnace removes binders (such as polyvinyl alcohol) from the pressed green body. By heating at low temperatures (400-600°C) in a protective atmosphere, it decomposes organic matter to prevent residual carbides that could affect the quality of the preform. The pore-forming agent treatment system is used to add and remove temporary pore-forming agents (such as ammonium bicarbonate) and control porosity through precise metering and heat treatment.

In process control, sintering temperature, holding time, and heating rate are key parameters. The temperature needs to be increased gradually to avoid thermal stress-induced cracking in the green body; the holding time is controlled between 2-4 hours to ensure a strong neck connection between the particles. Real-time monitoring of vacuum level or hydrogen flow prevents oxidation and the introduction of impurities. Porosity is controlled by optimizing the powder particle size ratio and sintering parameters, aiming for a connected porosity of 20-40% to support subsequent copper infiltration.

6.3 Vacuum Infiltration Equipment

Vacuum infiltration equipment is the core of tungsten copper rod production, responsible for infiltrating molten copper into the porous tungsten skeleton to form a dense composite material.

This equipment must have high vacuum performance, precise temperature control, and a stable operating environment to ensure uniform copper filling and avoid defects.

A vacuum infiltration furnace typically consists of a vacuum chamber, heating system, vacuum pump assembly, and cooling system. The vacuum chamber is constructed of high-temperature resistant materials and contains a graphite crucible for holding the tungsten preform and copper block. The heating system typically utilizes medium-frequency induction heating, capable of rapidly raising the temperature to 1100-1300 °C, ensuring complete melting and proper fluidity of the molten copper. The vacuum pump assembly, including Roots and molecular pumps, maintains a vacuum pressure below 10^{-3} Pa, eliminating gas resistance and promoting spontaneous infiltration of the copper. The cooling system uses water or air cooling to control the cooling rate and prevent cracking caused by thermal stress. Some advanced equipment is equipped with a high-pressure gas assist system, which uses inert gases (such as argon) to apply additional pressure to enhance penetration depth.

The infiltration furnace operation process consists of four stages: preheating, melting, infiltration, and cooling. The preheating stage heats the tungsten preform to 1000-1100°C to remove surface adsorbed gases. The melting stage heats the copper block above its melting point, allowing the molten copper to penetrate the skeleton under capillary forces and vacuum pressure. The holding stage ensures that the molten copper fully fills the pores. The cooling stage uses programmed cooling to avoid structural defects. The equipment must be equipped with high-precision temperature sensors and vacuum monitoring systems to provide real-time feedback on process parameters.

In process control, copper infiltration temperature, vacuum level, and holding time are critical. The temperature must be above the melting point of copper but below the recrystallization temperature of tungsten to prevent copper volatilization or skeletal grain coarsening. The vacuum level must be maintained consistently to prevent bubble formation or oxidation reactions. Infiltration dynamics are influenced by pore size and wettability and must be optimized through preform design and the addition of wetting agents (such as trace amounts of chromium). Regarding equipment maintenance, regular inspection of crucibles and heating elements is crucial to prevent material contamination or a decrease in thermal efficiency.

6.4 Post-processing and machining equipment

Post-processing and machining equipment are used to eliminate residual stress during the preparation process, adjust material properties, and achieve precise dimensional forming. These equipment must have high precision and wear resistance to cope with the high hardness and composite properties of tungsten copper rods.

Post-processing equipment primarily includes heat treatment furnaces and annealing furnaces. Heat treatment furnaces utilize a hydrogen or vacuum atmosphere, maintaining temperatures between 800°C and 1000°C for 1-3 hours to eliminate residual stresses generated during infiltration and cooling, thereby improving material toughness. Annealing furnaces utilize multi-stage heating and slow cooling to optimize crystal structure and reduce internal defects. The equipment is equipped with a precise temperature control system and atmosphere circulation device to ensure uniformity and safety during the heat treatment process.

Machining equipment includes CNC lathes, milling machines, grinders, and EDM machines. CNC lathes and milling machines are used for roughing and finishing, equipped with diamond or carbide tools to adapt to the high hardness of tungsten copper rods. Cutting speeds and feed rates must be strictly controlled to avoid overheating or surface damage. Grinders are used to achieve high surface finish (Ra < 0.2 μm) and process complex shapes through multi-axis linkage. EDM machines are suitable for the processing of precision molds and tiny features, utilizing the inherent conductivity of tungsten copper rods for efficient discharge machining. During the machining process, the coolant circulation system and tool wear monitoring device are key to ensuring machining accuracy and equipment life.

During process control, heat treatment requires optimizing the temperature profile and holding time to prevent overheating, which can lead to copper precipitation and strength loss. Machining requires CNC programming and online measurement to maintain dimensional tolerances within 0.01 mm. Tool selection and matching cutting parameters are crucial to avoiding microcracks and surface roughness.

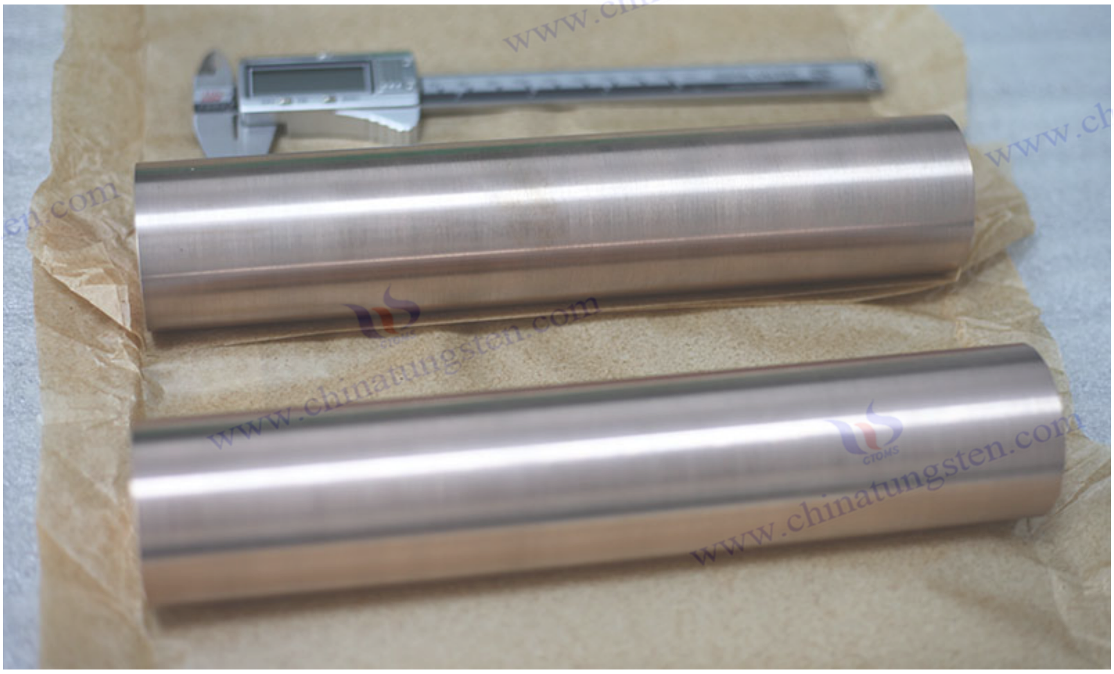
6.5 Testing and quality control equipment

Testing and quality control equipment is used to evaluate the performance and consistency of tungsten copper rods to ensure that the products meet the design requirements. These equipment covers physical, chemical and microstructural analysis throughout the production process.

Density measurement equipment, including an Archimedean densitometer and an X-ray density scanner, is used to assess the material's density and porosity, ensuring that there are no unfilled areas after infiltration. A thermal conductivity tester uses a laser flash method or heat flow method to measure the thermal conductivity of tungsten copper rods, verifying their thermal management capabilities. An electrical conductivity tester measures resistivity using a four-point probe method to ensure that the material meets electrical application requirements. Mechanical property testing equipment, including a universal testing machine and a hardness tester, is used for tensile, compression, flexural, and hardness testing, respectively, to assess the material's strength and wear resistance.

Microstructural analysis equipment includes scanning electron microscopes (SEMs), X-ray diffractometers (XRDs), and energy dispersive spectroscopy (EDS). SEMs are used to observe the distribution of tungsten and copper phases and interfacial bonding, detecting cracks or unpenetrated areas. XRDs analyze crystal structure and phase composition to ensure the absence of impurity phases. EDSs examine elemental distribution to verify material purity and uniformity. Nondestructive testing equipment such as ultrasonic flaw detectors and X-ray CT scanners are used to detect internal defects such as bubbles or inclusions, ensuring product quality.

In process control, testing must cover the entire process, from raw materials to semi-finished products and finished products. Particle size analyzers and chemical analysis are used to ensure quality during the powder stage. Online temperature and vacuum monitoring during the sintering and infiltration stages controls process stability. Multi-dimensional testing verifies performance consistency during the finished product stage. A data management system records and analyzes test results, allowing statistical process control (SPC) methods to optimize production parameters and reduce defect rates.



Chapter 7 Quality Inspection and Evaluation Methods of Tungsten Copper Rod

As a high-performance composite material, the quality inspection and evaluation of tungsten copper rods are critical to ensuring their stability and reliability in applications such as electrical, electronics, aerospace, and thermal management. Quality inspection encompasses not only a preliminary examination of appearance and dimensions but also a comprehensive assessment of physical, mechanical, chemical, and microstructural properties. These inspection methods, utilizing sophisticated equipment and standardized processes, fully verify that the tungsten copper rods meet design requirements, identify potential defects, and provide a basis for process optimization. This chapter systematically explains the quality inspection and evaluation methods for tungsten copper rods, detailing the technical principles, operational procedures, equipment requirements, and critical control points of each inspection step. Comparisons are also made to commonly used international standards, providing professional guidance for production and application.

7.1 Appearance and Dimension Inspection of Tungsten Copper Rod

Appearance and dimensional inspection are the first steps in the quality control of tungsten copper rods, aiming to ensure that the surface quality and geometric accuracy of the material meet the design specifications and lay the foundation for subsequent performance testing. Appearance inspection focuses on the surface integrity of the material, checking for defects such as cracks, pores,

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inclusions, copper pools or burns. These defects may be caused by uneven pressing, sintering defects or insufficient infiltration during the preparation process. Inspection is usually carried out by visual inspection combined with a magnifying glass or a low-power microscope. The operator needs to observe the surface of the rod under a bright and uniform light source to ensure that there are no defects visible to the naked eye. For tungsten copper rods with complex shapes, industrial endoscopes can be used to inspect internal surfaces or hard-to-reach areas.

Dimensional inspection ensures that the geometric parameters of the tungsten copper rod (such as diameter, length, and roundness) meet tolerance requirements, typically using high-precision measuring tools. Micrometers and vernier calipers are used to measure basic dimensions with an accuracy of up to 0.01 mm. For higher precision requirements, a coordinate measuring machine (CMM) uses a multi-point contact probe to scan the three-dimensional profile of the rod and check whether the tolerance is within 0.005 mm. Laser scanners quickly acquire surface profile data through a non-contact method, making them suitable for rapid inspection in large-scale production. Dimensional inspection also needs to account for minor deformations that may occur after heat treatment or machining, so multiple measurements are required at different stages of production.

During process control, visual inspection requires a standardized defect classification system. For example, criteria should be established based on defect size and type (e.g., a crack length <0.1 mm is acceptable). Dimensional inspection requires calibrated measuring equipment to ensure repeatability and accuracy, while also recording ambient temperature to correct for thermal expansion effects. Early identification of defects can be traced back to specific steps in the manufacturing process, such as insufficient pressing pressure or excessive infiltration temperature, providing data support for process optimization.

7.2 Physical properties test of tungsten copper rod

Physical property testing evaluates the density, thermal conductivity, electrical conductivity, and thermal expansion characteristics of tungsten copper rods, all of which directly impact their performance in thermal management and electrical applications. Density testing utilizes the Archimedean principle, using a high-precision electronic balance to measure the rod's mass in air and liquid. The calculated density is then compared to theoretical values to assess infiltration completeness and porosity. The density of a typical tungsten copper rod ranges from 11.8 to 17.0 g/cm³, depending on the tungsten content (50-90 wt %). Density deviations can indicate unfilled areas or uneven copper distribution.

Thermal conductivity testing utilizes a laser flash method, using equipment consisting of a laser thermal conductivity meter and a sample heating device. The rod sample is heated by a laser pulse, and an infrared detector measures the change in backside temperature over time to calculate thermal conductivity. The thermal conductivity of tungsten copper rods typically ranges from 180 to 250 W/m·K, depending on the copper content and microstructural uniformity. Electrical conductivity testing utilizes a four-point probe method, measuring resistivity using a constant current source and a voltmeter, which is then converted to electrical conductivity (typically 30-50% IACS). High electrical conductivity is critical for electrical contact applications, while thermal conductivity determines heat sink performance.

Thermal expansion coefficient testing is performed using a thermomechanical analyzer (TMA). The sample is heated at a controlled temperature (20-1000°C) and its linear expansion is measured . The thermal expansion coefficient of tungsten copper rods is typically between 6 and 10×10^{-6} /K, which matches well with semiconductor materials and is suitable for electronic packaging. The test requires a controlled heating rate (5-10°C/min) to avoid thermal stress affecting the results.

During process control, physical property testing must ensure consistent sample preparation, such as surface flatness and dimensional standardization. The testing environment must be humidity and temperature controlled to prevent external interference. Results are analyzed using statistical methods (such as mean and standard deviation) to assess batch consistency. Outliers can indicate process defects, such as excessive porosity or uneven copper phase distribution.

7.3 Mechanical Properties Test of Tungsten Copper Rod

Mechanical testing evaluates the hardness, strength, toughness, and wear resistance of tungsten copper rods, ensuring their reliability in mechanically stressed environments. Hardness testing utilizes a Vickers or Brinell hardness tester, which applies a specific load to the rod surface and measures the indentation size. The hardness of tungsten copper rods increases with tungsten content, typically ranging from 100-250 HV, making them suitable for wear-resistant applications such as molds and electrodes.

Strength testing includes tensile, compression, and bending tests, which are performed using a universal testing machine. Tensile testing measures tensile strength and elongation. The tensile strength of tungsten copper rods is usually between 500-800 MPa, and the elongation is low (1-5%), reflecting its limited ductility. Compression testing evaluates compressive strength and is suitable for counterweights or high-pressure components, usually in the range of 800-1200 MPa. The three-point bending test measures flexural strength and fracture toughness, reflecting the performance of the material under dynamic loads. The test requires the use of standard samples (such as tensile specimens specified in ASTM E8) and the control of the loading rate to ensure accurate results.

Wear resistance testing uses a tribometer to measure mass loss or wear scar depth by sliding a sample against a standard abrasive (such as aluminum oxide) under a specific load. Impact resistance testing is performed using a drop weight test or a Charpy impact tester to assess the material's ability to absorb impact energy. The wear and impact resistance of tungsten copper rods is due to the hardness of tungsten and the toughness of copper, making them suitable for high-speed cutting or vibration environments.

During process control, mechanical testing must ensure that the sample surface is free of defects, and testing equipment must be regularly calibrated. Test results must be combined with microstructural analysis to assess whether performance degradation is caused by poor interfacial bonding or porosity. Batch-to-batch consistency in mechanical properties is monitored through statistical process control (SPC) to ensure consistent product quality.

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Tungsten Copper Rod Introduction

1. Overview of Tungsten Copper Rod

Tungsten copper rod is composite materials produced by infiltrating high-purity tungsten powder with copper through a vacuum infiltration process. It possesses a unique microstructure that combines the high strength and high melting point of tungsten with the excellent electrical and thermal conductivity of copper. This results in a high-performance material with outstanding thermal stability, wear resistance, and electrical conductivity.

2. Characteristics of Tungsten Copper Rod

High Thermal Conductivity: The excellent thermal conductivity of copper ensures rapid heat dissipation, making it suitable for high-power devices and laser systems.
High Strength and High-Temperature Resistance: The stable mechanical properties of tungsten allow the material to remain reliable under extreme high-temperature conditions.
Resistance to Arc Erosion: The tungsten-copper composite structure provides exceptional resistance to arc erosion in electrical applications, significantly extending electrode service life.
Low Thermal Expansion Coefficient: Effectively reduces thermal stress and improves structural stability.
Excellent Machinability: Can be precisely fabricated into electrodes, heat sinks, or complex parts to meet diversified application requirements.

3. Performance Parameters of Tungsten Copper Rod

Product Name	Chemical Composition (%)		Physical and Mechanical Properties			
	Impurities ≤	W	Density (g/cm³)	Hardness (HB)	Resistivity (mΩ·cm)	Tensile Strength (MPa)
W50Cu	0.5	Balance	11.85	115	3.2	—
W60Cu	0.5	Balance	12.75	140	3.7	—
W70Cu	0.5	Balance	13.8	175	4.1	790
W80Cu	0.5	Balance	15.15	220	5	980
W90Cu	0.5	Balance	16.75	260	6.5	1160

4. Advantages of Tungsten Copper Rod

High-Performance Combination: A balanced integration of strength, electrical conductivity, thermal conductivity, and high-temperature resistance.
Customized Solutions: Tungsten-to-copper ratio and dimensions can be tailored to meet specific customer requirements.
Long Service Life and Stability: Significantly reduces maintenance and replacement costs.

5. Procurement Information

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7.4 Chemical Property Testing of Tungsten Copper Rod

Chemical performance testing evaluates the oxidation resistance, corrosion resistance, and high-temperature chemical stability of tungsten copper rods, ensuring their reliability in harsh chemical environments. Oxidation resistance testing is performed using a thermogravimetric analyzer (TGA). The sample is heated in air or oxygen (200-1000°C) and the mass change is measured to assess the oxidation rate. Tungsten copper rods exhibit excellent oxidation resistance due to their stable tungsten oxide layer, which suppresses the oxidation tendency of the copper phase at high temperatures.

Corrosion resistance testing uses either immersion tests or electrochemical tests. Immersion tests place samples in an acidic (e.g., sulfuric acid), alkaline (e.g., sodium hydroxide), or salt spray environment to observe the degree of surface corrosion and mass loss. Electrochemical testing uses potentiokinetic polarization to measure corrosion potential and corrosion current density, assessing the material's stability in the corrosive medium. Tungsten copper rods exhibit excellent corrosion resistance in a variety of chemical environments, making them suitable for marine or chemical applications.

High-temperature chemical stability testing is performed in a high-temperature furnace. The sample is exposed to a specific gas (such as nitrogen, hydrogen, or carbon dioxide) to detect whether a phase change or chemical reaction occurs. The high-temperature inertness of tungsten copper rods makes them stable in high-temperature reactors or sensors.

During process control, chemical performance testing requires controlled environmental conditions (such as temperature, humidity, and gas purity) to ensure reproducible results. Sample surfaces must be clean to prevent contamination that could affect the test. Results analysis should be combined with microstructural analysis to assess whether impurities or interfacial defects are contributing to the degradation of chemical performance.

7.5 Microstructure and Structure Analysis of Tungsten Copper Rod

Microstructural and structural analysis deeply reveals the microscopic properties of tungsten-copper rods, assessing the distribution of tungsten-copper phases, interfacial bonding, and defects, providing a basis for performance optimization. Scanning electron microscopy (SEM) is the primary tool used to observe the distribution and morphology of the tungsten-copper phases and detect the presence of unpenetrated areas, cracks, or inclusions. The SEM, equipped with backscattered electron (BSE) mode, can distinguish between tungsten (high atomic number, bright areas) and copper (dark areas), clearly demonstrating the uniformity of the phase distribution.

X-ray diffractometers (XRD) are used to analyze crystal structure and phase composition, verifying the body-centered cubic (BCC) structure of tungsten and the face-centered cubic (FCC) structure of copper, and detecting the formation of impurity phases (such as oxides). Energy dispersive spectroscopy (EDS) combined with scanning electron microscopy (SEM) analyzes elemental distribution, assesses the tungsten-copper ratio and impurity content, and ensures material purity. Electron backscatter diffraction (EBSD) further provides information on grain orientation and interface characteristics, revealing the tungsten-copper bonding mechanism.

Stereoscopic and optical microscopes are used for low-magnification observation to assess macroscopic structural homogeneity and surface defects. X-ray computed tomography (CT) is used for nondestructive internal structural examination to identify hidden bubbles, cracks, or inhomogeneous areas. Porosity analysis is performed using mercury intrusion or image analysis software to quantify pore distribution and connectivity.

For process control, microscopic analysis requires the use of standard sample preparation procedures (e.g., polishing and etching) to avoid artifacts. Test results should be combined with physical and mechanical properties to analyze the impact of microstructure on macroscopic properties. Abnormal structures (e.g., copper pools or porosity) can be traced back to defects in the infiltration or sintering process, providing a basis for optimization.

7.6 Comparison of Commonly Used International Testing Standards and Methods

International testing of tungsten copper rods follows a series of standardized specifications to ensure the comparability and reliability of test results. The following is a comparison of the main international standards and their scope of application:

1. ASTM standards
- ASTM B702: This standard specifies test methods for the chemical composition, physical properties, and mechanical properties of tungsten-copper composite materials, suitable for testing electrical contacts and heat sinks. It includes density, conductivity, hardness, and tensile testing specifications, emphasizing consistent sample preparation and testing conditions.
- ASTM E8: Tensile test standard, applicable to the strength and ductility testing of tungsten copper rods, specifies specimen size and loading rate.
- ASTM E384: Vickers hardness test standard, suitable for evaluating the hardness of tungsten copper rods, with particular emphasis on indenter selection and load control.

2. ISO standards
- ISO 4499-2: Hardness test standard for cemented carbide, partially applicable to tungsten copper rods, specifies the measurement method of Brinell and Vickers hardness.
- ISO 3369: Density test standard, using Archimedes' principle, suitable for density assessment of tungsten copper rods.
- ISO 6892-1: Tensile testing standard for metallic materials, applicable to mechanical properties testing at elevated and room temperatures.

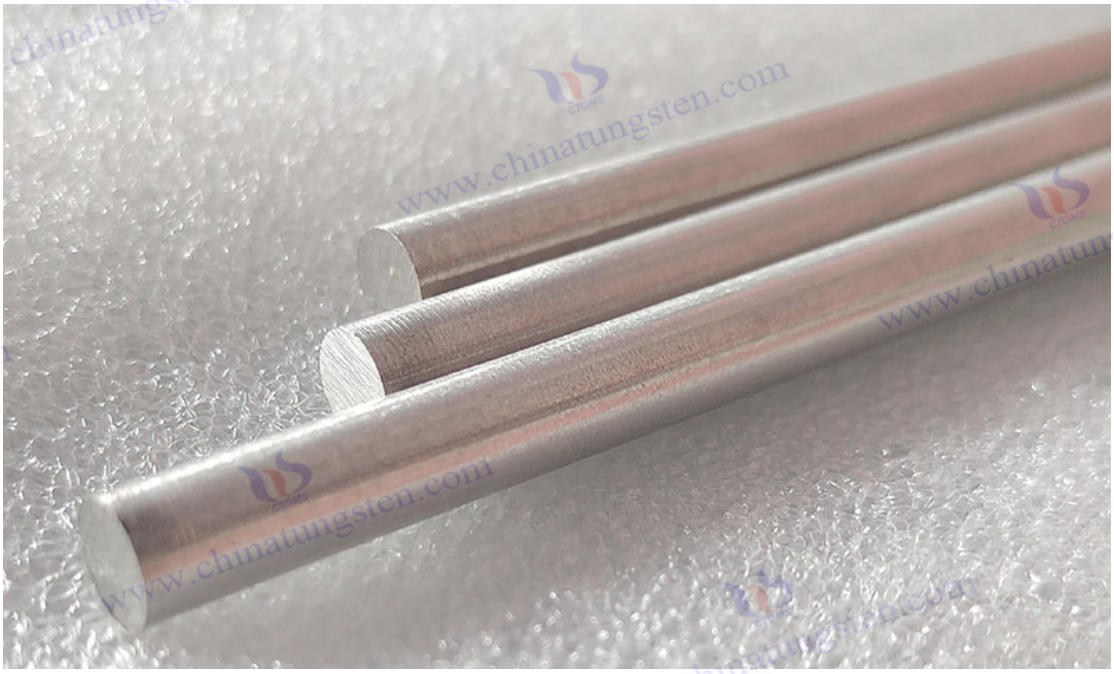
3. Chinese National Standard (GB/T)
- GB/T 3458-2006: Technical conditions for tungsten powder, which specifies the purity, particle size and impurity detection methods of tungsten powder, indirectly affecting the raw material quality of tungsten copper rod.
- GB/T 8320-2017: Tungsten-copper alloy electrical contact material standard, covering test requirements for conductivity, wear resistance, and arc resistance.

- GB/T 26038-2020: Tungsten-based composite materials standard, which specifies density, thermal conductivity and microstructure analysis methods.

4. Other standards
- JIS H 0502 (Japan): a standard for testing the wear resistance of metallic materials, applicable to the evaluation of the friction and wear performance of tungsten copper rods.
- DIN EN 623-4 (Europe): Electrical conductivity test standard for electronic materials, applicable to resistivity measurement of tungsten copper rods.

Method comparison:
ASTM standards focus more on testing for electrical and thermal management applications, emphasizing electrical and thermal conductivity. ISO standards are more general and applicable to a variety of metal composite materials. China's standards, tailored to national conditions, include detailed provisions for raw materials and contact applications. For density testing, the Archimedean method (ASTM, ISO) is simple and efficient, but X-ray CT (GB/T) is more suitable for detecting internal porosity. For mechanical testing, ASTM E8 and ISO 6892-1 are similar in tensile testing methods, but ISO emphasizes high-temperature testing. For microscopic analysis, SEM and XRD are core international methods, but EBSD is more widely used within ASTM and is suitable for interface analysis.

During process control, appropriate standards must be selected based on the application scenario. For example, GB/T 8320 is preferred for electrical contacts, while ASTM B702 is recommended for heat sink materials. Calibration of test equipment and operator training are key to ensuring consistent implementation of standards. Comparing multiple standards can optimize testing processes and enhance the international acceptance of results.



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Chapter 8 Standards and Specifications for Tungsten Copper Rod

As a high-performance composite material, tungsten copper rod's performance and quality requirements are subject to strict standards and regulations worldwide. These standards cover the material's chemical composition, physical and mechanical properties, manufacturing processes, and testing methods, ensuring product reliability and consistency in applications such as electrical, electronics, aerospace, and thermal management. While the standards systems of different countries and regions vary depending on the industrial context and application requirements, they all aim to provide unified technical guidance for the production, testing, and application of tungsten copper rod. This chapter systematically explains the relevant standards for tungsten copper rod in China, internationally, in the United States, Europe, and Japan, analyzing their requirements, scope of application, and differences, and comparatively evaluating their applicability.

8.1 China's National and Industry Standards for Tungsten Copper Rods

China's national and industry standards provide detailed technical specifications for the production and application of tungsten copper rods, combining domestic industrial characteristics, covering raw materials, manufacturing processes, performance testing and quality control. The following are the main relevant standards:

GB/T 3458-2006 Technical Requirements for Tungsten Powder: This standard specifies the chemical composition, particle size distribution, apparent density, and impurity content of tungsten powder. It applies to raw material control in the production of tungsten copper rods. The standard requires a purity of at least 99.95%, an oxygen content of less than 0.05 wt %, and a particle size range of 1-5 μm, ensuring the powder is suitable for pressing and sintering processes. It also specifies testing methods such as X-ray fluorescence (XRF) analysis for impurities and laser particle size analysis.

GB/T 8320-2017 Tungsten-Copper Alloy Electrical Contact Material: This standard is specifically formulated for tungsten-copper rods used as electrical contact materials, covering requirements for chemical composition, conductivity, wear resistance, and arc resistance. The standard stipulates a tungsten content range of 50-90 wt %, a conductivity of at least 30% IACS, and a hardness range of 100-250 HV. Test methods include four-point probe resistivity measurement, Vickers hardness testing, and arc erosion testing. It is applicable to high-voltage switch and circuit breaker contacts.

GB/T 26038-2020 Technical Requirements for Tungsten-Based Composite Materials: This standard applies to tungsten-based composite materials, including tungsten-copper rods, and specifies performance requirements such as density (11.8-17.0 g/cm³), thermal conductivity (180-250 W/m·K), and thermal expansion coefficient ($6\text{-}10\times10^{-6}$ / K). The standard also includes requirements for microstructural analysis, emphasizing uniform distribution of the tungsten-copper phase and the absence of significant porosity. Testing methods include Archimedean density testing, laser flash thermal conductivity testing, and scanning electron microscopy (SEM) observation.

YS/T 649-2016 Tungsten-Copper Alloy Standard for the Nonferrous Metals Industry: This industry standard specifies the chemical composition and machinability of tungsten-copper rods, specifying the performance parameters of different tungsten-copper ratios (e.g., W70Cu30 and W80Cu20). It is suitable for electrode and heat sink applications. The standard requires a surface roughness Ra < 0.2 μm and a dimensional tolerance of ±0.01 mm. It also specifies chemical analysis and mechanical testing methods.

The Chinese standard focuses on practicality and production operability, taking into account the advantages of domestic tungsten resources, emphasizing raw material purity and electrical performance. It is suitable for electrical contacts and thermal management. The strict process control requirements and detailed testing methods provide clear guidance for large-scale production.

8.2 International Standards for Tungsten Copper Rods (ISO, ASTM, IEC, etc.)
International standards provide unified specifications for the global trade and application of tungsten copper rods. They are mainly formulated by the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC), etc., covering material properties and test methods.

ISO 4499-2:2020 Hardness Testing of Cemented Carbide: While primarily focused on cemented carbide, this standard also partially applies to the hardness testing of tungsten-copper rods. It specifies Vickers and Brinell hardness measurement methods, requires a test load range of 5-100 kgf , and ensures accurate indentation dimensions. The standard emphasizes equipment calibration and sample surface preparation, making it suitable for evaluating the wear resistance of tungsten-copper rods.

ISO 3369:2006 Density of Metallic Materials: This standard specifies the Archimedean method for density measurement and is applicable to the density assessment of tungsten-copper rods. It requires the test liquid (e.g., deionized water) to be of high purity and temperature controlled at 20 ± 0.5°C to ensure measurement accuracy. This standard is suitable for verifying the integrity of the infiltration process.

ISO 6892-1:2019, Tensile Testing of Metallic Materials: This standard specifies tensile testing methods at room and elevated temperatures, applicable to the tensile strength and elongation testing of tungsten copper rods. Specimens must conform to standard dimensions (e.g., cylindrical specimens with a diameter of 6-12 mm) and a loading rate of 0.5-2 mm/min. This standard is suitable for evaluating the performance of materials under mechanical stress.

IEC 60468:1974 Test Methods for Electrical Contact Materials: This standard addresses the electrical conductivity and arc resistance of electrical contact materials and is applicable to tungsten copper rods used in switchgear. It specifies resistivity testing (four-point probe method) and arc erosion testing, requiring a minimum electrical conductivity of 30% IACS. Arc resistance is verified through cyclic testing.

International standards are universal, emphasizing compatibility across multiple countries. Their testing methods are scientific and rigorous, making them suitable for export products and high-end applications. ISO standards focus on general testing of material properties, while IEC standards focus on electrical performance, ensuring the reliability of tungsten copper rods in global electrical equipment.

8.3 American Standards for Tungsten Copper Rods (ASTM, ANSI, SAE)

American standards are known for their rigor and application orientation. They are mainly formulated by the American Society for Testing and Materials (ASTM), the American National Standards Institute (ANSI), etc., and are widely used in the North American market and aerospace field.

ASTM B702-93 (2019) Tungsten-Copper Composite Material: This standard is specifically formulated for tungsten-copper composite materials and covers requirements for chemical composition, physical properties, and mechanical properties. It specifies a tungsten content of 50-90 wt %, a density of 11.8-17.0 g/cm³, an electrical conductivity of 30-50% IACS, and a thermal conductivity of 180-250 W/m·K. Test methods include Archimedean density testing, four-point probe resistivity testing, and laser flash thermal conductivity testing. It is applicable to electrical contacts and heat sink materials.

-ASTM E8/E8M-21 Tensile Testing of Metallic Materials: This standard specifies sample preparation, test conditions, and data processing methods for tensile testing. It is applicable to tensile strength (500-800 MPa) and elongation testing of tungsten copper rods. The specimen surface must be free of defects, the test temperature must be controlled at 23±2°C, and the loading rate must be 0.015-0.05 mm/s.

-ASTM E384-17 Vickers Hardness Test: This standard applies to the hardness testing of tungsten copper rods. It specifies a load range of 0.1-100 kgf and an indentation measurement accuracy of ±0.5 μm. The test surface must be polished to Ra < 0.1 μm to ensure accurate results.

-ANSI C63.2-2016 Electromagnetic Compatibility Testing: Although primarily targeted at electromagnetic equipment, this standard partially applies to the conductivity testing of tungsten copper rods as electrode materials, emphasizing low resistivity and arc resistance, and is suitable for radar and communication equipment.

American standards focus on testing requirements for electrical and thermal management applications, with detailed test methods and strict equipment calibration, suitable for high-precision and high-end markets. ASTM standards are widely used in the aerospace and electronics industries, ensuring that tungsten copper rods meet demanding performance requirements.

8.4 European Standards for Tungsten Copper Rods (EN, DIN, BS)

European standards are formulated by the European Committee for Standardization (EN), the German Industrial Standards (DIN) and the British Standards Institution (BS), focusing on material performance and environmental protection requirements, and are suitable for the production and application of tungsten copper rods in the EU market.

-EN 623-4:2004 Electrical Conductivity Test for Electronic Materials: This standard specifies the resistivity test method for metal composite materials, applicable to applications where tungsten-copper rods are used as electrodes and contacts. The test requires the use of a four-point probe method, a minimum conductivity of 30% IACS, and an ambient temperature of 20-25°C.

DIN EN ISO 6507-1:2018 Vickers Hardness Test: Similar to ASTM E384, this standard applies to hardness testing of tungsten-copper rods. It specifies a load range of 0.2–100 kgf , requires high surface flatness, and an indentation measurement accuracy of ±0.5 µm. This standard emphasizes test repeatability and is suitable for wear resistance assessment.

EN ISO 6892-1:2019 Tensile testing of metallic materials: This standard, consistent with ISO standards, specifies the test methods for tensile strength and elongation of tungsten copper rods. It is suitable for evaluating mechanical properties. High specimen processing accuracy is required, and the testing machine calibration must comply with ISO 7500-1.

-BS EN 1011-1:2009 Welding material compatibility: This standard part applies to the welding performance test of tungsten copper rods and other metals, specifies the test methods for interface bonding strength and corrosion resistance, and is suitable for composite structure applications.

European standards focus on environmental protection and safety, and the test methods are highly compatible with international standards, making them suitable for tungsten copper rod products exported to the EU. DIN and EN standards are widely used in the machinery and electronics industries, emphasizing the reliability and consistency of material performance.

8.5 Japanese Standard (JIS) for Tungsten Copper Rod

Japanese Industrial Standards (JIS) provide technical specifications for the production and application of tungsten copper rods, combined with the high precision requirements of Japanese manufacturing, suitable for the electronics and mold industries.

-JIS H 0502:1986 Wear resistance test of metallic materials: This standard specifies friction and wear test methods applicable to evaluating the wear resistance of tungsten copper rods used as molds or electrodes. Standard abrasives (such as aluminum oxide) are used, test loads of 5-50 N are used, and mass loss or wear scar depth is measured.

-JIS Z 2241:2011 Tensile Test of Metallic Materials: This standard specifies sample preparation and test conditions for tensile testing. It applies to the tensile strength and elongation testing of tungsten copper rods. The specimen dimensions must meet the standard, and the loading rate must be 0.5-2 mm/min.

-JIS G 0557:2006 Hardness test method: This standard applies to Vickers and Brinell hardness tests, specifies the hardness measurement process of tungsten copper rods, requires the test surface to be polished, and the load range is 0.1-100 kgf .

-JIS C 2520:1999 Copper alloys for electrical purposes: Although primarily concerned with copper alloys, this standard partially applies to the conductivity testing of tungsten copper rods, specifies the resistivity measurement method, and requires that the conductivity meet the requirements of electrical contact applications.

JIS standards focus on the testing requirements for high-precision manufacturing and electronics applications. Their simple and efficient testing methods are well-suited to the Japanese market's precision machining and electronics industries. They emphasize equipment calibration and standardized operations to ensure reliable test results.

8.6 Comparison and Applicability Analysis of Tungsten Copper Rod Standards

The standards of different countries and regions have similarities and differences in the performance requirements and test methods of tungsten copper rods. Comparative analysis helps to select appropriate specifications and optimize production and application.

Commonalities:

-Chemical composition: All standards require high purity and low impurity content of tungsten copper rods. For example, GB/T 3458 and ASTM B702 stipulate that the purity of tungsten should be ≥99.95% and the purity of copper should be ≥99.99%.

- Physical Properties: Density, electrical conductivity, and thermal conductivity are core test items. ISO 3369, ASTM B702, and GB/T 26038 all use the Archimedes method and laser flash method, with similar test ranges (density 11.8-17.0 g/cm³, thermal conductivity 180-250 W/m·K).

- Mechanical properties: Tensile test and hardness test are common requirements. ISO 6892-1, ASTM E8 and JIS Z 2241 are highly consistent in specimen design and loading rate.

-Test methods: SEM, XRD and four-point probe method are internationally accepted microstructure and conductivity test methods to ensure comparability of results.

difference:

-Focus: The Chinese standard (GB/T 8320) emphasizes electrical contact performance, ASTM B702 focuses on thermal management and aerospace applications, IEC 60468 focuses on electrical performance, and JIS H 0502 highlights wear resistance.

-Testing conditions: ASTM and ISO standards have stricter requirements for high-temperature testing (e.g., tensile testing temperatures can reach 1000°C), while Chinese standards focus more on room-temperature performance. JIS standards have higher surface roughness requirements (Ra < 0.1 μm), making them suitable for precision machining.

- Environmental protection requirements: European standards (EN) emphasize the environmental compatibility and recyclability of materials and stipulate restrictions on hazardous substances, while other standards are less involved.

- Scope of application: ASTM and ISO standards are more suitable for international trade, GB/T standards are suitable for domestic large-scale production, and JIS standards are suitable for high-precision electronic applications.

Applicability analysis:

-Electrical contacts: GB/T 8320 or IEC 60468 are recommended, focusing on conductivity and arc resistance, suitable for high-voltage switches and circuit breakers.

-Heat sink material: ASTM B702 and GB/T 26038 are more applicable, emphasizing the matching of thermal conductivity and thermal expansion coefficient, suitable for microelectronic packaging.

-Mold manufacturing: JIS H 0502 and DIN EN ISO 6507-1 are preferred, focusing on wear resistance and hardness, suitable for EDM and stamping dies.

-Aerospace: ASTM B702 and EN 623-4 are suitable, emphasizing high temperature strength and compatibility, suitable for rocket nozzles and counterweight components.

-International trade: ISO and ASTM standards are more universal and facilitate cross-border certification and market access.

In practice, manufacturers must select standards based on target markets and application scenarios, optimizing processes by integrating multiple standards. For example, tungsten copper rods exported to the EU must comply with the environmental requirements of the EN standard, while domestic electrical contacts prioritize GB/T 8320. Cross-standard testing can enhance product competitiveness, but attention must be paid to consistent equipment calibration and testing conditions to ensure comparable results.

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Tungsten Copper Rod Introduction

1. Overview of Tungsten Copper Rod

Tungsten copper rod is composite materials produced by infiltrating high-purity tungsten powder with copper through a vacuum infiltration process. It possesses a unique microstructure that combines the high strength and high melting point of tungsten with the excellent electrical and thermal conductivity of copper. This results in a high-performance material with outstanding thermal stability, wear resistance, and electrical conductivity.

2. Characteristics of Tungsten Copper Rod

High Thermal Conductivity: The excellent thermal conductivity of copper ensures rapid heat dissipation, making it suitable for high-power devices and laser systems.

High Strength and High-Temperature Resistance: The stable mechanical properties of tungsten allow the material to remain reliable under extreme high-temperature conditions.

Resistance to Arc Erosion: The tungsten-copper composite structure provides exceptional resistance to arc erosion in electrical applications, significantly extending electrode service life.

Low Thermal Expansion Coefficient: Effectively reduces thermal stress and improves structural stability.

Excellent Machinability: Can be precisely fabricated into electrodes, heat sinks, or complex parts to meet diversified application requirements.

3. Performance Parameters of Tungsten Copper Rod

Product Name	Chemical Composition (%)		Physical and Mechanical Properties			
	Impurities ≤	W	Density (g/cm³)	Hardness (HB)	Resistivity (mΩ·cm)	Tensile Strength (MPa)
W50Cu	0.5	Balance	11.85	115	3.2	—
W60Cu	0.5	Balance	12.75	140	3.7	—
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4. Advantages of Tungsten Copper Rod

High-Performance Combination: A balanced integration of strength, electrical conductivity, thermal conductivity, and high-temperature resistance.

Customized Solutions: Tungsten-to-copper ratio and dimensions can be tailored to meet specific customer requirements.

Long Service Life and Stability: Significantly reduces maintenance and replacement costs.

5. Procurement Information

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Chapter 9 Performance Optimization of Tungsten Copper Rod

As a high-performance composite material, tungsten copper rods are widely used in industries such as electronics, aerospace, and power generation due to their excellent electrical and thermal conductivity, high strength, and high-temperature resistance. However, different applications require different performance from tungsten copper rods. Therefore, optimizing the alloy ratio, heat treatment process, microstructure, and wear and corrosion resistance can significantly improve their performance in specific environments. This chapter will delve into the principles, methods, and practical effects of these optimization techniques.

9.1 Effect of Alloy Ratio on Properties

Tungsten copper rods are made of tungsten (W) and copper (Cu) through powder metallurgy. Their properties are directly affected by the ratio of tungsten to copper. The tungsten content is usually between 50% and 90%, and the copper content varies accordingly. Different ratios have a significant impact on the physical, mechanical and thermal properties of the material.

9.1.1 Tungsten-Copper Ratio and Electrical and Thermal Conductivity

Copper is an excellent electrical and thermal conductor, while tungsten has poor electrical and thermal conductivity. The electrical and thermal conductivity of tungsten copper rods increase significantly with increasing copper content. For example, a tungsten copper rod with a 30% Cu content (W70Cu30) has an electrical conductivity of approximately 45% IACS (International Annealed Copper Standard), while at a 10% Cu content (W90Cu10), the conductivity drops to approximately 20% IACS. Thermal conductivity also exhibits a similar trend, with W70Cu30 reaching approximately 200 W/(m·K) and W90Cu10 dropping to approximately 150 W/(m·K). Therefore, tungsten copper rods with higher copper content are often chosen for applications requiring high electrical and thermal conductivity, such as electronic packaging and electrode materials.

9.1.2 Tungsten-Copper Ratio and Mechanical Properties

Tungsten has high hardness and density (19.25 g/cm³), while copper has a lower hardness (approximately 50 HB Brinell hardness). Increasing the tungsten content significantly improves the hardness, compressive strength, and wear resistance of tungsten copper rods. For example, W80Cu20 can reach a hardness exceeding 200 HB, while W60Cu40 has a hardness of only approximately 120 HB. However, increasing the copper content improves the material's toughness and impact resistance. Therefore, a high tungsten content is preferred in applications requiring high hardness and wear resistance (such as mold materials); while an appropriate increase in copper content is recommended for applications requiring a certain degree of toughness (such as electrical contacts).

9.1.3 Tungsten-to-Copper Ratio and Thermal Expansion Coefficient

Tungsten has a low coefficient of thermal expansion (approximately 4.5×10^{-6} / K), while copper has a higher coefficient of thermal expansion (approximately 16.5×10^{-6} / K). The thermal expansion coefficient of tungsten-copper rod increases with increasing copper content. For example, W80Cu20 has a thermal expansion coefficient of approximately 8.0×10^{-6} / K, making it suitable for matching with ceramics or semiconductor materials (such as SiC and AlN) for electronic packaging. Optimizing the tungsten-copper ratio ensures dimensional stability in high-temperature environments and reduces failures caused by thermal stress.

9.1.4 Optimization Strategy

Demand-oriented ratio selection: Choose the appropriate tungsten-copper ratio based on application requirements. For example, for electronic packaging, W70Cu30 or W75Cu25 is preferred to balance thermal conductivity and thermal expansion matching; for EDM electrodes, W80Cu20 is selected to ensure high hardness and wear resistance.

Trace element doping: By adding trace amounts of elements such as silver (Ag) or nickel (Ni), the conductivity or mechanical properties can be further optimized, but care must be taken to control the doping amount to avoid reducing high-temperature resistance.

Process synergy optimization: The optimization of alloy ratios needs to be combined with subsequent sintering and heat treatment processes to ensure the uniformity and stability of material properties.

9.2 Heat Treatment and Performance Enhancement

Heat treatment is an important means to improve the performance of tungsten copper rods. By controlling the heating, insulation and cooling processes, the microstructure of the material can be improved, internal stress can be eliminated and the performance can be enhanced.

9.2.1 Annealing

Annealing, typically performed at 800°C to 1000°C in an inert atmosphere (such as nitrogen or argon), eliminates internal stresses induced during the powder metallurgy process and improves the material's ductility. For example, annealing a W80Cu20 tungsten copper rod at 900°C for two hours can increase its tensile strength from 600 MPa to 650 MPa, while increasing its ductility by approximately 10%. Annealing also improves the uniformity of the copper phase , thereby enhancing electrical and thermal conductivity.

9.2.2 Solution treatment and aging treatment

For tungsten copper rods containing trace additives, a combination of solution treatment (rapid heating above 1000°C followed by quenching) and aging treatment (holding at 400°C to 600°C for several hours) can be used. Solution treatment evenly distributes additives (such as nickel) throughout the matrix, while aging promotes the formation of precipitation phases, thereby increasing hardness and strength. For example, W75Cu25 with a 0.5% nickel addition can achieve a 15% increase in hardness and significantly enhanced wear resistance after solution-aging treatment.

9.2.3 Hot Isostatic Pressing (HIP)

Hot isostatic pressing (HIP) is a high-temperature, high-pressure process (approximately 1000°C, 100 MPa) that significantly reduces porosity and increases density within tungsten copper rods. For example, HIP treatment can increase the density of W80Cu20 from 95% to over 99%, while also increasing thermal conductivity by approximately 10% and compressive strength by approximately 20%. HIP is particularly well-suited for the production of high-performance electronic packaging materials.

9.2.4 Notes

Temperature control: Excessively high heat treatment temperatures may cause the copper phase to melt or volatilize, reducing material properties. Precise control of temperature and holding time is required.

Atmosphere protection: An inert or reducing atmosphere (such as hydrogen) is required during heat treatment to prevent oxidation.

Process cost: Advanced heat treatment processes such as HIP are relatively expensive, and the cost and performance must be weighed based on application requirements.

9.3 Relationship between Microstructure and Properties

The performance of tungsten copper rod is closely related to its microstructure, including the size and distribution of tungsten particles, the continuity of copper phase and the interface bonding state.

9.3.1 Tungsten Particle Size and Distribution

Tungsten particle size typically ranges from 1 to 10 μm. Finer particles increase the material's strength and toughness, but also slightly decrease its electrical and thermal conductivity. Tungsten particle size can be optimized by controlling the powder size and sintering conditions during the powder metallurgy process. For example, W70Cu30 produced using 1 μm ultrafine tungsten powder can achieve a tensile strength of 700 MPa, approximately 15% higher than that of material produced using 5 μm tungsten powder.

9.3.2 Relationship between microstructure and properties

The copper phase forms a continuous network within the tungsten copper rod, directly impacting its electrical and thermal conductivity. Sintering temperature and pressure are key factors influencing copper phase continuity. For example, W75Cu25 sintered at 1350°C exhibits a more uniform copper phase network, increasing electrical conductivity by approximately 8%. Furthermore, liquid-phase sintering promotes copper penetration and enhances interphase bonding, but over-firing, which can lead to copper phase loss, must be avoided.

9.3.3 Interface Bonding State

The quality of the tungsten-copper interface is crucial to material performance. Interface defects (such as pores or cracks) can reduce thermal conductivity and mechanical strength. Optimizing the sintering process (such as vacuum sintering or adding trace amounts of surfactants) can enhance interfacial bonding. For example, adding 0.1% Co improves wettability at the tungsten-copper interface, reduces interfacial resistance, and increases thermal conductivity by approximately 5%.

9.3.4 Microstructure Analysis Technology

Scanning electron microscopy (SEM): used to observe the tungsten particle distribution and copper phase network.
X-ray diffraction (XRD): Analyze crystal structure and phase composition.
Electron Backscatter Diffraction (EBSD): Study interface bonding and grain orientation.

Through these technologies, the impact of microstructure on performance can be accurately evaluated, providing a basis for process optimization.

9.4 Optimization of wear and corrosion resistance

Tungsten copper rods often need to have excellent wear and corrosion resistance in high temperature, high pressure or corrosive environments. Optimizing these properties can extend the material's service life and improve reliability.

9.4.1 Wear resistance optimization

The high hardness of tungsten gives it a natural wear-resistant advantage, but the softness of the copper phase may cause the material to wear more severely in high-friction environments. Optimization strategies include:

Increase tungsten content: W85Cu15 has better wear resistance than W70Cu30 and is suitable for EDM electrodes.
Surface strengthening: Ion nitriding or laser surface cladding can generate a hard surface layer (such as WC or TiN), which can increase the wear resistance by 2-3 times.
Adding hard phase: Adding a small amount of tungsten carbide (W) or aluminum oxide (Al_2O_3) to the tungsten copper rod can significantly improve the wear resistance, but care should be taken to avoid reducing the conductivity.

9.4.2 Optimization of corrosion resistance

Tungsten copper rods may fail in humid or acidic environments due to corrosion of the copper phase. Optimization methods include:

Surface coating: Electroplating nickel or chemical vapor deposition (CVD) is used to apply a corrosion-resistant layer (such as CrN or DLC) to effectively prevent electrochemical corrosion of the copper phase.
Alloying modification: Adding trace amounts of silver or chromium can improve the corrosion resistance of the copper phase. For example, the corrosion resistance time of W75Cu24Ag1 in the salt spray test is extended by about 30%.
Optimizing microstructure: By increasing density and reducing porosity, the penetration path of corrosive media can be reduced, thereby improving corrosion resistance.

9.4.3 Comprehensive Optimization Case

In the aerospace field, tungsten copper rods are often used in high-temperature electrical contacts. By adopting the W80Cu20 ratio, HIP treatment and surface CrN coating, the following performance

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improvements can be achieved:

Wear resistance: Friction coefficient is reduced by 20% and wear is reduced by 50%.
Corrosion resistance: In high temperature and humid environment, the service life is extended by 2 times.
Conductivity: Maintained above 40% IACS, meeting electrical performance requirements.

9.4.4 Notes

Performance balance: Optimizing wear and corrosion resistance may result in decreased electrical conductivity, which needs to be weighed based on application needs.
Cost control: Surface coating and additive processes are expensive and their economic feasibility needs to be evaluated.
Environmental adaptability: Different corrosive environments (such as acidic, alkaline or high temperature) require targeted optimization solutions.

Summarize

By optimizing alloy ratios, heat treatment processes, microstructure, and wear and corrosion resistance, tungsten copper rods can meet diverse application requirements. Adjusting alloy ratios requires balancing electrical conductivity, thermal conductivity, and mechanical properties; heat treatment processes can significantly improve density and strength; optimizing microstructure is the foundation for improved performance; and enhancing wear and corrosion resistance extends the material's service life. In practical applications, the optimal optimization solution must be selected by comprehensively considering performance requirements, process costs, and environmental factors.

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Tungsten Copper Rod Introduction

1. Overview of Tungsten Copper Rod

Tungsten copper rod is composite materials produced by infiltrating high-purity tungsten powder with copper through a vacuum infiltration process. It possesses a unique microstructure that combines the high strength and high melting point of tungsten with the excellent electrical and thermal conductivity of copper. This results in a high-performance material with outstanding thermal stability, wear resistance, and electrical conductivity.

2. Characteristics of Tungsten Copper Rod

High Thermal Conductivity: The excellent thermal conductivity of copper ensures rapid heat dissipation, making it suitable for high-power devices and laser systems.

High Strength and High-Temperature Resistance: The stable mechanical properties of tungsten allow the material to remain reliable under extreme high-temperature conditions.

Resistance to Arc Erosion: The tungsten-copper composite structure provides exceptional resistance to arc erosion in electrical applications, significantly extending electrode service life.

Low Thermal Expansion Coefficient: Effectively reduces thermal stress and improves structural stability.

Excellent Machinability: Can be precisely fabricated into electrodes, heat sinks, or complex parts to meet diversified application requirements.

3. Performance Parameters of Tungsten Copper Rod

Product Name	Chemical Composition (%)		Physical and Mechanical Properties			
	Impurities ≤	W	Density (g/cm³)	Hardness (HB)	Resistivity (mΩ·cm)	Tensile Strength (MPa)
W50Cu	0.5	Balance	11.85	115	3.2	—
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Chapter 10 Guide to the Selection and Use of Tungsten Copper Rod

As a high-performance composite material, tungsten copper rod is widely used in industries such as electronics, aerospace, power generation, and mold manufacturing. Its performance directly affects the quality and lifespan of the final product. Choosing the right tungsten copper rod, ensuring its safe storage and transportation, proper use and maintenance, and effectively resolving common problems during use are key to ensuring its full performance.

10.1 How to choose the right tungsten copper rod

Choosing the right tungsten copper rod requires comprehensive consideration of the application scenario, performance requirements, cost budget, and supplier reliability. The following details how to make the selection from multiple perspectives.

10.1.1 Clarify application scenarios and performance requirements

The performance of tungsten copper rods is affected by the tungsten-copper ratio, manufacturing process and subsequent treatment. The performance requirements of different application scenarios vary significantly. The following are common application scenarios and recommended tungsten copper rod specifications:

Electronic packaging requires high electrical and thermal conductivity, while also matching the thermal expansion coefficient of ceramic or semiconductor materials. Recommended materials include W70Cu30 or W75Cu25, with a conductivity of approximately 40-45% IACS, a thermal expansion coefficient of approximately 7.5-8.5 $\times 10^{-6}$ / K, and a thermal conductivity of approximately 190-200 W/(m·K). These specifications are suitable for power modules, microwave devices, and chip heat sinks.

Electrode for electrical discharge machining (EDM): These electrodes require high hardness, wear resistance, and high temperature resistance to withstand arc erosion. Recommended choices include W80Cu20 or W85Cu15, which offer a hardness exceeding 200 HB and excellent wear resistance, making them suitable for machining complex molds.

Electrical contacts: A balance of electrical conductivity and arc erosion resistance is required, while also maintaining a certain degree of toughness to withstand mechanical shock. W75Cu25 is recommended , offering both electrical conductivity (approximately 40% IACS) and tensile strength (approximately 650 MPa).

Aerospace components: require high-temperature strength and low thermal expansion coefficient. W90Cu10 is recommended, with a thermal expansion coefficient as low as 6.5×10^{-6} / K, suitable for nozzles or connectors in high-temperature environments.

Medical equipment: such as X-ray targets, which require high density and wear resistance. W80Cu20 is recommended, with a density of approximately 15.5 g/cm³ and strong wear resistance.

When making a selection, the user should specify the following parameters:

Electrical and thermal conductivity requirements: Select materials with higher copper content based on electrical and thermal management requirements.

Mechanical properties: Prioritize hardness, strength, and toughness.

Thermal expansion matching: Ensure the coefficient of thermal expansion is similar to adjacent materials to avoid thermal stress failure.
Size and shape: Confirm whether the diameter, length and processing accuracy of the bar meet the design requirements.

10.1.2 Understand the specifications and standards of tungsten copper rods

Tungsten copper rods are usually classified by tungsten content (such as W70Cu30, W80Cu20). Common diameters range from 3-100 mm and lengths from 100-300 mm. Specific specifications should be selected based on the product catalog provided by the supplier. International standards (such as ASTM B702) and domestic standards (such as GB/T 8320) have clear requirements for the chemical composition, density, conductivity, and mechanical properties of tungsten copper rods. For example:

W70Cu30: Density is approximately 13.8-14.2 g/cm^3, conductivity is approximately 40-45% IACS.
W80Cu20: Density is approximately 15.1-15.5 g/cm^3, hardness is approximately 200-220 HB.

Users should request material test reports from suppliers to ensure product compliance. Furthermore, they should pay attention to tolerance requirements (e.g., diameter tolerance ±0.05 mm) to meet precision machining requirements.

10.1.3 Evaluating Supplier Reliability

Choosing a reliable supplier is the key to ensure the quality of tungsten copper rods. The following are the main criteria for evaluating suppliers:

Production Capabilities: Confirm whether the supplier has advanced powder metallurgy equipment and heat treatment facilities, such as vacuum sintering furnaces or hot isostatic pressing (HIP) equipment.
Quality Certification: Preference is given to suppliers with ISO 9001 or industry-specific certifications such as AS9100 for aerospace.
Supply capability: Evaluate suppliers' inventory levels and delivery cycles to ensure project schedules are met.
Technical support: A quality supplier should provide material selection advice, custom processing, and after-sales service.
Price and cost-effectiveness: Under the premise of ensuring quality, compare the quotations of multiple suppliers and choose the one with the best cost-effectiveness.

It is recommended to verify the supplier's reliability through on-site inspections, sample testing, or reviewing customer reviews. For example, you can ask the supplier to provide W80Cu20 samples for conductivity and hardness testing.

10.1.4 Customized Requirements

For special applications, customized tungsten copper rods may be required, such as specific diameters, surface coatings, or trace element doping. The following requirements must be specified when customizing:

Customized size: non-standard specifications such as diameter 50 mm and length 500 mm.
Surface treatment: such as nickel plating or polishing to improve corrosion resistance or surface finish.
Additives: such as adding 0.5% Ni to enhance strength, or adding Ag to improve conductivity.

Customization often requires negotiation of process parameters with suppliers and may increase costs and delivery times. It is recommended that performance indicators and acceptance criteria be clearly defined in the contract.

10.1.5 Cost and Performance Balance

The price of tungsten copper rods increases with tungsten content. For example, W90Cu10 can be 30-50% more expensive than W70Cu30. Furthermore, processes such as hot isostatic pressing (HIP) or surface coating can further increase costs. Users should select the appropriate specification based on their budget and performance requirements. For example, if budget is limited, W75Cu25 can be selected instead of W80Cu20 for applications where wear resistance is less critical.

10.1.6 Purchase Process Recommendations

Demand analysis: Clarify application scenarios and performance requirements, and list key parameters (such as conductivity and hardness).
Market research: Collect quotations and product information from multiple suppliers and compare specifications and quality.
Sample testing: Purchase a small amount of samples for performance testing to verify whether they meet the requirements.
Signing a contract: clarifying specifications, quantity, delivery time and quality standards.
Acceptance and feedback: After receiving the goods, quality inspection is carried out, performance data is recorded and improvements are communicated with suppliers.

10.2 Storage and transportation precautions

The storage and transportation of tungsten copper rods directly affect their performance and service life. The following is a detailed explanation of the storage environment, packaging requirements, and transportation precautions.

10.2.1 Storage Environment

The copper phase in tungsten copper rod is easily affected by humid, oxidative or corrosive environments, so the storage environment needs to be strictly controlled:

Temperature and Humidity: The storage environment should maintain a temperature of 15-25°C and a relative humidity below 60%. High temperature and humidity may cause copper phase oxidation, forming copper oxide (CuO), which reduces conductivity.
Dry and moisture-proof: It is recommended to place a desiccant (such as silica gel) in the storage area or use sealed packaging. For long-term storage, the tungsten copper rod can be placed in a

vacuum sealed bag.
Avoid chemical corrosion: Store away from acidic, alkaline, or salty substances to prevent electrochemical corrosion of the copper phase. For example, warehouses near the sea need to pay special attention to the effects of salt spray.
Dust prevention and cleaning: The storage environment should be clean to prevent dust or particles from adhering to the surface of the bar and affecting the subsequent processing accuracy.

For tungsten copper rods stored for a long time, it is recommended to check the surface condition every 6 months and clean and repack if necessary.

10.2.2 Packaging requirements

Tungsten copper rods have a high density (13-17 g/cm³) and are brittle and easily damaged by collisions. The following points should be noted when packaging:

Protective materials: Use foam plastic, bubble film or wooden boxes to ensure that the rods do not come into direct contact with each other. It is recommended that each rod be wrapped individually.
Anti-oxidation packaging: Add moisture-proof agent or vacuum seal to the packaging to prevent copper from oxidation.
Clear labeling: The packaging is clearly marked with the tungsten-copper ratio (such as W80Cu20), specifications (diameter, length), batch number and storage precautions for easy management and traceability.
Compression-resistant design: For large-volume transportation, use compression-resistant wooden boxes or metal frames to ensure that the bars are not crushed when stacked.

10.2.3 Transportation precautions

During transportation, the tungsten copper rod must be protected from vibration, collision and environmental changes:

Anti-vibration measures: Use shock-absorbing pads or spring fixing devices to ensure that the bars do not move during transportation.
Temperature control: Avoid transport in extremely high temperature (>50°C) or low temperature (<-10°C) environments to prevent thermal stress or cold brittleness.
Mode of transportation: Road transportation is suitable for short-distance transportation, while sea or air transportation is recommended for long-distance or international transportation. Ensure that the packaging complies with international transportation standards (such as ISTA).
Transportation Insurance: For high-value tungsten copper rods, it is recommended to purchase transportation insurance to reduce the risk of loss.
Acceptance process: Check the integrity of the packaging upon receipt, verify the specifications and quantity, and contact the supplier in a timely manner if any damage or oxidation is found.

10.2.4 Storage and transportation in special scenarios

Tungsten copper rods for aerospace use: They must be stored in a dust-free workshop, packaged with anti-static materials, and transported in a constant temperature and humidity container.

Tungsten copper rods for medical devices: Storage and transportation must comply with medical device standards (such as ISO 13485) to avoid any contamination.
Transportation in high temperature environments: If transported to tropical areas, additional insulation and moisture-proof measures are required.

Through standardized storage and transportation management, the shelf life of tungsten copper rods can be effectively extended and their performance can be ensured not to be damaged.

10.3 Maintenance and care during use

Tungsten copper rods require regular maintenance and care during use to maintain their performance and extend their service life. The following provides detailed guidance from the three stages of processing, operation, and storage.

10.3.1 Maintenance during processing

Tungsten copper rods often need to be turned, milled, drilled or processed by electrical discharge machining. The following matters need to be paid attention to during the processing:

Tool selection: Use carbide or diamond tools to avoid wear and tear caused by the lack of hardness of ordinary steel tools. Tool hardness higher than HRC 60 is recommended.
Coolant Use: Use water-based or oil-based coolant during machining to reduce cutting temperatures and prevent softening of the copper phase or shedding of tungsten particles. Keep the coolant clean to avoid the introduction of corrosive impurities.
Processing parameters: Control cutting speed (e.g. 100-200 m/min) and feed rate (e.g. 0.05-0.2 mm/rev) to avoid excessive stress causing cracks in the bar.
Surface protection: Immediately clean the coolant and metal chips remaining on the surface after processing to prevent chemical corrosion. It is recommended to wipe with alcohol or neutral detergent.

10.3.2 Maintenance during operation

Tungsten copper rods need to be regularly inspected and maintained in their use scenarios (such as electrodes, electrical contacts or radiators):

Surface inspection: Regularly check the surface of the bar for signs of oxidation, wear, or arc erosion. For example, if obvious erosion pits appear on the surface of the EDM electrode, it should be replaced promptly.
Cleaning and maintenance: Use ultrasonic cleaning or a soft cloth to remove surface dirt. Avoid using acidic or alkaline detergents. The cleaning frequency should be determined according to the usage environment (e.g. once a month).
Temperature monitoring: In high-temperature environments (such as electrical contacts), monitor that the operating temperature does not exceed the softening point of copper (approximately 800°C) to prevent performance degradation.
Anti-corrosion measures: In humid or corrosive environments, apply anti-rust oil or a temporary coating (such as a thin layer of silicone oil) regularly to protect the copper phase.

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High Thermal Conductivity: The excellent thermal conductivity of copper ensures rapid heat dissipation, making it suitable for high-power devices and laser systems.
High Strength and High-Temperature Resistance: The stable mechanical properties of tungsten allow the material to remain reliable under extreme high-temperature conditions.
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Product Name	Chemical Composition (%)		Physical and Mechanical Properties			
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10.3.3 Storage and Reuse

Unused tungsten copper rods or processed leftovers must be properly stored:

Short-term storage: Place in a moisture-proof sealed bag in a dry and ventilated place.
Long-term storage: Use vacuum packaging or nitrogen-filled packaging and check the surface condition regularly.
Recycling of residual materials: Processing residual materials can be recycled and used in low-requirement scenarios (such as experimental samples), but their performance needs to be tested to see if it meets the requirements.

10.3.4 Maintenance Records

It is recommended to establish maintenance records to record the time, status and treatment measures of each inspection, cleaning and replacement. For example:

Date: August 20, 2025
Inspection content: W80Cu20 electrode surface inspection
Status: Slightly ablated, conductivity decreased by 5%
Measures: Ultrasonic cleaning, planned to be replaced next month

Through standardized maintenance and care, the service life of tungsten copper rods can be significantly extended and the failure rate can be reduced.

10.4 Common Problems and Solutions

Tungsten copper rods may encounter a variety of problems during use. The following summarizes common problems and their solutions to help users deal with them quickly.

10.4.1 Surface oxidation

Problem description: A green or black oxide layer (CuO or Cu_2O) appears on the surface of the tungsten copper rod, and the conductivity decreases.
Cause: The storage or use environment is humid, or exposed to high temperature oxidizing atmosphere.
Solution:
Wipe the surface with dilute acetic acid (5%) or citric acid solution to remove the oxide layer, then rinse with alcohol and dry.
Optimize the storage environment, keep the humidity below 60%, and use sealed packaging.
In high-temperature applications, add inert gas protection (such as nitrogen or argon).

10.4.2 Arc Erosion

Problem description: Ablation pits appear on the surface of EDM electrodes or electrical contacts, affecting machining accuracy or contact performance.
Cause: The arc energy is too high or the wear resistance of the tungsten copper rod is insufficient.
Solution:
Reduce the discharge energy of EDM and optimize the pulse width and current (e.g. pulse width

50-100 μs).

Choose materials with high tungsten content (such as W85Cu15) to improve wear resistance.

Check the electrode surface regularly and repair or replace it in time.

10.4.3 Processing cracks

Problem description: Micro cracks appear in the tungsten copper rod during processing, resulting in a decrease in strength.

Cause: Excessive cutting speed, tool wear or internal defects in the material.

Solution:

Reduce the cutting speed (e.g. 80-150 m/min) and use a new tool.

Check material quality and ask suppliers to provide non-destructive testing reports (such as ultrasonic testing).

Preheat treatment (200-300°C) is used to reduce processing stress.

10.4.4 Decreased conductivity

Problem description: The conductivity of tungsten copper rod decreases significantly after being used for a period of time, affecting the electrical performance.

Causes: Copper phase oxidation, microstructural changes or surface contamination.

Solution:

To clean surface dirt, use ultrasonic cleaning or alcohol wipes.

Check the operating environment and avoid high temperature or corrosive atmosphere.

If the conductivity continues to decrease, consider replacing the rod with a new one or performing heat treatment to restore the performance.

10.4.5 Thermal Expansion Mismatch

Problem description: Tungsten copper rod and adjacent materials (such as ceramics) peel off or crack at high temperature.

Reason: The difference in thermal expansion coefficient is too large.

Solution:

The tungsten-copper ratio is reselected, such as W80Cu20 (thermal expansion coefficient of about 8.0×10^{-6} / K) to match the ceramic (such as AlN , about 4.5×10^{-6} / K).

Add a buffer layer (such as a thin layer of Ni or Mo) at the interface to relieve thermal stress.

Optimize the operating temperature and try to keep it below 600°C.

10.4.6 Storage deformation

Problem description: The tungsten copper rod stored for a long time is slightly bent or deformed.

Cause: Uneven force during storage or improper packaging.

Solution:

Check storage methods to ensure bars are stored horizontally to avoid stacking pressure.

Use a dedicated stand or wooden box to distribute the weight.

For minor deformations, stress relief can be achieved by low temperature annealing (approximately 600°C).

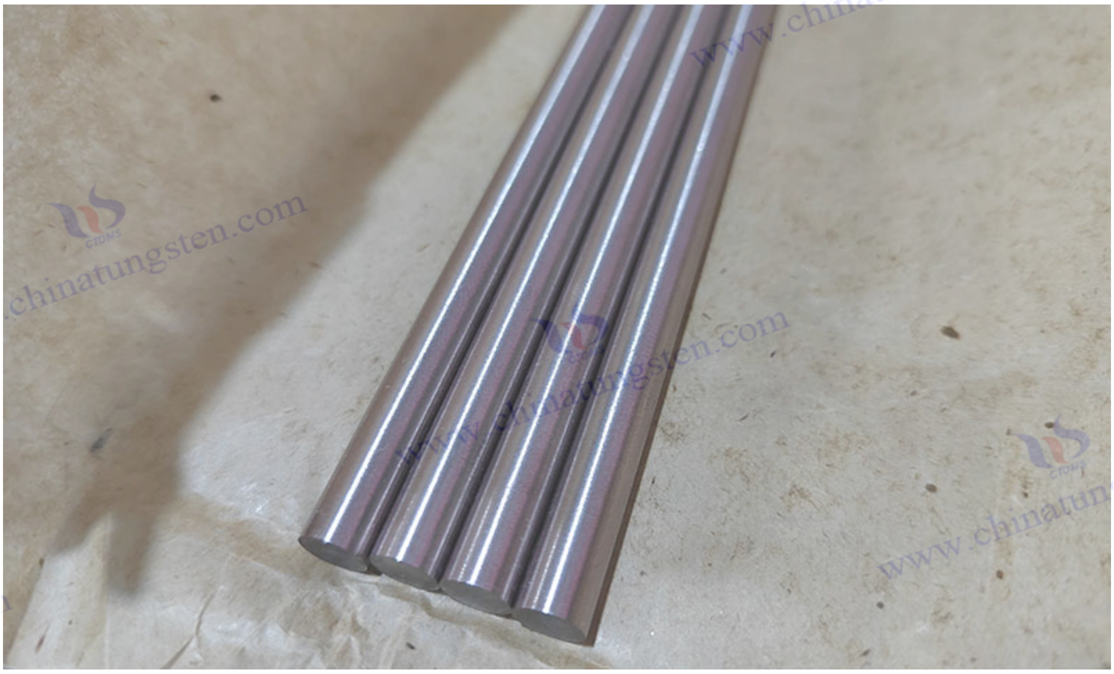
10.4.7 Case Analysis

Case 1: An electronics packaging factory used W70Cu30 tungsten copper rods and discovered that their thermal conductivity decreased at high temperatures. Inspection revealed severe surface oxidation. Solution: Vacuum packaging for storage and ultrasonic cleaning before use, which restored thermal conductivity to over 95%.

Case 2: A mold manufacturer's W80Cu20 electrodes experienced rapid wear during EDM. Analysis revealed excessive discharge energy. Solution: Reducing the current to 50 A and the pulse width to 80 μs doubled the electrode life.

Summarize

The selection and use of tungsten copper rods is a systematic process, involving multiple steps, including needs analysis, supplier selection, storage and transportation, maintenance, and problem solving. Selecting the right tungsten copper rod requires clarifying performance requirements based on the application scenario and conducting a comprehensive assessment based on specifications and supplier reliability. Storage and transportation require strictly controlled environmental conditions to prevent oxidation and physical damage. Standardized processing and maintenance during use can extend the rod's life and maintain its performance. Promptly implementing targeted measures to address common problems can effectively reduce failure rates. Through scientific management and operation, tungsten copper rods can perform optimally in a variety of demanding scenarios.



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Tungsten Copper Rod Introduction

1. Overview of Tungsten Copper Rod

Tungsten copper rod is composite materials produced by infiltrating high-purity tungsten powder with copper through a vacuum infiltration process. It possesses a unique microstructure that combines the high strength and high melting point of tungsten with the excellent electrical and thermal conductivity of copper. This results in a high-performance material with outstanding thermal stability, wear resistance, and electrical conductivity.

2. Characteristics of Tungsten Copper Rod

High Thermal Conductivity: The excellent thermal conductivity of copper ensures rapid heat dissipation, making it suitable for high-power devices and laser systems.

High Strength and High-Temperature Resistance: The stable mechanical properties of tungsten allow the material to remain reliable under extreme high-temperature conditions.

Resistance to Arc Erosion: The tungsten-copper composite structure provides exceptional resistance to arc erosion in electrical applications, significantly extending electrode service life.

Low Thermal Expansion Coefficient: Effectively reduces thermal stress and improves structural stability.

Excellent Machinability: Can be precisely fabricated into electrodes, heat sinks, or complex parts to meet diversified application requirements.

3. Performance Parameters of Tungsten Copper Rod

Product Name	Chemical Composition (%)		Physical and Mechanical Properties			
	Impurities ≤	W	Density (g/cm³)	Hardness (HB)	Resistivity (mΩ·cm)	Tensile Strength (MPa)
W50Cu	0.5	Balance	11.85	115	3.2	—
W60Cu	0.5	Balance	12.75	140	3.7	—
W70Cu	0.5	Balance	13.8	175	4.1	790
W80Cu	0.5	Balance	15.15	220	5	980
W90Cu	0.5	Balance	16.75	260	6.5	1160

4. Advantages of Tungsten Copper Rod

High-Performance Combination: A balanced integration of strength, electrical conductivity, thermal conductivity, and high-temperature resistance.

Customized Solutions: Tungsten-to-copper ratio and dimensions can be tailored to meet specific customer requirements.

Long Service Life and Stability: Significantly reduces maintenance and replacement costs.

5. Procurement Information

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Chapter 11 Market and Development Trend of Tungsten Copper Rod

As a high-performance composite material, tungsten copper rods are widely used in electrical, electronics, aerospace, thermal management, and other fields due to their excellent electrical and thermal conductivity, high-temperature resistance, and mechanical strength. With the advancement of global industrial technology and the rapid development of emerging industries, the market demand for tungsten copper rods continues to grow, the industry chain continues to improve, and technological innovation is driving its performance optimization and application expansion. This chapter will analyze in detail the structure of the global tungsten copper material industry chain, the distribution and characteristics of market demand, and key future development trends, covering high-performance, green manufacturing, and emerging applications.

11.1 Overview of the Global Tungsten-Copper Materials Industry Chain

The tungsten-copper material industry chain encompasses multiple links, from raw material mining to final product application, involving resource extraction, material preparation, processing and manufacturing, testing and certification, and end-use applications. The upstream of the industry chain primarily involves the mining and purification of tungsten and copper ores. Tungsten resources are primarily concentrated in China, Russia, Australia, and Canada. China accounts for approximately 80% of global tungsten reserves and 60% of global production, making it a core supplier of tungsten powder. Copper resources are widely distributed, with Chile, Peru, and Australia being the main producers. Electrolytic copper production technology is mature, ensuring ample supply.

The midstream segment includes the preparation and processing of tungsten copper rods. Tungsten powder is extracted from tungstate or tungsten trioxide through hydrogen reduction, while electrolytic copper is obtained through electrochemical refining. The preparation process utilizes powder metallurgy technology, including pressing, sintering, and vacuum infiltration. Core equipment such as vacuum sintering furnaces and infiltration furnaces require high-precision control to ensure product quality. The processing involves precision machining, heat treatment , and surface modification to meet the size and performance requirements of different application scenarios. Midstream companies are mostly specialized material manufacturers .

The downstream segment encompasses the end-use applications of tungsten copper rods, including electrical contacts, electronic packaging, aerospace components, heat sinks, and mold manufacturing. Distribution channels include direct supply to equipment manufacturers (such as Siemens and GE) and access to international markets through traders. Testing and certification are crucial components of the supply chain, requiring compliance with international standards (such as ASTM B702 and GB/T 8320) to ensure product competitiveness in the global market.

The industry chain is highly globalized, with China dominating raw materials and manufacturing, while Europe, the United States, and Japan have technological advantages in high-end applications and precision processing. Industry chain collaboration emphasizes supply chain stability and technological integration, with raw material price fluctuations and environmental regulations being key challenges.

11.2 Market Demand Structure and Application Share Analysis

Driven by the global industrialization process, the development of the electronics industry and new energy technologies, the market demand for tungsten copper rods is diversified. The market demand structure can be divided into the following major areas:

- Electrical and Electronics (approximately 45% market share): Tungsten copper rods dominate the market for applications in high-voltage switches, circuit breakers, and EDM electrodes. Their high electrical conductivity and resistance to arc erosion make them an ideal material for electrical contacts and electrodes, particularly in power transmission and distribution equipment. For example, global power grid upgrades and smart grid deployment are driving demand for high-performance contact materials. Furthermore, demand for tungsten copper rods used as heat sinks and electrodes in microelectronics packaging is rapidly growing, particularly in 5G communications, power semiconductors, and radar systems.

- Aerospace & Defense (approximately 20% market share): The application of tungsten copper rods in rocket engine nozzles, counterweight components, and armor-piercing projectile cores is driven by the aerospace and defense industries. The rapid development of the global aerospace industry, such as commercial space programs by SpaceX and Blue Origin, has increased demand for high-heat-resistant, high-density materials. Demand for high-performance electrodes and thermal management materials is also growing in the defense sector, particularly in radar and electronic warfare equipment.

Thermal Management and Heat Dissipation Devices (approximately 20% market share): With the increasing popularity of high-power electronic devices (such as lasers and IGBT modules) and new energy vehicles, the use of tungsten copper rods as heat sinks and heat dissipation substrates has rapidly expanded. Their high thermal conductivity and thermal expansion compatibility with semiconductor materials make them indispensable in data centers, electric vehicle battery management systems, and 5G base stations. Global demand for efficient heat dissipation solutions is driving rapid growth in this sector.

- Machinery and Mold Industry (approximately 10% market share): Tungsten copper rods are used in EDM dies, stamping dies, and cutting tools due to their high hardness and wear resistance. The global trend toward automation and precision manufacturing has increased demand for high-performance mold materials, particularly in automotive and medical device manufacturing.

-Other sectors (approximately 5% market share): These sectors include emerging applications such as medical radiation shielding, electrical contact components for photovoltaic inverters, and golf club weights. Although these sectors account for a small proportion, they have significant growth potential, particularly in the new energy and medical industries.

In terms of regional distribution of market demand, the Asia-Pacific region (primarily China) accounts for over 50% of the global market, with North America and Europe each accounting for approximately 20%. The remainder is distributed across South America, Africa, and the Middle East. Drivers of demand growth include the global energy transition, electronics industry upgrades, and increased aerospace investment. Challenges include raw material price fluctuations (for example, tungsten prices are significantly influenced by supply and demand) and the pressure of environmental regulations on production costs.

11.3 Future Development Trend of Tungsten Copper Rod

The future development of tungsten copper rods is driven by technological innovation, market demand, and sustainable development requirements. The following analyzes its development trends from three aspects: high performance, green preparation, and emerging applications.

11.3.1 High Performance and Nanotechnology

High performance is the core direction of tungsten copper rod technology development, aiming to improve the material's electrical conductivity, thermal conductivity, strength, and wear resistance to meet the needs of next-generation high-power electronic devices and extreme environment applications. Nanotechnology is a key path to achieving high performance. By using nanoscale tungsten and copper powders, the material's microstructure is significantly improved. The larger specific surface area of nanoparticles enhances inter-particle bonding, reduces sintering temperatures, and improves the density and uniformity of the tungsten copper rod. For example, nano-tungsten powder (particle size <100 nm) can form a finer skeleton structure, increasing the infiltration efficiency of the copper phase, thereby improving thermal conductivity and mechanical strength.

Another direction for high performance is the development of functionally graded materials (FGMs). By introducing a gradient distribution of tungsten to copper ratios within a tungsten-copper rod, the performance of specific areas can be optimized. For example, a high tungsten content on the surface enhances wear resistance, while a high copper content within the rod improves thermal conductivity, making it suitable for electrodes and heat sinks under complex working conditions. Furthermore, the addition of trace elements (such as zirconium and chromium) improves wettability at the tungsten-copper interface, further enhancing material performance. Advanced preparation techniques, such as plasma sintering (SPS) and microwave sintering, have shortened processing time and improved microstructure uniformity, driving the industrialization of high-performance tungsten-copper rods.

11.3.2 Green Preparation and Sustainable Development

Green manufacturing and sustainable development are long-term trends in the tungsten copper rod industry, responding to global demands for environmental protection and resource efficiency. Traditional powder metallurgy processes consume high energy and produce waste gas and waste liquid. Green manufacturing reduces environmental impact by optimizing processes and equipment. For example, low-temperature sintering technology reduces sintering temperatures by 20-30% by adding activators or using nanopowders, thereby reducing energy consumption. The tail gas recovery system in the vacuum infiltration process can capture volatile copper vapor and reduce emissions. Waste recycling technology is also becoming increasingly important. Through chemical purification and reprocessing, waste tungsten copper rods in production can be converted back into high-purity powder, achieving resource recycling.

Another key focus of sustainable development is the sustainable supply of raw materials. As a rare metal, tungsten faces resource shortages, leading to increased focus on green mining technologies and research into alternative materials (such as molybdenum-based composites). Manufacturers must also comply with international environmental regulations, such as the EU's RoHS Directive and REACH Regulation, which restrict the use of hazardous substances and ensure that tungsten copper rods meet environmental standards. The introduction of intelligent production systems, which optimize process parameters through real-time monitoring and data analysis, further improves energy efficiency and product quality.

11.3.3 Emerging Application Directions

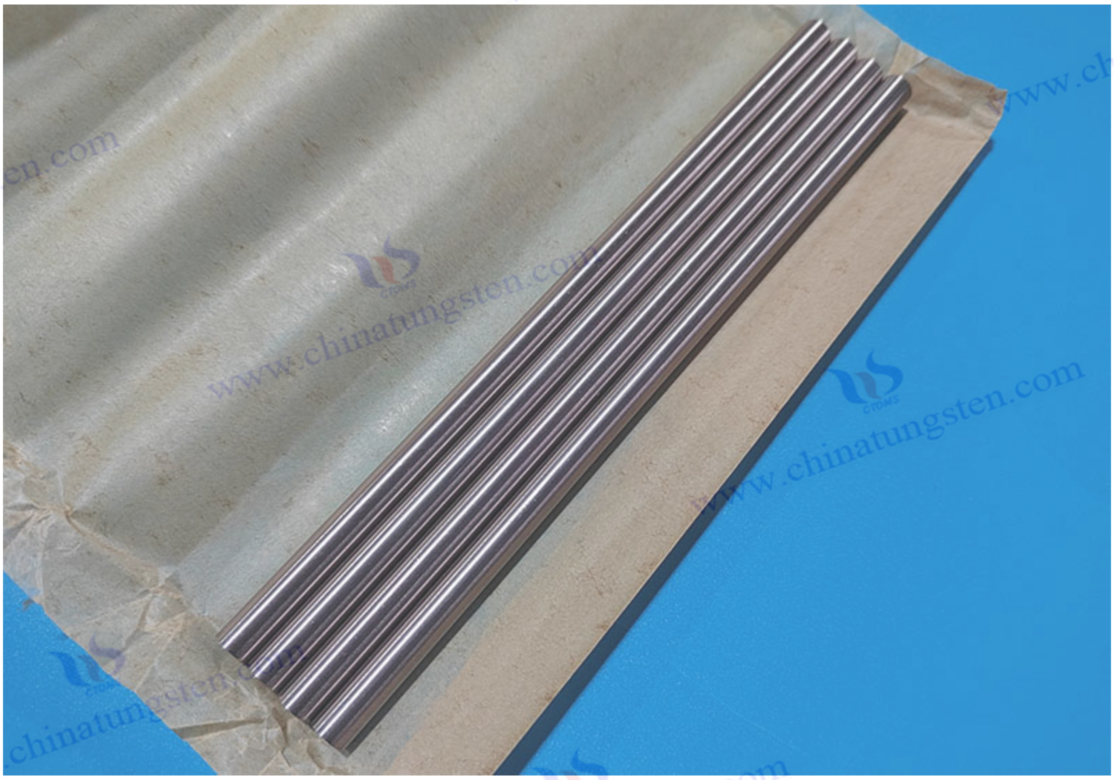
The future application areas of tungsten copper rods are expanding with technological advancements, encompassing emerging industries such as new energy, healthcare, and additive manufacturing. In the new energy sector, demand for tungsten copper rods is growing for electrical contact components in photovoltaic inverters and wind turbine converters, where their high conductivity and corrosion resistance support efficient energy conversion. In electric vehicle battery management systems, tungsten copper rods serve as heat dissipation substrates, effectively managing the heat of high-power batteries and extending battery life.

In the medical field, the radiation shielding properties of tungsten copper rods make them promising for use in X-ray and gamma ray protection equipment, such as shielding components for CT machine collimators and radiotherapy equipment. Its high density and processing performance support the manufacture of complex shapes, meeting the high precision requirements of medical equipment.

Additive manufacturing (3D printing) is another emerging area. Using laser or electron beam melt deposition technology to print a tungsten skeleton, combined with a vacuum infiltration process, it is possible to produce tungsten-copper components with complex geometries. This method overcomes the limitations of traditional processing and is suitable for small-batch customized production in the aerospace and electronics industries. For example, 3D-printed tungsten-copper heat sinks can implement internal microchannel designs, further improving heat dissipation efficiency.

Furthermore, the potential applications of tungsten copper rods in quantum computing and 6G communication equipment are also noteworthy. Quantum computing requires high thermal conductivity materials in ultra-low temperature environments, and the low thermal expansion and high thermal conductivity of tungsten copper rods make them a promising candidate. The high power density of 6G base stations places higher demands on heat dissipation and electrical contact materials, and the comprehensive performance of tungsten copper rods can meet these requirements.

In summary, the market and development trends for tungsten copper rods are driven by global industrial upgrades and emerging technologies. Improved supply chains and technological innovation are driving widespread adoption in both traditional and emerging sectors. The coordinated development of high-performance, green manufacturing, and emerging applications will further enhance the market competitiveness of tungsten copper rods, providing critical support for future industrial development. The industry needs to focus on raw material supply, environmental compliance, and technological R&D to address market challenges and seize growth opportunities.



Appendix

A. Glossary

Tungsten-copper alloy: A metal matrix composite material consisting of tungsten and copper, with the copper content typically ranging from 10% to 50%.

Vacuum infiltration process: A process for preparing tungsten copper rods by infiltrating copper into a tungsten skeleton under a vacuum environment.

Metal sweating effect: Under high temperature (such as above 3000℃), copper liquefies and evaporates, absorbing heat and lowering the surface temperature of the material.

Electrical conductivity (%IACS): International standard conductivity for annealed copper, used to measure the electrical conductivity of a material.

Coefficient of Thermal Expansion: The rate of change of volume or length of a material when its temperature changes.

Arc erosion resistance: The ability of a material to resist ablation damage under the action of an arc.

Near-net shaping: A manufacturing technology that directly obtains a shape close to the final shape by optimizing the process and reducing subsequent processing.

Resistance welding electrode: Electrode used for resistance welding, which needs to be resistant to high temperature and wear.

EDM electrode: An electrode used for EDM, with a high electrical erosion rate and low wear rate.

Electronic packaging materials: Materials used for semiconductor device packaging that have high thermal conductivity and low thermal expansion properties.

High-frequency combustion infrared absorption method: an analytical method used to determine the carbon content in tungsten-copper alloys.

Cinchonine Gravimetric Method: A chemical analysis method used to determine the tungsten content in tungsten-copper alloys.

Thermal conductivity: The ability of a material to conduct heat, usually expressed in W/m·K.

Hardness (HB/HV): Brinell hardness (HB) or Vickers hardness (HV) is used to measure a material's resistance to deformation.

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