What Is Molybdenum Copper Sheet

中钨智造科技有限公司

CTIA GROUP LTD

CTIA GROUP LTD

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

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INTRODUCTION TO CTIA GROUP

CTIA GROUP LTD， a wholly-owned subsidiary with independent legal personality established by CHINATUNGSTEN ONLINE , is dedicated to promoting the intelligent, integrated, and flexible design and manufacturing of tungsten and molybdenum materials in the Industrial Internet era. CHINATUNGSTEN ONLINE, founded in 1997 with www.chinatungsten.com 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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CTIA GROUP LTD Molybdenum Copper Sheet Picture

Chapter 1 Introduction

1.1 Overview of Molybdenum Copper Sheet

Molybdenum copper sheet is a composite material composed of molybdenum and copper , usually used in the form of thin sheets or plates in the fields of electronics, aerospace, energy and high-temperature industries. It combines the high melting point, corrosion resistance and excellent thermal stability of molybdenum with the high electrical conductivity and thermal conductivity of copper to form an advanced material with excellent mechanical properties and thermoelectric properties. Molybdenum copper sheet is mainly prepared by powder metallurgy technology, mixing molybdenum powder and copper powder in a specific proportion, pressing and sintering, or using melt infiltration to infiltrate liquid copper into the molybdenum matrix to form a composite structure.

Molybdenum copper sheet has the following remarkable characteristics: high thermal conductivity makes it excellent in thermal management and suitable for heat sinks and heat sinks; low thermal expansion coefficient ensures its dimensional stability in high temperature environment; by adjusting the molybdenum -copper ratio, thermal conductivity, electrical conductivity and mechanical strength can be customized to meet diverse application requirements; molybdenum 's high melting point (about 2623°C) and corrosion resistance enable it to serve for a long time in extreme environments. Typical applications include heat dissipation substrates in electronic packaging, power semiconductor devices, microwave devices, and aerospace thermal management components. Since the mid-to-late 20th century, with the growth of demand for high-performance electronic devices and high-temperature applications, the research and development and production technology of molybdenum copper sheets have been significantly improved.

1.2 Composition and structure of molybdenum -copper composite materials

Molybdenum -copper composite materials are made of molybdenum and copper metals through a specific process, and their properties are directly affected by the composition ratio and microstructure. The composition of the material is usually expressed in weight or volume percentage, such as Mo70Cu30 (70% molybdenum and 30% copper) or Mo85Cu15 and other common grades. The increase in molybdenum content improves the material's strength, high temperature resistance and low thermal expansion characteristics, but may slightly reduce thermal conductivity and electrical conductivity; while the increase in copper content significantly enhances thermal conductivity and electrical conductivity, but weakens mechanical strength and high temperature resistance. Trace additives (such as nickel or silver) are sometimes used to improve sintering performance or interface bonding, but the content is strictly controlled to avoid performance degradation.

In terms of microstructure, molybdenum -copper composite materials present a two-phase structure: molybdenum forms a continuous or semi-continuous skeleton, providing mechanical strength and high temperature resistance, and the particle size is usually between 1-10 microns; copper fills the pores of the molybdenum skeleton to form a continuous thermal and electrical conductive network. The interface bonding of the two phases mainly depends on physical intercalation and diffusion during sintering. Good interface bonding can effectively reduce thermal resistance and electrical resistance. Scanning electron microscopy (SEM) and X-ray diffraction (XRD) analysis show that molybdenum particles are usually uniformly wrapped by the copper matrix, and the continuity of the copper phase increases with the increase of copper content.

The preparation process has a significant impact on the material structure. The powder metallurgy method can accurately control the composition ratio by mixing molybdenum and copper powders, pressing and sintering, and is suitable for the production of high-density molybdenum copper sheets; the melt infiltration method is suitable for high-copper content materials by infiltrating liquid copper into a porous molybdenum skeleton, but the process control requirements are high; the hot pressing sintering method is directly formed under high temperature and high pressure, which is suitable for high performance requirements but has a high cost. Different processes lead to differences in particle size, phase distribution and interface bonding strength, which affect the material properties.

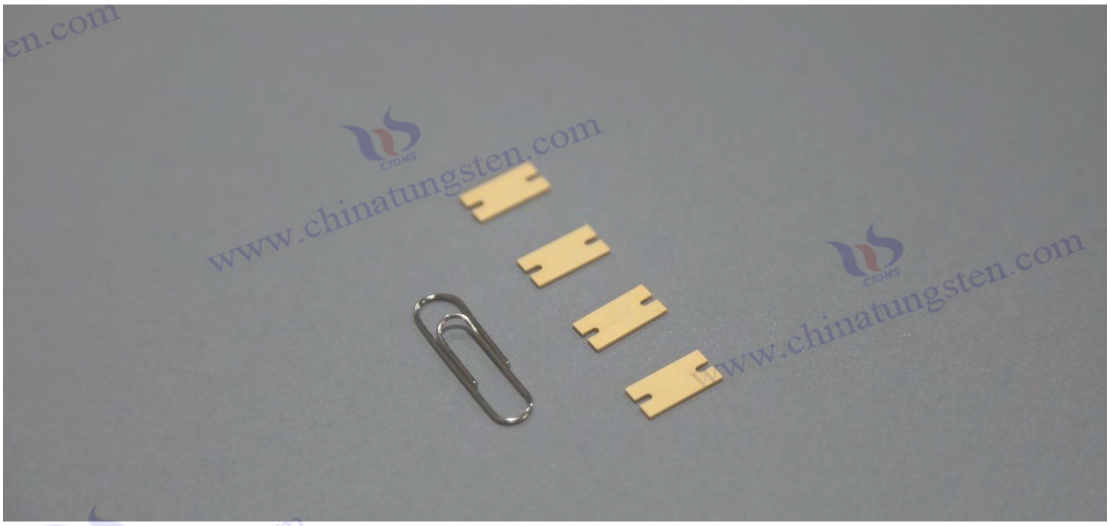
1.3 Importance of Molybdenum Copper Sheet in Materials Science

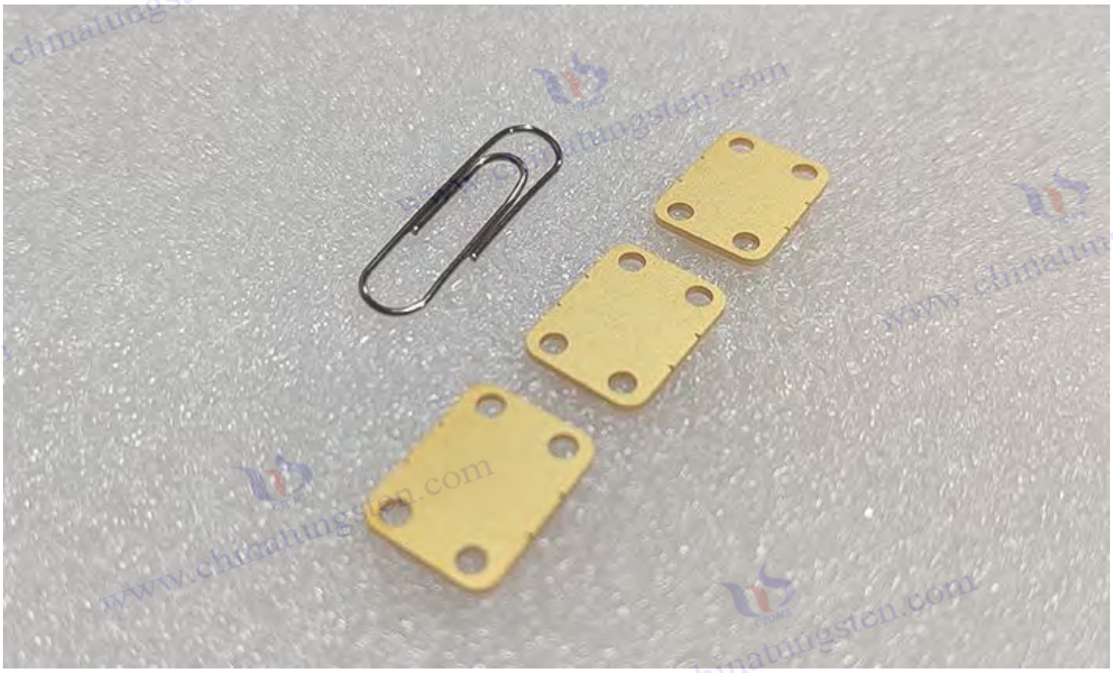
Molybdenum copper sheet has important value in materials science and engineering applications. Its performance in the field of thermal management is particularly outstanding. As electronic devices develop towards high power density and miniaturization, thermal management has become the key to restricting performance and life. With its excellent thermal conductivity and thermal expansion coefficient similar to that of ceramic materials (such as alumina and silicon nitride) , molybdenum copper sheet has become an ideal material for electronic packaging, power semiconductor devices (such as IGBT, MOSFET), microwave devices and laser heat sinks. It can effectively conduct heat and reduce interface cracking caused by thermal stress, thereby improving device reliability and life.

In the field of high-performance electronic devices, the electrical and thermal conductivity of molybdenum copper sheets make them the core materials for 5G communication equipment and new energy vehicle power modules. Its adjustable performance supports different device design requirements and promotes the development of electronic devices towards higher performance and miniaturization. In addition, the high melting point and corrosion resistance of molybdenum copper sheets give them significant advantages in extreme environments, such as heat exchange components of high-temperature reactors in the nuclear industry and high-temperature components of aerospace jet engines, demonstrating their reliability and stability under harsh conditions.

Molybdenum -copper sheets has also promoted the advancement of composite material design and preparation technology. The exploration of interface optimization, microstructure regulation and new preparation processes has not only improved the performance of molybdenum -copper sheets, but also provided theoretical and practical references for the development of other metal-based composite materials (such as tungsten-copper and aluminum-silicon), and promoted the interdisciplinary integration of multifunctional material design concepts. In addition, the preparation process of molybdenum -copper sheets is mature, the raw materials molybdenum and copper are abundant and recyclable, the cost is relatively low, and it has high economy and sustainability , making it suitable for large-scale production and application.

In summary, molybdenum copper sheets play a key role in thermal management, high-performance electronic devices and extreme environment applications due to their unique thermoelectric properties, mechanical properties and adjustability. Their research and application not only meet the needs of modern industry for high-performance materials, but also promote the innovative development of materials science. With technological progress, the performance optimization and application areas of molybdenum copper sheets will be further expanded, providing important support for scientific and industrial progress.





CTIA GROUP LTD Molybdenum Copper Sheet Picture

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Molybdenum Copper Sheets Introduction

1. Overview of Molybdenum Copper Sheets

Molybdenum-copper (Mo-Cu) sheets are composite materials composed of molybdenum and copper. Thanks to their unique combination of thermal, electrical, and mechanical properties, as well as their tunability, Mo-Cu sheets are widely used in fields such as thermal management, high-performance electronic devices, semiconductors, and aerospace. They are commonly utilized as packaging materials, integrated circuit substrates, heat sinks, and LED thermal dissipation substrates. At CTIA GROUP LTD, we can customize molybdenum-copper products with specific dimensions and compositions according to customer requirements.

2. Features of Molybdenum Copper Sheets

Excellent Electrical Conductivity: Suitable for applications requiring efficient electrical connections.

High Thermal Conductivity: Capable of rapid heat transfer, ideal for electronic devices that require effective thermal dissipation.

Low Coefficient of Thermal Expansion: Highly compatible with semiconductor materials like silicon, helping to minimize thermal stress caused by temperature fluctuations and preventing deformation or damage to components.

Good Workability: Can be processed through cutting and other techniques into parts of various sizes and shapes to meet diverse application needs.

3. Typical Properties of Molybdenum-Copper Alloys

Material Composition	Density (g/cm^3)	Thermal Conductivity (W/M·K at 25°C)	Thermal Expansion Coefficient (10^{-6}/°C)
Mo85Cu15	10.00	160-180	6.8
Mo80Cu20	9.90	170-190	7.7
Mo70Cu30	9.80	180-200	9.1
Mo60Cu40	9.66	210-250	10.3
Mo50Cu50	9.54	230-270	11.5

4. Production Method of Molybdenum Copper Sheets

The preparation of molybdenum-copper sheets is primarily carried out using the infiltration method, which takes advantage of molybdenum's high melting point and copper's excellent fluidity. In this process, copper is infiltrated into a molybdenum preform at high temperatures, resulting in the formation of a dense molybdenum-copper composite material.

5. Purchasing Information

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Chapter 2 Material Properties of Molybdenum Copper Sheet

2.1 Basic properties of molybdenum and copper

Molybdenum and copper are the main components of molybdenum-copper composites, and their respective physical and chemical properties determine the performance of the composites. Molybdenum is a high-melting transition metal with a melting point of about 2623°C. It has excellent high temperature resistance and corrosion resistance. Its low thermal expansion coefficient (about 4.8×10^{-6} /K at 25 ° C) can maintain dimensional stability in high temperature environments. Molybdenum has high strength, but its electrical conductivity (about 18% IACS) and thermal conductivity (about 138 W/m·K) are relatively low. Copper is known for its high electrical conductivity (close to 100% IACS) and high thermal conductivity (about 401 W/m·K). Its melting point is 1085°C, making it an ideal material for thermal management and electrical transmission, but its thermal expansion coefficient is high (about 16.5×10^{-6} /K at 25 ° C), and its strength decreases at high temperatures.

Molybdenum and copper are not completely soluble in each other at the atomic scale, forming a two-phase structure: molybdenum forms the skeleton, providing structural support and high temperature resistance; copper fills the pores to form a thermal and electrical conductive network. This complementarity enables molybdenum- copper sheets to achieve a balance between thermal conductivity, electrical conductivity and mechanical properties, meeting the needs of electronics, aerospace and other fields.

2.2 Density of molybdenum copper sheet

Molybdenum copper sheet is its key physical property, which affects the weight of the material, thermal conductivity efficiency and applicability of the application scenario. The density depends on the ratio of molybdenum to copper , which is between the density of molybdenum (10.28 g/cm³) and the density of copper (8.96 g/cm³). Molybdenum copper sheets with high molybdenum content have a higher density and are suitable for applications that require high strength and high temperature resistance, such as high-temperature aviation parts; molybdenum copper sheets with high copper content have a lower density, which helps to reduce the weight of the device and is suitable for lightweight design of portable electronic devices and aerospace. The preparation process has a significant impact on density: the powder metallurgy method can obtain materials close to the theoretical density through high-pressure molding and high-temperature sintering, usually reaching more than 98%; the melt infiltration method may result in a slightly lower density due to residual pores. Density also affects heat capacity and thermal conductivity. Low density is usually accompanied by high thermal conductivity, but may sacrifice some high-temperature stability. Therefore, density is an important parameter that needs to be weighed in the design of molybdenum copper sheets.

2.3 Mechanical properties of molybdenum copper sheet

Molybdenum copper sheet include hardness, toughness and strength, which determine its performance

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under mechanical stress and deformation conditions. The high strength of molybdenum and the ductility of copper together shape the mechanical properties of molybdenum copper sheet, and the specific properties vary with the composition ratio and preparation process.

2.3.1 Hardness of molybdenum copper sheet

Hardness reflects the ability of molybdenum copper sheets to resist local deformation and wear, and is usually measured by Vickers hardness (HV). The high hardness of molybdenum (about 230-250 HV) provides excellent wear resistance for the composite material, while the lower hardness of copper (about 50-70 HV) makes the high copper content material more flexible.

Molybdenum copper sheets with high molybdenum content (such as Mo85Cu15) have a higher hardness, close to the hardness of molybdenum , and are suitable for electronic packaging heat dissipation substrates that require wear resistance; molybdenum copper sheets with high copper content have lower hardness, but better ductility, and are suitable for applications that require a certain degree of flexibility. The hot pressing sintering method increases density and hardness through high temperature and high pressure; if the powder metallurgy method is not sintered enough, the hardness may be reduced due to the presence of pores. The hardness of molybdenum copper sheets enables them to withstand machining and assembly stresses and maintain surface integrity at high temperatures.

2.3.2 Toughness of molybdenum copper sheet

Toughness refers to the ability of molybdenum copper sheets to absorb energy and resist fracture, and is a key performance under dynamic loads or impact environments. Pure molybdenum has low toughness and is brittle, while copper has excellent ductility and toughness. Molybdenum -copper composites improve overall toughness and avoid brittle fracture by adding copper. Molybdenum copper sheets with high copper content (such as Mo60Cu40) have good toughness and are suitable for thermal management applications that require impact resistance; materials with high molybdenum content (such as Mo85Cu15) have lower toughness but higher strength and are suitable for high-strength requirements.

Molybdenum copper sheet prepared by the melt infiltration method is usually better in toughness than the powder metallurgy product because of the uniform distribution of copper phase . The interface bonding quality is crucial to toughness. A good molybdenum copper interface can effectively transfer stress and reduce crack propagation. The toughness of the molybdenum copper sheet enables it to withstand impact and cyclic loads in aerospace or high vibration environments, extending its service life.

2.3.3 Ductility of Mo-Cu Sheet

Ductility reflects the ability of molybdenum copper sheets to undergo plastic deformation without breaking when subjected to stress, and is an important characteristic for adapting to complex shapes or deformation requirements in processing and applications. Molybdenum has low ductility and is more brittle, while copper has excellent ductility (elongation can reach 40%-50%) and can absorb a large amount of deformation energy during stretching or bending.

Molybdenum -copper composite materials is mainly affected by the copper content . Molybdenum-copper sheets with high copper content (such as Mo60Cu40) have good ductility and can withstand large plastic deformation. They are suitable for electronic packaging or thermal management components that require molding processing; molybdenum-copper sheets with high molybdenum content (such as Mo85Cu15) have lower ductility and tend to be more rigid structures, which are suitable for scenarios with high strength requirements. The preparation process also affects ductility. The melt infiltration method can improve ductility through a uniformly distributed copper phase , while the powder metallurgy method may reduce ductility if there are pores or poor interface bonding. The ductility of molybdenum-copper sheets gives it a processing advantage when manufacturing complex-shaped heat dissipation substrates or aerospace components, while reducing the risk of brittle fracture under cyclic loads.

2.3.4 Mechanical strength of molybdenum copper sheet

Mechanical strength refers to the ability of molybdenum copper sheets to resist external damage, usually characterized by tensile strength or yield strength, and is a key performance in structural applications. Molybdenum has a high tensile strength (about 600-800 MPa, depending on the processing state), which provides a solid mechanical support for composite materials, while copper has a lower tensile strength (about 200-250 MPa), but it helps to improve the ductility of the material. Molybdenum copper sheets with high molybdenum content (such as Mo85Cu15) have high mechanical strength, close to the strength level of molybdenum , and are suitable for high-stress aerospace high-temperature components or electronic device substrates; molybdenum copper sheets with high copper content (such as Mo60Cu40) have lower strength, but are more flexible and suitable for applications that require certain deformation. The hot pressing sintering method can significantly enhance the mechanical strength by increasing the density of the material, while the powder metallurgy method may cause a decrease in strength due to porosity if the sintering is not sufficient. The mechanical strength of molybdenum copper sheets enables them to withstand assembly stress in electronic packaging, maintain structural stability in high temperature environments, and meet high reliability requirements.

2.3.5 Fatigue resistance of molybdenum copper sheet

Fatigue resistance reflects the ability of molybdenum copper sheets to resist crack initiation and expansion under cyclic loads, and is an important characteristic in dynamic or vibrating environments. Pure molybdenum has poor fatigue resistance and is prone to microcracks under cyclic stress, while copper's excellent ductility and toughness help absorb cyclic stress and improve fatigue life. The fatigue resistance of molybdenum -copper composites improves with the increase of copper content . Molybdenum copper sheets with high copper content (such as Mo60Cu40) show longer fatigue life under cyclic loads and are suitable for high vibration environments, such as thermal management components of aerospace devices ; molybdenum copper sheets with high molybdenum content (such as Mo85Cu15) have slightly inferior fatigue resistance, but can withstand higher stress amplitudes due to high strength. The preparation process has a significant impact on fatigue resistance. Molybdenum copper sheets prepared by the melt infiltration method can effectively inhibit crack expansion due to uniform copper phase distribution and good interface bonding; powder metallurgy methods may accelerate fatigue failure if there are micropores or interface defects. The fatigue resistance of molybdenum copper sheets enables them to withstand long-term cyclic loads in power semiconductor devices or aerospace high-temperature components, ensuring long-term reliability.

2.4 Chemical properties of molybdenum copper sheets

Molybdenum copper sheets, including corrosion resistance, oxidation resistance, and acid and alkali resistance, determine their stability and service life in harsh chemical environments. The chemical properties of molybdenum and copper are significantly different. Molybdenum has excellent corrosion and oxidation resistance, while copper is prone to oxidation or corrosion in specific environments. The chemical properties of molybdenum -copper composites are optimized due to the synergistic effect of the two-phase structure, and the specific performance is affected by the composition ratio, microstructure and preparation process.

2.4.1 Corrosion resistance of molybdenum copper sheet

Corrosion resistance reflects the ability of molybdenum copper sheets to resist surface erosion and performance degradation when in contact with corrosive media (such as moisture, salt spray or chemical gases). Molybdenum has excellent corrosion resistance and can remain stable in a variety of chemical environments, especially in non-oxidizing acids and salt solutions; copper has weak corrosion resistance, especially in humid or chlorine-containing environments, and is prone to electrochemical corrosion. The corrosion resistance of molybdenum -copper composite materials is mainly dominated by the molybdenum phase. Molybdenum copper sheets with high molybdenum content (such as Mo85Cu15) show good stability in corrosive environments and are suitable for thermal management components in aerospace devices or marine environments; molybdenum copper sheets with high copper content (such as Mo60Cu40) have slightly poor corrosion resistance and may experience copper phase corrosion in high humidity or salt spray environments . The preparation process has a certain influence on corrosion resistance. The hot pressing sintering method can reduce the penetration of corrosive media by increasing density and reducing pores; the powder metallurgy method may accelerate local corrosion if micropores exist. The corrosion resistance of molybdenum copper sheets enables them to maintain performance for a long time in electronic packaging and high temperature environments, extending the life of the device.

2.4.2 Antioxidation properties of molybdenum copper sheets

Antioxidation performance refers to the ability of molybdenum copper sheets to resist oxidation reactions and surface oxidation in high temperature or oxygen-containing environments. Molybdenum easily reacts with oxygen to generate volatile oxides (such as MoO_3) at high temperatures (above about 600°C) , but its oxidation rate is slow, and the distribution of copper phase in molybdenum copper composites can partially alleviate the oxidation tendency of molybdenum . Copper forms a dense copper oxide (Cu_2O) protective layer at room temperature, which has certain oxidation resistance, but it is easy to further oxidize to form loose oxides (CuO) at high temperatures (above about 300°C), reducing performance. Molybdenum copper sheets with high molybdenum content (such as Mo85Cu15) have good oxidation resistance at high temperatures and are suitable for high-temperature aerospace components or power semiconductor heat dissipation substrates; molybdenum copper sheets with high copper content (such as Mo60Cu40) have slightly inferior performance in high-temperature oxidative environments and need to avoid long-term exposure to high-temperature oxygen-containing environments.

Surface treatment (such as nickel plating or gold plating) or optimization of preparation process (such as hot pressing sintering to increase density) can significantly improve oxidation resistance and reduce oxide generation. The oxidation resistance of molybdenum copper sheet enables it to maintain structural and functional stability in high-temperature electronic devices or industrial environments.

2.4.3 Acid and alkali resistance of molybdenum copper sheet

Acid and alkali resistance reflects the chemical stability of molybdenum copper sheets in acidic or alkaline environments, and is an important characteristic in chemical processing or specific industrial environments. Molybdenum has excellent corrosion resistance to non-oxidizing acids (such as hydrochloric acid and sulfuric acid), but is easily corroded in strong oxidizing acids (such as nitric acid); copper is sensitive to most acidic environments, especially soluble in oxidizing acids, but relatively stable in weak alkaline environments .

The acid and alkali resistance of molybdenum -copper composite materials is improved due to the high molybdenum content. Molybdenum copper sheets with high molybdenum content (such as Mo85Cu15) show good stability in non-oxidizing acid and weak alkaline environments, and are suitable for thermal management components in the chemical industry; molybdenum copper sheets with high copper content (such as Mo60Cu40) have poor corrosion resistance in acidic environments and need to avoid contact with strong acids.

The preparation process has an impact on acid and alkali resistance. The melt infiltration method can reduce the risk of local corrosion through uniform copper phase distribution ; if there are pores in the powder metallurgy method, it may cause acid and alkali medium penetration and accelerate corrosion. The acid and alkali resistance of molybdenum copper sheet enables it to maintain its performance in electronic device manufacturing or chemical environment to meet specific application requirements.

2.5 Thermal properties of molybdenum copper sheet

Molybdenum copper sheets, including thermal conductivity and thermal diffusivity, thermal expansion behavior and stability, and high temperature resistance, are its core advantages in thermal management, high temperature applications, and electronic devices. The thermal properties of molybdenum and copper complement each other, with copper providing high thermal conductivity and molybdenum contributing low thermal expansion and high temperature stability, making molybdenum copper sheets an ideal thermal management material in the fields of electronic packaging, aerospace, and energy. Thermal

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properties are significantly affected by the molybdenum -copper ratio, microstructure, and preparation process.

2.5.1 Thermal conductivity and thermal diffusivity

Thermal conductivity and thermal diffusivity are key parameters for measuring the ability of molybdenum copper sheets to conduct heat, which directly affect their performance in heat dissipation and thermal management. Copper has an extremely high thermal conductivity (about 401 W/m·K) and is an excellent thermal conductor, while molybdenum has a lower thermal conductivity.

The thermal conductivity of molybdenum -copper composite materials increases with the increase of copper content. Molybdenum-copper sheets with high copper content (such as Mo60Cu40) have high thermal conductivity, close to 200-250 W/m·K, which is suitable for heat dissipation substrates of power semiconductor devices and microwave devices; molybdenum -copper sheets with high molybdenum content have low thermal conductivity, about 150-180 W/m·K, but are still better than many traditional materials and are suitable for scenarios that require both strength and thermal conductivity. Thermal diffusivity reflects the ability of a material to conduct heat quickly, which is related to thermal conductivity and density. Molybdenum -copper sheets with high copper content have high thermal diffusivity, which helps to dissipate heat quickly. The preparation process has a significant impact on thermal conductivity. The hot pressing sintering method enhances thermal conduction efficiency by increasing density; the powder metallurgy method may reduce thermal conductivity if there are pores. The excellent thermal conductivity and thermal diffusivity of molybdenum- copper sheets enable them to effectively manage heat in high-power electronic devices and improve device performance and life.

2.5.2 Thermal expansion behavior and stability

Thermal expansion behavior and stability reflect the degree of dimensional change of molybdenum copper sheets when the temperature changes and their structural stability, which are key characteristics for their application in thermal cycling environments. Molybdenum has a low thermal expansion coefficient (about 4.8×10^{-6} /K at 25 ° C), which can effectively resist deformation caused by temperature; copper has a higher thermal expansion coefficient (about 16.5×10^{-6} /K at 25 ° C), which is easy to cause thermal stress. The thermal expansion coefficient of molybdenum- copper composite materials is between the two, and decreases with the increase of molybdenum content. Molybdenum copper sheets with high molybdenum content (such as Mo85Cu15) have a thermal expansion coefficient close to 5-7×10^{-6} /K, which matches ceramic materials (such as alumina and silicon nitride) and is suitable for reducing interface cracking caused by thermal stress in electronic packaging; molybdenum copper sheets with high copper content (such as Mo60Cu40) have a higher thermal expansion coefficient of about 8-10×10^{-6} /K, which is suitable for heat dissipation applications with less stringent requirements on thermal expansion. Thermal expansion stability is also affected by the microstructure. Uniform molybdenum -copper interface and dense structure can reduce thermal stress concentration. Hot pressing sintering method enhances thermal expansion stability by optimizing interface bonding, while powder metallurgy method may lead to local stress concentration if there are defects. The low thermal expansion and high stability of molybdenum- copper sheet enable it to maintain structural integrity in high temperature cycle environment and extend the service life of the device.

2.5.3 High temperature resistance

High temperature resistance reflects the ability of molybdenum copper sheets to maintain physical and chemical stability in high temperature environments, which is an important characteristic in aerospace, nuclear industry and high-temperature electronic devices. The high melting point of molybdenum (about 2623°C) gives composite materials excellent high temperature resistance, while the low melting point of copper (1085°C) limits the application of high copper content materials under extreme high temperatures. Molybdenum copper sheets with high molybdenum content (such as Mo85Cu15) can maintain stable structure and performance at high temperatures of 600-800°C, suitable for aerospace jet engine components or nuclear reactor heat exchange components; molybdenum copper sheets with high copper content (such as Mo60Cu40) have slightly inferior high temperature resistance, and the recommended operating temperature is below 400°C to avoid softening or oxidation of the copper phase. The preparation process has an important influence on high temperature resistance. The hot pressing sintering method enhances high temperature stability by increasing density and interface strength; if the copper phase is unevenly distributed in the melt infiltration method, it may cause performance degradation at high temperatures. Surface treatment (such as nickel plating) can further improve high temperature resistance and reduce high temperature oxidation. The high temperature resistance of molybdenum copper sheets enables them to serve for a long time in harsh thermal environments and meet high reliability requirements.

2.6 Electrical properties of molybdenum copper sheets

Molybdenum copper sheets, including conductivity and resistance characteristics, electrical contact performance and electrochemical stability, are the key to their application in electronic devices, power modules and conductive components. The high conductivity of copper combined with the structural stability of molybdenum gives molybdenum copper sheets unique advantages in electrical properties, meeting the requirements of high-performance electronic devices for conductivity and reliability. Electrical properties are affected by the molybdenum -copper ratio, microstructure and preparation process.

2.6.1 Conductivity and resistance characteristics

The conductivity and resistance properties reflect the ability of molybdenum copper sheets to conduct current and are their core performance in conductive applications. Copper has extremely high conductivity (close to 100% IACS, international annealed copper standard) and is an excellent conductive material, while molybdenum has a lower conductivity (about 18% IACS). The conductivity of molybdenum -copper composite materials increases with the increase of copper content. Molybdenum copper sheets with high copper content (such as Mo60Cu40) have high conductivity, close to 30-40% IACS, which is suitable for conductive substrates of power semiconductor devices and microwave devices; molybdenum copper sheets with high molybdenum content (such as Mo85Cu15) have low conductivity, about 20-25% IACS, but it is still sufficient to meet the needs of many electronic applications.

The resistance property is directly related to the conductivity. Molybdenum copper sheets with high copper content have low resistance, which helps to reduce power loss and heat generation. The preparation process has a significant impact on the conductivity. The hot pressing sintering method can enhance the conductivity by increasing the density and optimizing the molybdenum copper interface; the powder metallurgy method may increase the resistance if there are pores or interface defects. The excellent conductivity and low resistance characteristics of molybdenum copper sheets enable them to efficiently conduct current in high-power electronic devices, reduce energy loss, and improve device performance.

2.6.2 Electrical contact performance

Electrical contact performance refers to the ability of molybdenum copper sheets to maintain low contact resistance and stable electrical connection at electrical contact interfaces (such as connectors or electrodes). Copper's low contact resistance and high conductivity make it an ideal contact material, while molybdenum 's high hardness and wear resistance help maintain the mechanical stability of the contact interface.

Performance of molybdenum -copper composite materials improves with the increase of copper content. Molybdenum-copper sheets with high copper content (such as Mo60Cu40) have low contact resistance and are suitable for electrical connection components in high-current electronic devices, such as conductive substrates of power modules; Molybdenum -copper sheets with high molybdenum content (such as Mo85Cu15) have slightly higher contact resistance, but due to their high hardness, they can resist contact wear and are suitable for applications that require long-term stable contact. Surface treatment (such as silver plating or gold plating) can further reduce contact resistance and improve wear resistance. The preparation process has an important influence on electrical contact performance. The melt infiltration method can optimize the contact interface through uniform copper phase distribution ; the powder metallurgy method may lead to increased contact resistance if micropores exist. The electrical contact performance of molybdenum -copper sheets enables them to maintain reliable electrical connections in electronic packaging and power devices , reducing the risk of contact failure.

2.6.3 Electrochemical stability

Electrochemical stability reflects the ability of molybdenum copper sheets to resist electrochemical corrosion in electrochemical environments (such as electrolyte solutions or humid salty environments). Molybdenum has excellent corrosion resistance and performs well in non-oxidizing electrolytes, but may be corroded in strong oxidizing environments; copper has poor electrochemical stability and is prone to electrochemical corrosion in humid or chlorine-containing environments. The electrochemical stability of molybdenum -copper composites is mainly dominated by the molybdenum phase. Molybdenum copper sheets with high molybdenum content (such as Mo85Cu15) show good stability in electrochemical environments and are suitable for conductive components in marine environments or chemical industries; molybdenum copper sheets with high copper content (such as Mo60Cu40) have weak electrochemical stability and may suffer from copper phase corrosion in high humidity or salt spray environments . The preparation process has an impact on electrochemical stability. The hot pressing sintering method can reduce electrolyte penetration and corrosion risks by increasing density and reducing pores; the powder metallurgy method may accelerate local electrochemical corrosion if micropores exist. Surface protective layers (such as nickel plating) can significantly improve electrochemical stability. The electrochemical stability of molybdenum copper sheets enables them to maintain performance for a long time in electrical contact and conductive applications, extending device life.

2.7 Comparison between molybdenum copper sheet and other materials

Molybdenum copper sheet has unique advantages in thermal management, electronics and high-temperature applications. Compared with other commonly used materials (such as pure copper, tungsten copper, aluminum silicon and ceramic materials), its performance is balanced in terms of thermal conductivity, thermal expansion, mechanical properties and cost. Pure copper has extremely high thermal conductivity (about 401 W/m·K) and electrical conductivity (100% IACS), but its thermal expansion coefficient is high (about 16.5×10^{-6} /K at 25 ° C) and high-temperature strength is low (about 200-250 MPa), which is not suitable for high temperature or thermal cycle environment; molybdenum copper sheet (such as Mo60Cu40) has slightly lower thermal conductivity (about 200-250 W/m·K), but lower thermal expansion coefficient (about $8\text{-}10\times10^{-6}$ /K), better high-temperature stability, and is suitable for electronic packaging. The thermal conductivity of tungsten copper composites is comparable to that of molybdenum copper (about 180-220 W/m·K), but the density is higher (about 15-17 g/cm³ vs. 9-10 g/cm³ of molybdenum copper), the cost is higher, and the processing is difficult; molybdenum copper sheets have lower density, more cost advantages, and are suitable for lightweight applications. Aluminum silicon composites (such as AlSiC) have slightly lower thermal conductivity (about 150-200 W/m·K), but the thermal expansion coefficient is close to that of molybdenum copper, and the weight is lighter, which is suitable for aerospace, but its mechanical strength and high temperature resistance are not as good as molybdenum copper sheets. Ceramic materials (such as aluminum oxide and silicon nitride) have a low thermal expansion coefficient (about $4\text{-}7\times10^{-6}$ /K), but poor thermal and electrical conductivity (aluminum oxide is about 20-30 W/m·K), which is not suitable for conductive applications, while molybdenum copper sheets have both conductivity and thermal management capabilities. The manufacturing process of molybdenum -copper sheets (such as powder metallurgy or melt infiltration) is relatively mature, the raw materials molybdenum and copper have abundant reserves, strong recyclability, and lower cost than tungsten-copper and some ceramic materials, making it widely competitive in the fields of electronics, aerospace, and energy.

2.8 CTIA GROUP LTD Molybdenum Copper Sheet MSDS

CTIA GROUP LTD Molybdenum Copper Sheet is a guidance document that provides safety information for the production, transportation, storage and use of the material, aiming to ensure that workers, emergency personnel and users understand its characteristics, potential hazards and safe operation requirements.

Molybdenum copper sheet is a composite metal material composed of molybdenum (CAS No.: 7439-98-7) and copper (CAS No.: 7440-50-8). The product name is usually named after the composition ratio, such as Mo85Cu15 (85% molybdenum , 15% copper) or Mo60Cu40 (60% molybdenum , 40% copper) . Its main uses include heat dissipation substrates for electronic packaging, aerospace thermal management components and power module conductive parts. It is recommended to avoid long-term use in strong oxidizing acids (such as nitric acid) or high-temperature oxygen-containing environments to prevent copper phase corrosion or oxidation.

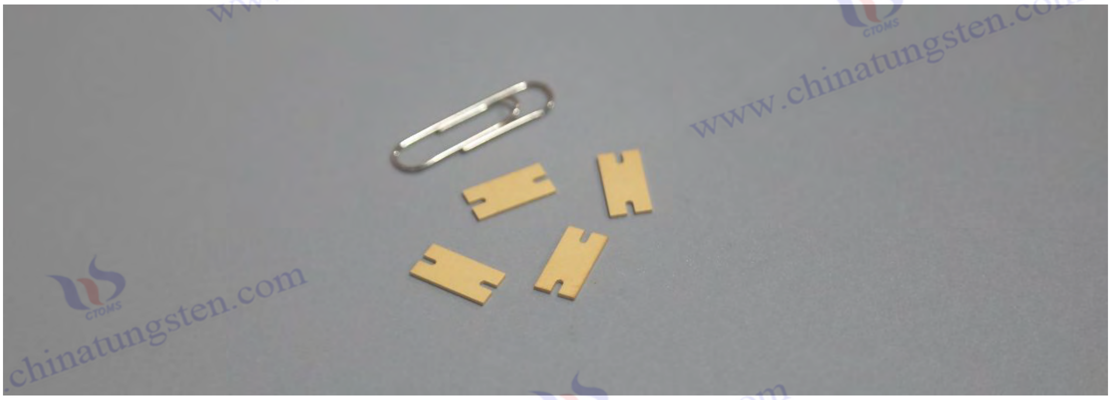
Under normal use conditions, molybdenum copper sheets are solid plates and are not classified as hazardous chemicals, but the processing process (such as cutting, grinding, and welding) may produce dust or metal fragments, posing health and safety risks. Inhalation of dust may cause mild respiratory irritation, and long-term contact may cause lung discomfort; skin contact with metal fragments may cause mechanical irritation or cuts. In terms of the environment, molybdenum copper sheets are inert materials and will not cause significant pollution to water or soil, but waste must be handled in accordance with local regulations. The GHS classification indicates that it is not a hazardous chemical, but protective measures must be taken during processing.

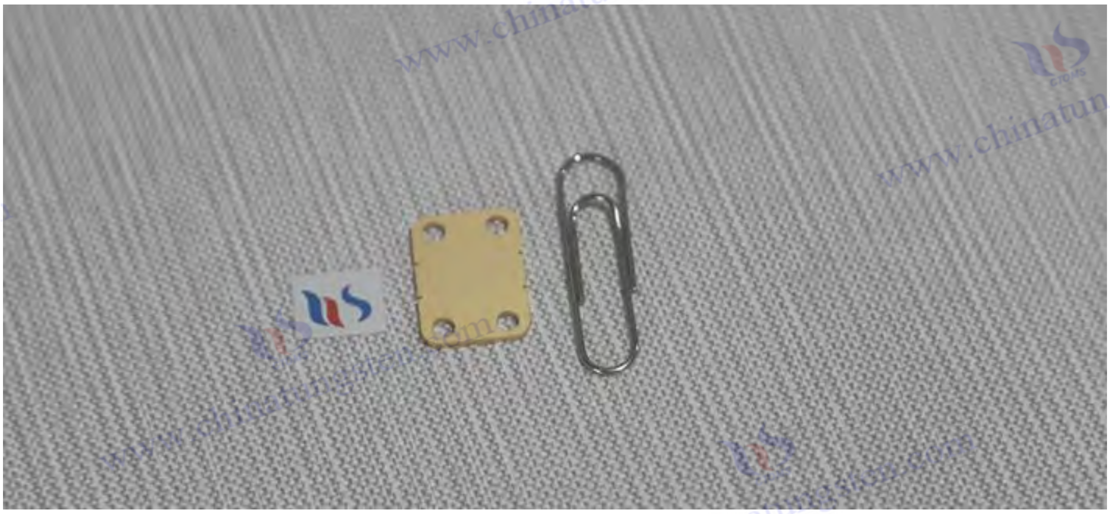
Emergency treatment For dust or debris generated during processing, the affected area needs to be isolated and cleaned with dust-proof equipment (such as a vacuum cleaner) to avoid dust. The collected materials should be placed in sealed containers and handled in accordance with regulations. Cleaning personnel need to wear dust masks and gloves. It is recommended to cut, grind or weld in a well-ventilated area during operation, use local dust removal equipment, and operators should wear protective glasses, gloves and dust masks. When storing, molybdenum copper sheets should be placed in a dry and cool environment, avoid contact with strong oxidizing acids or high-temperature oxygen-containing environments, and be properly packaged to prevent moisture or mechanical damage.

Exposure control requires that local exhaust systems be installed in processing areas to keep dust concentrations below occupational exposure limits (such as ACGIH TLV: 10 mg/m^3 for molybdenum dust and 1 mg/m^3 for copper dust). Personal protective equipment includes N95 or higher grade dust masks, protective glasses and wear-resistant gloves. Long-term exposure requires regular health checks. The physical and chemical properties of molybdenum copper sheets vary depending on the composition ratio. For example, the density of Mo85Cu15 is about 10.0 g/cm^3, the thermal conductivity is about 1 6 0-180 W/m·K, and the thermal expansion coefficient is about $5\text{-}7\times10^{-6}$ /K; the density of Mo60Cu40 is about 9. 6 g/cm^3, the thermal conductivity is about 2 1 0-250 W/m·K, and the thermal expansion coefficient is about $10\text{-}11\times10^{-6}$ /K. The material is a silver-gray metal solid, odorless, insoluble in water, and chemically stable.

Under normal conditions, molybdenum copper sheets are chemically stable and do not react with water, air or common chemicals. However, in a high-temperature oxygen-containing environment, the copper phase may generate copper oxide and the molybdenum phase may generate volatile oxides. Contact with strong oxidizing acids should be avoided to prevent the copper phase from dissolving , and processing dust should be kept away from fire sources. In terms of toxicology, solid molybdenum copper sheets have no significant toxicity, and dust may cause mild respiratory or skin irritation. Long-term inhalation of high-concentration dust may cause lung discomfort. Ecologically, molybdenum copper sheets do not cause bioaccumulation or environmental pollution, and waste should be recycled or disposed of in accordance with regulations, such as in accordance with China's "Law on the Prevention and Control of Environmental Pollution by Solid Waste".

During transportation, molybdenum copper sheets are not dangerous goods and do not require special requirements, but they must be properly packaged to prevent mechanical damage, using sturdy wooden boxes or plastic containers with MSDS attached. In terms of regulations, the materials comply with China's "Regulations on the Safety Management of Hazardous Chemicals" and international GHS standards, and must comply with occupational safety and health regulations. Exports meet EU REACH and RoHS requirements.





CTIA GROUP LTD Molybdenum Copper Sheet Picture

Chapter 3 Classification of Molybdenum Copper Sheets

3.1 Classification by brand (typical) Molybdenum copper sheet

The classification of molybdenum copper sheets is mainly based on their composition ratio, that is, the mass or volume percentage of molybdenum (Mo) and copper (Cu). Different grades correspond to specific performance characteristics to meet the diverse needs of electronics, aerospace, thermal management and conductive applications. The grade naming is usually directly marked with the content of molybdenum and copper , for example, Mo85Cu15 means 85% molybdenum and 15% copper. By adjusting the molybdenum- copper ratio, thermal conductivity, electrical conductivity, thermal expansion coefficient and mechanical properties can be optimized.

3.1.1 Mo85Cu15

Mo85Cu15 is a grade with a high molybdenum content, with 85% molybdenum and 15% copper. It is mainly characterized by high strength, low thermal expansion coefficient and high high temperature resistance. Its density is about 10.0 g/cm³, which is close to the density of molybdenum . Its thermal conductivity is about 1 6 0-180 W/m·K, its electrical conductivity is about 20-25% IACS, and its thermal expansion coefficient is about 5-7×10 $^{-6}$ /K, which is highly matched with ceramic materials. Mo85Cu15 has excellent mechanical properties, a Vickers hardness of about 180-220 HV, and a tensile strength of nearly 600 MPa, which is suitable for applications with high stress. Due to its high molybdenum content, it has excellent high temperature resistance and can operate stably in an environment of 600-800°C. It has strong corrosion resistance and oxidation resistance, and is suitable for high-temperature components in aerospace (such as jet engine thermal management components), nuclear industry heat exchangers, and heat dissipation substrates for power semiconductor devices. Mo85Cu15 has low ductility and toughness, and is slightly more difficult to process. It is often produced by hot pressing and sintering to ensure high density. It is suitable for scenarios with strict requirements on thermal expansion control and high-temperature stability.

3.1.2 Mo80Cu20

Mo80Cu20 is a grade with a relatively balanced ratio of molybdenum and copper , with 80% molybdenum and 20% copper, achieving a good compromise between strength, thermal conductivity and thermal expansion performance. Its density is about 9.9 g /cm³, thermal conductivity is about 170-200 W/m·K, electrical conductivity is about 25-30% IACS, and thermal expansion coefficient is about 6-8×10 $^{-6}$ /K, which is still matched with ceramic materials, but slightly higher than Mo85Cu15. The mechanical properties of Mo80Cu20 are slightly lower than those of Mo85Cu15, with a Vickers hardness of about 160-200 HV and a tensile strength of about 500-600 MPa. The ductility and toughness are improved, which is suitable for applications that require certain processing performance. It has good high temperature resistance and can work stably in an environment of 500-700°C. It has excellent corrosion resistance and oxidation resistance, and is suitable for heat dissipation substrates, microwave device heat sinks and aerospace structural parts in electronic packaging. Mo80Cu20 is produced by powder metallurgy or melt infiltration. The melt infiltration method can optimize the copper phase distribution , improve thermal conductivity and electrical conductivity, and is widely used in scenarios with comprehensive requirements for thermal management and mechanical properties.

3.1.3 Mo70Cu30

Mo70Cu30 is a grade with a high copper content, with molybdenum accounting for 70% and copper accounting for 30%. Its main advantages are high thermal conductivity and high electrical conductivity, and it is suitable for efficient thermal management and conductive applications. Its density is about 9.6 g/cm³, which is close to the density of copper (8.96 g/cm³), its thermal conductivity is about 200-250 W/m·K, its electrical conductivity is about 30-40% IACS, and its thermal expansion coefficient is about $8\text{-}10\times10^{-6}$ /K, which is higher than the previous two. It is suitable for scenes with less stringent requirements for thermal expansion. The mechanical properties of Mo70Cu30 are weak, with a Vickers hardness of about 120-160 HV and a tensile strength of about 400-500 MPa, but its ductility and toughness are significantly improved, and it is easy to process and shape, making it suitable for manufacturing heat sinks or conductive parts with complex shapes. Its high temperature resistance is slightly inferior, and the recommended operating temperature is below 400°C to avoid softening or oxidation of the copper phase. Its corrosion resistance and oxidation resistance are slightly lower than those of Mo85Cu15 and Mo80Cu20. It is suitable for thermal management components of 5G communication equipment, power modules and new energy vehicles. Mo70Cu30 is often produced by melt infiltration to ensure uniform distribution of the copper phase and optimize thermal conductivity and electrical contact performance.

3.1.4 Mo60Cu40

Molybdenum copper sheet grade with a high copper content , with 60% molybdenum and 40% copper. It has excellent thermal conductivity and electrical conductivity as its core characteristics, and is suitable for efficient thermal management and conductive applications. Its density is about 9.3 g/cm³, close to the density of copper (8.96 g/cm³), and its thermal conductivity is relatively high, about 200-250 W/m·K, its electrical conductivity is about 30-40% IACS, and its thermal expansion coefficient is about $8\text{-}10\times10^{-6}$ /K, which is suitable for scenes with relatively loose thermal expansion requirements. Mo60Cu40 has moderate mechanical properties, with a Vickers hardness of about 100-140 HV and a tensile strength of about 350-450 MPa. Compared with grades with high molybdenum content, its ductility and toughness are significantly improved, and it is easy to process and form, suitable for manufacturing heat sinks, conductive substrates or connectors with complex shapes. Its high temperature resistance is limited by the copper content . The recommended operating temperature is below 400°C to avoid softening or oxidation of the copper phase. Its corrosion resistance and oxidation resistance are slightly lower than those of high molybdenum content grades, but it is stable in non-harsh chemical environments. Mo60Cu40 is widely used in thermal management components of 5G communication equipment, power semiconductor modules, and new energy vehicles, especially in scenarios requiring high thermal conductivity and certain processing performance. Infiltration is its common preparation process, which can ensure uniform distribution of the copper phase and further optimize thermal conductivity and electrical contact performance. Powder metallurgy can also be used for production, but high density must be ensured to maintain performance.

3.1.5 Mo50Cu50

Molybdenum copper sheet grade with the highest copper content , with molybdenum and copper accounting for 50% each. Its main advantages are extremely high thermal conductivity and electrical conductivity, which are close to the performance of pure copper, while retaining a certain mechanical strength and thermal stability. Its density is about 9.1 g/cm³, which is very close to the density of copper. Its thermal conductivity is about 220-270 W/m·K, its electrical conductivity is about 35-45% IACS, and its thermal expansion coefficient is about $10\text{-}12\times10^{-6}$ /K, which is suitable for applications with low requirements for thermal expansion control. The mechanical properties of Mo50Cu50 tend to be flexible, with a Vickers hardness of about 80-120 HV and a tensile strength of about 300-400 MPa. Its ductility and toughness are close to those of pure copper, making it suitable for complex processing techniques such as stamping or bending. Its high temperature resistance is weak, and the recommended operating temperature is below 350°C to prevent the copper phase from softening or oxidizing at high temperatures. Its corrosion resistance and oxidation resistance are further reduced compared to Mo60Cu40, and it is necessary to avoid long-term use in humid or chlorine-containing environments. Mo50Cu50 is mainly used for heat dissipation substrates of high-power electronic devices, conductive components of microwave devices, and power modules of new energy vehicles. It is particularly suitable for scenarios that require efficient heat conduction and electrical transmission. The melt infiltration method is the preferred preparation process, which can optimize the continuity of the copper phase and improve thermal conductivity and electrical conductivity; powder metallurgy can also be used, but the pores need to be strictly controlled to ensure stable performance.

Molybdenum Copper Sheets by Manufacturing Process

Molybdenum copper sheet has a significant impact on its performance, microstructure and application scenarios, mainly including powder metallurgy and melt infiltration. Different processes affect thermal conductivity, electrical conductivity, mechanical properties and chemical stability by controlling the bonding mode of molybdenum and copper and the density of the material. The following describes in detail the characteristics and applications of molybdenum copper sheets manufactured by powder metallurgy and melt infiltration .

copper sheet manufactured by powder metallurgy

Molybdenum copper sheets manufactured by powder metallurgy are prepared by mixing molybdenum powder and copper powder, pressing and high-temperature sintering. They are suitable for producing molybdenum copper sheets with various composition ratios, such as Mo85Cu15, Mo80Cu20 and Mo70Cu30. The process first mixes molybdenum and copper powders in a specified ratio, forms a blank by cold pressing or hot pressing, and then sinters under the protection of high-temperature inert gas (such as argon or nitrogen) to partially melt the copper phase and fill the pores between the molybdenum particles to form a dense composite structure. Molybdenum copper sheets manufactured by powder metallurgy have high mechanical strength. The tensile strength of Mo85Cu15 can reach 500-600 MPa, and the Vickers hardness is about 180-220 HV. They are suitable for high-strength aerospace high-temperature components and electronic packaging heat dissipation substrates. Its thermal conductivity increases with the increase of copper content, such as Mo70Cu30 can reach 200-250 W/m·K, and the electrical conductivity is about 30-40% IACS. Powder metallurgy can precisely control the proportion of ingredients and is suitable for customized production, but if the sintering temperature or pressure is insufficient, it may lead to the presence of micropores, slightly reducing thermal conductivity and electrical conductivity. Molybdenum copper sheets produced by powder metallurgy are widely used in power semiconductor devices, microwave devices and thermal management components, especially in scenarios that require high strength and precise dimensions, but the processing cost is high and it is suitable for high-performance applications.

Molybdenum-copper sheet manufactured by melt infiltration

Molybdenum copper sheet manufactured by the melt infiltration method is formed by first preparing a porous molybdenum skeleton and then infiltrating molten copper into the pores of the molybdenum skeleton to form a composite material. It is suitable for producing grades with high copper content, such as Mo60Cu40 and Mo50Cu50. The process first presses and sinters molybdenum powder through powder metallurgy technology to form a porous molybdenum skeleton, and then infiltrates molten copper into the pores of the skeleton at high temperature, forming a uniform two-phase structure after cooling. The molybdenum copper sheet manufactured by the melt infiltration method has excellent thermal conductivity and electrical conductivity. The thermal conductivity of Mo60Cu40 can reach 200-250 W/m·K, and the electrical conductivity is about 30-40% IACS. Mo50Cu50 is close to 220-270 W/m·K and 35-45% IACS, which is suitable for efficient thermal management and conductive applications, such as 5G communication equipment and new energy vehicle power modules. Its mechanical properties are slightly lower than those of powder metallurgy products. The tensile strength of Mo60Cu40 is about 350-450 MPa, and the Vickers hardness is about 100-140 HV, but it has better ductility and toughness, making it easier to process complex shapes. The melt infiltration method optimizes thermal conductivity and electrical contact performance through uniform copper phase distribution , but if the porosity of the molybdenum skeleton is not properly controlled, it may lead to local copper phase unevenness and affect performance stability. The cost of molybdenum copper sheets produced by the melt infiltration method is relatively low, suitable for mass production, and widely used in electronic radiators and conductive substrates.

3.3 Classification of Molybdenum Copper Sheets by Application Field

Molybdenum copper sheets can be divided into general-purpose and other special-purpose types (such as aerospace or electronic packaging) according to different needs in the application field. The application field classification is based on the matching of material properties and usage scenarios. General-purpose molybdenum copper sheets are widely used in various industries with their balanced

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performance. The following describes in detail the characteristics and applications of general-purpose molybdenum copper sheets.

3.3.1 General Molybdenum Copper Sheet

General-purpose molybdenum copper sheet is a standardized product to meet the needs of various industries, usually including grades such as Mo80Cu20, Mo70Cu30 and Mo60Cu40. It has balanced thermal conductivity, electrical conductivity, mechanical properties and thermal expansion characteristics, and is suitable for electronics, communications, energy and industrial fields. Its density range is 9.3-9.8 g/cm³, thermal conductivity is about 170-250 W/m·K, electrical conductivity is about 25-40% IACS, and thermal expansion coefficient is about 6-10×10 $^{-6}$ /K, which matches well with ceramics and semiconductor materials (such as alumina and silicon nitride). The mechanical properties of general-purpose molybdenum copper sheet are moderate, with a tensile strength of about 350-600 MPa and a Vickers hardness of about 100-200 HV. The ductility and toughness are sufficient to support conventional processing such as cutting and stamping. Its high temperature resistance can support working environments of 400-700°C, and its corrosion resistance and oxidation resistance are stable in non-harsh environments. Universal molybdenum copper sheet is produced by powder metallurgy or melt infiltration. The melt infiltration method is more suitable for high copper content grades to optimize thermal conductivity, and the powder metallurgy method is suitable for high strength requirements. Typical applications include heat dissipation substrates in electronic packaging, heat sinks in communication equipment, conductive parts of power modules, and thermal management components of new energy vehicles. The flexibility and cost-effectiveness of universal molybdenum copper sheet make it the material of choice for thermal management and conductive applications, meeting the needs of everything from consumer electronics to industrial equipment.

3.3.2 High frequency molybdenum copper sheet

High-frequency molybdenum copper sheets are designed for high-frequency electronic equipment, focusing on meeting the needs of microwave, radio frequency and communication equipment for high conductivity, low thermal expansion and excellent thermal management . Grades with higher copper content, such as Mo60Cu40 or Mo50Cu50, are usually selected to ensure efficient electrical transmission and heat conduction. Its thermal conductivity is about 200-270 W/m·K, and its electrical conductivity is about 30-45% IACS, which can effectively reduce energy loss and heat accumulation in high-frequency signal transmission. Its thermal expansion coefficient is about 8-12×10 $^{-6}$ /K, which is suitable for ceramics or semiconductor materials (such as aluminum nitride) in high-frequency devices.

High-frequency molybdenum copper sheets are moderate, with a tensile strength of about 300-450 MPa, a Vickers hardness of about 80-140 HV, good ductility, and support for complex shape processing, such as microwave device heat sinks or antenna substrates. High temperature resistance is limited by the copper content , and the recommended operating temperature is below 400°C to avoid copper phase oxidation . The corrosion resistance and electrochemical stability are good in conventional environments and are suitable for 5G communication base stations, radar systems, and satellite communication equipment. Infiltration is the main preparation process, which optimizes electrical conductivity and thermal conduction through uniform copper phase distribution . Powder metallurgy can also be used for high-precision component production. Surface treatment (such as silver plating) is often used to further reduce contact resistance and improve high-frequency performance. High-frequency molybdenum copper sheets are widely used in RF power amplifiers, microwave integrated circuits, and communication modules to ensure signal integrity and thermal stability.

3.3.3 Aerospace Molybdenum Copper Sheet

Aerospace-type molybdenum copper sheet is specially designed for the extreme environment in the aerospace field, emphasizing high strength, low thermal expansion and excellent high temperature resistance. Usually, grades with higher molybdenum content, such as Mo85Cu15 or Mo80Cu20, are selected to cope with high temperature and high stress conditions. Its density is about 9.8-10.0 g/cm³, thermal conductivity is about 150-200 W/m·K, electrical conductivity is about 20-30% IACS, and thermal expansion coefficient is about 5-8×10 $^{-6}$ /K, which is highly matched with ceramic materials and reduces interfacial stress in thermal cycles. Aerospace-type molybdenum copper sheet has excellent mechanical properties, tensile strength of about 500-600 MPa, Vickers hardness of about 160-220 HV, suitable for bearing mechanical loads and vibrations, excellent high temperature resistance, can operate stably in 600-800°C environment, strong oxidation resistance and corrosion resistance, and is suitable for the harsh chemical environment of aerospace devices. Hot pressing and sintering is the main preparation process, ensuring high density and interface strength, and melt infiltration can also be used for specific parts to balance cost and performance. Aerospace molybdenum copper sheets are widely used in jet engine thermal management components, satellite heat sinks and spacecraft power modules. They can maintain performance in high temperature, high vibration and vacuum environments, ensuring equipment reliability and long life.

3.3.4 Photoelectric device type molybdenum copper sheet

Optoelectronic device type molybdenum copper sheet is designed for optoelectronic devices (such as lasers, LEDs and optical communication modules), focusing on meeting the requirements of high thermal conductivity, low thermal expansion and electrical contact performance. Mo70Cu30 or Mo60Cu40 grades are usually selected to balance thermal conductivity and thermal expansion matching. Its thermal conductivity is about 200-250 W/m·K, and its electrical conductivity is about 30-40% IACS. It can quickly dissipate heat and protect optoelectronic devices from thermal damage. Its thermal expansion coefficient is about 8-10×10 $^{-6}$ /K, which matches well with optoelectronic materials (such as gallium arsenide and silicon nitride) to reduce device failure caused by thermal stress. The mechanical properties of optoelectronic device type molybdenum copper sheet are moderate, with a tensile strength of about 350-500 MPa and a Vickers hardness of about 100-160 HV. The ductility supports precision processing and is suitable for manufacturing small heat dissipation substrates or electrodes. The high temperature resistance is moderate, and the recommended operating temperature is below 400°C. The corrosion resistance and electrochemical stability meet the needs of optoelectronic devices in conventional environments.

Chapter 4 Preparation Technology of Molybdenum Copper Sheet

4.1 Preparation of molybdenum copper sheet by powder metallurgy technology

Powder metallurgy technology is one of the main processes for preparing molybdenum copper sheets . It is suitable for producing molybdenum copper sheets with various composition ratios, such as Mo85Cu15, Mo80Cu20 and Mo70Cu30. By precisely controlling the mixing, pressing and sintering process of molybdenum and copper powders , excellent mechanical properties, thermal conductivity and electrical conductivity are achieved. This technology processes metal powders into dense composite materials to meet the needs of electronic packaging, aerospace and thermal management .

4.1.1 Process flow of powder metallurgy technology

Molybdenum copper sheets by powder metallurgy technology includes the steps of powder preparation, mixing, pressing, sintering and post-processing.

First, high-purity molybdenum powder (purity is usually ≥99.95%) and copper powder (purity is usually ≥99.9%) are selected and screened to ensure uniform particle size to improve the mixing effect. The powders are uniformly mixed in a mechanical mixing device according to the target ratio (such as Mo85Cu15 or Mo70Cu30), and a small amount of lubricant (such as stearic acid) is often added to improve the pressing performance. The mixed powder is pressed in a mold by cold pressing or isostatic pressing technology, and the pressure is usually 100-300 MPa to form a green body with a certain strength. Then, the green body is sintered in a high-temperature sintering furnace (temperature range 1000-1400°C) under the protection of inert gas (such as argon or nitrogen) or hydrogen, and the copper phase partially melts and fills the pores between the molybdenum particles to form a dense molybdenum -copper composite structure. The sintering time is usually 2-6 hours, depending on the composition and equipment conditions. The sintered molybdenum copper sheet can be post-processed, such as hot pressing to further increase the density, or mechanical processing (such as cutting, drilling) to meet the size requirements. The final product can be surface treated (such as nickel plating or gold plating) as needed to enhance oxidation resistance and electrical contact performance.

The entire process can precisely control the ratio of molybdenum to copper, making it suitable for high-performance applications such as aerospace high-temperature components and electronic heat dissipation substrates.

4.1.2 Advantages and limitations of powder metallurgy technology

Powder metallurgy technology has significant advantages in the preparation of molybdenum- copper sheets, but it also has certain limitations. In terms of advantages, this technology can accurately control the ratio of molybdenum and copper , and produce diversified grades such as Mo85Cu15 and Mo80Cu20 to meet different thermal conductivity and electrical conductivity (20-40% IACS) requirements. The process is highly flexible and the material properties can be optimized by adjusting the powder particle size, pressing pressure and sintering temperature. For example, the tensile strength of Mo85Cu15 can reach 500-600 MPa, which is suitable for high-strength applications.

Powder metallurgy can also achieve high density (usually ≥98% theoretical density), ensuring excellent mechanical properties and thermal conductivity efficiency, and is suitable for electronic packaging and aerospace fields.

In addition, this technology is suitable for small-batch customized production and can manufacture parts with complex shapes, such as heat sinks for microwave devices. In terms of limitations, the production cost of powder metallurgy is relatively high, involving the preparation of high-purity powders, precision molds, and high-temperature sintering equipment, with high energy consumption and equipment maintenance costs. If the sintering process is not properly controlled, it may lead to poor micropores or interface bonding, reducing thermal conductivity and electrical conductivity, especially in high-copper content grades (such as Mo60Cu40). Powder metallurgy has strict requirements on powder quality, and impurities or uneven particle size may affect material consistency. In addition, the sintering process needs to be carried out in an inert or reducing atmosphere, which increases the complexity of the process. Compared with other methods, powder metallurgy is widely applicable in the production of high-performance molybdenum copper sheets, but it is necessary to balance cost and performance, and is suitable for high-precision and high-reliability scenarios.

4.2.1 Process flow of melt infiltration

Molybdenum copper sheet by melt infiltration includes several important steps. The first is the preparation of molybdenum sheet and copper source . Molybdenum sheet usually needs to be cleaned before use to remove surface oxides and impurities, which helps to ensure good bonding of copper and molybdenum during the melt infiltration process . The copper source is usually copper powder or copper alloy powder. The copper powder selected has an appropriate particle size so that it can better penetrate into the pores of the molybdenum sheet after melting. Next, the cleaned molybdenum sheet and the copper source are placed in a high-temperature furnace and heated. The temperature is gradually increased to the melting point of copper (about 1,083°C) to completely melt the copper. The molten copper liquid penetrates into the pores and microcracks of the molybdenum sheet through capillary action, forming the basis of the molybdenum -copper composite material. During the melt infiltration process, the control of temperature and time is crucial, because if the temperature is too high or the infiltration time is too long, it may cause excessive copper penetration and affect the physical properties of the molybdenum copper sheet. Therefore, in this process, it is very critical to control the melt infiltration temperature between 1,100°C and 1,200°C and ensure the penetration depth and uniformity of copper.

When the copper liquid completely penetrates into the pores of the molybdenum sheet, the entire system will enter the cooling stage. During the cooling process, the combination of copper and molybdenum will gradually stabilize to form a solid composite material. At this time, the control of the cooling rate is also very important, because rapid cooling may cause internal stress in the material, affecting its mechanical properties. After cooling to room temperature, the shape and size of the molybdenum copper sheet are basically fixed. Finally, in order to ensure the surface quality and dimensional accuracy of the final molybdenum copper sheet, post-processing is usually required. The post-processing steps include removing excess copper on the surface, grinding and polishing the material, etc., to improve the smoothness and dimensional accuracy of the molybdenum copper sheet. If necessary, heat treatment can also be performed to further improve the mechanical properties and thermal conductivity of the molybdenum copper sheet.

4.2.2 Advantages and limitations of the infiltration method

The melt infiltration method has significant advantages. First, the process efficiency is high, and copper and molybdenum can be combined in a short time to form a stable composite material. Since the melt infiltration process can accurately control the penetration depth and distribution of copper, the various properties of the composite material can be effectively optimized, especially in terms of thermal conductivity, electrical conductivity and high temperature resistance. The melt infiltration method is highly adaptable and can adjust the copper content according to different industrial needs to produce molybdenum copper sheets with different properties. In addition, the melt infiltration method is suitable for large-scale production and can meet the requirements of industrial applications. It is particularly suitable for use in high-frequency electronic equipment, aerospace and high-power electrical components.

However, the infiltration method also has some limitations. First, temperature control during the infiltration process is very critical. Too high a temperature or too long an infiltration time may lead to excessive copper penetration, and even destroy the structure of the molybdenum sheet, affecting the performance of the material. Secondly, if the penetration depth of copper is not well controlled, unevenness may occur, resulting in unstable performance of the composite material. In addition, during the infiltration process, the volatilization and excessive penetration of copper will lead to material waste and increase production costs. Moreover, the process has high requirements for equipment, requiring a high-temperature furnace and a precise temperature control system, which increases equipment investment and difficulty of operation. Therefore, although the infiltration method has high production efficiency, it has very strict requirements for process and equipment control.

4.3 Application of 3D printing technology in the preparation of molybdenum copper sheets

3D printing technology provides new possibilities for the preparation of molybdenum- copper sheets, especially in complex shapes and customized production. Unlike traditional casting, sintering and other processes, 3D printing uses a layer-by-layer stacking method to precisely melt molybdenum -copper powder and deposit it layer by layer through technologies such as laser melting or electron beam melting to create complex geometric shapes and fine structures . This process can accurately control the material composition and structure of each layer according to design requirements, ensuring that the performance of molybdenum -copper composite materials is precisely controlled.

In the 3D printing process, molybdenum and copper powders need to be mixed first, usually a composite powder of molybdenum powder and copper powder. During the printing process, the powder is heated

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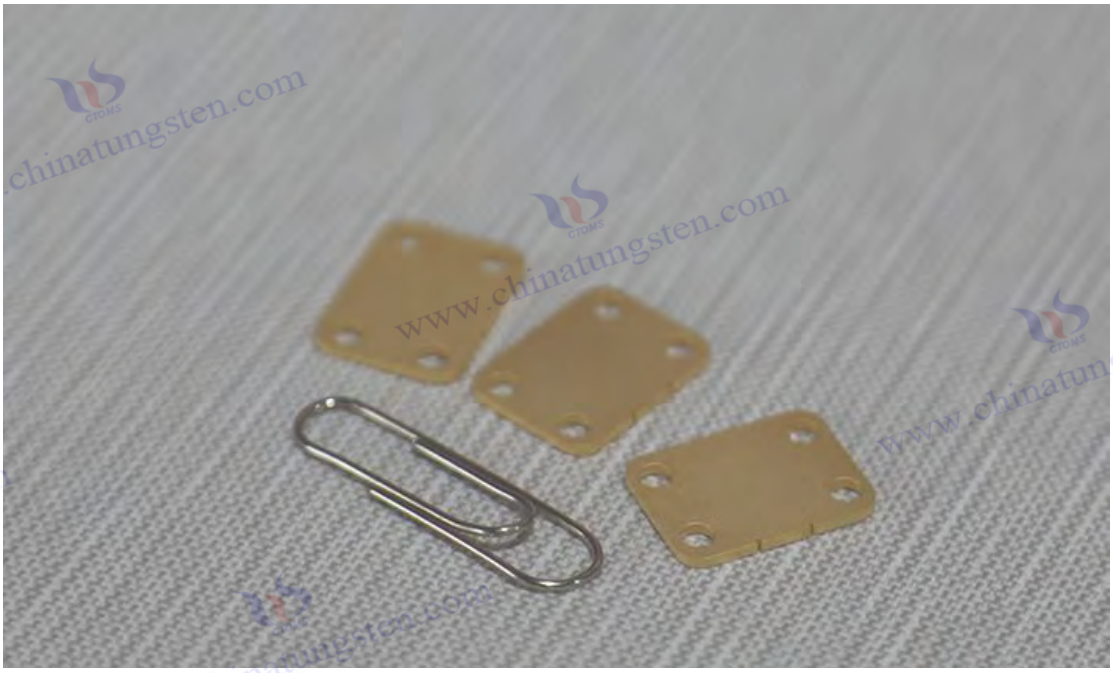
to the melting temperature by a laser or electron beam, and the melted molybdenum- copper mixture is accumulated layer by layer on the printing platform, gradually forming a three-dimensional structure. Due to the high flexibility of 3D printing technology, molybdenum- copper sheets with complex shapes and precise structures can be manufactured, which is particularly suitable for small-batch production that requires a high degree of customization.

One of the main advantages of 3D printing technology is that it can achieve precise control over the distribution of materials, thereby improving the overall performance of the materials. Compared with traditional methods, 3D printing excels in saving materials, improving production efficiency, and reducing waste, and is particularly suitable for applications with complex structures and high precision requirements. In addition, 3D printing technology can also adjust the material composition and structure in real time during the production process, making the design of molybdenum copper sheets more flexible.

However, 3D printing technology also has some limitations. First, although the printing process has high flexibility, the printing speed is relatively slow, especially in large-scale production, and may not be comparable to traditional manufacturing processes. Secondly, the equipment used for 3D printing is expensive and requires high operating skills. Since the printing of molybdenum -copper composite materials requires high temperature and a precisely controlled environment, this requires the equipment to have high performance. In addition, the surface of the molybdenum -copper sheet after 3D printing may be rough and requires post-processing, such as grinding and polishing, to achieve the ideal surface finish and dimensional accuracy.



CTIA GROUP LTD Molybdenum Copper Sheet Picture

CTIA GROUP LTD
Molybdenum Copper Sheets Introduction

1. Overview of Molybdenum Copper Sheets

Molybdenum-copper (Mo-Cu) sheets are composite materials composed of molybdenum and copper. Thanks to their unique combination of thermal, electrical, and mechanical properties, as well as their tunability, Mo-Cu sheets are widely used in fields such as thermal management, high-performance electronic devices, semiconductors, and aerospace. They are commonly utilized as packaging materials, integrated circuit substrates, heat sinks, and LED thermal dissipation substrates. At CTIA GROUP LTD, we can customize molybdenum-copper products with specific dimensions and compositions according to customer requirements.

2. Features of Molybdenum Copper Sheets

Excellent Electrical Conductivity: Suitable for applications requiring efficient electrical connections.

High Thermal Conductivity: Capable of rapid heat transfer, ideal for electronic devices that require effective thermal dissipation.

Low Coefficient of Thermal Expansion: Highly compatible with semiconductor materials like silicon, helping to minimize thermal stress caused by temperature fluctuations and preventing deformation or damage to components.

Good Workability: Can be processed through cutting and other techniques into parts of various sizes and shapes to meet diverse application needs.

3. Typical Properties of Molybdenum-Copper Alloys

Material Composition	Density (g/cm^3)	Thermal Conductivity (W/M·K at 25°C)	Thermal Expansion Coefficient (10^{-6}/°C)
Mo85Cu15	10.00	160-180	6.8
Mo80Cu20	9.90	170-190	7.7
Mo70Cu30	9.80	180-200	9.1
Mo60Cu40	9.66	210-250	10.3
Mo50Cu50	9.54	230-270	11.5

4. Production Method of Molybdenum Copper Sheets

The preparation of molybdenum-copper sheets is primarily carried out using the infiltration method, which takes advantage of molybdenum's high melting point and copper's excellent fluidity. In this process, copper is infiltrated into a molybdenum preform at high temperatures, resulting in the formation of a dense molybdenum-copper composite material.

5. Purchasing Information

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Chapter 5 Main Production Equipment of Molybdenum Copper Sheet

5.1 Molybdenum copper sheet powder metallurgy technology production equipment

Powder metallurgy technology is a commonly used method in the preparation of molybdenum- copper sheets . It mainly forms the final molybdenum- copper composite material by mixing molybdenum powder and copper powder, and then pressing and sintering them . During the entire production process, the quality and uniformity of the powder are crucial to the performance of the molybdenum -copper sheet. Therefore, the powder preparation equipment becomes a key link in the production process.

5.1.1 Powder preparation equipment

The first step of powder metallurgy technology is powder preparation. Common equipment includes ball mills and atomizers, which are used to process molybdenum and copper raw materials into fine, uniform powders. The quality of the powder directly affects the effect of subsequent preparation of molybdenum-copper sheets, so it is very important to choose the right powder preparation equipment.

5.1.1.1 Ball mill

In the field of powder metallurgy technology, ball mills, as core powder preparation equipment, occupy an important position in the production of molybdenum- copper composite materials with their efficient and stable performance. Molybdenum -copper composite materials combine the high melting point and low expansion characteristics of molybdenum with the high electrical conductivity and good thermal conductivity of copper. They are widely used in high-end fields such as electronic packaging and aerospace, and ball mills are the key equipment to achieve the fine processing of their raw material powders. The working principle of the ball mill is based on dynamics and mechanochemical effects. When the equipment is running, the internal grinding balls (mostly made of stainless steel, zirconium oxide or tungsten carbide) are driven by the high-speed rotating cylinder to form a composite motion trajectory such as falling, sliding and rolling. When the grinding balls come into contact with the molybdenum and copper raw material powders, the impact force generated instantly can crush the coarse particles, and the friction between the grinding balls and the cylinder wall further grinds the powder to achieve particle refinement. In this process, the powder not only undergoes physical size changes, but also its surface activity and lattice distortion degree increase, creating good conditions for the subsequent sintering process.

Precise control of process parameters is the core of ball mill application. By extending the ball milling time, the powder particle size can be reduced from the initial tens of microns to the submicron level, but too long may lead to cold welding agglomeration; adjusting the rotation speed (usually controlled at 60%-80% of the critical speed) can change the movement mode of the grinding balls, high rotation speed enhances impact crushing, and low rotation speed focuses on grinding and refinement; and the selection of grinding ball media (such as size ratio, material hardness) directly affects the crushing efficiency—large diameter steel balls are conducive to coarse crushing, and small particle size zirconia balls are

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suitable for fine grinding. A company has reduced the average particle size of molybdenum -copper composite powder from 15μm to 1.2μm by optimizing ball milling parameters, significantly improving the density and interface bonding strength of the material. The advantages of the equipment itself further promote its widespread application. Large-scale industrial ball mills can process up to several tons at a time, and with the automatic feeding system, they can meet the needs of large-scale production; its modular design makes it easy to replace and maintain components such as the cylinder, liner, and grinding balls, and has strong operating stability.

In a molybdenum-copper electronic packaging material production line, after the ball mill has been running continuously for 3,000 hours, the fluctuation of powder particle size is still controlled within ±5%, effectively ensuring the uniformity of product quality . In addition, the ball milling process is highly tolerant of the form of raw materials. Whether it is bulk waste or high-purity powder, it can be recycled or finely processed through this equipment, which conforms to the concept of green manufacturing and has become an indispensable basic equipment for the powder metallurgy industry.

5.1.1.2 Atomization equipment

Atomization equipment is another commonly used powder preparation tool, especially suitable for the preparation of copper and molybdenum alloy powders. The atomization method sprays molten metal into tiny droplets, which are cooled and solidified to form fine metal powder. Compared with ball mills, atomization equipment can produce more uniform powders, especially in terms of particle size distribution and morphology control. Atomized powder has a finer particle size and good fluidity and dispersibility, which is very suitable for precision processing and high-performance material preparation in powder metallurgy.

Atomization equipment usually includes different types such as gas atomization and centrifugal atomization. Choosing the right atomization method can effectively improve the quality of the powder. Gas atomization equipment uses high-pressure gas to spray molten metal into mist droplets, and obtains fine powder after cooling. This method is particularly suitable for the production of molybdenum -copper alloy powder, which can improve the uniformity and stability of the powder, thereby helping to improve the performance of subsequent molybdenum- copper sheets.

The advantage of atomization equipment is that it can produce high-quality metal powder quickly and efficiently, which is suitable for large-scale industrial production. By fine-tuning the parameters of the atomization process, the desired powder properties can be obtained to meet the production needs of different molybdenum- copper sheets.

5.1.2 Powder molding equipment

Powder molding is a crucial step in the powder metallurgy process. Its purpose is to press the mixed molybdenum -copper powder into a blank with the required shape and density under the action of external force, laying the foundation for the subsequent sintering process. Commonly used powder molding equipment includes hydraulic presses and isostatic presses.

5.1.2.1 Hydraulic press (for cold forming of molybdenum- copper billets)

Hydraulic presses are widely used in cold pressing in powder metallurgy, especially in the preparation process of molybdenum copper sheets. The hydraulic press provides uniform pressure through the hydraulic system to press the mixed molybdenum copper powder into a blank of the desired shape. The equipment is able to provide high pressure to ensure good contact between the powders, thereby improving the density and uniformity of the blank. During the cold pressing process, the molybdenum copper powder is placed in the mold, and the hydraulic press applies pressure, and the powder is compressed and formed into a blank. The pressure and time control during the forming process are crucial and can affect the density and strength of the blank. The advantage of the hydraulic press is that it can handle large quantities of powder while ensuring the stable quality of the formed blank. The application of hydraulic press is not limited to the production of molybdenum copper sheets, but is also widely used in powder molding of other metals and alloys. The equipment is easy to operate and maintain, suitable for continuous production and batch production, and can meet the needs of industrial production.

5.1.2.2 Isostatic press

Isostatic press is a molding device that applies uniform static pressure to powder materials, and can apply equal pressure in all directions to ensure the uniformity and density of the molded blank. The biggest advantage of isostatic pressing is that it can effectively increase the density of the blank and ensure the uniform distribution of copper powder and molybdenum powder in the molybdenum -copper composite material, thereby improving the quality stability during the subsequent sintering process.

The molybdenum -copper powder evenly in a closed mold . By applying hydraulic or pneumatic pressure, the powder is subjected to uniform pressure in all directions at the same time to form a high-density billet. Unlike hydraulic presses, isostatic presses can apply more uniform pressure, making the physical properties of the formed billet more consistent in all directions, which is particularly suitable for the production of molybdenum- copper sheets that require high density. The advantage of the isostatic press is that it can achieve higher density at lower pressure, which is particularly suitable for some products that require high uniformity and precision. The isostatic press can ensure that the molybdenum -copper powder is fully integrated during the forming process , improve the structure of the composite material, and thus improve the quality of the formed billet. Although the equipment cost is relatively high, it is still widely used in the production of high-end powder metallurgy products due to its excellent forming effect.

5.1.3 Sintering equipment

Sintering is the last step in the powder metallurgy process. It combines the metal particles in the powder together through high temperature to form a molybdenum -copper composite material with a dense structure. Sintering equipment plays a key role in the entire production process and affects the final performance of the molybdenum -copper sheet. Commonly used sintering equipment includes vacuum sintering furnaces, atmosphere sintering furnaces, etc. During the sintering process, the formed molybdenum -copper billet is placed in the sintering furnace and heated to a certain temperature to allow diffusion and bonding between the molybdenum and copper powder particles. The control of sintering temperature, time and atmosphere has a vital influence on the sintering quality. Under high temperature conditions, a physical and chemical reaction will occur at the interface between molybdenum and copper , gradually forming a strong bond.

Vacuum sintering furnace and atmosphere sintering furnace are the most common sintering equipment at present. Vacuum sintering furnace is mainly used for the production of molybdenum copper sheets that need to be sintered in an oxygen-free environment, which can avoid oxidation reactions and improve the quality of materials. Atmosphere sintering furnace is suitable for sintering under controlled atmosphere conditions. By adjusting the composition of the atmosphere in the furnace (such as nitrogen, hydrogen, etc.), the sintering process of the material and the performance of the material after sintering can be effectively controlled. The selection of sintering equipment needs to be determined according to the specific requirements of the molybdenum copper sheet. For example, vacuum sintering furnace is suitable for products with strict requirements on oxidation and atmosphere, while atmosphere sintering furnace is suitable for the production of large-scale and efficient molybdenum copper sheets. In industrial production, the stability and efficiency of sintering equipment directly affect the yield and production cost of the product. Therefore, the reasonable selection of sintering equipment is one of the keys to ensure the quality of molybdenum copper sheets.

5.1.3.1 Vacuum sintering furnace (used for high temperature sintering, controlled atmosphere to prevent oxidation)

Vacuum sintering furnaces are widely used in the production of molybdenum copper sheets, especially when sintering is required in an oxygen-free or controlled atmosphere environment. The vacuum sintering furnace creates a near-vacuum environment by extracting the air in the furnace, thereby avoiding the oxidation reaction caused by the contact between the metal and oxygen at high temperature. Molybdenum and copper materials can maintain their original physical and chemical properties in this environment, avoid the formation of oxide film, and ensure the electrical conductivity, thermal conductivity and high temperature resistance of the molybdenum copper sheet. In the vacuum sintering furnace, the temperature, pressure and time of the sintering process are precisely controlled according to the properties of the material and product requirements. In a vacuum environment, the sintering temperature is usually higher, which helps the diffusion and bonding between metal particles to achieve the ideal density and strength. The vacuum sintering furnace also has the function of atmosphere adjustment. By adjusting the gas composition in the furnace (such as nitrogen, hydrogen, etc.), the reaction during the sintering process can be further controlled to improve the mechanical properties and surface quality of the molybdenum copper sheet. The advantage of the vacuum sintering furnace is that it can effectively prevent oxidation reactions, improve the purity and quality of sintered materials, and is especially suitable for the production of molybdenum copper sheets with strict requirements on oxidation .

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It is widely used in aerospace, high-end electronic equipment and material preparation in high-temperature environments.

5.1.3.2 Hot Press Sintering Furnace

The hot pressing sintering furnace combines the two processes of hot pressing and sintering, and is suitable for the sintering process of molybdenum copper sheets that require simultaneous application of pressure at high temperatures. Unlike traditional sintering methods, the hot pressing sintering furnace not only provides heat during the sintering process, but also applies a certain amount of pressure to promote the close bonding between powder particles. By applying pressure, the hot pressing sintering furnace can improve the density and mechanical properties of the material, and is particularly suitable for the production of high-density, high-strength molybdenum -copper composite materials. The working principle of the hot pressing sintering furnace is to place the powder billet into a mold, apply pressure while heating, and cause the molybdenum -copper powder particles to deform and fuse at the sintering temperature. This process can achieve higher density and more uniform particle distribution, thereby improving the overall performance of the material. The hot pressing sintering furnace is suitable for products that require particularly dense and high strength requirements, especially in high-end fields such as high-power electronic components and aerospace materials . The advantage of the hot pressing sintering furnace is that it can achieve a higher density in a shorter time, and can accurately control the sintering effect by adjusting the pressure and temperature to improve the physical properties of the molybdenum- copper sheet. Its disadvantages are that the equipment is relatively complex and the investment is high, but for the production of high-performance molybdenum copper sheets, the hot pressing sintering furnace is still an indispensable equipment.

5.1.4 Post-processing equipment

Post-processing equipment plays a vital role in the production process of molybdenum copper sheets, and is mainly used to improve the mechanical properties, surface quality and shape accuracy of molybdenum copper sheets. Common post-processing equipment includes heat treatment furnaces and precision grinders, which help improve the final performance of molybdenum copper sheets.

5.1.4.1 Heat treatment furnace

Heat treatment furnaces are used in the heat treatment process of molybdenum copper sheets, mainly by heating and controlling the cooling rate to change the crystal structure of the material, thereby improving its hardness, strength and wear resistance. Heat treatment furnaces usually use precise temperature control systems to anneal, age or quench molybdenum copper sheets at a certain temperature to achieve the required physical properties. The role of heat treatment furnaces in the production of molybdenum copper sheets is particularly important, especially for improving the internal structure of materials and eliminating internal stress. The heat treatment process can effectively change the organizational structure of molybdenum copper sheets, improve their mechanical properties, and enhance their resistance to thermal expansion, oxidation and corrosion by adjusting the heating temperature and holding time.

Through heat treatment, the density, surface hardness and fatigue strength of molybdenum copper sheets can be significantly improved. There are many types of heat treatment furnaces, including box furnaces, pit furnaces, rotary furnaces, etc. Selecting a suitable heat treatment furnace can ensure the stability and uniformity of the heat treatment process, thereby improving the quality and performance of molybdenum copper sheets.

5.1.4.2 Precision grinding machines

Precision grinders are used for surface finishing of molybdenum copper sheets, mainly for removing uneven areas on the surface and improving surface finish. Precision grinders use high-speed rotating grinding wheels to finely grind the surface of molybdenum copper sheets, which can remove rough parts of the surface and enable the molybdenum copper sheets to achieve the required dimensional accuracy and surface quality. Precision grinders play a vital role in the post-processing of molybdenum copper sheets, especially in applications with high precision requirements, where precision grinders can provide high-quality surface treatment effects. Precision grinders can not only ensure that the surface of molybdenum copper sheets is smooth and defect-free, but also make their dimensions more precise and meet technical requirements. Precision grinders have a wide range of applications, including contour finishing, surface grinding, and size adjustment of molybdenum copper sheets. Through the processing of precision grinders, molybdenum copper sheets can achieve higher precision and adapt to more demanding working environments and application requirements.

5.2 Molybdenum -copper sheet infiltration production equipment

Infiltration is an important technology in the production of molybdenum- copper sheets. It forms a molybdenum- copper composite material by melting copper and infiltrating it into the pores of the molybdenum sheet . In this process, the selection of appropriate production equipment has a decisive influence on the performance and quality of the final material. The main production equipment of the infiltration method includes hydraulic presses and vacuum sintering furnaces, which are used for the molding of molybdenum powder and the sintering and infiltration of molybdenum -copper composite materials respectively.

5.2.1 Hydraulic press (for pressing molybdenum powder into shape)

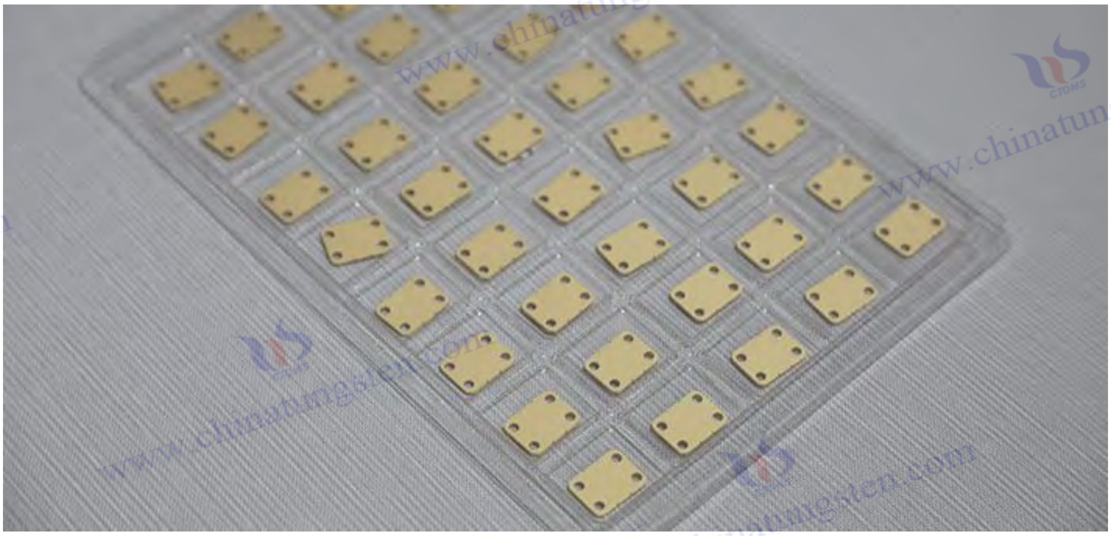
Hydraulic press in the infiltration method of molybdenum copper sheet is mainly used to press the molybdenum powder into shape in the initial stage. The shaping of molybdenum powder is the first step of the infiltration method, which determines the quality of subsequent copper infiltration and the final molybdenum copper sheet. The hydraulic press uses high pressure to press the molybdenum powder into a blank with a certain shape and density. The equipment can provide stable pressure, so that the molybdenum powder is evenly distributed in the mold, thereby obtaining a dense molybdenum skeleton.

The advantage of hydraulic presses is the precision of their pressure control. The pressing force and time can be adjusted as needed to ensure the density and uniformity of the molybdenum powder blank. The formed molybdenum skeleton will be sent to the next stage of infiltration process. Hydraulic presses are not only suitable for the production of molybdenum copper sheets, but also widely used in the forming of other metal powders. They have the advantages of simple operation, high stability and high production efficiency.

5.2.2 Vacuum sintering furnace (for sintering of molybdenum skeleton and infiltration of copper)

The vacuum sintering furnace plays a vital role in the molybdenum -copper sheet infiltration method. It is mainly used for the sintering of the molybdenum skeleton and the infiltration of copper . After the molybdenum skeleton is formed, the molybdenum powder particles need to be connected into a dense molybdenum matrix through a sintering process in a vacuum or a specific atmosphere to ensure the mechanical strength and structural stability of the molybdenum- copper composite material. In the vacuum sintering furnace, the formed molybdenum skeleton is first placed in the furnace and sintered at high temperature. The vacuum environment can effectively prevent the molybdenum material from reacting with oxygen at high temperature, avoid the oxidation process, and maintain the purity and stability of the molybdenum . After sintering, the copper source (usually copper powder or copper alloy powder) is added to the furnace, and the copper is melted by heating in the furnace. The molten copper liquid begins to penetrate into the pores of the molybdenum skeleton to form a molybdenum- copper composite structure.

The key advantage of the vacuum sintering furnace is that it can perform sintering and infiltration in a strictly controlled vacuum environment, which can effectively avoid oxidation reactions and ensure the excellent performance of the molybdenum -copper sheet. The vacuum sintering furnace can accurately control the sintering process by adjusting the temperature and atmosphere composition, thereby optimizing the final quality of the molybdenum- copper sheet. For molybdenum materials that are easily oxidized at high temperatures , the vacuum sintering furnace is a key equipment to ensure the production of high-quality molybdenum -copper composite materials.



CTIA GROUP LTD Molybdenum Copper Sheet Picture

Chapter 6 Molybdenum Copper Sheet Performance Test Methods and Equipment

6.1 Density test of molybdenum copper sheet

Density is one of the important physical properties to measure the quality of molybdenum copper sheet, which directly affects the mechanical properties, electrical conductivity and thermal conductivity of the material. The commonly used density test method is the Archimedes drainage method, which is a simple and high-precision measurement method widely used in the production process of molybdenum copper sheet.

6.1.1 Principle and operation of Archimedes drainage method

The Archimedean displacement method is based on the principle of buoyancy, which states that when an object is completely immersed in a liquid, it displaces a volume of liquid equal to the volume of the object. By measuring the volume displaced by the object in the liquid, the density of the object can be calculated. To perform this test, you first need an electronic balance and enough liquid (water or other suitable liquid). The density of the liquid needs to be known, usually water is used, with a density of $1g/cm^3$. Make sure the liquid in the container is pure and free of bubbles.

First, use an electronic balance to measure the dry weight of the molybdenum copper sheet (the mass not immersed in the liquid) and record the mass value. Next, immerse the molybdenum copper sheet completely in the liquid, making sure that the object is not suspended or has bubbles. During the immersion process, it must be ensured that the molybdenum copper sheet is completely surrounded by the liquid to avoid any errors. After the molybdenum copper sheet is immersed, measure the floating mass it produces in the liquid and record it as the wet weight. The volume of the molybdenum copper sheet can be calculated by using the following formula:

$$V = \frac{m_1}{\rho_{液体}}$$

Among them, m1 is the dry weight of the molybdenum copper sheet, and ρliquid is the density of the liquid. Next, the density formula is:

$$\rho_{钼铜片} = \frac{m_1}{V}$$

Through this method, the Archimedes drainage method can accurately measure the density of the molybdenum copper sheet and avoid the disadvantage of damaging the sample. It is particularly suitable for testing the density of metal materials.

6.2 Porosity test of molybdenum copper sheet

Porosity is an important indicator to measure the internal microstructure of molybdenum copper sheet, which directly affects the mechanical strength, thermal conductivity and electrical conductivity of the material. The porosity test is achieved through metallographic microscope observation and calculation, which can provide high-precision measurement results. This test method observes the microstructure of the surface of molybdenum copper sheet, identifies the existence and distribution of pores, and calculates the porosity.

6.2.1 Metallographic microscope observation and calculation

Metallographic microscopy is a high-resolution microscopic analysis method that can accurately reveal the microstructure of molybdenum copper sheets. Before conducting the porosity test, the molybdenum copper sheet samples need to be prepared. The samples are first cut to obtain test pieces of suitable size. Then, the test pieces are metallographically polished to ensure that their surfaces are smooth and flat without obvious defects or scratches so that they can be clearly observed under the microscope. During the polishing process, sandpaper of different grits is used to gradually polish the sample surface to obtain the ideal finish.

Next, the sample is etched. The purpose of etching is to use chemical reagents to treat the surface of the sample, enhance the visibility of pores and grain boundaries, and make pores easier to identify. Commonly used etching solutions include ammonia water, ferric chloride, etc. The specific chemical reagents used depend on the material of the sample and the microstructural characteristics that need to be observed.

After the sample is prepared, it is placed under a metallographic microscope for observation. The microscope provides high-resolution images that can magnify the surface of the molybdenum copper sheet to several hundred times or even higher, accurately showing the morphology and distribution of pores. By adjusting the magnification of the microscope, the microstructure at different levels is observed, with special attention paid to identifying defective areas such as pores and cracks. Pores usually appear as black or transparent areas, showing physical properties different from those of the metal matrix.

In order to calculate the porosity, you first need to take images under a microscope. These images will be used for subsequent analysis and automated processing through image analysis software. The software can automatically identify the pore areas in the image based on different algorithms and calculate the area ratio of the pores. Usually, the image analysis software will use different colors to distinguish the pore area from the metal area and calculate the area ratio occupied by the pores. The porosity is calculated using the formula:

$$\text{孔隙率} = \frac{\text{孔隙区域的面积}}{\text{总面积}} \times 100\%$$

According to this formula, the porosity of the sample can be obtained. In order to ensure the accuracy of the test results, it is usually necessary to perform multiple measurements in different areas and take the average value. The advantage of metallographic microscope is that it can provide high-resolution images, so that tiny pores and defects can be clearly displayed, so that the porosity of molybdenum copper sheets can be evaluated more accurately. The introduction of image analysis software makes the entire porosity test process more efficient and accurate, and reduces human errors.

6.3 Tensile test of molybdenum copper sheet

Tensile testing is an important method for evaluating the mechanical properties of molybdenum copper sheets. It is mainly used to measure the stress-strain characteristics of materials under tension, which can reflect their strength, ductility and toughness. Tensile testing is usually carried out using a universal material testing machine, which can accurately control the application of loads and record the deformation of molybdenum copper sheets during the stretching process.

6.3.1 Use of universal material testing machine

Universal material testing machine is a commonly used mechanical testing equipment, which is widely used for mechanical property testing such as tension, compression, and bending of materials. In the tensile test, the molybdenum copper sheet sample is placed between the two clamps of the testing machine. The testing machine deforms the sample during the force application by applying gradually increasing tensile force until the material breaks or reaches the maximum load-bearing capacity. During operation, first clamp the two ends of the molybdenum copper sheet in the clamp of the testing machine to ensure that the clamping position is fixed to avoid test errors caused by unstable clamping. Then, the testing machine applies tensile force at a constant speed while monitoring the elongation of the sample. During the stretching process, the testing machine automatically records the load and deformation data, and obtains important parameters such as tensile strength, yield strength, and elongation of the material through data analysis. The universal material testing machine can provide a reliable basis for the performance evaluation of molybdenum copper sheets by controlling the stretching speed and recording accurate mechanical data. It is widely used in the quality control and research and development of molybdenum copper sheets, which helps to optimize the performance of materials.

6.4 Bending test of molybdenum copper sheet

The bending test is used to determine the deformation capacity of materials under bending load and evaluate their bending strength and toughness. The bending test usually adopts the three-point bending method and the four-point bending method, which are widely used in the performance testing of molybdenum copper sheets and other metal materials .

6.4.1 Three-point bending method

The three-point bending method is one of the most common bending test methods. It applies a concentrated load perpendicular to the surface of the molybdenum copper sheet in the middle to induce bending deformation when supported at both ends. During the test, the molybdenum copper sheet is placed between two supporting points and a uniform load is applied in the middle. As the load increases, the molybdenum copper sheet will bend until the yield point or fracture point of the material.

This method can intuitively measure the bending strength and bending stiffness of molybdenum copper sheets. By observing the fracture or plastic deformation of the sample during the bending process, the bending resistance of the material can be evaluated. In the production of molybdenum copper sheets, the three-point bending method is particularly suitable for testing the performance of the material when subjected to concentrated loads during actual use. The advantages of the three-point bending method are that the test process is simple, it is suitable for samples of different sizes and thicknesses, and it is easy to operate and can quickly obtain reliable bending performance data.

6.4.2 Four-point bending method

The four-point bending method is another commonly used bending test method. The difference between it and the three-point bending method lies in the way the load is applied. The four-point bending method forms a uniform bending stress on the molybdenum copper sheet by applying a uniform load between two points of the sample and applying an additional two-point pressure between the support points. Compared with the three-point bending method, the four-point bending method can produce a more uniform stress distribution on the sample, avoid the influence of concentrated stress, and more accurately reflect the bending resistance of the material.

During the test, the molybdenum copper sheet sample is placed between two supporting points, and the applied load is applied to the central area of the sample through two-point pressure. As the load increases, the bending deformation of the molybdenum copper sheet gradually increases until the yield point or fracture of the material is reached. The four-point bending method can effectively avoid the local excessive stress that occurs in the three-point bending method, and is suitable for testing the bending properties of thin plate materials or large-sized samples.

The advantage of the four-point bending method is that it can more accurately simulate the behavior of materials under uniform load, and is suitable for test scenarios with high requirements on the bending performance of high-performance molybdenum copper sheets.

6.5 Impact toughness test of molybdenum copper sheet

Impact toughness test is to evaluate the ability of molybdenum copper sheet to resist crack propagation and damage under the action of sudden external force, usually carried out by pendulum impact test. Impact toughness reflects the brittleness or toughness of the material under extreme conditions, which is particularly important for the performance of molybdenum copper sheet under high impact or high stress environment.

6.5.1 Key points for pendulum impact test operation

The pendulum impact test is one of the most common methods for testing the impact toughness of materials. During the test, the sample is placed on a fixed support and impacted by a pendulum. The pendulum swings at a certain angle and speed, hitting the sample, causing it to break or plastically deform.

The testing machine records the energy absorbed by the sample after the impact, reflecting its impact toughness.

During operation, the standard size of the molybdenum copper sheet sample is first cut into small samples for testing, and the surface is ensured to be free of defects. Then, the sample is fixed on the support table of the testing machine, and the support point position must ensure that both ends of the sample are evenly stressed. After the pendulum is ready at the starting position, it is released and the pendulum hits the sample and breaks it. During the test, the kinetic energy of the pendulum is transferred to the sample through the impact, and the height change of the pendulum before and after the impact is recorded, so as to calculate the impact energy absorbed by the sample.

The pendulum impact test can effectively test the performance of molybdenum copper sheets under extreme mechanical conditions, especially in the case of large temperature changes or rapid loading. The impact toughness of the material is an important indicator for evaluating its reliability.

6.6 Thermal conductivity test of molybdenum copper sheet

Thermal conductivity is an important parameter to measure the heat conduction ability of molybdenum copper sheet, which directly affects its performance in high temperature environment. Thermal conductivity test can help evaluate the ability of molybdenum copper sheet in heat conduction and thermal management , which is particularly important for applications in electronics, aerospace and other fields.

6.6.1 Principle and application of laser flash method

The laser flash method is a non-contact method commonly used to measure the thermal conductivity of materials. Its principle is to irradiate a laser beam onto the surface of the material, quickly heat a small area of its surface, and then calculate the thermal conductivity of the material by measuring the change in surface temperature. In the laser flash test, the laser pulse irradiates the surface of the molybdenum copper sheet, instantly heating the surface. After the surface of the material absorbs the laser energy, the temperature rises rapidly and expands downward through internal conduction. By using a high-precision thermal imager or infrared sensor, the change in the surface temperature of the material over time is tested. Based on the time curve of the temperature change, the thermal diffusivity and thermal conductivity of the material can be calculated.

The advantage of the laser flash method is that it is a non-contact, non-destructive test method that can quickly and accurately measure the thermal conductivity of materials. Due to its fast measurement speed and high accuracy, the laser flash method is often used to evaluate the thermal properties of molybdenum copper sheets and other high-performance materials, especially for thermal conductivity testing of thin sheet materials. This method is widely used in high-temperature materials, electronic components, aerospace materials, etc., and is essential for optimizing the thermal management performance of molybdenum copper sheets. In the design and application of molybdenum copper sheets, understanding

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their thermal conductivity is essential to ensure their stability and effectiveness in complex thermal environments.

6.7 Thermal Expansion Coefficient Test of Molybdenum Copper Sheet

The coefficient of thermal expansion is the ratio of the dimensional change of a material when the temperature changes. The thermal expansion characteristics of molybdenum copper sheets in high temperature environments are particularly important for their applications, especially in the electronic and electrical fields that require high temperature stability. The test of the coefficient of thermal expansion is usually performed using a thermomechanical analyzer (TMA).

6.7.1 Use of Thermomechanical Analyzer (TMA)

Thermomechanical Analyzer (TMA) is a thermal analysis instrument used to measure the dimensional changes of materials under controlled temperature programs as a function of temperature, time and applied force. The core principle is to characterize the thermomechanical properties of materials by applying a constant or dynamic mechanical load to the sample while controlling the temperature change and monitoring the expansion, contraction, softening or other deformation behavior of the sample. TMA is widely used in materials science, engineering and manufacturing to study the thermal expansion, softening point and phase change characteristics of metals, ceramics, polymers and composite materials (such as molybdenum copper sheets). For example, in molybdenum copper sheet testing , TMA can be used to evaluate the matching of its coefficient of thermal expansion (CTE) with ceramic or semiconductor materials to ensure the reliability of electronic packaging or aerospace applications. TMA is usually equipped with a probe, sample clamping system, heating furnace and displacement sensor (such as linear variable differential transformer, LVDT), which can accurately record the dimensional changes of samples in compression, tension or bending mode. Some advanced TMA instruments also support simultaneous differential scanning calorimetry (SDTA), which can simultaneously measure thermal effects (such as melting or crystallization) to provide more comprehensive information on material behavior.

TMA Procedure

The use of TMA involves a series of standardized steps to ensure accurate and repeatable test results. First, prepare the sample. Make sure the sample has a regular shape (such as a thin plate or cylindrical sample of molybdenum copper sheet) to fit the clamping system. The sample size is usually determined by the type of fixture, for example, the sample height and diameter in compression mode need to fit the fixture. Next, choose the appropriate probe type (such as compression probe, tension fixture, or three-point bending fixture) and configure it according to the test objectives (such as thermal expansion or softening point). For example, when testing the thermal expansion coefficient of molybdenum copper sheet, a compression probe is usually used to measure linear expansion. Instrument calibration is a key step. The temperature sensor and displacement sensor need to be calibrated to ensure measurement accuracy. After calibration, the sample is placed in the furnace close to the temperature sensor to ensure accurate temperature control. Set the test conditions, including the temperature program (heating, cooling, or isothermal), the applied force (constant or dynamic), and the atmosphere (such as inert gas or air). During the test, the probe records the dimensional changes of the sample through the displacement sensor, and the data is collected and analyzed in real time by the instrument software. After the test is completed, the fixture is cleaned and the sample status is checked to avoid contamination or equipment damage. The entire process must strictly follow operating procedures, such as referring to the ASTM E831 standard, to ensure that the test results meet industry specifications.

Application of TMA in Molybdenum Copper Sheet Testing

TMA is widely used in molybdenum copper sheet testing, especially in evaluating its thermomechanical properties to meet the needs of electronics, aerospace and optoelectronics. Molybdenum copper sheets (such as Mo85Cu15, Mo70Cu30) are often used in heat dissipation substrates and thermal management components due to their high thermal conductivity and low thermal expansion properties .

Molybdenum copper sheets in compression mode to verify their thermal compatibility with ceramic materials (such as aluminum nitride) and prevent thermal stress failure in electronic packaging. For example, in 5G communication equipment, TMA testing ensures that the thermal expansion coefficient of Mo60Cu40 is consistent with the substrate material to optimize signal transmission stability. In addition, TMA can be used to detect the softening point of molybdenum copper sheets and evaluate their stability in high temperature environments (such as aerospace jet engines). Tensile mode testing can characterize the mechanical behavior of molybdenum copper sheets, such as tensile strength and ductility, and is suitable for design verification of aerospace-type molybdenum copper sheets. TMA can also analyze the bending resistance of molybdenum copper sheets through three-point bending tests to ensure their reliability in complex stress environments. The synchronous SDTA function further enhances the testing capabilities. For example, when testing Mo50Cu50, thermal expansion and potential phase changes or chemical reactions can be detected simultaneously to provide comprehensive material property information.

Precautions for using TMA

When using TMA, several aspects need to be paid attention to to ensure the reliability of test results and the safety of the instrument. First, the shape and size of the sample should be strictly controlled to avoid irregular samples causing poor contact of the fixture or measurement errors. The choice of environmental atmosphere is also crucial. For example, when testing molybdenum copper sheets, inert gases (such as nitrogen or argon) should be used to prevent copper phase oxidation at high temperatures. The setting of the temperature program should be reasonably selected according to the material properties. For example, the test temperature range of molybdenum copper sheets usually covers its actual application environment (such as -50°C to 800°C) to avoid exceeding the material tolerance limit. The control of the applied force needs to be precise. Excessive force may cause deformation or damage to the sample, while too small force may not accurately detect dimensional changes. In addition, regular calibration of instruments (such as temperature and displacement sensors) is a necessary step to ensure data accuracy.

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It is recommended to refer to ASTM E2113 and E1363 standards for calibration. Operators need to be familiar with the instrument software and data analysis methods to correctly interpret the test results, such as distinguishing dimensional changes caused by thermal expansion and softening. Finally, the sample residues need to be properly cleaned after the test to prevent contamination of the fixture or furnace body to ensure long-term stable operation of the instrument.

6.8 Resistivity test of molybdenum copper sheet

Resistivity is a key parameter to measure the conductivity of materials. For metal materials such as molybdenum copper sheets, their resistivity directly affects their applications in high-frequency equipment and power transmission. The resistivity test is often performed using the four-probe method.

6.8.1 Four-probe measurement process

The four-probe method accurately calculates the resistivity of a material by applying a current on the surface of the material and measuring the voltage drop. During the test, four probes are evenly arranged on the surface of the sample, with the two outer probes used to apply a constant current and the two inner probes used to measure the voltage drop. In this way, the relationship between the current and the voltage drop can be used to calculate the resistance value of the material. The sample surface must be flat and clean, and any dirt or oxide layer may affect the measurement results. During the test, the four probes pass current and measure voltage by contacting the sample surface. The equipment records the changes in voltage and current to calculate the resistivity. This method can eliminate the influence of contact resistance and ensure the accuracy of measurement. It is suitable for resistivity testing of highly conductive materials such as molybdenum copper sheets.

The four-probe method is very suitable for measuring the resistivity of thin-film materials. It provides high-precision resistivity data, which is crucial for the application of molybdenum copper sheets in electronics, semiconductors and other fields.

6.9 Contact resistance test of molybdenum copper sheet

Contact resistance refers to the resistance generated by the contact surface of two materials due to surface roughness, oxidation or other factors. In the application of molybdenum copper sheets, contact resistance affects the conduction efficiency of current, especially in high-frequency electronic components, the size of contact resistance directly affects the performance and stability of the equipment.

6.9.1 DC voltage drop method operating specifications

The DC voltage drop method is a commonly used contact resistance test method. The contact resistance is calculated by applying a DC current and measuring the voltage drop on the contact surface. During the test, the molybdenum copper sheet sample is first brought into close contact with another electrode, and it is ensured that the surface of the contact point is free of dirt and oxides, and the surface treatment must reach the required flatness.

During the test, current is applied to the contact surface through an external power supply, and the voltage drop at the contact point is measured. The contact resistance can be obtained from the relationship between current and voltage. This method can effectively measure the resistance characteristics of molybdenum copper sheets when they are in contact with other metals, and is especially suitable for quality control of high-frequency electrical connectors. The advantages of the DC voltage drop method are that it is easy to operate, the data is reliable, and no special equipment is required. It is very suitable for daily quality control and contact resistance detection in the production process. For molybdenum copper sheets, maintaining low contact resistance is the key to ensuring their good performance in electrical applications, so regular contact resistance testing is very important to ensure material quality and stability.

CTIA GROUP LTD Molybdenum Copper Sheet Picture

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Molybdenum Copper Sheets Introduction

1. Overview of Molybdenum Copper Sheets

Molybdenum-copper (Mo-Cu) sheets are composite materials composed of molybdenum and copper. Thanks to their unique combination of thermal, electrical, and mechanical properties, as well as their tunability, Mo-Cu sheets are widely used in fields such as thermal management, high-performance electronic devices, semiconductors, and aerospace. They are commonly utilized as packaging materials, integrated circuit substrates, heat sinks, and LED thermal dissipation substrates. At CTIA GROUP LTD, we can customize molybdenum-copper products with specific dimensions and compositions according to customer requirements.

2. Features of Molybdenum Copper Sheets

Excellent Electrical Conductivity: Suitable for applications requiring efficient electrical connections.

High Thermal Conductivity: Capable of rapid heat transfer, ideal for electronic devices that require effective thermal dissipation.

Low Coefficient of Thermal Expansion: Highly compatible with semiconductor materials like silicon, helping to minimize thermal stress caused by temperature fluctuations and preventing deformation or damage to components.

Good Workability: Can be processed through cutting and other techniques into parts of various sizes and shapes to meet diverse application needs.

3. Typical Properties of Molybdenum-Copper Alloys

Material Composition	Density (g/cm^3)	Thermal Conductivity (W/M·K at 25°C)	Thermal Expansion Coefficient (10^{-6}/°C)
Mo85Cu15	10.00	160-180	6.8
Mo80Cu20	9.90	170-190	7.7
Mo70Cu30	9.80	180-200	9.1
Mo60Cu40	9.66	210-250	10.3
Mo50Cu50	9.54	230-270	11.5

4. Production Method of Molybdenum Copper Sheets

The preparation of molybdenum-copper sheets is primarily carried out using the infiltration method, which takes advantage of molybdenum's high melting point and copper's excellent fluidity. In this process, copper is infiltrated into a molybdenum preform at high temperatures, resulting in the formation of a dense molybdenum-copper composite material.

5. Purchasing Information

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molybdenum copper sheet has been widely used in many high-tech fields due to its unique advantages in thermal conductivity, electrical conductivity, high temperature resistance, etc. Especially in the electronics industry, molybdenum copper sheet has become an indispensable material in many high-power and high-frequency devices due to its excellent performance. The following are the three major applications of molybdenum copper sheet in the electronics industry: packaging materials, integrated circuit substrates and heat dissipation components in microwave devices.

7.1.1 Packaging materials

In electronic packaging technology, the application of molybdenum copper sheet is crucial. Electronic components generate a lot of heat during operation, especially high-power semiconductor components and microelectronic devices. If the heat is not effectively dissipated, it may cause electronic components to overheat, damage or fail. Therefore, efficient heat dissipation solutions are essential for electronic packaging. Molybdenum copper sheet has become an ideal choice for electronic packaging materials due to its unique physical properties.

Molybdenum copper sheet lies in its high thermal conductivity and high temperature stability. As a metal with a high melting point (about 3,262°C), molybdenum can maintain structural stability in high temperature environments and avoid deformation or failure of materials due to high temperatures. Copper is a good electrical and thermal conductor, which can effectively conduct the heat generated by electronic components from the package to the external environment. Combining these two materials, molybdenum copper sheet has excellent heat dissipation performance and good mechanical strength, making it the preferred material for efficient heat dissipation in electronic packaging.

In semiconductor packaging, molybdenum copper sheets can not only provide effective heat dissipation, but also withstand temperature changes under long-term, high-power operation. For high-frequency, high-power devices, the stability of molybdenum copper sheets is particularly important. They can withstand drastic temperature fluctuations without thermal fatigue, thereby ensuring the long-term reliability of electronic equipment. In addition, the thermal expansion coefficient of molybdenum copper sheets is relatively uniform, which is crucial to avoiding stress caused by thermal expansion differences in the package, and can effectively prevent package failure caused by thermal stress.

Molybdenum copper sheet also has strong corrosion resistance. Many high-frequency circuits and power electronic devices need to work in harsh environments, such as high temperature, high humidity and high voltage, which puts strict requirements on the performance of packaging materials. Molybdenum copper sheet can maintain stable performance under these extreme conditions and extend the service life of electronic equipment.

In integrated circuit packaging, molybdenum copper sheets are increasingly used as substrate materials. They can withstand the heat load of high-power signals while avoiding the performance degradation of integrated circuits due to overheating. With the continuous improvement of the integration of electronic devices, the requirements for heat dissipation are also getting higher and higher. The emergence of molybdenum copper sheets effectively solves this problem and becomes an indispensable key material in high-power density packaging.

7.1.2 Integrated Circuit Substrates

Molybdenum copper sheet in integrated circuit (IC) substrate is also very important. Integrated circuits are widely used in computers, communication equipment, consumer electronics and other fields. These devices usually work at high power and high frequency, so the heat dissipation problem of integrated circuits is particularly critical. As an IC substrate material, molybdenum copper sheet can meet the heat dissipation requirements of high-power and high-frequency circuits and maintain a low thermal expansion coefficient, thereby improving the reliability and long-term stability of ICs. The main function of the integrated circuit substrate is to support the integrated circuit chip and provide the necessary electrical connections. As the functions of integrated circuits become more and more complex and the integration becomes higher and higher, their heat load is also increasing. Traditional IC substrate materials often cannot effectively dissipate heat, resulting in performance degradation or even failure of integrated circuits when working at high temperatures. Molybdenum copper sheet has extremely high thermal conductivity and can effectively conduct the heat generated by the chip to prevent the chip from overheating and damage.

Molybdenum copper sheet has multiple advantages as an integrated circuit substrate. First, the thermal conductivity of molybdenum copper sheet is extremely high, which can quickly transfer heat from the integrated circuit chip to the external environment to avoid damage caused by overheating. Secondly, the thermal expansion coefficient of molybdenum copper sheet is relatively close to that of integrated circuit materials (such as silicon chips), which reduces thermal stress caused by temperature changes, thereby improving the reliability and working life of the integrated circuit. Finally, molybdenum copper sheet has strong oxidation resistance and corrosion resistance, and can maintain good performance in harsh working environments, extending the service life of electronic equipment.

The material requirements for integrated circuit substrates are gradually increasing. For high-frequency and high-power devices, molybdenum copper sheets have become an ideal choice. Especially in areas that require efficient heat dissipation, high-frequency signal transmission, and high-power output, the advantages of molybdenum copper sheets are becoming more and more significant. In high-tech fields such as radar systems, satellite communications, and optical fiber communications, molybdenum copper sheets, as integrated circuit substrates, can effectively improve the system's operating efficiency and stability, and ensure the long-term operation of electronic equipment in complex environments.

7.1.3 Heat Dissipation Components in Microwave Devices

Microwave devices are important components in communications, radar and remote sensing equipment used in the microwave frequency band (generally in the range of 300 MHz to 300 GHz), and are widely used in satellite communications, radio communications, medical diagnosis and military radar. These devices usually need to withstand high-power signals and high-frequency working environments, so the requirements for the heat dissipation system are very high. Molybdenum copper sheets have become important heat dissipation components in microwave devices due to their excellent thermal conductivity and high temperature resistance.

In microwave devices, the heat dissipation of molybdenum copper sheets is particularly critical. Microwave devices usually operate at high frequencies and generate a lot of heat during signal transmission. If the heat cannot be dissipated in a timely and effective manner, the device will malfunction or performance will degrade due to overheating. As a heat dissipation component, the molybdenum copper sheet can quickly absorb the heat generated by the device and conduct the heat to the external environment through its high thermal conductivity, thereby effectively reducing the operating temperature of the device and ensuring the stability and reliability of the device.

molybdenum copper sheet in microwave devices is not limited to heat dissipation, but also includes being used as a structural support material. The high strength and high rigidity of molybdenum copper sheet enable it to play a supporting role in the structure of microwave devices and withstand the high temperature and mechanical stress inside microwave devices. At the same time, the thermal expansion coefficient of molybdenum copper sheet matches that of other materials in microwave devices, avoiding stress accumulation caused by thermal expansion differences, thereby improving the stability of the device.

In radar systems, the heat dissipation of molybdenum copper sheets is also crucial. Radar systems need to operate at high power for a long time, and radar waves generate a lot of heat during transmission and reception. As a heat dissipation component, molybdenum copper sheets can ensure long-term stable operation of radar equipment under high temperature conditions. In satellite communication systems, the excellent heat dissipation performance of molybdenum copper sheets ensures the reliable operation of satellite equipment in extreme environments and extends the service life of satellites.

7.1.4 Structural Support Components in Microwave Devices

Microwave devices usually work in high-frequency and high-power environments, so they need to have good heat dissipation, structural stability and resistance to thermal expansion. Molybdenum copper sheets play an important role as structural support components in microwave devices. Microwave devices, such as microwave amplifiers, radar equipment, communication modules, etc., will generate a lot of heat when working. If they cannot be dissipated in time, it will cause the equipment to overheat, thus affecting its stability and life. The high thermal conductivity of molybdenum copper sheets enables it to effectively absorb and conduct heat in microwave devices, avoiding damage to circuits or components due to excessive temperatures. In addition, the high temperature resistance of molybdenum copper sheets enables it to work stably in high-power environments and withstand the heat and mechanical stress generated when microwave devices are running. In microwave devices, molybdenum copper sheets not only play a role in heat dissipation, but also bear the function of supporting and fixing the devices. The high rigidity and strength of molybdenum copper enable it to support the components inside the microwave device and maintain structural stability. Since the thermal expansion coefficient of molybdenum copper sheets is relatively close to that of other common microwave materials (such as ceramics, silicon, etc.), it can effectively avoid material stress caused by thermal expansion differences, thereby improving the working reliability of microwave devices.

In addition, the anti-oxidation property of molybdenum copper sheet also gives it an advantage in the long-term use of microwave devices. Microwave devices are often exposed to harsh working environments, such as high temperature, high humidity and electromagnetic radiation. Molybdenum copper sheet can maintain stable performance under these extreme conditions and extend the service life of microwave devices.

7.1.5 Heat sink materials

Heat sinks are key components used for heat dissipation in electronic devices, especially in the fields of high-power electronic devices, lasers, and radio frequency equipment. The design and material selection of heat sinks are crucial to the long-term stable operation of the equipment. Molybdenum copper sheets, as heat sink materials, have been widely used in the field of heat dissipation due to their excellent thermal conductivity and thermal expansion properties.

In electronic devices, especially high-power devices such as power semiconductors and laser diodes, molybdenum copper sheets can efficiently conduct the heat generated by the components from the inside to the external cooling system, thereby avoiding component failure or performance degradation due to overheating. The high thermal conductivity of molybdenum copper sheets gives it a significant advantage in miniaturized, high-power density applications. It can quickly disperse heat and ensure stable operation of the device at high temperatures.

In addition, the thermal expansion coefficient of molybdenum copper sheet is relatively uniform, matching that of many electronic device materials, which reduces the stress caused by thermal expansion differences. Especially in application scenarios that require frequent heating and cooling, molybdenum copper sheet as a heat sink material can effectively withstand these temperature changes and avoid material deformation or damage caused by thermal stress.

Molybdenum copper sheet also makes it an ideal heat sink material, especially in extreme environments, such as high humidity or corrosive gas environments, it can work stably for a long time without being affected by the external environment. It plays a vital role as a heat sink material in high-end applications such as lasers, RF modules, semiconductor lasers and satellite communication equipment.

7.1.6 RF Module

Radio frequency (RF) modules are widely used in wireless communications, radar, satellite communications and other fields. They operate in high-frequency and high-power environments, so the

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requirements for materials are very high. The materials in RF modules need to have not only excellent electrical conductivity, but also good thermal management capabilities. Molybdenum copper sheets, as the core material in RF modules, are widely used in this field due to their unique properties.

The heat generated by the RF module during operation needs to be dissipated quickly and effectively, otherwise it will affect the stability of the device and the signal quality. The high thermal conductivity of the molybdenum copper sheet enables it to quickly conduct the heat generated by the RF module to the external heat dissipation system, thereby keeping the temperature of the device within a safe range and preventing performance degradation or failure caused by overheating. Compared with traditional copper or aluminum materials, the thermal conductivity of the molybdenum copper sheet is significantly improved, and it can carry higher power density in a small volume, adapting to the needs of high-power RF modules . The electrical connection and signal conduction in the RF module have high requirements on the conductivity of the material. The molybdenum copper sheet combines the high temperature stability of molybdenum and the excellent conductivity of copper , and can achieve efficient electrical connection in the RF module, ensuring stable transmission and precise control of the signal. Because the molybdenum copper sheet has low loss in high-frequency signal transmission, it can reduce signal attenuation and ensure the efficient operation of the RF module.

In addition, the high temperature resistance of molybdenum copper sheet enables it to operate stably in high power and high temperature environments. RF modules usually need to work stably for a long time. Molybdenum copper sheet can maintain excellent performance in these extreme environments and will not fail due to long-term high temperature exposure. This makes molybdenum copper sheet an indispensable key material in high-end RF modules.

7.1.7 LED heat dissipation substrate

With the continuous advancement of LED technology, LED light sources have been widely used in lighting, display, signal processing and other fields. Although LED light sources have advantages such as high energy efficiency and long service life, they will also generate a lot of heat when driven at high power. If the heat cannot be dissipated in a timely and effective manner, it will cause the LED performance to deteriorate and shorten its service life. Therefore, heat dissipation has become an important challenge in the application of LED light sources.

molybdenum copper sheets are an ideal choice for solving this problem due to their high thermal conductivity, good mechanical strength and high temperature resistance. Molybdenum copper sheets combine the high melting point of molybdenum (about 3,262°C) and the excellent thermal conductivity of copper . When the LED light source is working, it can quickly and effectively transfer the heat generated from the light source chip to the heat sink or the external environment, thereby effectively avoiding the adverse effects of heat accumulation.

Compared with traditional aluminum substrates or other heat dissipation materials, molybdenum copper sheets have higher thermal conductivity and can withstand greater power density. This allows them to

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maintain lower temperatures in the heat dissipation systems of high-power LED light sources such as high-power LED lamps, high-brightness displays, and laser diodes, thereby improving the working efficiency and service life of LED light sources. In addition, the thermal expansion coefficient of molybdenum copper sheet is relatively uniform, matching the thermal expansion coefficient of LED chips and other packaging materials, which reduces the stress caused by thermal expansion differences, thereby improving the stability and long-term reliability of LED light sources. In the packaging of LED modules and integrated circuits, molybdenum copper sheets not only serve as heat dissipation substrates, but also ensure long-term and efficient heat dissipation, avoiding the degradation of LED light source performance due to overheating.

7.2 Application of molybdenum copper sheet in aerospace field

The aerospace field has extremely stringent requirements on materials, especially in high temperature, high pressure, strong radiation and other environments, materials need to have excellent high temperature stability, strength, thermal conductivity and radiation resistance. Molybdenum copper sheets are widely used in the aerospace field due to their excellent performance, especially in aircraft metal components, thermal protection materials for spacecraft, and missile and spacecraft components, showing their irreplaceable role.

7.2.1 Aircraft Metal Components

Molybdenum copper sheets play an important role as metal components in aerospace, especially in the structural parts of aircraft. During flight, aircraft experience high-speed flight, severe airflow pressure and complex temperature changes, which requires the metal components of the aircraft to have not only high strength, but also good resistance to thermal expansion and heat dissipation. Among these metal components, molybdenum copper sheets are used for components in aircraft structures, such as engine components, aerodynamic shape components and other places that need to withstand high temperatures and high stresses. The high melting point of molybdenum and the thermal conductivity of copper enable molybdenum copper sheets to maintain excellent structural stability in high temperature environments and avoid the effects of thermal expansion. At the same time, molybdenum copper sheets can effectively conduct the heat generated by the engine and other components, prevent local overheating, and ensure the stable operation of the aircraft under extreme conditions. molybdenum copper sheets in aircraft metal components is also reflected in its corrosion resistance. Aircraft are exposed to various climatic conditions, especially in environments with high humidity and salt content. The corrosion resistance of molybdenum copper sheets enables them to work for a long time in these environments without failure.

7.2.2 Thermal protection materials for spacecraft

Spacecraft will experience extreme temperature changes during launch, flight and re-entry into the atmosphere. Especially when entering the atmosphere, spacecraft will be subjected to very high temperatures, even reaching several thousand degrees Celsius. Therefore, spacecraft need to have a strong thermal protection system to ensure the safe operation of the spacecraft and its internal equipment.

The application of molybdenum copper sheet in the thermal protection system of spacecraft is mainly reflected in its use as a heat shielding material. The high melting point of molybdenum allows it to remain stable in high temperature environments, while the thermal conductivity of copper allows it to quickly transfer heat from the surface of the spacecraft to other parts, effectively avoiding local overheating. This allows molybdenum copper sheets to effectively prevent damage caused by high temperatures in the thermal protection system of spacecraft. During the re-entry of spacecraft, molybdenum copper sheets are often used in thermal insulation layers, heat shields and heat dissipation systems. The high thermal conductivity of molybdenum copper sheets ensures that heat can be quickly transferred to other heat dissipation components, while its strong resistance to thermal expansion effectively reduces the thermal stress caused by excessive temperature differences, ensuring that the spacecraft can maintain structural integrity during high-temperature re-entry.

In addition, the corrosion resistance of molybdenum copper sheets is also very suitable for use in space environments, especially under conditions of high radiation and extreme temperatures, molybdenum copper sheets can work stably for a long time.

7.2.3 Missile and spacecraft components

Molybdenum copper sheets are also used in various components of missiles and spacecraft. In missile systems, molybdenum copper sheets are often used in the heat dissipation system of missile engines and other high-temperature components. Missile engines generate a lot of heat during high-speed flight. If this heat cannot be dissipated in time, it may cause engine performance to decline or even fail. Molybdenum copper sheets can quickly and effectively dissipate heat in these components to ensure the efficient operation of the missile.

Molybdenum copper sheets are also widely used in the electrical systems of spacecraft. In the electronic equipment of spacecraft, molybdenum copper sheets serve as conductive and heat dissipating components, helping to effectively conduct current and keep the temperature of the equipment stable, avoiding equipment failure due to overheating. In addition, the stability and high strength of molybdenum copper sheets also make them used in the structural components of spacecraft, especially in key components that are subjected to huge mechanical stress and high temperature changes, molybdenum copper sheets provide additional strength and durability.

7.2.4 Radar system radiator

Radar systems, especially those in the military and aviation fields, need to work stably under high power and high frequency conditions for a long time. In this environment, heat dissipation of radar systems becomes an important issue in design. The application of molybdenum copper sheets in radar system radiators gives full play to their high thermal conductivity and high temperature stability, becoming an indispensable core component of high-performance radar systems. The transmitting and receiving units in the radar system generate a lot of heat, and efficient heat dissipation is the key to ensure the reliable operation of the radar system. Molybdenum copper sheets are widely used in the heat dissipation design of radar systems due to their high thermal conductivity (better than most traditional metals). Molybdenum copper composite materials can quickly transfer heat from heat-generating components (such as transmitters, receivers, etc.) to the external heat dissipation system to prevent overheating from causing performance degradation or failure of the radar system.

molybdenum copper sheet enables it to maintain good thermal stability in high temperature environment, and maintain structural integrity and stability under extreme temperature fluctuations and strong thermal shock. In addition, the thermal expansion coefficient of molybdenum copper sheet is similar to that of other materials in radar system (such as ceramics, silicon chips, etc.), which can effectively reduce the stress caused by thermal expansion difference and avoid mechanical deformation or structural failure caused by temperature difference. In military radar system, the application of molybdenum copper sheet as heat dissipation device, especially in high-power and high-frequency radar, can ensure the long-term efficient and stable operation of radar equipment, and avoid damage or performance degradation caused by overheating. This makes molybdenum copper sheet play an important role in modern radar technology.

7.2.5 Military Electronic Packaging

Military electronic packaging has very high requirements for materials, especially for equipment working in harsh environments, such as missiles, satellites, and drones. Military electronic packaging must meet multiple requirements such as high temperature resistance, impact resistance, radiation resistance, and waterproof and dustproof. As a new type of packaging material, molybdenum copper sheet is widely used in military electronic packaging due to its excellent physical properties. One of the main advantages of molybdenum copper sheet in military electronic packaging is its high thermal conductivity. Electronic components generate a lot of heat during operation, especially in high-power and high-frequency working environments, where thermal management is particularly important. Molybdenum copper sheet can effectively transfer heat from electronic components to the external heat dissipation system to avoid equipment failure due to overheating. This is crucial to the reliability of military equipment, especially in extreme environments such as high temperature, high pressure, and radiation. Molybdenum copper sheet can ensure the long-term stability of electronic packaging.

Molybdenum copper sheet also make it an ideal choice for military electronic packaging. Military equipment often needs to work under harsh conditions such as drastic temperature changes, shock and vibration. Molybdenum copper sheet can withstand these conditions without performance degradation or damage. Its high strength and rigidity ensure that the packaging material can withstand external stress. At the same time, its thermal expansion coefficient matches that of many other military materials (such as ceramics and metals), reducing the impact of thermal stress on the packaging structure.

In military electronic packaging, molybdenum copper sheets are not only used for heat dissipation, but also provide better electrical performance. Its excellent conductivity enables molybdenum copper sheets to be used as carrier materials for electronic components to ensure stable electrical connections and signal transmission. The application of molybdenum copper sheets in military packaging can effectively improve the performance, reliability and durability of equipment, ensuring its stable operation in extreme environments.

7.3 Application of Molybdenum Copper Sheet in Energy and Thermal Management

Molybdenum copper sheets in the energy field, especially in power electronics and thermal management systems, has demonstrated its unique advantages. With the global focus on energy efficiency and sustainable development, molybdenum copper sheets are increasingly used in the energy field, especially in power electronics and thermal management systems, becoming an important material for solving the heat dissipation problem of high-power electronic equipment.

7.3.1 Power Electronic Devices

Power electronic devices play a vital role in modern energy systems. Whether in power conversion, battery management systems, or in electric vehicles and renewable energy systems, power electronic devices are widely used in energy regulation, control and conversion. However, these high-power electronic devices generate a lot of heat during operation. If the heat cannot be effectively dissipated, it will cause the equipment to overheat, performance degradation or even failure. Therefore, excellent thermal management materials are essential for the reliable operation of power electronic devices. Molybdenum copper sheets play an irreplaceable role as thermal management materials in power electronic devices . Molybdenum copper sheets have extremely high thermal conductivity and can quickly remove the heat generated by power electronic devices from the inside of the device, keeping the temperature of the device stable, thereby improving its working efficiency and service life. The high thermal conductivity and high temperature stability of molybdenum copper sheets make it an ideal heat dissipation material in power electronic devices, especially for high-power, long-running devices. In addition, the high strength and thermal expansion resistance of molybdenum copper sheets enable them to withstand high temperature changes and mechanical stress in power electronic devices. In electric vehicles and power conversion equipment, molybdenum copper sheets can effectively support and protect electronic components while providing good heat dissipation performance to avoid component damage caused by excessive temperature.

Molybdenum copper sheets in power electronic devices not only improves the thermal management performance of the equipment, but also improves the overall efficiency and reduces energy loss. With the development of electric vehicles, solar power generation and energy storage systems, the importance of molybdenum copper sheets as thermal management materials will continue to increase, becoming a key technical material for improving energy efficiency and sustainable development.

7.3.2 Nuclear power equipment

Nuclear equipment, especially nuclear reactors and their related components, require materials with extremely high thermal stability, strength and radiation resistance. Nuclear reactors generate huge amounts of heat when working, and are also exposed to strong radiation environments. Therefore, heat

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dissipation management in nuclear power equipment is crucial. Molybdenum copper sheets, as thermal management materials in nuclear power equipment , have become an ideal choice for solving high-temperature and high-power thermal management problems due to their excellent thermal conductivity and high-temperature stability .

In nuclear power equipment, the main application of molybdenum copper sheets is as part of heat exchangers, cooling systems and radiators. A large amount of heat is generated in the core area of the nuclear reactor, and the molybdenum copper sheets can quickly conduct this heat and effectively dissipate it, ensuring the normal operation of the equipment at high temperatures. The high melting point of molybdenum enables the molybdenum copper sheets to withstand extremely high temperatures, while the good thermal conductivity of copper ensures that the heat can be quickly conducted from the core of the nuclear reactor to the cooling system. In addition, the high mechanical strength and corrosion resistance of molybdenum copper sheets enable them to work stably and long-term in nuclear power equipment. Some important components in nuclear power equipment, such as nuclear reactor control rods, cooling pumps and heat exchangers, are faced with long-term high temperature and high radiation environments. The stability and corrosion resistance of molybdenum copper sheets enable them to resist radiation damage and ensure the long-term reliability and stability of the equipment.

In the future, with the further development of nuclear energy technology, the application of molybdenum copper sheets in new nuclear reactors such as high temperature gas-cooled reactors and fast neutron reactors will increase further. Molybdenum copper sheets will provide more efficient and reliable thermal management solutions for nuclear energy equipment, ensuring the sustainability and safety of nuclear energy technology in future energy systems.

7.3.3 Renewable energy systems

With the growing global demand for environmentally friendly and sustainable energy, renewable energy (such as solar energy, wind energy, hydropower, etc.) has become an important form of energy. In renewable energy systems, especially solar power generation systems and wind power generation systems, efficient thermal management is essential to improve system efficiency, extend service life, and ensure equipment stability. Molybdenum copper sheets, as thermal management materials in renewable energy systems , have become key materials for improving energy conversion efficiency and equipment stability due to their excellent thermal conductivity and high temperature resistance. In solar energy systems, molybdenum copper sheets are mainly used in heat exchangers and heat dissipation components in solar thermal power generation systems. Solar collectors generate a lot of heat when working. If the heat cannot be effectively dissipated, the system efficiency may decrease or even damage the solar collector. Molybdenum copper sheets can quickly transfer the heat in the collector to the external cooling system to ensure the efficient operation of the thermal power generation system. In wind power generation systems, molybdenum copper sheets, as heat dissipation materials for fan motors and other high- power electronic equipment, can effectively transfer the heat generated during the operation of the motor from the inside of the fan to the outside to avoid overheating and equipment failure. Electronic components and power converters in wind power generation systems usually generate a lot of heat during high-speed operation. Molybdenum copper sheets, with their high thermal conductivity, can effectively improve the heat dissipation performance of the system and ensure the stability of the wind turbine when running at high power.

Molybdenum copper sheet is not limited to heat exchangers and heat dissipation components, it also plays an important role in the battery management system in renewable energy systems. In solar and wind energy systems, energy storage systems (such as battery packs) are an indispensable component. Molybdenum copper sheet as a thermal management material can effectively reduce the heat generated by the battery during the charging and discharging process, and prevent the battery from overheating and causing performance degradation or damage. With the continuous advancement of renewable energy technology, the application of molybdenum copper sheet in these systems will become more extensive, providing key thermal management solutions for the efficient use and stable operation of renewable energy .

7.3.4 Electric Vehicle Battery Thermal Management

Electric vehicles (EVs) have become an important alternative energy source in modern transportation systems. One of the core components of electric vehicles is the battery system, especially the power battery system. Batteries generate a lot of heat during charging and discharging. If the heat is not effectively managed, the battery temperature will be too high, which will affect the performance, life and even safety of the battery. Therefore, the battery thermal management system has become an important part of electric vehicle design that cannot be ignored.

As a key material in the thermal management system of electric vehicle batteries, molybdenum copper sheet is an ideal choice for battery thermal management due to its high thermal conductivity and high temperature resistance . In electric vehicles, molybdenum copper sheet can be used in the heat dissipation system of battery packs, especially during high-power charging and discharging. Molybdenum copper sheet can quickly transfer the heat generated by the battery from the battery cell to the radiator or external cooling system to prevent the battery temperature from being too high, resulting in performance degradation or safety problems. The excellent thermal conductivity of molybdenum copper sheet ensures that the battery system can be kept within the optimal operating temperature range, improve the charging efficiency and discharge performance of the battery, and extend the service life of the battery. The battery system of electric vehicles will face different challenges in high and low temperature environments. Molybdenum copper sheet can adapt to these extreme conditions and provide stable thermal management support. By improving the heat dissipation performance of the battery system, molybdenum copper sheet not only optimizes the working efficiency of the battery, but also improves the overall performance and safety of electric vehicles. Molybdenum copper sheet can also be used in the structural design of battery modules and battery packs of electric vehicles. The high strength and good resistance to thermal expansion of molybdenum copper sheet enable it to provide stable structural support in the battery module to prevent mechanical deformation caused by temperature changes. The excellent performance of molybdenum copper sheets ensures that the battery system can operate stably for a long time under high temperature and high power working conditions, meeting the strict requirements of electric vehicles for cruising range, charging speed and safety.

7.4 Molybdenum copper sheet in other emerging application areas

Molybdenum copper sheets in emerging fields has demonstrated its unique advantages under high-precision and complex working conditions, especially in those technical fields that have extremely high requirements for material performance.

7.4.1 Medical equipment

Molybdenum copper sheets in medical equipment is mainly reflected in the fields of medical imaging equipment, radiotherapy equipment and in vitro diagnostic equipment. With the advancement of medical technology, especially the development of radiology, nuclear medicine and high-precision diagnostic equipment, molybdenum copper sheets have become one of the key materials in medical equipment due to their excellent thermal conductivity, strength and biocompatibility. In medical imaging equipment, especially CT (computed tomography) and MRI (magnetic resonance imaging) equipment, molybdenum copper sheets are usually used as heat dissipation materials in the thermal management system of electronic components and high-power equipment. CT scanners and MRI equipment generate a lot of heat during operation, especially in high-power radio frequency systems and electronic components. If the heat cannot be effectively dissipated, the equipment may overheat and affect the imaging quality. The high thermal conductivity of molybdenum copper sheets can quickly transfer the generated heat from these components to the heat dissipation system, thereby ensuring the long-term stable operation of the equipment. In addition, molybdenum copper sheets are also used in the thermal management of radiotherapy equipment. During radiotherapy, the radiation source of the equipment usually generates a lot of heat. The role of molybdenum copper sheets in these devices is to effectively transfer heat from the radiation source area to avoid equipment failure or decreased treatment accuracy due to heat accumulation. The high strength, high temperature resistance and stability of molybdenum copper sheets make them very reliable materials in high-precision medical devices. The application of molybdenum copper sheets in in vitro diagnostic equipment is also very important. In these devices, molybdenum copper sheets not only provide effective thermal management, but also serve as component support materials to ensure the stability and precision of the equipment in long-term use.

7.4.2 7G Communication Base Station

With the popularization of 5G technology, the research and development of 7G communication technology is in full swing. 7G communication will further promote ultra-high-speed transmission, large-scale connection and low-latency network applications. As the core infrastructure of future communication networks, 7G base stations have higher requirements for thermal management, anti-interference and stability of equipment. As an efficient thermal management material, molybdenum copper sheet is gradually becoming an important component of 7G communication base stations.

In 7G communication base stations, the main function of molybdenum copper sheets is to serve as heat dissipation materials to help deal with the huge amount of heat generated in the base stations. 7G communication technology will support higher frequency and larger capacity data transmission, and the power demand and heat load of base stations will be greater than in the 5G era. The high thermal conductivity of molybdenum copper sheets enables it to quickly dissipate the heat generated by electronic components in the base station, preventing overheating from causing base station equipment failure or performance degradation. In addition to heat dissipation, the anti-electromagnetic interference ability of molybdenum copper sheets is also one of its application advantages in 7G communication base stations. 7G communication base stations will face a more complex electromagnetic environment. As a structural support material, molybdenum copper sheets can effectively isolate electromagnetic interference and ensure the stable operation of electronic components in the base station. The application of molybdenum copper sheets in base stations will effectively improve the reliability and communication quality of the equipment and meet the stringent requirements of future ultra-high-speed network transmission.

7.4.3 Laser and optical system

Lasers and optical systems are widely used in scientific research, medical treatment, industrial processing, laser printing and other fields. With the continuous advancement of laser technology, the power of lasers and optical systems is getting higher and higher, and the requirements for heat dissipation and temperature control are also getting higher and higher. Molybdenum copper sheets play an important role in lasers and optical systems as efficient heat dissipation materials. In lasers, especially high-power lasers, a lot of heat is generated during operation. If this heat is not effectively dissipated, the efficiency of the laser will be greatly reduced, and even the equipment will be damaged. The high thermal conductivity of molybdenum copper sheet makes it an ideal material for the heat dissipation system in the laser. It can quickly transfer the heat generated by the laser from the inside of the laser to the external heat dissipation device, keep the operating temperature of the laser stable, and improve the power output and operating efficiency of the equipment.

Molybdenum copper sheets are also widely used in optical systems, especially in laser scanning systems, optical communication systems and precision measuring equipment . Laser transmitters and receivers in optical systems usually need to operate in extremely fine temperature control environments. Molybdenum copper sheets can not only provide stable heat dissipation, but also effectively avoid deformation of optical components caused by thermal expansion differences, ensuring the stability and accuracy of the optical system. The application of molybdenum copper sheets in lasers and optical systems can not only improve the heat dissipation capacity of the system, but also improve the beam quality and stability of the laser, ensuring its efficient operation in various application scenarios.

7.4.4 Additive Manufacturing and Customized Components

Additive manufacturing (3D printing) technology is one of the manufacturing technologies that has developed rapidly in recent years. Especially in the fields of aerospace, medical, and automotive, additive manufacturing has gradually become a manufacturing solution for customized, high-precision

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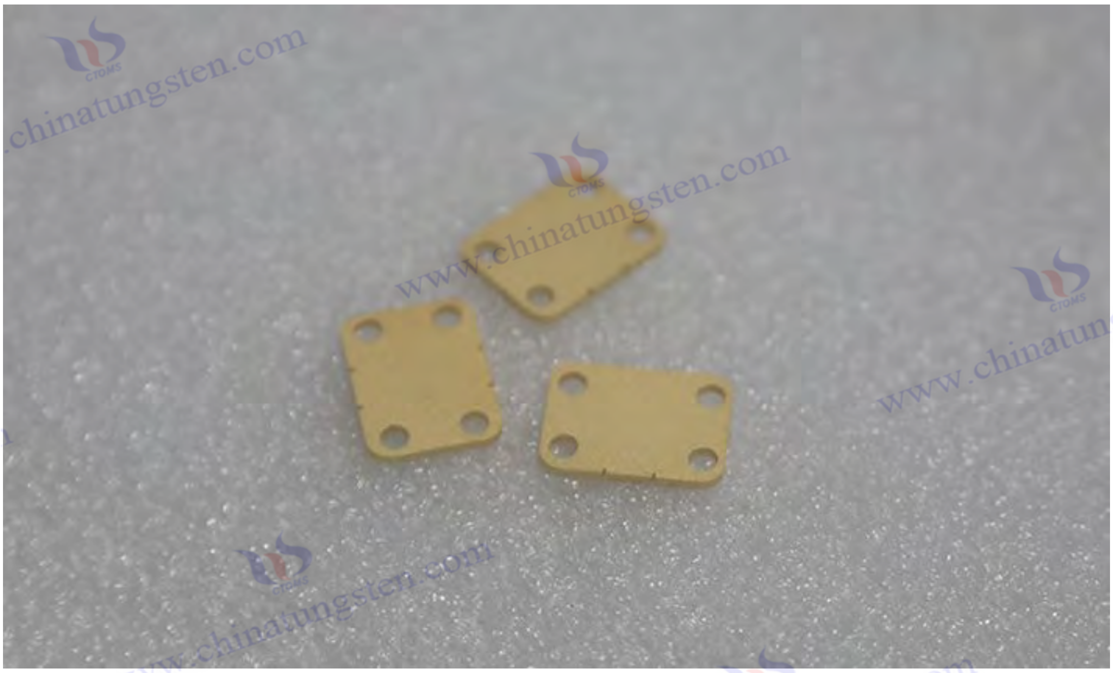
components. As one of the materials in additive manufacturing , molybdenum copper sheets are being widely used in the manufacturing of high-temperature, high-power, and high-precision customized components.

Additive manufacturing technology allows complex-shaped parts to be manufactured by stacking materials layer by layer, which is very effective for manufacturing complex geometries that cannot be achieved by traditional processing methods. The excellent properties of molybdenum copper sheet make it an ideal material for additive manufacturing , especially in applications that require high thermal conductivity, high strength and good high temperature resistance, such as aerospace components, automotive engine components, and customized parts for medical devices.

additive manufacturing process, the molybdenum copper sheet can maintain good structural stability during laser melting and maintain its excellent physical properties in high temperature environments. The customized manufacturing of molybdenum copper sheets enables better thermal management in complex structural components , and achieves efficient component manufacturing by reducing thermal stress and improving performance.

In addition, the additive manufacturing of molybdenum copper sheets can also accurately adjust the performance according to different application requirements, meeting the different requirements of various industrial products for thermal management, mechanical strength, high temperature resistance and corrosion resistance. This makes molybdenum copper sheets have broad application prospects in emerging fields and become a key material in the manufacture of customized components.



CTIA GROUP LTD Molybdenum Copper Sheet Picture

Chapter 8 Market and Industry Status of Molybdenum Copper Sheet

8.1 Global Molybdenum Copper Sheet Market Overview

As an important branch of the molybdenum alloy market, the global molybdenum copper sheet market has shown a steady growth trend in recent years due to its unique advantages in high-performance application scenarios. Molybdenum copper sheet is a composite material composed of molybdenum (Mo) and copper (Cu), which has the characteristics of high thermal conductivity, adjustable thermal expansion coefficient and high strength. It is widely used in electronics, aerospace, communications and new energy. Its market growth is mainly driven by the global demand for high-performance materials, especially in 5G communications, electric vehicles (EV) and renewable energy equipment. With the overall molybdenum market, the growth rate of the molybdenum copper sheet market is more prominent. The growth trend of the overall molybdenum market is relatively slow, while the importance of molybdenum copper sheets in high value-added fields (such as electronic packaging and thermal management components) is becoming increasingly prominent, further promoting the expansion of its market size.

Molybdenum copper sheet market is mainly driven by the following key factors. First, the demand for high thermal conductivity and low thermal expansion materials is increasing. The thermal conductivity of molybdenum copper sheets ranges from 150-270 W/m·K and the adjustable thermal expansion coefficient is $5\text{-}12\times10^{-6}$ /K, making it an ideal material for electronic packaging and thermal management applications. For example, in 5G base stations, Mo60Cu40 molybdenum copper sheets are widely used as heat dissipation substrates due to their excellent thermal conductivity and thermal expansion matching with ceramic substrates, ensuring the stability of the equipment under high-frequency operation. Secondly, the rapid growth of the electric vehicle (EV) market has driven the demand for molybdenum copper sheets.

The battery management systems and power semiconductors of electric vehicles require efficient thermal management materials, and molybdenum copper sheets are the first choice due to their high thermal conductivity and reliability. In addition, the expansion of renewable energy fields, such as wind and solar energy equipment, has increased the demand for molybdenum copper sheets. For example, molybdenum copper sheets are used in the conductive layer of solar thin-film cells to support the efficient operation of clean energy equipment. Finally, the demand for high-performance alloys in the aerospace and defense fields continues to grow, and the lightweight properties and high-temperature stability of molybdenum copper sheets have led to their use in jet engines and missile components. For example, Mo85Cu15 molybdenum copper sheets are suitable for aerospace thermal management components due to their low thermal expansion coefficient and excellent mechanical properties.

Global molybdenum copper sheet market is segmented into electronics, aerospace, optoelectronics, and new energy by application . In the electronics sector, molybdenum copper sheets are widely used in heat dissipation substrates for power semiconductors, RF amplifiers, and 5G base stations due to their high thermal conductivity and low thermal expansion coefficient. For example, Mo60Cu40 is suitable for high-frequency communication equipment due to its conductivity of about 30-40% IACS (International

Annealed Copper Standard). The aerospace sector is another important market, where molybdenum copper sheets are used to manufacture jet engine thermal management components and missile components, and Mo85Cu15 is favored for its high temperature stability (resistant to 600-800°C) and lightweight characteristics. In the optoelectronics sector, molybdenum copper sheets are used as carriers for laser and LED chips, and Mo70Cu30 has excellent thermal expansion matching with materials such as gallium arsenide, ensuring long-term stability of the device. With rapid growth in demand in the new energy sector, molybdenum copper sheets play a key role in battery management systems for electric vehicles and solar thin-film batteries. For example, molybdenum copper sheets support the production of copper indium gallium selenide (CIGS) solar cells as a conductive layer . The diverse demands of these application sectors have driven the continued expansion of the molybdenum copper sheet market. Molybdenum copper sheet market is divided into molybdenum copper alloys with different proportions according to the brand , such as Mo85Cu15, Mo70Cu30, Mo60Cu40 and Mo50Cu50. Mo85Cu15 is mainly high in molybdenum content and has a low thermal expansion coefficient (about 5-7×10 $^{-6}$ /K), which is suitable for aerospace and optoelectronic applications and requires a high degree of matching with ceramic or semiconductor materials. Mo70Cu30 balances thermal conductivity and mechanical properties and is widely used in 5G base stations and electric vehicle heat dissipation substrates. Mo60Cu40 and Mo50Cu50 have a high copper content and a thermal conductivity of 220-270 W/m·K, which is suitable for high-frequency electronic equipment and new energy fields. The performance differences of different brands enable molybdenum copper sheets to meet diverse application needs and enhance market competitiveness.

Molybdenum copper sheet market are mainly divided into direct manufacturing and distribution. Direct manufacturing is the direct supply from manufacturers to end users, which is common in large electronics and aerospace companies. The distribution channel distributes products to small and medium-sized enterprises through intermediaries, covering a wider market. Distributors focus on cost competitiveness and supply chain reliability to ensure timely delivery. For example, distributors in North America and Europe provide customized molybdenum copper sheets to the automotive and new energy industries to meet diverse needs. The combination of direct manufacturing and distribution channels optimizes market coverage and promotes the popularization of molybdenum copper sheets. Global molybdenum copper sheet market is dominated by China, the United States and Chile, and suppliers have consolidated their market positions through technological innovation and strategic cooperation. For example, China Molybdenum has strengthened its control over the supply chain by investing in overseas minerals and downstream processing. American companies produce high-purity molybdenum copper sheets through copper-molybdenum associated mineral mining to serve the aerospace and electronics markets. In addition, suppliers have enhanced their market competitiveness by developing new molybdenum -copper composite materials (such as Mo70Cu30 with graphene added) to improve thermal conductivity and interface strength.

8.2 Major Molybdenum Copper Sheet Manufacturers - CTIA GROUP LTD

CTIA GROUP LTD is a subsidiary of China Tungsten Online Technology Co., Ltd. Founded in 1997, CTIA started with www.chinatungsten.com, China's first top tungsten products website, and is the first e-commerce company in China focusing on tungsten, molybdenum and rare earth industries. Relying on nearly three decades of deep technical accumulation and global business reputation in the field of tungsten and molybdenum, CTIA has become one of the major manufacturers in the global molybdenum copper sheet market, and is committed to promoting the intelligent, integrated and flexible design and manufacturing of molybdenum copper materials in the era of industrial Internet. It produces a variety of grades of molybdenum copper sheets, such as Mo85Cu15, Mo80Cu20, Mo60Cu40 and Mo50Cu50, which are widely used in electronic heat dissipation substrates, aerospace thermal management components, 5G communication equipment and optoelectronic devices.

CTIA GROUP LTD inherits the technology and experience of China Tungsten Online, focuses on the personalized needs of customers, uses AI technology and industrial Internet platform to collaborate with customers to design, and produces molybdenum copper sheets that meet specific chemical composition and physical properties (such as density of about 9.1-10.0 g/cm³, thermal conductivity of 150-270 W/m·K, electrical conductivity of 20-45% IACS, thermal expansion coefficient of $5\text{-}12\times10^{-6}$ / K) , providing full-process integrated services from mold opening, trial production to finishing, packaging, and logistics.

For example, the Mo60Cu40 molybdenum copper sheet it produces is widely used in heat sinks for 5G base station RF modules due to its high thermal conductivity and good ductility; Mo85Cu15 is used in thermal management components of aerospace jet engines due to its low thermal expansion and high strength . CTIA GROUP LTD produces molybdenum copper sheets through powder metallurgy and melt infiltration . Powder metallurgy ensures high density and mechanical properties (such as the tensile strength of Mo85Cu15 reaches 500-600 MPa), and the melt infiltration method optimizes the thermal conductivity and electrical conductivity of high copper content grades.

Over the past 30 years, China Tungsten Online has provided R&D, design and production services for more than 500,000 tungsten and molybdenum products to more than 130,000 customers worldwide , covering Europe, America, Asia, Mauritius, Cyprus and other regions, laying the foundation for customized, flexible and intelligent manufacturing.

Based on this, CTIA GROUP LTD has further deepened the intelligent manufacturing in the era of industrial Internet, developed intelligent production management systems, improved product consistency through automated sintering and processing technology, and met the high-precision requirements of the electronics, communications and new energy industries. The company actively responds to global ESG (environmental, social and governance) standards and adopts sustainable mining and processing technologies, such as reducing resource consumption by recycling molybdenum and copper waste, which meets the requirements of China's "14th Five-Year Plan" for green manufacturing. Its supply chain network covers North America, Europe and Asia, and achieves efficient global delivery through strategic cooperation and e-commerce platforms (such as www.ctia.com.cn) .

CTIA GROUP LTD 's competitiveness is also reflected in cost control and large-scale production, especially with China's abundant molybdenum resources and government support, it continues to expand production capacity to meet the growth needs of the infrastructure, 5G and electric vehicle markets.

8.3 Market demand and development trend of molybdenum copper sheet

Molybdenum copper sheet market is driven by global industrialization and technological progress, especially in the fields of electronics, communications, aerospace and new energy. The electronics industry is the main source of demand. Molybdenum copper sheet is widely used in power semiconductor devices, microwave devices and heat sinks due to its high thermal conductivity and low thermal expansion coefficient. In 2023, the global electronics industry's demand for molybdenum copper sheet accounts for a significant share of the total market. The rapid development of 5G communications has driven the demand for high-frequency molybdenum copper sheet, which is used for RF power amplifiers and antenna substrates to ensure signal integrity and thermal stability. The rapid growth of the electric vehicle industry has also significantly driven demand. Molybdenum copper sheet is used for heat dissipation components of battery management systems and power modules. The growth in global electric vehicle sales in 2023 has driven the demand for related materials. Renewable energy fields, such as wind and solar energy, are expected to consume a large amount of molybdenum copper alloys by 2050 for the absorption layer of solar cells and corrosion-resistant components of wind turbines. Antaike China predicts that the wind power industry will consume about 300,000 tons of molybdenum . The aerospace field has a stable demand for high-strength, low thermal expansion molybdenum copper sheet, and grades such as Mo85Cu15 are used in jet engines and satellite thermal management components. In terms of development trends, the rise of 3D printing and additive manufacturing technologies has opened up new applications for molybdenum copper sheets, such as precision aerospace components and medical equipment. In addition, intelligent production and green manufacturing technologies have promoted the optimization of molybdenum copper sheet production processes, such as improving product consistency through automated control of the sintering process. The Asia-Pacific region will continue to dominate demand growth, and China's "14th Five-Year Plan" supported high-end manufacturing and infrastructure construction are expected to further increase molybdenum copper sheet consumption.

8.4 Challenges and opportunities facing the molybdenum copper sheet market

Challenge

Molybdenum copper sheets relies on two key raw materials, molybdenum and copper , whose prices are affected by the global economy, supply and demand balance and geopolitical factors, and are significantly volatile. Molybdenum is usually mined as a by-product of copper and tungsten mines, and copper price fluctuations directly affect molybdenum supply. Such price fluctuations increase the cost pressure on molybdenum copper sheet manufacturers, especially in the electronics and aerospace industries that require a stable supply chain, which may lead to profit margin compression or reduced market competitiveness. Global concerns about environmental protection have prompted countries to strengthen supervision of mining and processing, especially in China and North America. In 2023, North America's molybdenum production declined due to declining copper-molybdenum ore grades and strict environmental regulations (such as emission standards in the United States and Canada), limiting the production capacity of molybdenum copper sheets. In China, the government's strict supervision of mine approvals (such as the revision of the Environmental Protection Law) has increased operating costs, such as requiring the use of low-emission equipment and wastewater treatment technologies. Although these regulations have improved the level of environmental governance, they have increased the compliance costs of molybdenum copper sheet producers , which may lead to the market exit of small and medium-sized enterprises.

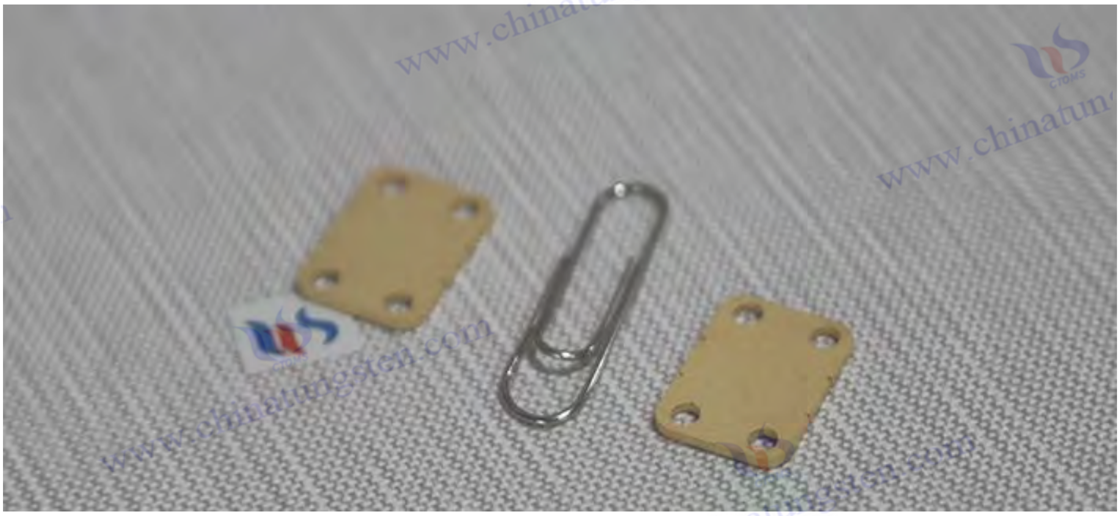
Molybdenum copper sheet in high thermal conductivity and low thermal expansion coefficient make it unique in the electronics and aerospace fields, but other materials such as vanadium, tungsten and chromium have competitive potential in certain applications. For example, tungsten can partially replace molybdenum copper sheet in high-temperature environments due to its higher melting point (about 3,422°C) , especially in aerospace components. The use of vanadium in high-strength steel alloys may weaken the indirect demand for molybdenum copper sheet in the field of steel reinforcement , while the use of chromium in corrosion-resistant coatings may replace the demand for molybdenum copper sheet in certain chemical industry applications. The cost advantages or performance optimization of these alternative materials in specific scenarios may lead to partial loss of molybdenum copper sheet market share. For example, the application of molybdenum copper sheet in 5G base station heat dissipation substrates may be challenged by tungsten-based composites , especially in cost-sensitive markets. In addition, the increasing application of ceramic materials (such as aluminum nitride) in electronic packaging may pose a threat to the demand for grades such as Mo70Cu30. In some regions, especially in emerging markets such as the Middle East and Africa, insufficient awareness of the advantages of molybdenum copper sheet has limited market penetration. Many potential users (such as small and medium-sized electronic manufacturers) lack understanding of the thermal conductivity (150-270W/m·K) and adjustable thermal expansion coefficient ($5\text{-}12\times10^{-6}$ /K) of molybdenum copper sheets, which leads them to prefer traditional materials such as pure copper or aluminum. In addition, supply chain instability is another major challenge. Geopolitical tensions and logistics issues (may interrupt the supply of molybdenum and copper , affecting the production of molybdenum copper sheets. Transportation delays and port bottlenecks may further exacerbate supply chain risks, which may lead to delays in the delivery of molybdenum copper sheets and affect production plans in the aerospace and electronics industries.

Opportunity

The rapid development of the global new energy and electronics industries provides broad prospects for the molybdenum copper sheet market. Molybdenum copper sheets are widely used in electric vehicles (EVs), 5G communication equipment, and renewable energy equipment due to their high thermal conductivity and low thermal expansion coefficient. For example, in the field of electric vehicles, Mo60Cu40 molybdenum copper sheets are used for heat dissipation substrates in battery management systems to ensure the stability of batteries under high-power operation. In the field of 5G communications, molybdenum copper sheets (such as Mo70Cu30) are widely used in base station RF amplifiers and power semiconductors due to their electrical conductivity (about 30-40% IACS) and thermal expansion matching with ceramic substrates to ensure the stability of high-frequency signal transmission. Demand for renewable energy equipment is also driving market growth, for example, molybdenum copper sheets are used as the conductive layer of copper indium gallium selenide (CIGS) thin-film solar cells to support the improvement of solar power generation efficiency. The rapid growth of these emerging application areas provides a stable source of demand for the molybdenum copper sheet market. Technological innovation has opened up new growth points for the molybdenum copper sheet market. Advanced extraction technologies (such as hydrometallurgy) have improved the recovery rate of molybdenum and reduced production costs. Advances in additive manufacturing (3D printing) technology have made it possible to produce complex-shaped parts from molybdenum copper sheets, especially in the aerospace and medical fields. For example, molybdenum -copper composites produced by electron beam melting (EBM) 3D printing technology have high density and crack resistance, and are suitable for high-temperature aerospace parts, such as turbine blades made of Mo85Cu15.

In addition, the application of nanocomposite technology (such as adding graphene to Mo70Cu30) improves thermal conductivity and interface strength, expanding the application of molybdenum copper sheets in precision manufacturing. For example, the demand for high-performance molybdenum copper sheets in X-ray targets and heat sink components in the medical field is increasing. These technological innovations not only improve the performance of molybdenum copper sheets, but also reduce material waste in the production process and enhance market competitiveness.

China's 14th Five-Year Plan emphasizes manufacturing upgrades and new energy development, increasing demand for molybdenum copper sheets. For example, in smart grid and high-speed rail projects, Mo60Cu40 is used to make efficient conductive components. In addition, rapid urbanization and expansion of the electronics industry in Asia-Pacific countries such as India and Japan have further expanded the market. These regional demands provide suppliers with diversified market opportunities, especially in high value-added applications. The green manufacturing trend of recycling molybdenum copper waste also provides new opportunities for the market. The use of molybdenum copper sheets in renewable energy equipment is in line with global carbon reduction goals . For example, in wind turbines and solar cells, the corrosion resistance and thermal conductivity of molybdenum copper sheets extend the life of the equipment.



CTIA GROUP LTD Molybdenum Copper Sheet Picture

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Molybdenum Copper Sheets Introduction

1. Overview of Molybdenum Copper Sheets

Molybdenum-copper (Mo-Cu) sheets are composite materials composed of molybdenum and copper. Thanks to their unique combination of thermal, electrical, and mechanical properties, as well as their tunability, Mo-Cu sheets are widely used in fields such as thermal management, high-performance electronic devices, semiconductors, and aerospace. They are commonly utilized as packaging materials, integrated circuit substrates, heat sinks, and LED thermal dissipation substrates. At CTIA GROUP LTD, we can customize molybdenum-copper products with specific dimensions and compositions according to customer requirements.

2. Features of Molybdenum Copper Sheets

Excellent Electrical Conductivity: Suitable for applications requiring efficient electrical connections.
High Thermal Conductivity: Capable of rapid heat transfer, ideal for electronic devices that require effective thermal dissipation.
Low Coefficient of Thermal Expansion: Highly compatible with semiconductor materials like silicon, helping to minimize thermal stress caused by temperature fluctuations and preventing deformation or damage to components.
Good Workability: Can be processed through cutting and other techniques into parts of various sizes and shapes to meet diverse application needs.

3. Typical Properties of Molybdenum-Copper Alloys

Material Composition	Density (g/cm^3)	Thermal Conductivity (W/M·K at 25°C)	Thermal Expansion Coefficient (10^{-6}/°C)
Mo85Cu15	10.00	160-180	6.8
Mo80Cu20	9.90	170-190	7.7
Mo70Cu30	9.80	180-200	9.1
Mo60Cu40	9.66	210-250	10.3
Mo50Cu50	9.54	230-270	11.5

4. Production Method of Molybdenum Copper Sheets

The preparation of molybdenum-copper sheets is primarily carried out using the infiltration method, which takes advantage of molybdenum's high melting point and copper's excellent fluidity. In this process, copper is infiltrated into a molybdenum preform at high temperatures, resulting in the formation of a dense molybdenum-copper composite material.

5. Purchasing Information

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Chapter 9 Future Development of Molybdenum Copper Sheet

9.1 Potential of new preparation technology for molybdenum copper sheet

Based on the traditional powder metallurgy and melt infiltration methods, the preparation technology of molybdenum copper sheets is developing towards intelligence, greenness and high efficiency. With the progress of materials science and manufacturing technology, new preparation technologies have shown great potential. Additive manufacturing (3D printing) technology is an important direction. Through laser powder bed melting or electron beam melting technology, complex-shaped molybdenum copper sheet parts such as aerospace thermal management components or microwave device heat sinks can be directly printed.

3D printing technology allows precise control of the molybdenum-copper ratio and microstructure, optimizes thermal conductivity (150-270 W/m·K) and electrical conductivity, and reduces material waste. For example, by melting Mo60Cu40 powder layer by layer, a heat sink with complex internal channels can be manufactured to meet the high heat load requirements of 5G equipment.

Nanocomposite technology is another potential area. By introducing nano -scale reinforcement phases (such as graphene or carbon nanotubes) at the molybdenum -copper interface, the interface bonding strength and thermal conductivity efficiency can be improved. For example, adding graphene to Mo70Cu30 can increase the thermal conductivity to 260 W/m·K while maintaining a low thermal expansion coefficient ($8\text{-}10\times10^{-6}$ /K). In addition, intelligent production technologies, such as AI-assisted process optimization and automated sintering control, improve the density and performance consistency of molybdenum- copper sheets by real-time monitoring of temperature and pressure parameters, and are suitable for large-scale production of high-copper content grades such as Mo50Cu50. Green manufacturing technologies have also attracted much attention, such as using recyclable molybdenum -copper waste as raw materials and reducing energy consumption through low-temperature sintering or plasma sintering technology, which meets global ESG (environmental, social and governance) standards.

CTIA GROUP LTD have begun to explore these technologies and use the industrial Internet platform to achieve full-process intelligence from design to production, such as using AI to collaboratively design Mo85Cu15 molybdenum copper sheets to meet the customized needs of high-temperature aerospace components. These new technologies are expected to reduce production costs, shorten cycles and improve product performance, opening up new possibilities for molybdenum copper sheets in high-performance applications.

9.2 Research directions for optimizing the performance of molybdenum copper sheets

Molybdenum copper sheet focuses on improving thermal conductivity, electrical conductivity, mechanical properties and environmental adaptability to meet the stringent requirements of electronics, aerospace and new energy fields. Interface optimization is the core direction. By improving the bonding quality of the molybdenum -copper interface, thermal resistance and electrical contact resistance are reduced. For example, chemical vapor deposition (CVD) is used to deposit a transition layer on the surface of molybdenum particles to enhance the thermal conductivity of Mo60Cu40 to more than 250 W/m·K, while increasing the tensile strength to 400 MPa. Alloying design is another important direction. Adding trace elements (such as rhenium or titanium) can enhance the high temperature resistance and oxidation resistance of molybdenum copper sheet. For example, adding a small amount of rhenium to Mo85Cu15 can keep its structural stability at 800°C, which is suitable for aerospace jet engine components. Microstructure regulation has also received attention. By controlling the uniformity of the distribution of molybdenum and copper phases , the thermal expansion coefficient ($5\text{-}12\times10^{-6}$ /K) is optimized to match the ceramic material. For example, the microstructure of Mo80Cu20 is adjusted by plasma sintering technology to reduce thermal stress and extend the life of electronic packaging devices. Surface modification technology, such as magnetron sputtering to deposit copper-molybdenum thin film coatings, can improve electrical contact performance and corrosion resistance, and is suitable for the application of high-frequency molybdenum- copper sheets in 5G RF modules.

The application of computational materials science provides a new path for performance optimization. By simulating the thermal and mechanical properties of molybdenum -copper alloys, the optimal composition ratio is predicted. For example, molecular dynamics simulation is used to optimize the copper phase distribution of Mo50Cu50 and increase the conductivity to 45% IACS. In addition, green performance optimization is also a focus, studying low-energy preparation processes and recyclable materials to reduce environmental impact. For example, by recycling molybdenum -copper waste to produce Mo70Cu30, production costs are reduced and sustainability is improved. These research directions promote the application of molybdenum- copper sheets in high-performance fields through technological innovation and interdisciplinary integration .

9.3 Expansion of cross-industry applications of molybdenum copper sheets

Molybdenum copper sheets is accelerating. Benefiting from its high thermal conductivity, low thermal expansion and excellent mechanical properties, it has gradually expanded from traditional electronics and aerospace fields to new energy, medical and defense fields. In the field of new energy, molybdenum copper sheets are widely used in electric vehicle battery management systems and renewable energy equipment due to their high thermal conductivity and corrosion resistance. For example, Mo60Cu40 is used for heat dissipation substrates of electric vehicle power modules to effectively manage high heat loads; Mo70Cu30 is used for solar cell absorption layers and wind turbine corrosion-resistant components. It is expected that the wind power industry will consume a large amount of molybdenum copper alloys by 2050 .

In the medical field, the biocompatibility and high strength of molybdenum copper sheets have made them stand out in the manufacturing of medical equipment. For example, Mo85Cu15 is used in the heat dissipation components of X-ray equipment to ensure the stability of the equipment in high-radiation environments; 3D printed molybdenum copper sheets can be used to manufacture thermal management components for precision implantable medical devices . Molybdenum copper sheets in the defense sector

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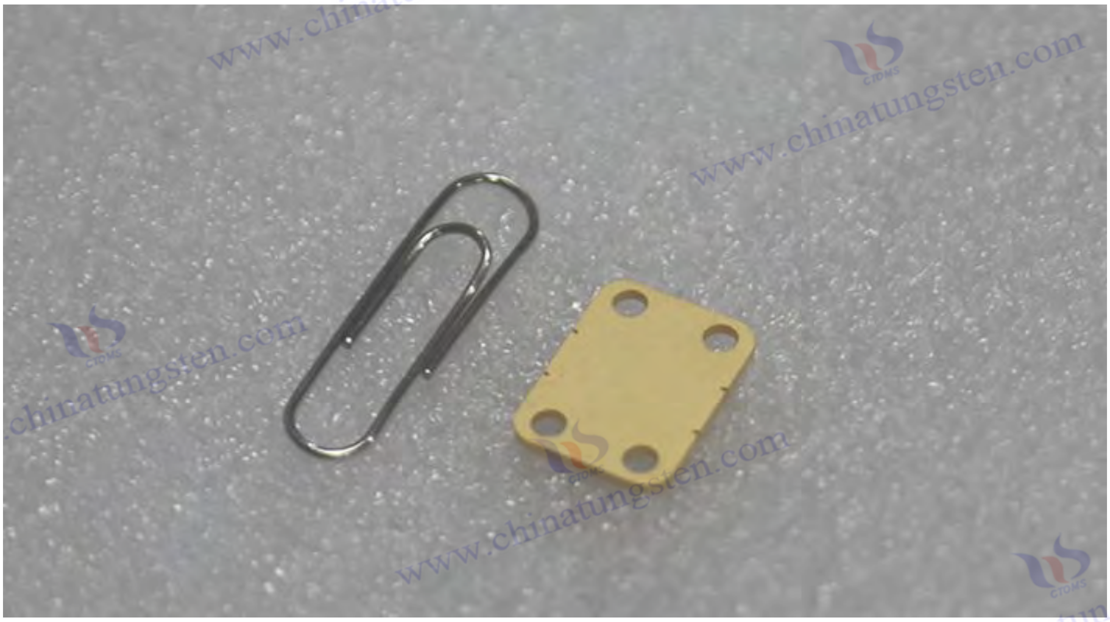
is also growing. Mo80Cu20 is suitable for heat sinks in missile and radar systems due to its low thermal expansion and high strength, meeting the requirements of high temperature and high vibration environments. High-performance computing and artificial intelligence have opened up new markets for molybdenum copper sheets. The high thermal conductivity and electrical conductivity of Mo50Cu50 make it an ideal choice for heat dissipation substrates for data center server chips, supporting high-density 3D packaging technology.

In addition, new applications of molybdenum copper sheets in the optoelectronic field continue to expand, such as Mo70Cu30 for high-power lasers and LED chip carriers to optimize thermal management and electrical contact performance. Cross-industry expansion also benefits from new preparation technologies, such as 3D printing and nanocomposite technology, which enable molybdenum copper sheets to customize complex structures to meet the precision needs of the medical and defense fields. In the future, with the global focus on efficient energy and intelligent manufacturing, the application potential of molybdenum copper sheets in nuclear heat exchangers, fuel cells and smart terminals will be further released, driving the growth of its market size.



CTIA GROUP LTD Molybdenum Copper Sheet Picture

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5. Purchasing Information

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Chapter 10 Domestic and International Standards for Molybdenum Copper Sheets

10.1 Chinese National Standard for Molybdenum Copper Sheet

China's national standards provide normative guidance for the production, testing and application of molybdenum copper sheets to ensure product quality and industry consistency. At present, the main standard related to molybdenum copper sheets is the industry standard YS/T 1546-2022 "Molybdenum Copper Alloy Plate", which is managed by the Ministry of Industry and Information Technology, issued on September 30, 2022, and implemented on April 1, 2023. The filing number is 88796-2023. This standard is applicable to molybdenum copper alloy plates in deformed annealed and infiltrated states, covering common grades such as Mo85Cu15, Mo80Cu20, and Mo70Cu30. It specifies the chemical composition, physical properties (such as density, thermal conductivity) and processing requirements, and is suitable for heat dissipation substrates and conductive components in the fields of electronic packaging, aerospace, and communications.

For example, the standard requires that the density of Mo70Cu30 is about 9.6 g/cm³, the thermal conductivity is about 200-250 W/m·K, and the thermal expansion coefficient is about 8-10×10 $^{-6}$ /K to ensure matching with ceramic materials. In addition, YS/T 660-2022 "Molybdenum and Molybdenum Alloy Processing Product Brands and Chemical Composition" also provides a reference for the chemical composition of molybdenum copper sheets, clarifying the content range of molybdenum and copper and the requirements for impurity control. Other relevant standards include YS/T 1562.1-2022 "Chemical Analysis Methods for Tungsten Copper Alloys Part 1: Determination of Copper Content by Iodine Digitization and Inductively Coupled Plasma Atomic Emission Spectrometry", which provides method support for the composition detection of molybdenum copper sheets. These standards are supervised by the China Nonferrous Metals Industry Association and the National Technical Committee for Nonferrous Metals Standardization (TC243) to ensure consistency with the high-end manufacturing industry requirements in the country's "14th Five-Year Plan". Companies such as CTIA GROUP LTD strictly follow these standards to produce molybdenum copper sheets that meet the needs of electronics and aerospace .

10.2 International Standards for Molybdenum Copper Sheets

International standards provide uniform specifications for the production and trade of molybdenum copper sheets in the global market, but the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) have not yet issued independent standards specifically for molybdenum copper sheets. The relevant requirements are usually integrated into the standards of molybdenum alloys or composite materials. ISO 1554:1976 and ISO 1553:1976 (Chemical analysis methods for processed and cast copper alloys and pure copper) provide references for the determination of copper content in molybdenum copper sheets. The copper content is analyzed by electrolysis to ensure the accuracy of the chemical composition. These standards are partially adopted by the Chinese standard YS/T 1562.1-2022 for detecting the copper content of grades such as Mo60Cu40. In addition, the ISO 9001 quality management system standard is widely used in the quality control of molybdenum copper sheet manufacturers to ensure product performance consistency. For example, CTIA GROUP LTD has passed ISO 9001 certification and optimized the production process of Mo50Cu50 to meet the needs of 5G communication equipment. International standards also involve environmental and safety requirements, such as ISO 14001 environmental management system, which requires the reduction of waste and energy consumption in the production process, in line with global ESG standards. Although there is a lack of dedicated international standards for molybdenum copper sheets, molybdenum copper sheet manufacturers usually refer to ISO/TC 119 (powder metallurgy) and ISO/TC 26 (copper and copper alloys) related standards, combined with customer contract requirements, to customize performance parameters such as thermal conductivity (150-270 W/m·K) and thermal expansion coefficient ($5\text{-}12\times10^{-6}$ /K). In the future, as the application of molybdenum copper sheets in new energy and electronics expands, ISO may formulate more specific standards to regulate the global market.

Molybdenum copper sheet standards in Europe, America, Japan, South Korea and other countries around the world

Molybdenum copper sheet standards in Europe, America, Japan, South Korea and other countries are usually based on their own material standard systems or industry specifications. Since molybdenum copper sheets are specific application materials, there are few special standards, and the relevant requirements are integrated into the standards of copper alloys, molybdenum alloys or composite materials. In the United States, the American Society for Testing and Materials (ASTM) standards such as ASTM B777 (high-density tungsten alloy standard) provide indirect references for the performance testing of molybdenum copper sheets. Although they are not directly targeted at molybdenum copper sheets, their test methods (such as density and tensile strength) are applicable to the quality control of grades such as Mo85Cu15. American companies often combine customer customization requirements to produce molybdenum copper sheets that meet aerospace needs, such as Mo80Cu20 for satellite thermal management components, with a thermal conductivity of about 170-200 W/m·K. In Europe, the European Committee for Standardization (CEN) indirectly regulates the processing requirements of molybdenum copper sheets through EN 13599 (copper and copper alloy plates and strips), emphasizing chemical composition and mechanical properties (such as tensile strength 400-600 MPa). The German Institute for Standardization (DIN) also provides similar guidance. Some companies refer to DIN EN ISO 6892-1 to conduct tensile tests on molybdenum copper sheets to ensure that the strength and ductility of Mo70Cu30 meet the requirements of electronic packaging.

In Japan, Japanese Industrial Standards (JIS) such as JIS H 3100 (copper and copper alloy sheets and strips) provide references for the production of molybdenum copper sheets, emphasizing electrical conductivity and thermal conductivity. Mo60Cu40 molybdenum copper sheets produced by Japanese companies are widely used in high-frequency communication equipment, with an electrical conductivity of about 30-40% IACS. The Korea Agency for Technology and Standards (KATS) produces molybdenum copper sheets that meet the needs of new energy, such as Mo50Cu50 for electric vehicle power modules, in accordance with international standards and customer contracts. These countries usually customize the performance parameters of molybdenum copper sheets in combination with ISO standards and industry practices, and ensure quality and environmental compliance through ISO 9001

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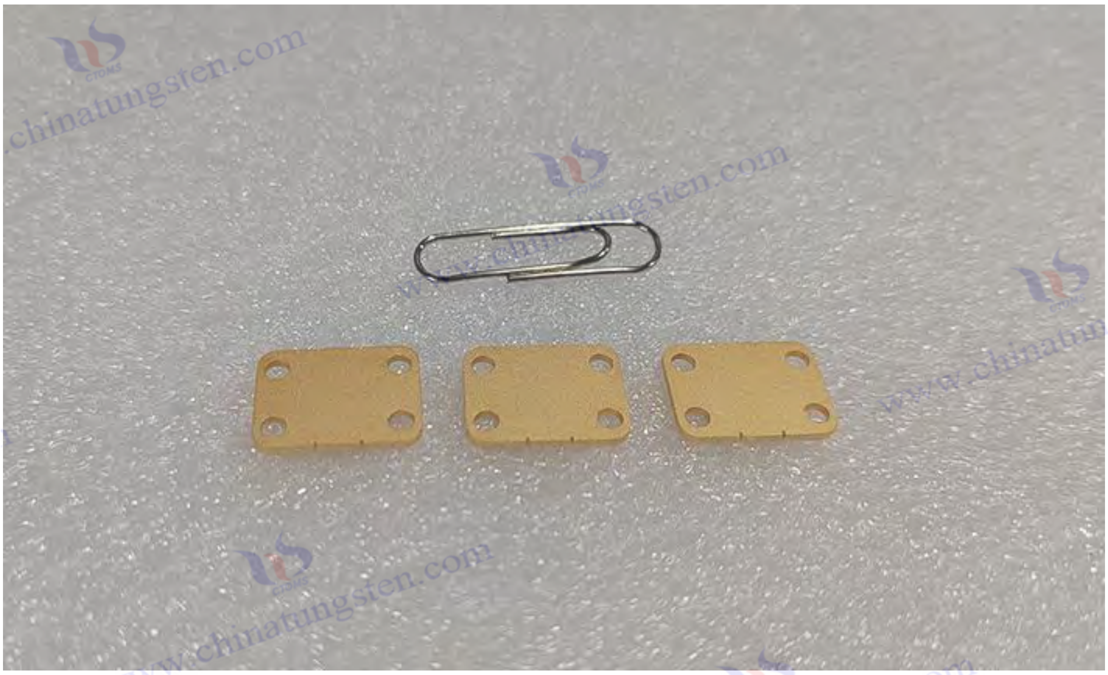
and ISO 14001 certification . European, American, Japanese and Korean companies also cooperate with Chinese manufacturers such as CTIA GROUP LTD , using the Chinese standard YS/T 1546-2022 as a reference to ensure product consistency in the global market.



CTIA GROUP LTD Molybdenum Copper Sheet Picture

Appendix: Glossary of Molybdenum Copper Sheet Terms

the term	definition	Application Examples
Molybdenum copper sheet	Of molybdenum (Mo) and copper (Cu) in a specific ratio are prepared by powder metallurgy or melt infiltration, and have high thermal conductivity, low thermal expansion coefficient and high strength.	Mo70Cu30 molybdenum copper sheet is used for 5G base station heat dissipation substrate, and its thermal conductivity is about 200-250 W/m·K.
molybdenum	High melting point transition metal (melting point about 2623°C), with excellent high temperature resistance and corrosion resistance, low thermal expansion coefficient, and provides structural support.	the structural skeleton of molybdenum copper sheets in high-temperature aerospace components .
copper	Highly conductive and thermally conductive metals (thermal conductivity of about 401 W/m·K, electrical conductivity of about 100% IACS), forming a thermally and electrically conductive network and improving ductility.	The copper phase in Mo60Cu40 improves the electrical conductivity and is suitable for heat sinks in communication equipment.
Brand	Indicates the mass or volume percentage of molybdenum and copper in molybdenum-copper sheets, such as Mo85Cu15 (85% molybdenum , 15% copper).	Mo85Cu15 is used in aerospace, and Mo50Cu50 is used in high-frequency electronic equipment.
Thermal conductivity	A measure of the ability of molybdenum copper sheets to conduct heat, measured in W/m·K, which increases with the copper content .	The thermal conductivity of Mo50Cu50 is 220-270 W/m·K and is used for power semiconductor heat dissipation substrates.
Coefficient of thermal expansion	It indicates the expansion rate of molybdenum copper sheet when the temperature changes, the unit is 10^{-6} /K, which decreases with the increase of molybdenum content.	The CTE of Mo85Cu15 is about 5-7×10^{-6} /K, which matches the ceramic material and reduces thermal stress.
Conductivity	A measure of the ability of a molybdenum copper sheet to conduct current, expressed as a percentage of IACS, which increases with copper content .	The conductivity of Mo60Cu40 is about 30-40% IACS, which is suitable for high-frequency communication equipment.
Mechanical properties	Molybdenum copper sheet under triaxial loading or thermal cycling reflects the fatigue resistance.	Mo70Cu30 has good toughness due to its high copper content and is suitable for high vibration environments in aerospace.

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Corrosion resistance	Molybdenum copper sheet to resist corrosion by corrosive media (such as moisture and salt spray) is mainly dominated by the molybdenum phase.	Mo85Cu15 performs well in marine environments and is suitable for aerospace thermal management components.
Antioxidant properties	molybdenum copper sheet to resist oxidation reaction in high temperature oxygen-containing environment.	Mo80Cu20 remains structurally stable at 600°C and is suitable for high-temperature electronic devices.
Acid and alkali resistance	Molybdenum copper sheets in acidic or alkaline environments.	Mo85Cu15 performs well in non-oxidizing acids such as hydrochloric acid and is suitable for chemical industry parts.
Powder Metallurgy	Molybdenum- copper sheets by mixing molybdenum powder and copper powder, pressing and sintering at high temperature (1000-1400°C) .	Mo85Cu15 is produced by powder metallurgy and has a tensile strength of 500-600 MPa.
Infiltration method	Molybdenum- copper sheets by infiltrating molten copper into a porous molybdenum skeleton is suitable for grades with high copper content.	Mo50Cu50 optimizes thermal conductivity through melt infiltration and is suitable for heat sinks in 5G communication equipment.
Hot Press Sintering	A variation of powder metallurgy, which improves the density and mechanical properties of molybdenum copper sheets through high temperature and high pressure sintering.	The Vickers hardness of Mo80Cu20 reaches 160-200 HV, which is suitable for high-temperature aerospace components.
High frequency molybdenum copper sheet	Molybdenum copper sheets are specially designed for high frequency electronic equipment , with high electrical and thermal conductivity.	Mo60Cu40 is used in RF power amplifiers and has a conductivity of about 30-40% IACS.
Aerospace Molybdenum Copper Sheet	Molybdenum copper sheets designed for the aerospace industry have low thermal expansion and high strength.	Mo85Cu15 is used in jet engine thermal management components and can operate stably at 600-800°C.
Photoelectric device type molybdenum copper sheet	Molybdenum copper sheets designed for optoelectronic devices have high thermal conductivity and matching thermal expansion coefficient.	Mo70Cu30 is used for high power laser heat dissipation substrate and matches gallium arsenide.
Material Safety Data Sheets	A document that provides safety information for molybdenum copper sheet, describing the	China Tungsten Intelligence 's MSDS recommends wearing a

	chemical composition, potential hazards and handling guidelines.	dust mask to prevent dust inhalation during processing.
Intelligent Manufacturing	Use AI technology and the Industrial Internet to optimize molybdenum copper sheet production and improve consistency and efficiency.	CTIA GROUP LTD produces Mo50Cu50 through automated sintering control to meet the needs of 5G equipment.
Additive Manufacturing	Molybdenum- copper sheets through 3D printing technology , complex-shaped parts can be produced and material waste can be reduced.	Mo60Cu40 is made into complex heat sinks through 3D printing, which is suitable for the aerospace field.
Nanocomposite technology	Introducing nano-reinforcement phases (such as graphene) at the molybdenum-copper interface can improve thermal conductivity and interface strength.	reaches 260 W/m·K after adding graphene .
ESG Standards	Global environmental, social and governance norms require molybdenum copper sheet production to reduce energy consumption and waste.	Recycle molybdenum -copper waste to produce Mo70Cu30.
YS/T 1546-2022	China's industry standard "Molybdenum-Copper Alloy Plate" specifies the chemical composition and physical properties.	Mo70Cu30 has a density of about 9.6 g/cm³ and is suitable for electronic packaging and aerospace.
ISO 9001	International quality management system standards, used for quality control of molybdenum copper sheet production enterprises.	The company has passed ISO 9001 certification and optimized the Mo50Cu50 production process.
ISO 14001	International environmental management system standards require that the production of molybdenum copper sheets reduce environmental impact.	Low temperature sintering technology is used to produce molybdenum copper sheets to reduce energy consumption.

illustrate :

- The table clearly presents terms, definitions and application examples, covering the material properties, preparation process, market status and standards of molybdenum copper sheet, combining the information from previous chapters and search results.

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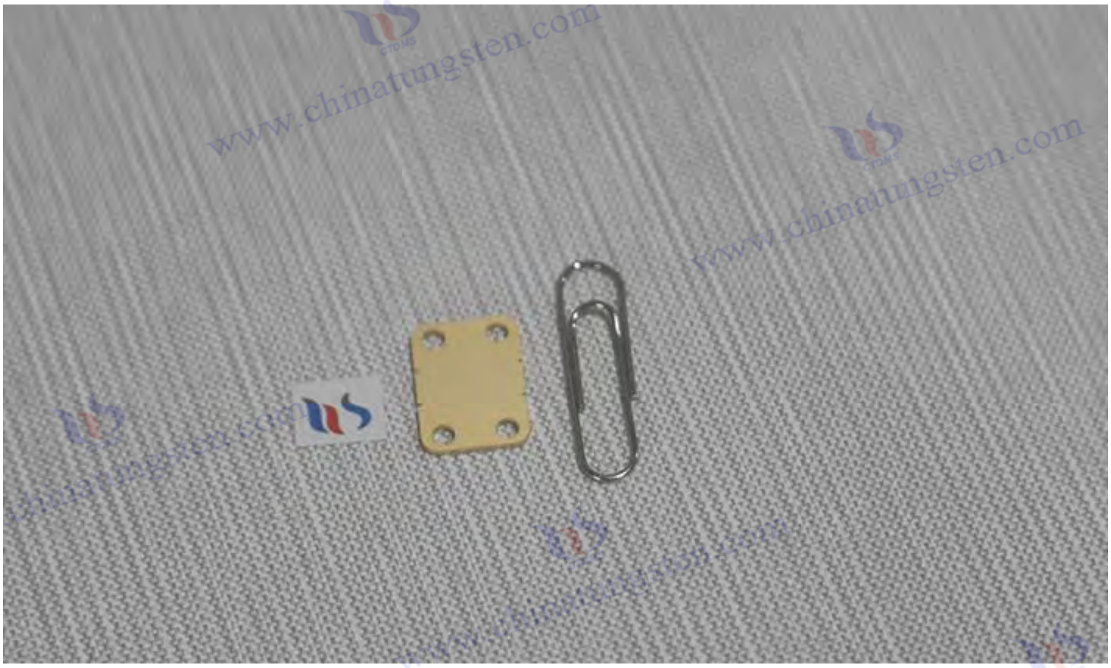

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