

INDUSTRY OVERVIEW

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OVERVIEW OF ELECTRONIC METAL POWDERS

Definition and Classification

Electronic metal powders are high-purity metal or alloy powders produced through precision manufacturing processes for critical functional applications in electronics. They are distinguished by a tightly controlled particle size distribution and high sphericity, meeting the stringent performance requirements of high-frequency and high-density electronic devices.

Leveraging their electrical conductivity, thermal conductivity and electromagnetic properties, electronic metal powders are widely used in multi-layer ceramic capacitors (MLCCs), semiconductor components, precision interconnect materials, electrode pastes and advanced packaging. As key raw materials in the electronics value chain, their quality directly affects the performance and reliability of downstream products.

Electronic metal powders can be classified by chemical composition, particle size and morphology. By composition, they include single-metal powders and alloy powders selected for conductivity, magnetic properties and thermal stability. By particle size and morphology, they range from micron- to nano-size powders and may appear in spherical, flake or dendritic forms. Among them, nano-size spherical powders, with high specific surface area, good flowability and narrow particle size distribution, are particularly suitable for advanced miniaturized electronic components.

Downstream Applications of Electronic Metal Powders

Driven by the trend toward higher power density, higher integration and device miniaturization, demand for micron- and nano-size electronic metal powders is expected to continue expanding across high-growth electronics applications.

The following table sets forth the major downstream application categories of electronic metal powders:

Application	Description	Main Powder	Particle Size
MLCC	• Core application of high-end metal powders, driven by 5G, AI servers, and automotive electronics; trend toward miniaturization and higher capacitance	• Nano-size nickel powder (inner electrode), ultrafine copper/silver powder (outer electrode)	80–400 nm
Photovoltaic Cell Electrodes	• Metal pastes printed by screen printing to form busbars; powder quality directly affects photovoltaic conversion efficiency	• Silver powder and silver-coated copper powder (HJT/TOPCon), copper powder (BC)	1–5 μm
Semiconductor Packaging	• Conductive adhesives used for chip-to-lead frame bonding, providing mechanical connection and electrical/thermal conduction	• Nano/micron-size silver, gold, copper powders	50–500 nm
Automotive Electronics	• Used in EV power modules, radar systems, and sensors	• Alloy soft magnetic powders, carbonyl iron powder (EM shielding), nickel/copper powders (automotive-grade MLCC)	5–50 μm
Additive Manufacturing	• 3D printing of electronic housings, heat-dissipation structures, and lightweight precision components	• Titanium alloy powder, nickel-based superalloy powder, stainless steel powder, copper alloy powder	15–45 μm

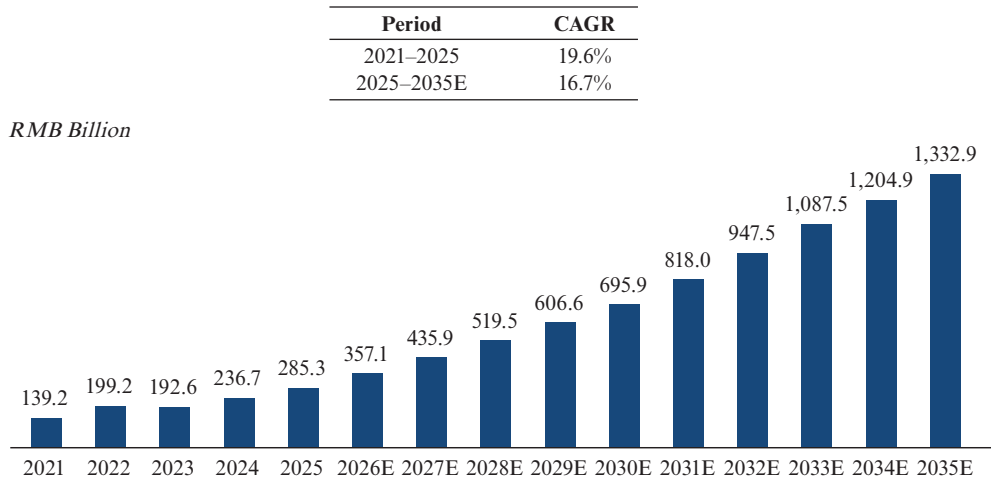
Source: Literature Review, Frost & Sullivan analysis

INDUSTRY OVERVIEW

Global Electronic Metal Powder Market Size

The global electronic metal powder market was RMB139.2 billion in 2021 and RMB285.3 billion in 2025, representing a CAGR of 19.6% from 2021 to 2025. The market is projected to reach RMB1,332.9 billion by 2035, with a CAGR of 16.7% from 2025 to 2035, driven by growing demand from the electronics, automotive, aerospace, and advanced manufacturing sectors, as well as the increasing adoption of high-performance and additive manufacturing applications.

Global Electronic Metal Powder Market Size, 2021–2035E

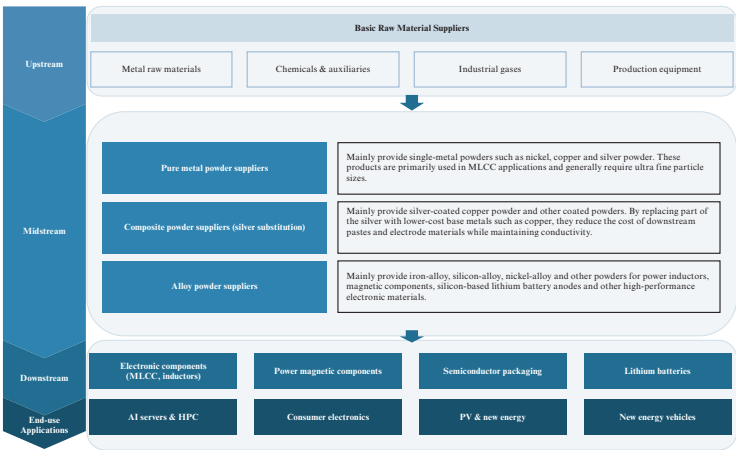


Source: Expert Interview, Frost & Sullivan analysis

Industry Ecosystem Analysis of Electronic Metal Powders

The industry value chain of electronic metal powders consists of upstream suppliers, midstream powder manufacturers and downstream applications. Upstream suppliers provide metal raw materials, chemicals and auxiliaries, industrial gases and production equipment. Midstream manufacturers produce pure metal powders, composite powders for silver substitution and alloy powders. At the downstream level, these powders are first used in electronic components and functional materials such as MLCCs, inductors, power magnetic components, semiconductor packaging and lithium batteries, which are further incorporated into end-use systems, particularly AI servers and HPC, as well as consumer electronics, PV and new energy, and new energy vehicles.

Electronic Metal Powder Industry Value Chain



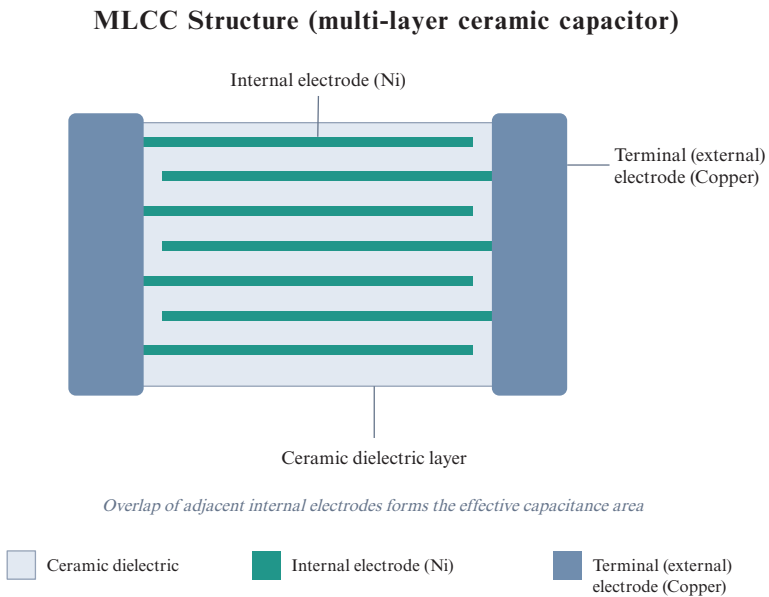
Source: Literature Review, Frost & Sullivan analysis

INDUSTRY OVERVIEW

OVERVIEW OF MLCC NICKEL POWDERS FOR MLCC

Definition

Nickel powders for MLCC are ultrafine metallic nickel materials engineered to form the internal electrodes of Multi-layer Ceramic Capacitors (MLCCs). They are formulated into conductive pastes, layered alternately with ceramic dielectric sheets, and co-fired at high temperature under a controlled atmosphere to form continuous conductive films that enable the capacitor’s energy storage and discharge functions.



Source: Literature Review, Frost & Sullivan analysis

Competitive Landscape

The global supply market for MLCC nickel powders is highly concentrated, with major suppliers primarily located in Japan and Mainland China. In terms of global revenue generated from MLCC nickel powders in 2025, the top five market participants accounted for an aggregate market share of approximately 61.7%.

Among global suppliers of high-end MLCC nickel powders, the Company ranked No. 2 in 2025 with a market share of approximately 11.0%. The Company was also the largest China-based supplier of MLCC nickel powders in the global market in 2025.

Ranking of Global MLCC Nickel Powder Suppliers by Revenue, 2025

Competitive Landscape of Global Suppliers of High-end MLCC Nickel Powders

Ranking	Company Name	Market Share
1	Company A	31.6%
2	The Company	11.0%
3	Company B	9.2%
4	Company C	5.4%
5	Company D	4.5%
	Others	38.3%

INDUSTRY OVERVIEW

1. Company A is a Japanese company established in 1956, focusing on functional electronic materials.
2. Company B is a Tokyo Stock Exchange-listed Japanese company established in 2002 through the merger of NKK and Kawasaki Steel. It operates in steel, engineering and trading, with group companies also engaged in metal and electronic materials such as nickel powder.
3. Company C is a Japanese company established in 1948, with businesses covering titanium metals, catalysts and chemicals. Its products include titanium sponge, high-purity titanium, ultrafine nickel powder and high-purity titanium oxide.
4. Company D is a Tokyo Stock Exchange-listed Japanese company engaged in non-ferrous metal resources, smelting and materials manufacturing, with products including battery cathode materials, thick-film pastes and nickel-based electronic materials.

Source: Expert Interview, Frost & Sullivan analysis

Analysis of Mainstream Production Technologies for MLCC Nickel Powders

For MLCCs and other electronic components, the production technology decisively affects particle size distribution, morphology, and purity. The most common methods are physical vapor deposition (PVD), liquid-phase chemical reduction and chemical vapor deposition (CVD).

The following table sets forth and compares the technical characteristics and typical applications of these major preparation methods:

Method	Description	Morphology Control	Purity	Co-firing Compatibility	Production Stability	Pollution	Typical Applications
Physical Vapor Deposition (PVD)	Under atmospheric pressure, metal raw materials are heated, melted and vaporized by a plasma heating to form metal vapor. The vapor is then carried by nitrogen and rapidly cooled, followed by nucleation and growth to produce ultrafine metal powders with sub-micron to nano-size particle sizes.	Good	High (minimal contamination)	High (particles adapt well to ceramic co-firing, low defect risk)	High (consistent between batches, suitable for industrial-scale production)	Low (no chemical precursors, minimal emissions)	High-end MLCC internal electrodes
Liquid Phase Chemical Reduction	Reduction of metal ions in solution using reducing agents (e.g., NaBH_4 , hydrazine) to form metal nanoparticles.	Moderate	Moderate (possible residual reducing agents or ions)	Moderate (particles may agglomerate during sintering)	Moderate (possible residual reducing agents or ions)	Moderate to high (chemical reagents can generate waste)	Mid- to high-end MLCC powder
Chemical Vapor Deposition (CVD)	Metal precursors decompose in a high-temperature hydrogen atmosphere to form fine metal powder.	Good	Moderate (possible impurities from precursor decomposition)	Moderate (may require additional post-treatment to improve co-firing compatibility)	Moderate (batch-to-batch variations possible)	High (reactive precursors, may produce waste gas)	Mid- to high-end MLCC internal electrodes

Source: Literature Review, Frost & Sullivan analysis

Technical Advantages of PVD Method for MLCC Nickel Powder Production:

- **Process Advantages in Purity and Superior Sphericity:** This physical vapor condensation process uses plasma heating under atmospheric pressure to melt and vaporize metallic nickel, which is subsequently condensed into powder in an inert gas atmosphere. This process helps reduce the introduction of impurities during production, and nickel powder prepared through this method generally exhibits good crystallinity. In addition, particles produced by the PVD method typically demonstrate high sphericity, which helps improve powder flowability and tap density, facilitates more uniform coating of electrode paste during the coating process, and supports the electrical performance of end products.

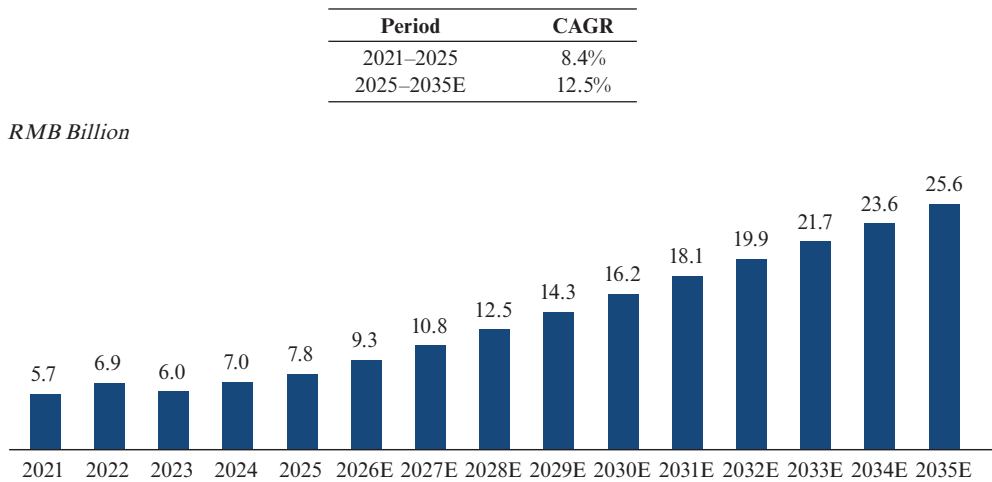
INDUSTRY OVERVIEW

- Co-firing Compatibility between Nickel Powder and Ceramic Substrates at High Temperatures:* A core manufacturing process of MLCCs involves the synchronous sintering of internal electrodes and ceramic substrates under high-temperature conditions. Nickel powders prepared through the PVD process, characterized by uniform particle size distribution and high sintering activity, are better equipped to accommodate the shrinkage and expansion characteristics of ceramic materials during thermal treatment. Such robust co-firing compatibility helps mitigate the formation of cracks, pores, or interfacial stress, thereby playing a pivotal role in enhancing product consistency. In contrast, powders produced by certain traditional preparation methods may experience particle agglomeration under extreme sintering conditions, posing significant challenges to yield control for high-end miniaturized products.

Market Size of Global Nickel Powder Market for MLCC, 2021–2035E

The market size in terms of revenue reached approximately RMB5.7 billion in 2021 and grew to RMB7.8 billion by 2025, representing a CAGR of 8.4%. The market is expected to witness a further surge, primarily driven by the exponential growth of AI infrastructure and the rapid expansion of high-performance computing, as well as the increasing demand from the electric vehicle sector. By 2035, the market size is projected to reach RMB25.6 billion, with the CAGR accelerating to 12.5% during the 2025 to 2035.

Global MLCC Nickel Powder Market Size, 2021–2035E



Source: Company Annual Reports, Frost & Sullivan analysis

Future Trends of Nickel Powder for MLCC

- Sustained Growth in Market Demand:* AI servers and data centers, new energy vehicles, and upgrades in consumer electronics are driving demand growth for high-performance MLCCs, which in turn raises the performance requirements for nickel powder used in internal electrodes. To meet the requirements of miniaturized, high-capacitance and high-reliability MLCCs, nickel powder needs to have higher purity, finer particle size, narrower particle size distribution, higher sphericity and more stable sintering performance, thereby driving continued demand growth for high-end MLCC nickel powder.
- Process Upgrading and Scale Production Capability:* To meet the performance requirements of high-end MLCC nickel powder, nickel powder preparation processes have continued to improve. PVD has become an important preparation route for high-end MLCC nickel powder due to its advantages in particle purity, particle size control and

INDUSTRY OVERVIEW

morphology consistency. At the same time, large-scale and stable production capability has become a key competitive factor in the industry, as mass production depends on advanced equipment, precise process control and batch-to-batch consistency.

Entry Barriers to Nickel Powder Market For MLCC

The MLCC nickel powder market is technology and capital-intensive, constrained by strict process requirements, long customer validation cycles, and substantial initial investment, as outlined below:

- *Technological and Process Barriers:* As MLCCs develop toward smaller size and higher capacitance, requirements for nickel powder have become increasingly stringent. High-end MLCC nickel powder typically requires particle sizes of around 80 nm, narrow particle size distribution, high sphericity and good sintering activity, while maintaining compatibility with ceramic substrates during co-firing. Only a limited number of companies globally can achieve stable mass production of such nano-size nickel powder, creating a high technological barrier.
- *Stringent Customer Qualification and High Switching Costs:* MLCC manufacturers generally require long qualification cycles for nickel powder suppliers, including material compatibility testing and validation in end-product manufacturing processes, which may take three to five years. As minor changes in raw materials may affect product quality, customers are unlikely to switch suppliers once certification is completed, resulting in strong customer stickiness.
- *Scale Production and Capital Barriers:* Mass production of high-end nickel powder requires substantial capital investment, customized production equipment and precise process control. Companies must also overcome challenges in process optimization and batch stability when scaling from laboratory R&D to commercial production. These requirements create high barriers in terms of funding, R&D capability and production management experience.

Overview of MLCC

Multi-Layer Ceramic Capacitors (“MLCCs”) are manufactured by alternately stacking ceramic dielectric layers and metal electrodes, followed by high-temperature sintering. MLCCs are a fundamental component in modern electronics, with their core function being the storage and release of electrical charge, serving key roles in filtering, decoupling, bypass, and energy regulation in electronic circuits.

Owing to their compact size, high voltage and temperature tolerance, reliability, and cost efficiency, MLCCs have become an indispensable base component within electronic systems. Their downstream applications span multiple sectors, including consumer electronics, telecommunications equipment, automotive electronics, and industrial control. As end-user electronic products evolve toward higher integration, enhanced performance, and miniaturization, both the per-unit usage and specification diversity of MLCCs have continued to increase.

Downstream Application Scenarios of MLCC

- *AI Servers and High-Performance Computing (HPC):* MLCCs serve as key components to ensure power integrity and signal stability in AI servers. They are widely used in processors, GPU accelerator cards, and high-speed interfaces for decoupling and filtering. High-computing environments impose stringent requirements on transient current response, typically necessitating the deployment of large arrays of low-ESR/ESL MLCCs. A single mainstream AI server may incorporate approximately 30,000 to 40,000 MLCC units, representing 10–20 times the quantity used in traditional servers, highlighting significant growth potential.

INDUSTRY OVERVIEW

- *Automotive Electronics and Electrification:* With vehicle electrification, MLCCs are widely used in BMS, motor controllers, OBCs and autonomous driving systems for power filtering and noise suppression. BEVs typically require 2–6 times more MLCCs than conventional vehicles, driving demand for high-end and high-reliability MLCCs.
- *High-Performance Consumer Electronics:* MLCCs are used in smartphones, tablets and laptops for power stabilization and RF filtering. The adoption of 5G and higher device integration continue to increase MLCC usage, with a typical 5G smartphone containing approximately 1,000–1,200 MLCCs.
- *Telecommunications Infrastructure:* MLCCs are widely used in 5G base stations and network equipment for RF filtering and power management. The rollout of Massive MIMO and high-frequency technologies drives demand for high-capacity, high-reliability MLCCs.
- *Industrial Control and Automation Systems:* MLCCs are used in industrial robots, PLCs, servo drives and automation systems for voltage stabilization and EMI suppression, supporting equipment reliability and industrial automation upgrades.

OVERVIEW OF COPPER BASED POWDERS

Copper Based Powders

Copper-based powders are powder materials with copper as the base component, manufactured through physical or chemical processes. Owing to their excellent electrical conductivity, good processability and relatively low cost, copper-based powders are widely used across two key application domains: electronic components and photovoltaics.

Electronic Component Applications

Copper Powder for MLCC

In MLCC manufacturing, copper powder must form dense electrodes after high-temperature sintering to meet miniaturization requirements. In IGBT packaging, its high thermal conductivity and low-temperature sintering characteristics directly determine chip heat dissipation efficiency and operational reliability, making it a critical material for power electronic device upgrades.

The electrical performance of MLCC end electrodes depends highly on the physical and chemical properties of the copper powder used. To ensure reliability and electrical stability of the final products, copper powder for MLCCs is required to meet the following performance criteria:

- *Precise Particle Size Distribution and Microstructural Control:* Copper powder used for MLCC end electrodes must have a controlled particle size distribution and uniform morphology to ensure paste rheology, printing stability and electrode densification after sintering. In industry practice, particle sizes are typically controlled between 0.5 μm and 5.0 μm , as particle size variation may affect electrode conductivity, mechanical strength and final component performance.
- *Sintering Compatibility with Ceramic Substrates:* Copper powder must be compatible with ceramic or glass layers during co-firing. Differences in thermal expansion coefficients may generate interfacial stress, affecting electrode reliability and product quality.
- *Excellent Dispersion and Paste Rheology:* Copper powder must exhibit good dispersion stability in paste systems to prevent agglomeration and maintain printing consistency. Highly dispersible powders help ensure uniform electrode structures and stable electrical performance.

INDUSTRY OVERVIEW

Photovoltaics Applications

Low-Cost Metal Substitution: “Low-silver” and “Silver-free” Pathways

With the large-scale commercialization of back-contact (BC), heterojunction (HJT) and TOPCon solar cells, cost pressure associated with silver powder has increased significantly. In particular, HJT cells, which adopt low-temperature processing, consume more silver than conventional PERC cells, while BC cells require higher conductivity and printing precision for metallization materials due to their back-side-only electrode layout and fine-line design. These factors have collectively made low-silver and silver-free metallization key cost-control initiatives in the industry. At present, the mainstream low-cost metal substitution routes include pure copper powder, silver-coated copper powder and other copper-based powders.

Classification of Low-Cost Metal Substitution Routes in Photovoltaics

Substitution Route	Technical Definition	Application Scenario	Key Advantages	Current Industrialization Level
Pure Copper	High-concentration copper used as conductive filler; suitable for various cell types	- BC cells, - TOPCon cells and HJT cells; (currently under production-line validation)	Low-cost raw material; nearly fully metallized without silver; compatible with existing printing processes	Mass production achieved in BC cells; application in HJT and TOPCon cells remains at the research, with conductivity and reliability still under validation.
Silver-Coated Copper	Copper particles are coated with a thin silver layer; applied via screen printing to form photovoltaic cell gridlines	Low-temperature process cells, including heterojunction (HJT) and some tandem/rear structure cells	Conductivity close to traditional silver; silver usage reduced by ~40–60%; gridlines can be printed with fine resolution	Mature technology; widely applied in HJT cell mass production; mainstream solution for short-term cost reduction
Electroplated Copper	Copper seed layer is first formed on the cell surface (e.g., thin copper layer), followed by electroplated copper grid	BC cells and high-efficiency TOPCon cells	Low-cost copper raw material; enables ultrafine grid lines; complex process improves conductivity	Process is complex; mass production yield needs verification; mainly at mid-term promotion stage

Source: Literature Review, Frost & Sullivan analysis

Pure Copper Powder

Definition

Pure copper powder is a powder material composed solely of copper as the metallic component. In the photovoltaic industry, submicron- and micron-size pure copper powders have been commercialized in the metallization electrodes of back-contact (BC) solar cells, serving as a low-cost alternative to conventional silver powder, supported by their cost advantage and favorable low-temperature curing properties.

Downstream Applications

In back-contact (BC) solar cells, ultrafine copper powder is a key metallization material used to replace conventional silver paste in busbars and finger electrodes. Given the complex rear-side electrode layout of BC cells, copper particles are required to be controlled within the submicron-to-micron size range to achieve uniform dispersion, suitable paste rheology and a continuous conductive network, thereby supporting high-performance busbars and finger electrodes.

Particles with a narrow size distribution and smaller particle size can improve paste printability and promote densification during low-temperature curing, enabling the resistivity of copper electrodes to approach that of silver-based metallization. Conversely, larger particles or particles with a broad size distribution may reduce printing precision and curing density, thereby limiting their effectiveness in fine-line electrodes for BC cells.

As a result, submicron- and micron-size copper powders with narrow particle size distribution and surface passivation are preferred in BC cell metallization to ensure reliable electrical contact, cost-effective silver substitution and scalable production of high-efficiency photovoltaic modules.

INDUSTRY OVERVIEW

Future Trends of Pure Copper Powder in the PV Base Metal Substitution Route

- *Cost Advantage Supporting Silver Substitution:* As the photovoltaic industry moves toward low-silver and silver-free metallization, pure copper powder is expected to become an important low-cost alternative to silver-based materials. Compared with silver, copper offers stronger cost competitiveness and broader supply availability, supporting its economic feasibility in high-efficiency solar cells.
- *PVD Process and Powder Performance Improvement:* The adoption of pure copper powder also depends on improved powder quality and application performance. PVD offers advantages in particle purity, particle size control, morphology consistency and surface quality. Together with advances in surface modification, anti-oxidation treatment and low-temperature sintering, pure copper powder is expected to further improve in conductivity, dispersion stability, oxidation resistance and interface compatibility for photovoltaic metallization.

Silver-coated copper powder

Definition

Silver-coated copper powder is a composite powder in which copper particles are uniformly coated with a thin silver layer through chemical plating, electroplating, or mechanochemical processes, forming a core-shell structure. The copper core provides a low-cost framework, while the silver shell offers high electrical conductivity and oxidation resistance. The core preparation technology focuses on creating a dense, uniform silver coating on the copper substrate.

The technical characteristics and advantages are summarized as follows:

- *Excellent Conductivity and Synergistic Performance:* The outer silver layer forms a continuous conductive network on the copper core through precision processes such as electroless plating or electroplating. Benefiting from the skin effect and silver’s high conductivity, electron transport mainly occurs through the silver layer, enabling conductivity close to pure silver while significantly reducing material cost. The resulting low volume resistivity meets the requirements of high-frequency signal transmission in thick-film ICs and conductive adhesives.
- *Oxidation Resistance and Chemical Stability:* As copper is prone to oxidation into CuO or Cu₂O, which impairs conductivity, the dense silver coating serves as a physical barrier against oxygen exposure. This helps extend storage life and maintain stable resistivity during high-temperature curing and long-term storage, thereby improving the reliability and service life of electronic components.
- *Cost Efficiency and Compatibility:* Silver-coated copper powder offers a cost-effective alternative to pure silver and supports the trend of copper substitution. With adjustable morphology and good resin compatibility, it is suitable for applications such as shielding materials, solar cell pastes and FPCs.

Downstream Applications

- **HJT Cells:** Applied in low-temperature conductive pastes for front and rear electrodes. With processing temperatures below 250°C, silver-coated copper powder maintains excellent conductivity while reducing costs to 30–50% of pure silver paste. High particle uniformity and intact silver layers are required for precision screen or inkjet printing. Adoption is expected to increase with HJT production capacity expansion.
- **TOPCon Cells:** In TOPCon cell manufacturing, a two-step metallization process leverages silver-coated copper paste to balance performance and cost. Initially, a conventional silver paste is screen-printed on the backside of the silicon wafer and fired at temperatures

INDUSTRY OVERVIEW

exceeding 700°C–850°C to establish a stable ohmic contact and a dense silver seed-layer network with low resistivity. Subsequently, an silver-coated copper paste is deposited atop this sintered silver seed layer and cured at approximately 200°C–300°C, enabling the formation of a robust silver interconnection network while preventing copper-core oxidation and diffusion, thereby ensuring electrode reliability and cost-effectiveness.

Future Trends of Silver-Coated Copper Powder

- *Growth Driven by PV Cell Industrialization:* China’s PV cell production has expanded rapidly from 2020 to 2024. Among cell technologies, HJT and TOPCon are the fastest-growing, with TOPCon expected to account for a large portion of new capacity additions. This scale-up has driven strong demand for low-temperature conductive pastes, which support gentler thermal processing. Silver-coated copper powder, with its ultra-thin silver shell, is widely used in HJT cells for its conductivity, cost efficiency, and compatibility with fine-line metallization. The growth of TOPCon lines further supports the adoption of silver-reduction strategies across multiple cell platforms.
- *Substitution Trend Under High Silver Prices:* Persistently high silver prices have increased cost pressure, prompting adoption of low-silver or silver-free alternatives. Silver-coated copper powder combines high conductivity with cost advantages, making it valuable in cost-sensitive markets. Its applications are expanding beyond photovoltaics into electronics, FPCs, conductive adhesives, and wearable devices, with growing market penetration expected.
- *Overcoming Technical Challenges in Silver-Coated Copper Powder:* The development of silver-coated copper coating technology is focusing on addressing key technical challenges to achieve uniform, dense, and stable silver shells on copper cores. Surface modification and interface engineering are being advanced to improve silver adhesion and coating continuity, directly addressing issues with oxidation resistance and long-term conductivity stability. At the same time, developing nano-size and environmentally friendly coating techniques helps minimize silver usage and enables greener, more consistent production processes — all aimed at solving the current hurdles in quality, cost, and durability for high-performance electronic and energy applications.

OVERVIEW OF ALLOY POWDER

Definition

Alloy powder refers to powder materials composed of two or more elements, at least one of which is a metal, and is designed to achieve properties such as magnetic performance, conductivity, strength, corrosion resistance and thermal stability.

Application Areas of Iron Alloy Powder

Iron-based alloy powder is a major type of alloy powder used in electronic metal powders. It mainly includes Fe-Si, Fe-Co, Fe-Ni, Fe-Si-Cr, Fe-Ni-Cr, Fe-Ni-Si, and can be tailored to meet requirements for magnetic permeability, core loss, DC bias performance, saturation flux density and temperature stability.

Iron alloy powders serve as important functional materials in magnetic components and other advanced material systems. Benefiting from relatively high saturation flux density, stable magnetic permeability, and low-loss performance, iron alloy powders are particularly suitable for applications requiring miniaturization, high power density, and high-frequency operation. As electronic systems continue to evolve toward smaller form factors and higher power consumption, the industry is witnessing a shift toward ultrafine iron alloy powders with nano- to micron-size particle sizes and more controlled particle size distribution.

INDUSTRY OVERVIEW

Power Inductors

Ultrafine iron alloy powders are widely used as magnetic core materials in power inductors, supporting miniaturized and high-power-density designs in space-constrained electronic systems. Their relatively high saturation flux density, stable permeability and high-frequency performance make them suitable for DC-DC converters, UPS systems, switching power supplies, PFC inductors, high-frequency transformers and EMI filters, where they help improve current-carrying capability, energy storage density and electromagnetic interference suppression.

High-performance inductors incorporating these materials are widely used across electric vehicle powertrains, 5G base station modules, industrial variable frequency drives, robotic control systems, and high-performance computing platforms such as AI servers and accelerator cards. In high-performance computing platforms, multi-phase DC-DC converters and voltage regulator modules, or VRMs, are widely adopted to deliver low-voltage, high-current power within compact form factors. This requires power inductors with low DC resistance, high saturation current, and stable high-frequency performance. Powdered metal cores based on ultrafine iron alloy powders are commonly used due to their distributed air-gap structure, which helps accommodate DC bias without sudden saturation and supports compact, low-loss inductor designs in line with rising system integration levels and power density requirements.

Application Areas of Silicon Alloy Powder

Silicon alloy powder refers to powder materials in which silicon is the primary functional component and is combined with one or more elements such as iron, aluminum, titanium or carbon. Compared with pure silicon powder, it offers improved structural stability, conductivity and processability. Si-Fe alloy powder is a type of silicon alloy powder mainly composed of silicon and iron.

Lithium-Ion Battery Anodes

Si-Fe alloy powders can serve as anode active materials in lithium-ion batteries. The iron-containing phase acts as an inactive buffer matrix to accommodate the volume expansion of silicon during charge-discharge cycling, while the silicon component contributes high theoretical specific capacity, enabling higher energy density compared with conventional graphite anodes. As energy density requirements continue to rise across electric vehicles and consumer electronics, Si-Fe alloy powders represent an emerging material category within the battery supply chain.

OVERVIEW OF SILVER POWDER

Definition

Silver powder is a high-purity metallic powder with silver as its primary component, exhibiting excellent electrical conductivity, thermal conductivity, and chemical stability. Silver powders can be classified by particle size into micron-size and nano-size powders, and by morphology into flake-shaped, spherical, and dendritic forms.

Downstream Application Scenarios of Silver Powder

Driven by evolving industrial demands, the market application of silver powder is exhibiting a pronounced structural bifurcation:

- *Dominant Position in Electronic Components and Advanced Semiconductor Packaging* As integrated circuits continue to evolve toward higher density and higher power, ultrafine silver powder is widely used in high-performance electronic components, MLCCs and advanced semiconductor packaging due to its precise particle size control, excellent conductivity and thermal stability. Under high-temperature and high-electrical-stress conditions, ultrafine silver powder helps maintain the stability of conductive networks and enhance product reliability.

INDUSTRY OVERVIEW

- *Automotive Electronics and High-Power Industrial Applications:* Ultrafine silver powder can be used as a functional filler in conductive adhesives, solders and thermal interface materials for electric drive systems and power modules, supporting current transmission and thermal management.
- *Conventional Matrix Metallization in the Photovoltaic Sector:* Within the solar photovoltaic industry, standard-grade silver powders are generally utilized as functional constituents in conventional photovoltaic silver pastes. Given that generic photovoltaic silver powders are predominantly manufactured via conventional liquid-phase chemical precipitation methodologies, the relevant technologies have reached a stage of high maturity and commoditization.

Raw Material Analysis of Electronic Metal Powders

The primary raw materials for the electronic metal powder industry include nickel, copper, and silver.

Nickel

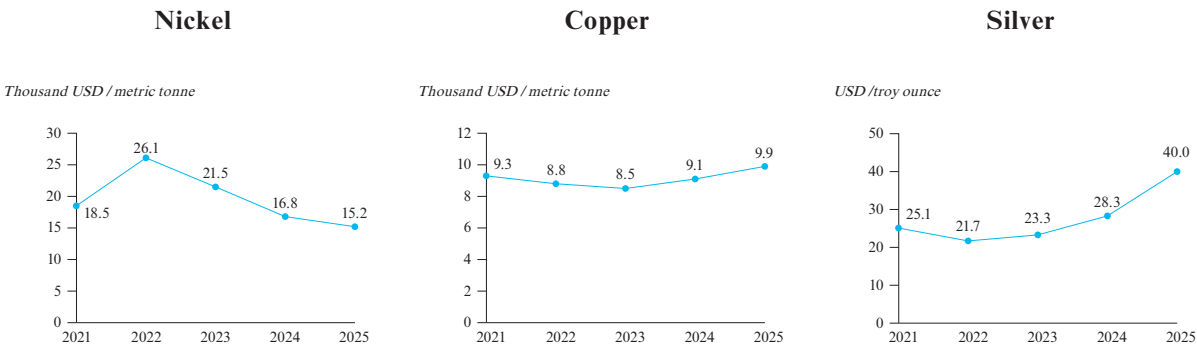
Nickel is the main raw material for MLCC nickel powder. Nickel prices rose to approximately USD26.1 thousand per tonne in 2022, mainly due to supply disruptions, low inventories and geopolitical factors, before declining to approximately USD21.5 thousand per tonne in 2023 and USD16.8 thousand per tonne in 2024. Going forward, nickel prices will be affected by supply capacity, inventory levels, macroeconomic conditions and downstream demand.

Copper

Copper is the key raw material for copper-based powders. Copper prices remained at a relatively high level during 2021–2023, supported by economic recovery, but later came under pressure from tighter monetary policy and slower demand growth. Since 2024, demand from renewable energy, electric vehicles and power infrastructure has supported copper prices. Going forward, copper prices will depend on demand growth, inventory levels, macroeconomic policies and geopolitical factors.

Silver

Silver is the main raw material for silver powder and silver-coated copper powder. Silver prices were relatively stable during 2021–2023, followed by a recovery driven by industrial demand and commodity inflation. Going forward, silver prices will be affected by macroeconomic conditions, industrial consumption, inflation expectations and supply conditions.



Source: LME, Frost & Sullivan analysis

INDUSTRY OVERVIEW

REPORT COMMISSIONED BY FROST AND SULLIVAN

In connection with the [REDACTED], we have engaged Frost & Sullivan to conduct a detailed analysis and prepare an industry report on the major markets for which our products are positioned. Frost & Sullivan is an independent global market research and consulting company which was founded in 1961 and is based in the United States. We have agreed to pay Frost & Sullivan a total fee of approximately RMB450 thousand for the preparation of the Frost & Sullivan Report, and we believe that such fees are consistent with the market rate. The payment of such amount is not contingent upon our successful [REDACTED] or on the results of the Frost & Sullivan Report. Except for the Frost & Sullivan Report, we did not commission any other industry report in connection with the [REDACTED].

The market projections in the Frost & Sullivan Report were based on the following key assumptions: (i) the overall social, economic and political environment globally is expected to remain stable during the forecast period; (ii) the economic and industrial development globally is likely to maintain a steady growth trend over the next decade; (iii) related key industry drivers are likely to continue driving the growth of the market during the forecast period; and (iv) there is no extreme force majeure or industry regulation in which the market may be affected dramatically or fundamentally. The reliability of the Frost & Sullivan Report may be affected by the accuracy of the foregoing key assumptions.