

Silver Industrial Products : Global Giants (Volume 1, 2026)

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TEAM EVENTELL

DIRECTOR & CEO
G Srivatsava

DIRECTOR & COO
Vinayak Meharwade

CHIEF MARKETING OFFICERS
Abhinaya S
Swapna B E

CONTENT TEAM
N Srinivasa Moorthy, Prathik Tambre

MARKETING TEAM
Ravi Bhandage, Prajakta Sardesai, Prathamesh

GRAPHIC DESIGNERS
Radhika K & Sathiyam K

WEB DEVELOPERS
Manivannan & Imayavaramban G

DATA SUPPORT
Gajendra & Sanjay

TEAM
Chandrasekaran, Jaisheelan,
Khushi, Krishnendu, Ramya,
Sindhu, Shravya, Shrivanthi
Srikantharaman, Shivakumar,
Sumalatha, Venkatraman, Varun

VIDEOGRAPHER
RA Jirali

PUBLISHING OFFICE
Bullion World
#146, 1-2 Floor, Gopal Towers
Ramaiah Street, HAL Airport Road, Kodihalli
Bengaluru - 560008

Tel: +91-80-41535476, +91 9343734140
Email: editor@bullionworld.in
Web: www.bullionworld.in

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Preface

Silver Industrial Products: Global Giants (Vol-1) is the second special publication (Silver Icons of India was the first) of Bullion World as a part of its Knowledge Sharing Initiative. In this publication, we have compiled and presented some of the best global companies in silver industrial products manufacturing. Each profile aims to capture the following aspects of the organization - core capabilities, technological strengths, and strategic positioning. We are happy to release the special publication at the India Silver Conference 2026.

While this edition presents a diverse set of industry leaders, it is not an exhaustive representation of all the global players. Hence, we have called it as volume-1. However, the publication serves as a knowledge-driven snapshot of influential participants contributing to the advancement of industrial silver applications. For ease of reference, the companies featured in this book have been arranged in alphabetical order. We hope this special edition provides valuable insights to industry stakeholders, and contributes meaningfully to the ongoing dialogue around silver's expanding role in the global industrial economy.

We take this opportunity to place our gratitude to all the companies profiled here for generously sharing their information through their website and social media.

Please note, we have entirely relied on company websites and social media briefing of the company for compiling the publication. Due care has been taken to proof-read. However, readers are advised to due their due diligence before entering into any transactions.

Special thanks to Srinivasa Moorthy and Prathik Tambre for curating the content, Sathiyam K and Radhika K for the design, and Ravi B and Prajakta S for leading the promotional efforts.

Do let us know your suggestions and feedback. Also, if you want your company to be featured in this, please share the details.

Warm Regards

Srivatsava Ganapathy, Vinayak Meharwade & Abhinaya SG

INDUSTRIAL SILVER: THE QUIET ENGINE OF DEMAND

Over the past decade, **industrial applications** have become the quiet engine driving global silver demand. While investors and jewellery often dominate headlines, it is factories, data centres, EV platforms and power networks that now absorb the largest share of silver each year. In 2025, industrial fabrication accounted for well over half of total silver demand, even after a modest decline linked mainly to a cyclical cooling in solar installations.

What makes industrial demand structurally important is that it is anchored in **physics, not fashion**. Silver’s combination of the highest electrical and thermal conductivity among metals, excellent reflectivity and reliable performance in harsh environments gives it a role in countless critical systems—from servers and power electronics to chemical plants and medical devices.

Even when individual segments slow or thrifting reduces per unit loadings, new uses keep emerging. The rise of **artificial intelligence, high speed communications, electrified transport and renewable power** means more silver-rich hardware is deployed each year. Over the medium term, this creates a powerful baseline of “hard” demand that complements, and sometimes stabilises, more volatile investment flows. Industrial silver is no longer a side story; it is the backbone of the metal’s long-term relevance.

Table 1: Industrial Silver Demand

Year	Total Silver Demand (tons)	Industrial Demand (tons)	Industrial Share of Total (%)
2022	39939	18422	46.0%
2023	37231	20440	54.9%
2024	36001	21120	58.6%
2025	35166	20446	58.1%

Source - Silver Institute/ Metals Focus





GIGA SOLAR MATERIALS CORP

Engineering the Invisible Backbone of Solar Power



In the global transition toward decarbonisation, where gigawatts define ambition and efficiency determines leadership, the most critical innovations are often those least visible. Conductive silver paste—responsible for carrying electrons across photovoltaic cells—remains one of the most indispensable yet under-recognised components of solar technology.

At the centre of this transformation stands Giga Solar Materials Corp, a company that has steadily emerged as one of the most influential players in solar metallisation materials, enabling efficiency at the very core of photovoltaic performance.

A Focused Evolution in Photovoltaic Innovation

Established in 2003 in Taiwan, Giga Solar was founded with a clear vision—to specialise in photovoltaic conductive materials at a time when the solar industry itself was still evolving. A pivotal shift in 2008 saw the company transform into a dedicated photovoltaic materials enterprise, sharpening its technological and commercial focus on conductive pastes.

Over two decades, Giga Solar has transitioned from a regional supplier into a globally recognised metallisation specialist, operating within a concentrated and technically demanding industry alongside a handful of dominant global players.

The Science of Conductivity

Giga Solar's core business is anchored in the development of high-performance conductive pastes, including front-side and rear-side silver pastes, as well as aluminium-based formulations. These materials form the electrical architecture of solar cells—directly influencing effi-

ciency, durability, and long-term module performance.

In modern photovoltaic manufacturing, silver paste is no longer a passive input but a critical determinant of both cost structure and efficiency optimisation, placing it at the intersection of materials science and strategic economics.

Materials Engineering & Process Excellence

Giga Solar's competitive advantage lies in its deep materials engineering capabilities. Its expertise spans particle size optimisation, binder chemistry, and low-temperature sintering technologies tailored for next-generation cell architectures.

The company operates a fully integrated manufacturing model—from raw material sourcing and formulation to precision production and final validation—ensuring consistency in performance. In photovoltaic applications, where marginal deviations can impact output efficiency, such control is critical.

Product Integration & Industrial Compatibility

The company's product portfolio is engineered for seamless integration into high-throughput photovoltaic manufacturing lines. Its offerings include screen-printable silver pastes for front and rear contacts, aluminium pastes for back surface field applications, and specialised materials for adjacent electronic uses.

This alignment with industrial-scale production ensures that Giga Solar's materials are not only technologically advanced but also commercially viable across large manufacturing ecosystems.

Strategic Manufacturing Footprint

Giga Solar's manufacturing infrastructure is concentrated in Taiwan, particularly in Hsinchu and Taoyuan—regions that form part of Asia's advanced solar manufacturing ecosystem.

This strategic localisation enables rapid scalability, strong process control, and efficient coordination with upstream and downstream partners, reinforcing its role as a reliable supplier within global photovoltaic supply chains.

Global Positioning & Market Relevance

Within the global silver paste market, Giga Solar occupies a strategic position characterised by strong integration with leading solar cell manufacturers and a significant presence across Asian photovoltaic hubs.

Its positioning reflects a balance between technological innovation and commercial adaptability, enabling it to compete effectively in a market defined by high entry barriers and continuous technological evolution.

Sustainability & Resource Efficiency

Sustainability in silver paste manufacturing is intrinsically linked to resource efficiency. Giga Solar's approach focuses on reducing silver consumption per cell while enhancing paste performance, aligning with broader industry trends toward recycling and circular material flows.

Conclusion

Powering the Solar Revolution from Within
While solar panels capture sunlight, it is companies like Giga Solar that enable energy to flow. In an industry defined by visible scale, Giga Solar represents the invisible precision that drives efficiency, reliability, and performance.

As the global energy transition accelerates, its role is set to become increasingly central—positioning the company not merely as a participant, but as a key architect of the solar future.

Given silver's cost and resource intensity, optimising its use without compromising efficiency has become a central strategic priority—both for manufacturers and the solar industry at large.

Application Strategy & Customer Integration

Giga Solar's materials are central to crystalline silicon solar cells and advanced architectures such as PERC, TOPCon, and emerging high-efficiency technologies. The company adopts a collaborative "design-in" approach, working closely with cell manufacturers to develop customised formulations aligned with specific production processes. This model not only strengthens long-term customer relationships but also embeds the company deeply within its clients' manufacturing ecosystems.

Certifications

Giga Solar operates under globally recognised quality and environmental frameworks, including ISO 9001 and ISO 14001 certifications, while ensuring full compliance with RoHS and REACH directives. Its conductive paste portfolio undergoes rigorous SGS-led validation and IEC-standard reliability testing, reinforcing its commitment to performance integrity, environmental stewardship, and next-generation green manufacturing systems."

Strategic Roadmap & Future Outlook

As the solar industry evolves, Giga Solar stands at a critical intersection of opportunity and disruption. Increasing demand for high-efficiency cells, combined with the need to reduce silver usage, is shaping the next phase of metallisation technology.

The company's forward trajectory is expected to focus on advanced formulations for next-generation cell technologies, efficiency-driven material innovation, and expansion of its global market presence.



For further information on the company, please visit: <https://www.gigasolar.com.tw/>



FROM WATER TO SUNLIGHT - HAITIAN GROUP'S JOURNEY TOWARD A BRIGHTER, SUSTAINABLE WORLD



Haitian Group owns and operates the ex-Heraeus PV silver-paste business in Shanghai and Singapore; the Shanghai site was built for ~3,000 t/yr and serves as the primary manufacturing/R&D base now under Haitian Group.

In a landmark move that has reshaped the global photovoltaic materials landscape, Haitian Water Group Co., Ltd.-a name long synonymous with advanced water treatment and environmental solutions-has made a powerful entry into the solar technology sector. Through its newly established division, Haitian Group, the company has taken over one of the most respected silver paste portfolios in the world: the photovoltaic metallization business of Heraeus, Germany's pioneering solar materials specialist.

The acquisition, valued at approximately CNY 502 million (USD 68.5 million) and completed in May 2025, included Heraeus's entities in Shanghai and Singapore, effectively transferring world-class R&D, production facilities, patents, and customer relationships to the Haitian fold. This strategic step marks Haitian's evolution from an environmental engineering company into a global player in advanced renewable materials-and signals its intent to anchor itself firmly in the high-growth solar ecosystem.

A Legacy of Excellence, Reimagined

For over a decade, Heraeus Photovoltaics stood as an innovation leader in conductive silver pastes used for solar-cell front contacts and busbars. Its SOL series-recognized globally for precision, consistency, and high

conversion efficiency-has powered solar cell production across PERC, TOPCon, and HJT technologies.

By inheriting this legacy, Haitian Group gains not only a technological edge but also a legacy of trust built with the world's top solar manufacturers. With operations in Shanghai and Singapore, the business boasts an estimated annual production capacity of 3,000 tonnes of solar pastes, supported by sophisticated R&D and application laboratories.

Today, under Haitian's stewardship, the former Heraeus portfolio is being re-energized-combining German innovation, Asian scalability, and Chinese manufacturing excellence. This integration gives Haitian Group the scale and agility needed to serve the evolving demands of the n-type PV era, where ultra-fine printing, low silver consumption, and high reliability are critical success factors.

Technology that Defines the Future

At the heart of Haitian Group's success lies a robust suite of next-generation metallization technologies, designed to match the speed of change in the solar cell landscape:

- **Fine-Line Screen Printing:** Achieving ultra-narrow fingers (<20 μm) with stable rheology for high-yield, high-speed lines.
- **TOPCon-Compatible Pastes:** Engineered for contact with poly-Si/tunnel oxide structures, offering low contact resistivity and superior adhesion.
- **Low-Temperature Ag Pastes for HJT:** Advanced formulations that cure at $\sim 200^\circ\text{C}$, safeguarding

TCO layers while ensuring excellent conductivity and reliability.

- Ag-Al and Back-Side Pastes: Optimized for robust interconnection, solderability, and long-term performance under stress conditions.

The integration of Heraeus's IP portfolio—historically exceeding 300 patents—into Haitian's R&D framework further strengthens its ability to innovate for upcoming PV technologies, including perovskite tandem and hybrid cell architectures.

A Global Footprint with Asian Agility

From its Shanghai headquarters, Haitian Group now oversees end-to-end operations, from formulation to customer application support. The Singapore hub acts as a vital bridge to Southeast Asia and India—two of the fastest-growing solar markets. Together, these centers position Haitian Group as a global supplier with regional responsiveness, capable of offering just-in-time deliveries, technical consultation, and product customization.

Looking Ahead

For Haitian Water Group, this acquisition is more than diversification—it is a declaration of intent. The company envisions Haitian Group as a pillar of its new-energy materials division, targeting global leadership in solar metallization within the next five years.

As the world's energy transition accelerates, Haitian Group stands at the crossroads of science, sustainability, and scale—ready to empower the next generation of solar technology with materials that make sunlight work smarter, faster, and cleaner.

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For further information on the company, please visit: <https://www.haitian.com/>.

The company's clients include some of the world's largest cell and module manufacturers, many of whom have already qualified its pastes for n-type TOPCon and heterojunction (HJT) mass production lines.

Driving the Transition to a Sustainable Future

As the photovoltaic industry races toward higher efficiencies and lower costs, silver paste remains one of the most critical materials determining cell performance and manufacturing economics. Haitian Group's entry comes at a pivotal moment—when the global market is undergoing consolidation and a technological shift from PERC to n-type architectures.

By merging Heraeus's proven science with its own production excellence, Haitian Group is poised to redefine the economics of solar metallization. Its products promise not only higher energy yields but also silver-thrifty formulations, aligning with the industry's sustainability and resource-efficiency goals.





Process Integrity at Scale: Johnson Matthey and the Industrial Science of Silver Brazing Alloys

In the global silver brazing alloys market, performance is not defined by purity at the margins alone. It is defined by repeatability at scale—the ability of a brazed joint to perform identically across thousands of production cycles, multiple factories, and volatile raw-material environments. For many industrial manufacturers, reliability is measured not in laboratory perfection, but in the absence of deviation.

It is within this demanding industrial context that Johnson Matthey has established its position in silver brazing alloys. The company does not operate as a niche, ultra-high-purity specialist, nor as a volume commodity supplier. Instead, Johnson Matthey occupies a distinct position as a technology-led, industrial-scale provider of silver brazing systems, designed to integrate seamlessly into customer manufacturing processes while meeting modern regulatory, safety, and cost requirements.

History and Evolution: From Precious Metals to Industrial Joining

Founded in 1817 in London, Johnson Matthey began as a precious-metals assayer and refiner serving the early industrial economy. Over the following two centuries, the company evolved alongside global manufacturing, expanding from bullion and refining into applied precious-metal technologies, including catalysts, chemicals, and joining materials.

Silver brazing alloys emerged as a natural extension of this evolution. As mass manufacturing expanded across tooling, HVAC, electrical equipment, and engineered assemblies, demand grew for silver-based joining materials capable of delivering consistent performance at scale.

Johnson Matthey's silver brazing portfolio was developed to meet this requirement—focused on metallurgical reliability, controlled processing behavior, and compatibility with industrial production environments. This historical trajectory continues to shape JM's

approach today: silver brazing alloys are treated not as consumables, but as process-critical materials embedded within manufacturing systems.

Silver Brazing as a System, Not a Commodity

Johnson Matthey's silver brazing philosophy is built around system integration. Alloy chemistry, melting range, flow behavior, flux compatibility, and product form are developed together to ensure predictable outcomes across a wide range of substrates and heating methods.

The portfolio is structured around three core silver brazing pillars:

- SILVER-FLO™ silver brazing alloys**
 Covering high-silver and mid-silver compositions, SILVER-FLO™ alloys are engineered for controlled melting, reliable wetting, and consistent joint strength. A defining feature of the range is its emphasis on cadmium-free formulations,

- supporting modern workplace safety and environmental regulations without sacrificing performance.
- **Argo-braze™ engineered silver alloys**
Developed for mechanically demanding joints—particularly tungsten-carbide-to-steel—Argo-braze™ alloys focus on stress accommodation, impact resistance, and long-term durability in tooling and wear-part applications.
- **EASY-FLO™ / MATTIFLUX™ flux systems**
Flux chemistry is treated as integral to joint performance. JM's fluxes are formulated to ensure consistent oxide removal and wetting across copper alloys, steels, stainless steels, aluminum bronzes, and free-machining brasses.

Together, these elements form a co-engineered silver brazing system, rather than a collection of standalone materials.

Manufacturing Technologies and Process Control

Johnson Matthey's silver brazing alloys are produced using controlled melting and alloying practices optimized for industrial consistency. The focus is not on extreme vacuum metallurgy, but on tight metallurgical discipline across high-repeatability production environments.



Key characteristics include:

- Narrow melting-range control to ensure predictable flow
- Tight composition tolerances to minimize joint variability
- Process routes optimized for different product forms and application methods
- Batch-to-batch repeatability across long production runs

Manufacturing is aligned with internationally recognized brazing standards, enabling qualification under ISO, EN, AWS, AMS, and customer-specific specifications commonly required in industrial supply chains. This standards-based discipline is essential for customers operating in regulated or high-responsibility environments.

Product Forms and Integration Capability

A central differentiator in Johnson Matthey's silver brazing portfolio is the breadth of application-ready product forms, enabling customers to design the alloy directly into their manufacturing process.

Available formats include:

- Rods and wires for manual or automated feeding
- Flux-coated rods to simplify operations
- Foils, strip, and sheet for controlled alloy volume placement
- Engineered preforms (rings, washers, custom shapes)
- Brazing pastes and paints for automated and high-repeatability lines

By controlling not only alloy chemistry but also how the alloy is delivered to the joint, JM helps customers reduce scrap, stabilise yields, and improve cycle-time consistency—critical advantages in cost-sensitive, high-volume production.

Application-Driven Joining Know-How

Johnson Matthey's strength in silver brazing alloys lies in applied joining science. Its technical guidance addresses practical industrial challenges, including:

- Voiding and inconsistent wetting in leaded brasses
- Brittle joint risks in aluminium-bronze-to-steel assemblies
- Stress management in carbide tooling
- Optimising alloy-flux combinations for mixed-metal joints

This application-level expertise positions JM as a design-in partner, supporting customers from early development through serial production, rather than a transactional material supplier.

Certifications and Quality Systems

Silver brazing alloys from Johnson Matthey are produced within robust quality and compliance frameworks designed for industrial and regulated environments.

Relevant systems include:

- ISO 9001 – Quality management
- ISO 14001 – Environmental management (site-specific)
- ISO 45001 – Occupational health and safety (site-specific)

Products are supplied in conformity with recognised silver brazing standards (ISO, EN, AWS, AMS), ensuring traceability, documentation discipline, and controlled change management—critical safeguards where requalification costs are high.

End-Use Focus

Johnson Matthey's silver brazing alloys are widely used across high-volume, high-responsibility industrial applications, including:

- Tooling and wear-resistant components
- HVAC and refrigeration assemblies
- Electrical and power-distribution equipment
- General engineered and fabricated products

The emphasis is on sectors where consistent joint integrity and regulatory compliance are decisive factors in supplier selection.

Silver Economics and Raw-Material Exposure

Silver remains the dominant cost driver in brazing alloys. Johnson Matthey addresses this through a total-cost-of-ownership approach, combining:

- Alloy optimisation to balance silver content and performance
- Product forms that minimise metal loss
- Commercial structures linked to precious-metal pricing mechanisms

This integration of metallurgy and metal-price discipline allows customers to manage volatility without compromising reliability.

Sustainability and Compliance

Within its silver brazing portfolio, Johnson Matthey places strong emphasis on:

- Comprehensive cadmium-free alloy offerings
- Compliance with RoHS and REACH
- Efficient alloy utilisation to reduce effective silver consumption per joint

Longevity, yield optimisation, and responsible material use are central to sustainability in industrial silver brazing.

Global Footprint and Supply Continuity

Johnson Matthey supports its silver brazing alloy customers through a globally distributed manufacturing and commercial network, including:

- Metal-joining operations and technical expertise in the United Kingdom
- An established Indian presence via Johnson Matthey Chemicals India Pvt. Ltd., Taloja (Maharashtra)
- Regional technical and commercial support across Europe, Asia, and the Americas

This footprint provides supply-chain resilience for long-cycle industrial programs.

Competitive Positioning

In silver brazing alloys, Johnson Matthey is differentiated by:

- System-level integration of alloy, flux, and form
- Industrial-scale repeatability rather than niche metallurgy
- Leadership in cadmium-free silver brazing solutions
- Strong application engineering and design-in support
- Deep precious-metals expertise underpinning pricing and supply stability



For further information on the company, please visit: <https://matthey.com/>



SILVER IN ELECTRICAL & ELECTRONICS: WIRING THE DIGITAL AGE

The **electrical and electronics sector** is the single largest industrial user of silver and a prime example of how technology quietly transforms demand. Every step in the digital chain—power generation, transmission, data storage and computing—relies on components where low resistance, reliability and heat management are critical. Silver delivers these properties better than any other metal.

From **high-speed connectors and relay contacts** to complex power management modules, silver-bearing materials help ensure that signals are transmitted cleanly and that equipment can withstand years of switching and thermal cycling. The rapid buildout of **AI enabled data centres, 5G and now 6G networks, and high power charging infrastructure** is expanding these needs. Even where manufacturers reduce the silver content per unit, the sheer scale of deployed hardware keeps overall consumption significant.

In parallel, the continuing electrification of transport is pushing more silver into on board electronics—control units, safety systems, power distribution and high voltage switching. As grids modernise to handle bidirectional flows, distributed generation and storage, silver’s role in advanced switchgear and monitoring systems becomes even more important. Put simply, every time the world becomes “more electric” or “more digital,” the invisible silver within circuits, connectors and contacts becomes more indispensable.

Table 2: Industrial Demand Composition (2025)

Segment	Demand (tons)	Share of Industrial Demand (%)	Industrial Share of Total (%)
Electrical & Electronics	13980	68.37%	46.0%
of which Photovoltaics	5804	28.38%	54.9%
Brazing Alloys & Solders	1569	7.67%	58.6%
Other Industrial	4896	23.94%	58.1%
Total Industrial	20446	100%	

Source - Silver Institute/ Metals Focus





Linbraze: Precision Engineering in Silver Brazing Alloys and Advanced Powder Technologies

In the specialised domain of silver-based joining materials, Linbraze S.r.l. has established a technically differentiated position through its focused expertise in silver brazing alloys and precision-engineered silver powders—segments where metallurgical control, process integrity, and application performance are intrinsically linked. Operating at the intersection of materials science and industrial application, the company has steadily evolved into a recognised European player within the global silver materials value chain.

Origins and Evolution

Linbraze's origins are closely tied to Italy's long-standing metallurgical and engineering heritage—an ecosystem known for its precision manufacturing and advanced materials development. Established with a clear focus on silver-based joining technologies, the company has built its identity around metallurgical expertise and process discipline rather than scale alone.

From its early years, Linbraze positioned itself within a specialised niche: high-performance silver brazing alloys designed for demanding industrial applications. Over time, this focus expanded to include silver powders, allowing the company to serve a broader spectrum of advanced manufacturing needs. This dual capability—solid alloy systems and engineered powders—has become a defining feature of its evolution.

As global manufacturing requirements became more exacting, Linbraze responded by strengthening its process controls, expanding its product formats, and building a wider international commercial footprint. Today, the company's growth reflects a consistent strategy: deepen technical capability while maintaining strict control over quality and performance.



Manufacturing Excellence and Technological Know-how

At the core of Linbrazé's operations lies its primary manufacturing facility in Italy, where key processes—including melting, alloying, casting, rolling, and finishing—are integrated within a controlled production environment. This centralised European manufacturing base is a deliberate strategic choice, enabling stringent quality assurance, full traceability, and compliance with demanding regulatory frameworks.

Silver brazing alloy production is carried out through controlled-atmosphere melting systems, where silver is precisely combined with alloying elements such as copper, zinc, and tin. These formulations are engineered to achieve specific melting ranges, wettability, and flow characteristics—critical parameters in ensuring reliable joint performance.

Downstream processes such as extrusion, wire drawing, rolling, and precision cutting are governed by strict process controls to maintain metallurgical homogeneity and dimensional consistency. The result is a product range capable of delivering repeatable performance in high-stress and high-reliability environments.

Complementing this is Linbrazé's capability in silver powder production. Here, the emphasis shifts to controlling particle size distribution, morphology, and purity—parameters that directly influence conductivity, sintering behaviour, and bonding performance. This capability positions the company within advanced applications such as conductive pastes, electronic materials, and emerging joining technologies.



Product Portfolio and Integration Capability

Linbrazé offers a comprehensive portfolio of silver brazing alloys tailored to diverse industrial requirements. These are available in multiple forms—including rods, wires, strips, foils, rings, and customised preforms—engineered for seamless integration into both automated and manual brazing operations.

The emphasis on engineered forms is particularly significant. Rather than supplying standard materials alone, Linbrazé develops application-specific solutions designed to reduce process variability, improve efficiency, and enhance joint reliability. This integration capability is especially valuable in high-volume manufacturing environments where consistency is paramount.

In parallel, its silver powders are developed to meet the requirements of industries where electrical and thermal performance are critical. Applications span conductive pastes, sintering processes, and specialised joining systems, reflecting the company's positioning within high-value segments of the silver materials market.

Global Footprint and Market Positioning

While manufacturing remains concentrated in Europe, Linbrazé maintains a strong global presence through an established network of sales offices, agents, and distribution partners across Europe, Asia, and the Americas. This network enables efficient market access while ensuring proximity to key industrial customers.

Equally important is the company's ability to provide application-specific technical support. In industries where material performance is closely linked to process parameters, this engagement is critical. Linbrazé's approach goes beyond supply—it involves collaboration with customers to optimise alloy selection, joint design, and production processes.

Sustainability, Compliance, and Certifications

A defining aspect of Linbrazé's operations is its adherence to internationally recognised quality and environmental standards. The company operates in compliance with ISO 9001 for quality management and ISO 14001 for environmental management, reflecting its commitment to process discipline and sustainable manufacturing practices.



In addition, Linbraz aligns with key regulatory frameworks such as REACH and RoHS, ensuring that its products meet the requirements of global markets, particularly in Europe and advanced manufacturing sectors. These certifications underpin the company's credibility in supplying to OEMs and industries where compliance, traceability, and consistency are essential.

Sustainability considerations are increasingly integrated into its operations, particularly in the sourcing and efficient use of silver, as well as in process optimisation aimed at reducing waste and environmental impact.

Application Focus and Customer Engagement

Linbraz serves a diverse range of industries, including HVAC, refrigeration, automotive, electrical engineering, and advanced manufacturing. In each of these sectors, reliability of joints and material performance are critical to overall system integrity.

The company's "design-in" approach is central to its customer engagement strategy. By working closely with clients during the development phase, Linbraz supports the optimisation of materials and processes—ensuring that its alloys and powders are fully aligned with application requirements. This collaborative model not only enhances performance outcomes but also strengthens long-term partnerships.

Competitive Differentiation

What distinguishes Linbraz is its depth of specialisation within silver-based materials. Unlike broader materials suppliers, the company maintains a focused approach, combining expertise in both brazing alloys and silver powders with rigorous process control.

Its integrated manufacturing model, European production base, and strong emphasis on quality and compliance provide a competitive edge in industries where reliability is non-negotiable. At the same time, its global sales network and technical support capabilities enable it to compete effectively across international markets.

Strategic Outlook

Looking ahead, Linbraz is well positioned to benefit from structural trends shaping global industry. The transition towards electrification, the growing demand for energy-efficient systems, and the expansion of advanced electronics all require high-performance joining materials and conductive solutions.

The company's continued investment in manufacturing technologies, powder engineering, and market expansion reflects a forward-looking strategy grounded in both technical capability and market awareness. By reinforcing its core strengths while adapting to evolving industrial requirements, Linbraz is poised to strengthen its role within the global silver materials ecosystem.



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For further information on the company, please visit: <https://www.linbraz.com/>



PHOTOVOLTAICS: FROM HYPER GROWTH TO HIGH EFFICIENCY

Over the last decade, **solar photovoltaics (PV)** has been one of the most dynamic growth engines for industrial silver, transforming the metal into a critical ingredient of the energy transition. Silver pastes are used to form ultra fine conductive fingers and busbars on solar cells, ensuring efficient collection and transport of the current generated by sunlight.

This segment experienced explosive growth as global solar installations multiplied, especially in China, India, Europe and the US. At the same time, manufacturers have engaged in aggressive **silver thrifting**—pushing line widths thinner, optimising pastes and gradually substituting some silver with alternative materials—to contain costs and manage price volatility. Recently, this tension between volume growth and thrifting has become more visible. After several years of strong gains, PV silver demand has started to level off and even decline year on year in some scenarios, as the drive to reduce silver per watt accelerates.

However, the story is far from over. Emerging high efficiency cell architectures such as **TOPCon, heterojunction and future tandem designs** will still depend on highly engineered metallisation solutions where silver's performance is hard to match. The balance between higher efficiency, lower silver loading and sheer expansion in global solar capacity will be a key determinant of industrial silver demand in the years ahead.

Table 3: Silver demand from PV segment (2025)

Year	PV Silver Demand (tons)
2021	2766
2022	3672
2023	5993
2024	6143
2025	5804

Source - Silver Institute/ Metals Focus





Global Manufacturing Power, Localized Service

Lucas-Milhaupt’s manufacturing capability and global footprint underpin its reputation for reliability. Its new 125,000-sq-ft headquarters and production facility in Cudahy, Wisconsin, serves as both a technological hub and a symbol of long-term commitment to U.S. manufacturing. Complementing this are plants in Warwick (Rhode Island), Ribérac (France), and Suzhou (China)-a configuration that ensures dual-continent redundancy, regional responsiveness, and optimized logistics.

This global presence means customers can count on consistent quality, flexible lead times, and just-in-time supply across multiple time zones. The company’s logistics model supports both high-volume OEM production and small-batch specialty orders, an increasingly vital capability as manufacturers pursue leaner supply chains and risk mitigation strategies.

Technology Meets Application

Lucas-Milhaupt doesn’t simply sell brazing materials-it delivers brazing science as a service. Through its network of application engineers, metallurgists, and training specialists, the company provides deep technical partnership from concept to production line.

Core technology capabilities include:

- Fine control of melting ranges through proprietary alloy blending and atomization techniques.
- Flux-cored and coated products that minimize waste and improve operator safety.
- Preform engineering-custom rings and washers that ensure perfect alloy volume, reduce spatter, and cut cycle time.
- Silver-thrift optimization, allowing customers to maintain joint integrity with lower silver content alloys.
- Automation-ready pastes, designed for precision dispensing and high repeatability in robotic and induction-brazing systems.

Lucas-Milhaupt’s Brazing Book and Quick Reference Guides-widely cited in engineering curricula-serve as educational cornerstones for generations of brazing professionals worldwide.

With a brand lineage stretching back nearly a century, Lucas-Milhaupt’s reputation is anchored in trust and performance. The company’s Sil-Fos® 5, Sil-Fos® 15, and Silvaloy® 450 alloys are household names in workshops and assembly plants around the world.



Innovation Protected by Patents

Innovation has always been Lucas-Milhaupt's hallmark. Over the years, the company has secured numerous patents in flux technology, preform design, and aluminum brazing, reflecting its continuous investment in R&D.

Key patents include:

- Advanced flux-composition systems that minimize residue and improve wetting.
- Processes for flux-coating and flux-coring preforms, enhancing consistency in high-volume brazing.
- Specialized aluminum and multi-metal brazing technologies, expanding beyond traditional copper-silver systems.

Sustainability and Regulatory Stewardship

As global environmental regulations tighten, Lucas-Milhaupt has proactively aligned its operations and products with sustainability goals.

- Its facilities operate under ISO 14001 Environmental Management Systems, ensuring responsible resource use and waste management.
- The company offers a wide selection of cadmium-free silver brazing alloys, eliminating toxic elements without compromising performance.
- Materials are fully traceable and compliant with RoHS, REACH, and DFARS/ITAR requirements, making them suitable for global OEMs in regulated sectors.

Silver is a precious and finite resource; Lucas-Milhaupt's R&D focus on silver-thrift formulations directly supports customers' efforts to reduce material intensity and carbon footprint. The company's engineers frequently assist clients in transitioning to lower-silver, higher-efficiency alloys—a small change that yields enormous sustainability dividends across thousands of joints.

Applications Across Industries



HVAC & Refrigeration

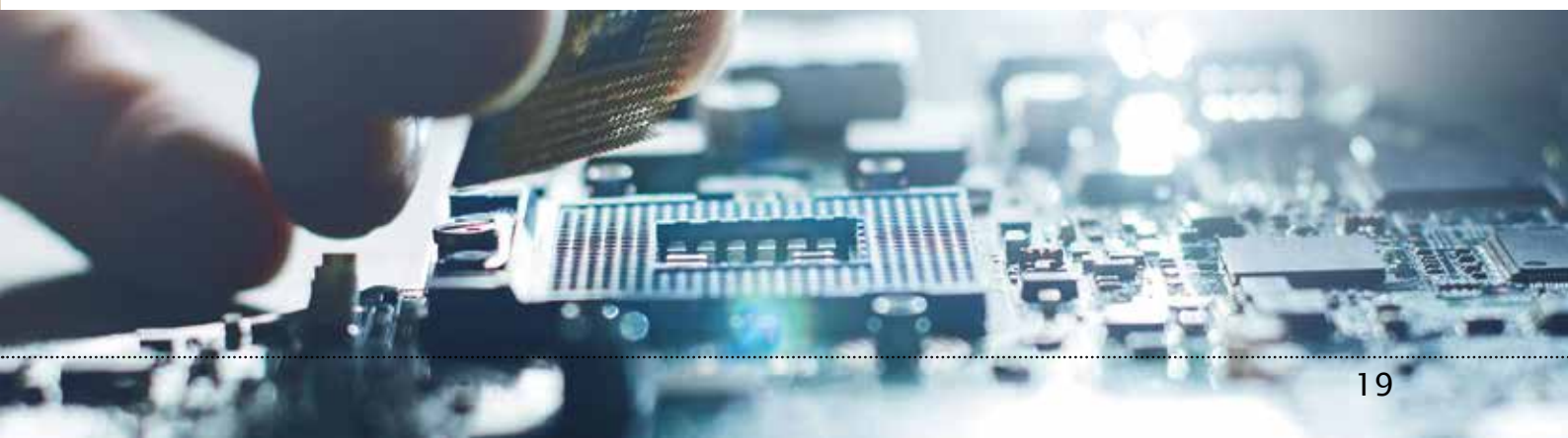
Lucas-Milhaupt's Sil-Fos® alloys are a mainstay of the HVAC industry, where millions of copper joints are brazed each year. Their self-fluxing properties and high reliability make them indispensable in compressor and heat-exchanger manufacturing.

Automotive & Mobility

From fuel lines to electric-vehicle heat exchangers, Lucas-Milhaupt's silver brazing alloys enable lightweight, durable, and corrosion-resistant assemblies. Their IATF 16949 certification reinforces trust among Tier-1 automotive suppliers.

Aerospace & Defense

In the skies, joints must withstand extreme stress and temperature cycles. Lucas-Milhaupt's high-purity silver-nickel alloys, manufactured under AS9100D protocols, meet these demands with exceptional consistency.





Electronics & Energy

For power electronics, sensors, and renewable-energy components, the company offers low-temperature silver alloys and pastes suitable for fine-pitch assembly and vacuum brazing.

Global Reach, Local Understanding

What differentiates Lucas-Milhaupt from many competitors is its geographical spread and cultural agility. With production hubs in Cudahy (USA), Ribérac (France), and Suzhou (China), the company offers customers supply continuity and market-specific expertise.

In Europe, engineers in France work closely with high-tech manufacturers for aerospace and automotive applications. In Asia, the Suzhou plant serves the fast-growing HVAC and electronics sectors, ensuring on-time delivery and localized service.

As industries evolve toward electrification, miniaturization, and low-carbon manufacturing, silver brazing alloys will remain a critical enabler-and Lucas-Milhaupt is ensuring that these materials are cleaner, smarter, and more efficient than ever before. In a world where precision, sustainability, and dependability define competitive advantage, Lucas-Milhaupt stands as the silver standard. Its century-long legacy, global manufacturing scale, and relentless focus on innovation have made it a trusted partner for industries that cannot afford to fail.

Whether in the copper tubing of an air conditioner, the fuel systems of an aircraft, or the power electronics of a solar inverter, Lucas-Milhaupt's silver brazing alloys form invisible but vital bonds-uniting components, companies, and continents in a shared pursuit of engineering excellence.

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For further information on the company, please visit: <https://www.lucasmilhaupt.com/>



BRAZING ALLOYS & SOLDERS: ENGINEERING STRONG, CONDUCTIVE JOINTS

In **brazing alloys and solders**, silver plays a vital but often unnoticed role: it literally holds the industrial world together. Silver-containing brazing alloys join metals in demanding environments—high pressures, wide temperature swings and long service lives—where joint failure is simply not an option.

Typical applications span **HVAC and refrigeration systems, power equipment, automotive and aerospace components, and a wide range of engineered assemblies**. Here, silver contributes not only to mechanical strength but also to thermal and electrical performance. As manufacturers push for higher efficiency and compact designs, joint quality and heat transfer become even more important, supporting the case for carefully engineered silver alloys.

Over time, users have worked to **optimise silver content** in these materials, shifting towards “silver thrifty” formulations that maintain performance while reducing precious metal intensity. Even so, the underlying demand drivers—urbanisation, rising living standards, electrification of transport, and the buildout of efficient cooling and heating—provide a resilient base.

The brazing and solder segment thus anchors silver in the heart of global manufacturing. Every air conditioner coil, power transformer connector or high-end mechanical assembly relying on a silver-bearing joint quietly adds to the industrial footprint of the metal.

Table 4: Brazing & Solders vs Total Industrial Demand (2025)

Segment	Demand (tons)	Share of Industrial Demand (%)
Total Industrial Demand	20446	
Brazing alloys & Solders	1569	7.67%

Table 4: Trends in Brazing & Solders vs Total Industrial Demand

Year	Brazing & Solders Demand (tons)	Total Industrial Demand (tons)	Share of Industrial Demand (%)
2022	1529	18422	8.29%
2023	1561	20440	7.63%
2024	1547	21120	7.32%
2025	1569	20446	7.67%

Source - Silver Institute/ Metals Focus



MITSUBISHI MATERIALS: ENGINEERING THE BACKBONE OF SILVER ELECTRICAL CONTACT TECHNOLOGY



Mitsubishi Materials Corporation

occupies a uniquely strategic position in the global silver ecosystem. Unlike companies that entered industrial silver applications as a downstream diversification, Mitsubishi Materials traces its electrical contact business directly to Japan's early industrialization. Its evolution—from mining and non-ferrous metals to precision silver engineering—mirrors the transformation of silver itself from a precious metal into a mission-critical industrial material.

Originating in the late nineteenth century as part of the Mitsubishi Group's mining and smelting operations, the company developed deep expertise in silver refining, alloy control, and metallurgical precision. These foundational capabilities would later prove indispensable as electricity spread across Japan and demand surged for reliable switching, protection, and control systems. Today, Mitsubishi Materials stands among the world's most established and technologically advanced manufacturers of silver-based electrical contact materials, supplying components that underpin global power systems, industrial automation, automotive electrification, and advanced electronics.

From Mining Heritage to Functional Materials Engineering

Mitsubishi Materials' electrical contact business did not emerge from a single strategic pivot. Instead, it evolved organically as industrial requirements changed. In the early electrification era of the twentieth century, switches, relays, and circuit breakers became essential to factories, railways, and power networks. Silver quickly emerged as the preferred contact material due to its superior electrical conductivity and arc resistance. However, pure silver presented performance limitations, including wear, erosion, and welding under repeated switching.

Addressing these challenges required more than access to silver; it demanded advanced alloying, powder metallurgy, and process control. Mitsubishi Materials responded by transitioning from a metal supplier into a functional materials engineer, developing silver alloy and composite systems designed for durability, safety, and repeat switching performance. This marked a fundamental shift in the company's role within the industrial value chain.

Post-war reconstruction and rapid industrial expansion further accelerated this transition. As Japan rebuilt and electrified at scale, electrical contacts became embedded as a core business segment. Over time, Mitsubishi Materials' capabilities expanded beyond domestic markets, aligning with the globalisation of Japanese electrical and automotive OEMs.

Manufacturer Profile & Legacy

With more than a century of metallurgical and materials-engineering expertise, Mitsubishi Materials benefits from a legacy few competitors can replicate. Within the broader Mitsubishi Group ecosystem, the company has continuously refined its understanding of non-ferrous metals, precious metals, and advanced materials science.



This legacy underpins its long-standing leadership in silver electrical contacts—a segment where performance consistency, reliability, and trust are paramount. Unlike commodity silver applications, electrical contacts demand precision metallurgy, deep application knowledge, and long-term customer integration. Mitsubishi Materials has built durable competitive advantages in all three areas, creating high entry barriers for new players.

Core Product Portfolio

Mitsubishi Materials' silver electrical contact portfolio spans a wide range of engineered solutions, including:

- Silver–Tin Oxide (AgSnO₂) contacts
- Silver–Copper (AgCu) and advanced silver alloy systems
- Environmentally compliant cadmium-free contact materials
- Multi-layer and composite contact solutions

These materials are supplied in multiple engineered forms tailored for OEM integration, such as:

- Contact tips and rivets
- Strips and profiles
- Semi-finished components for direct assembly

Rather than offering standardised materials, Mitsubishi Materials focuses on application-specific silver formulations, optimised for current load, switching frequency, arc energy, and environmental requirements. This customisation capability is central to its positioning as a Tier-1 supplier.



Manufacturing Technologies & Process Know-How

Mitsubishi Materials' differentiation is rooted in advanced manufacturing technologies and rigorous process control. Key capabilities include:

- Powder metallurgy and advanced sintering techniques
- Controlled oxidation and dispersion of tin oxide phases
- High-precision rolling, extrusion, and bonding technologies
- Tight control of grain structure, density, and surface morphology

These processes enable silver contacts to perform consistently under high current, high arc energy, and repeated switching cycles—conditions where failure is not acceptable. The company's emphasis on metallurgical precision ensures repeatability across large production volumes, a critical requirement for global OEM customers.

Integration Capability & Design-In Strategy

Beyond material supply, Mitsubishi Materials supports deep integration of its silver contact solutions into customer systems. Its products are designed to integrate seamlessly into:

- Circuit breakers
- Relays and contactors
- Switchgear and protection devices
- Automotive electrical architectures

This design-in capability allows Mitsubishi Materials to become embedded early in customer product development cycles. Once a silver contact system is qualified for a safety-critical application, switching suppliers becomes costly and risky. As a result, long-term relationships and stable demand profiles are reinforced.

Application Focus & End-Use Strategy

Mitsubishi Materials' silver electrical contacts serve a broad range of end-use sectors, including:

- Power distribution and transmission equipment
- Industrial automation and robotics
- Automotive electrification, including EV subsystems
- Renewable energy balance-of-system components

As global electrification accelerates, these applications continue to underpin structurally resilient silver

demand. Electrical contacts remain essential wherever electricity must be switched, protected, or controlled reliably.

Global Manufacturing Footprint & Supply Chain Resilience

The company operates a globally diversified manufacturing and technical footprint, with core production and R&D anchored in Japan, supported by facilities across Asia, Europe, and the Americas. This distributed model enhances supply chain resilience, proximity to customers, and regional risk diversification.

While precise silver contact manufacturing capacities are commercially sensitive, Mitsubishi Materials is widely regarded as a Tier-1 global supplier by both volume and technical capability. Its ability to support multinational OEMs with consistent quality across regions has become a critical competitive advantage.

Sustainability, Compliance & Circular Economy

Electrical contacts face increasing regulatory and ESG scrutiny, particularly regarding hazardous substances. A major inflection point occurred in the 1990s, when global restrictions on cadmium reshaped the industry. Mitsubishi Materials emerged as a leader in cadmium-free silver contact technologies, notably AgSnO₂ systems that matched or exceeded legacy performance.

Beyond compliance, the company leverages its broader precious-metal recycling expertise to support:

- Recovery and reuse of silver from industrial scrap
- Closed-loop material flows
- Reduced lifecycle environmental impact
- These circular-economy capabilities help mitigate long-term raw-material risks and align the electrical contact business with evolving sustainability expectations.

Competitive Differentiation

Mitsubishi Materials differentiates itself through:

- Deep metallurgical and materials-science expertise
- Integrated precious-metal processing capabilities
- Strong intellectual property and proprietary formulations
- Long-standing OEM relationships
- Proven global manufacturing reliability

Together, these factors create substantial barriers to entry and reinforce the company's leadership position.

Why Mitsubishi Materials Matters to the Silver Market

Silver electrical contacts remain one of the most technologically entrenched and performance-critical uses of silver. As electrification reshapes the global economy, Mitsubishi Materials illustrates how industrial silver demand is driven by engineering necessity rather than substitution ease.



Source: <https://www.mmtc.co.jp/en/products/cases/detail-002.html>



WHY SILVER REMAINS IRREPLACEABLE IN INDUSTRIAL APPLICATIONS

Silver's industrial importance rests on a rare combination of physical and functional properties that few materials can match. It offers the highest electrical conductivity of any metal, along with outstanding thermal conductivity and reflectivity, making it indispensable in applications where performance, precision, and energy efficiency matter most.

These characteristics explain silver's central role in electronics, electrical contacts, solar photovoltaics, high performance components, and a growing range of advanced technologies. What makes silver even more valuable is its versatility under demanding conditions: it is ductile, workable, and reliable in miniaturised systems, while its antimicrobial properties give it an added role in medical, hygiene, and water related applications. In a world moving toward electrification, digitalisation, and cleaner energy systems, silver is not just useful— it is increasingly difficult to replace without compromising performance.

Table 5 : Key Properties That Make Silver Industrially Unique

Property	Why it matters in industry
Electrical conductivity	Critical for electronics, electrical contacts, connectors, and photovoltaic applications.
Thermal conductivity	Helps manage heat efficiently in high-performance and compact systems.
Reflectivity	Valuable in optical equipment, mirrors, and energy applications including solar technologies.
Ductility and workability	Enables use in engineered components, fine wires, coatings, and precision fabrication.
Reliability in harsh conditions	Supports long-term performance in demanding industrial and technical environments.
Antimicrobial properties	Useful in medical devices, hygiene products, coatings, and water purification systems.

Source - Silver Institute/ Metals Focus



MORGAN ADVANCED MATERIALS – WESGO® METALS AND THE SCIENCE OF SILVER BRAZING ALLOYS

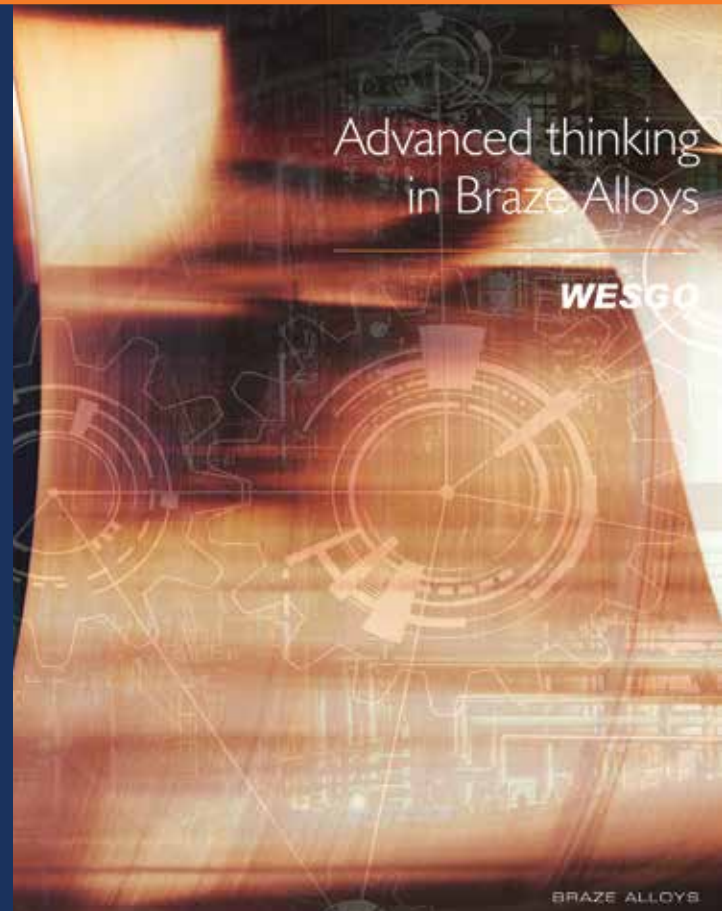


Morgan Advanced Materials – WESGO® Metals and the Science of Silver Brazing Alloys

In the specialized world of silver brazing alloys, performance is not measured in tonnes shipped or market share captured. It is measured in microns of metallurgical purity, vapor-pressure stability under vacuum, and the long-term integrity of joints that are never meant to fail.

It is within this unforgiving engineering environment that Morgan Advanced Materials, through its WESGO® Metals business, has established itself as one of the world's most trusted names in high-purity silver brazing alloys.

WESGO® Metals does not compete as a volume supplier. Its reputation has been built over decades on vacuum-grade metallurgy, engineered silver joining systems, and unwavering reliability-qualities that are indispensable in industries where joint failure is unacceptable and requalification costs can reach millions of dollars. Where many suppliers compete on throughput, WESGO competes on certainty.



Invisible Bonds, Unforgiving Standards

Silver brazing at WESGO® Metals is treated as a science, not a commodity. Every alloy is designed, produced, and supplied as a critical component of a joining system-one that must perform consistently under extreme thermal, mechanical, electrical, and vacuum conditions.

Vacuum-grade metallurgy is not optional in these environments; it is foundational. By vacuum melting every silver brazing alloy, WESGO dramatically reduces dissolved gases, volatile contaminants, and trace impurities. This metallurgical discipline is essential for applications requiring:

- Hermetic sealing
- Vacuum-compatible assemblies
- Ultra-low outgassing behavior
- Long-life performance in high-voltage and microwave devices

Only a limited number of global producers can consistently meet these requirements. WESGO® Metals operates firmly within this elite tier.

Global Manufacturing Power, Focused Precision

WESGO® Metals' silver brazing alloy manufacturing is centered in Hayward, California (USA)-a facility purpose-built for vacuum melting, controlled alloying, and high-purity forming operations. Unlike conventional brazing alloy plants optimized for speed and scale, this facility is engineered around:

- Process control
- Metallurgical cleanliness
- Absolute batch-to-batch consistency

Supporting this U.S. manufacturing hub is Morgan Advanced Materials' European infrastructure, particularly in the United Kingdom, which enables global program coordination, application engineering

support, and supply-chain resilience for long-cycle aerospace, defense, and vacuum electronics programs.

This focused yet globally connected footprint delivers tangible advantages to customers operating in zero-failure environments:

- Exceptional repeatability across qualified alloy batches
- Predictable and reliable lead times
- Long-term supply continuity for regulated and mission-critical programs

For customers, this is not simply manufacturing capacity—it is manufacturing confidence.

Silver Brazing as an Engineered System

At WESGO® Metals, silver brazing alloys are never treated as consumables. They are engineered joining systems, designed to integrate seamlessly with customer processes, materials, and performance requirements.

The product portfolio is deliberately broad, allowing customers to design-in the brazing alloy early in the development cycle and optimize both performance and cost. Silver brazing alloys are supplied in multiple application-ready forms, including:

- **Foil and sheet** for precise alloy volume control
- Wire and rod for manual or automated feeding
- **Powders and pastes** for complex geometries and fine joints
- **Engineered preforms** (rings, washers, and custom shapes) to reduce scrap and cycle time
- **Pre-Sintered Preforms (PSP™)** delivering near-net density and minimal shrinkage

This flexibility enables improved yields, reduced rework, and greater compatibility with automated production-critical advantages as manufacturers pursue leaner, more resilient supply chains.

Advanced Joining Know-How

A defining differentiator of WESGO® Metals is its depth of joining science expertise. Beyond supplying materials, the organization brings decades of application-level knowledge to complex joining challenges, including:

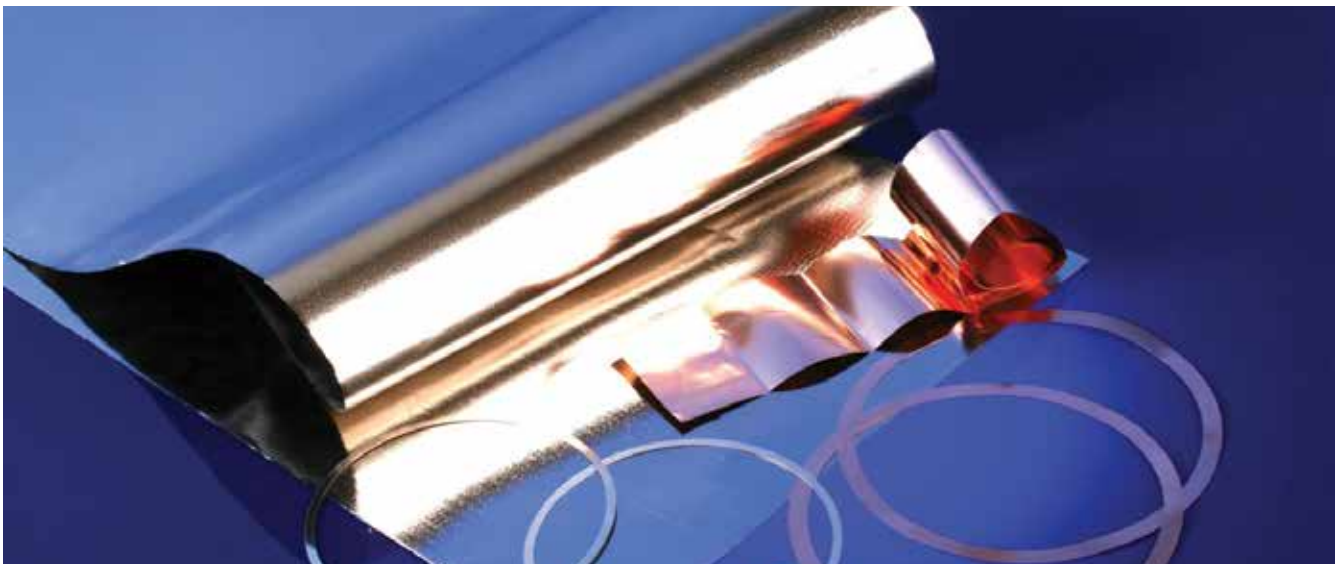
- **Active silver brazing systems** enabling ceramic-to-metal joining without metallization
- **Low-vapor-pressure formulations** optimized for vacuum and controlled atmospheres
- **Process development expertise** focused on wetting behavior, thermal stability, and long-term joint durability

These capabilities are supported by experienced application engineers and metallurgists who work directly with customers from prototype through full-scale production. This collaborative approach positions WESGO not as a material vendor, but as a long-term technical partner.

Quality Systems for Zero-Failure Applications

Silver brazing alloys from WESGO® Metals are produced under aerospace-grade quality systems designed for environments where traceability and change control are non-negotiable. Certifications include:

- AS9100D
- ISO 9001:2015



These systems ensure full material traceability, rigorous documentation discipline, and controlled process change management-critical safeguards for aerospace, defense electronics, medical devices, and other regulated sectors where requalification costs are exceptionally high.

Applications Across High-Consequence Industries

WESGO® Metals' silver brazing alloys serve industries where performance margins are narrow and reliability defines reputation: Aerospace & Defense / Vacuum Electronics & Power Tubes/ Semiconductor & High-Vacuum Equipment / Medical & Specialty Electronics

Silver Economics and Material Stewardship

Silver is both a performance enabler and a cost driver. WESGO® Metals addresses this duality through a total-cost-of-ownership approach rather than a narrow focus on price per kilogram. Key elements include:

- Optimized alloy chemistries balancing silver content with joint performance
- Yield-focused product forms that minimize metal loss
- Application support to help customers migrate to lower-silver alternatives where feasible

The result is cost optimization across the full lifecycle of the joint, an increasingly important distinction in volatile precious-metal markets.

Sustainability, Compliance, and Responsible

Manufacturing

Operating within Morgan Advanced Materials' global ESG framework, WESGO® Metals aligns its silver brazing alloy operations with stringent sustainability and compliance standards, including:

- ISO-aligned environmental management practices
- A comprehensive portfolio of cadmium-free silver brazing alloys
- Full compliance with RoHS, REACH, DFARS, and ITAR requirements

By emphasizing silver-thrift formulations, high yields, and long service life, WESGO contributes meaningfully to resource efficiency and circular-economy objectives in high-value manufacturing.

Competitive Differentiation

What ultimately distinguishes WESGO® Metals is not scale, but capability depth:

- Vacuum-melted, vacuum-grade silver brazing alloys

- Advanced ceramic-to-metal joining expertise
- Engineered preforms and PSP™ technologies
- Aerospace-grade quality systems
- Long-term program stability for mission-critical applications

These strengths make WESGO a preferred supplier where failure is unacceptable and trust is built over decades.

FAST FACTS | WESGO® Metals –

Silver Brazing Alloys

Focus

High-purity, vacuum-grade silver brazing alloys for critical applications

Manufacturing & Operations

- Hayward, California, USA – Dedicated vacuum-melting and forming facility
- United Kingdom – Global coordination, engineering access, supply-chain support

Certifications

- AS9100D
- ISO 9001:2015

Product Forms

- Foil & Sheet
- Wire & Rod
- Powders & Pastes
- Engineered Preforms
- Pre-Sintered Preforms (PSP™)

Key End-Use Markets

- Aerospace & Defense
- Vacuum Electronics & Power Tubes
- Semiconductor & High-Vacuum Equipment
- Medical & Specialty Electronics

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For further information on the company, please visit:
<https://www.morganadvancedmaterials.com/en-gb/>

PHOTOGRAPHY & THE INDUSTRIAL OUTLOOK: LEGACY AND NEW FRONTIERS

Photography is one of silver’s oldest industrial uses. Traditional film and X ray systems relied on silver halide chemistry to capture images with remarkable clarity and durability. Over time, the shift to digital technologies has led to a **structural decline** in this segment, with medical imaging and niche analogue photography keeping a smaller but still important residual demand.

While photographic silver continues to shrink gradually, its story illustrates a broader truth: some uses fade as new technologies emerge, but silver’s overall industrial relevance persists because new applications grow faster than old ones decline. The centre of gravity has shifted decisively toward **electronics, photovoltaics, industrial joining, catalysts and advanced materials**.

Looking ahead, the industrial outlook for silver will be shaped by three forces:

- The **energy transition**, particularly solar, grid modernisation and electric mobility;
- The **digitisation and electrification** of everything—from AI data centres to smart infrastructure;
- Continuous **materials innovation**, where silver’s unique properties solve problems in demanding environments.

Together, these drivers suggest that while specific segments may be cyclical, the long term industrial case for silver remains robust—and increasingly central to the way modern economies function.

Table 6: Trends in Photographic Demand – Long-Term Decline

Year	Photographic Demand (tons)
2018	977
2020	836
2022	860
2024	792
2025	787

Source - Silver Institute/ Metals Focus





PRECISION, PARTNERSHIP AND PERFORMANCE: INSIDE PRINCE & IZANT COMPANY'S EVOLUTION IN SILVER BRAZING TECHNOLOGY

In the hierarchy of industrial materials, silver shines brightest not only for its aesthetic and monetary allure but for its unmatched engineering properties. Across aerospace, medical technology, HVAC and advanced manufacturing, silver-based brazing alloys form the invisible bonds that make modern machinery work. Bridging metallurgy with precision engineering, Prince & Izant Company stands as one of the pioneers transforming precious-metal science into high-performance joining solutions.

A Legacy in Metallurgy

Founded in Cleveland, Ohio in 1927, Prince & Izant emerged at a pivotal moment in American manufacturing-when new alloys, lighter structures and rising performance standards demanded more sophisticated joining methods. Brazing, and particularly silver brazing, became the preferred choice for joining complex or heat-sensitive metal assemblies where welding or mechanical fastening could not perform reliably.

From its earliest days, the company's focus was not on trading metal but on engineering how metals join. This philosophy shaped its long-standing expertise in designing silver brazing alloys known for low melting ranges, high ductility and superb capillary action-attributes critical to aerospace and industrial applications alike. Over the decades, this foundation expanded into a full-fledged engineering ecosystem that pairs alloy chemistry with form precision and process control.

Engineered Forms for Industrial Consistency

While composition defines a brazing alloy's baseline performance, geometry, cleanliness and consistency decide how it performs on the production floor. Recognizing this, Prince & Izant has built one of the most diverse portfolios of silver brazing product forms in the world, including:

- Wire and rod
- Strip and ribbon
- Rings and lathe-wound preforms
- Stamped and laser-cut shapes
- Atomized powders and pastes
- Flux-integrated wires and preforms





Among these, preforms—precisely dimensioned rings or inserts—are especially impactful. They simplify assembly, ensure uniform alloy placement and dramatically improve metal yield, a vital factor when dealing with silver-intensive materials. Flux-integrated wires, combining alloy and flux in a single solution, further enhance efficiency and repeatability, particularly in automated brazing operations.

Industrial-Grade Process Control

Behind every product form lies a tightly controlled suite of metallurgical processes. Prince & Izant’s manufacturing capabilities cover the full spectrum—from precision melting and casting under vacuum or inert atmospheres to advanced conversion operations like wire drawing, ribbon rolling, ring forming and powder atomization.

Every step, from alloy melt to final form, adheres to stringent quality and traceability standards, backed by certifications including AS9100D (Aerospace Quality), ISO 13485 (Medical Devices) and ITAR registration. This rigorous process discipline ensures that each product meets the high-reliability requirements of aerospace, defense and medical device manufacturers worldwide.

Where Silver Matters Most

The company’s silver brazing alloys play a central role in industries where strength, conductivity and reliability converge:

- **Aerospace & Defense:** Fuel lines, turbine assemblies and fluid systems.
- **Medical Devices:** Surgical instruments and diagnostic assemblies requiring clean, precise joints.

- **HVAC & Refrigeration:** Copper-tube connections and heat exchanger joints.
- **Automotive & Industrial Applications:** Cutting tools, oil and gas components, and engineered assemblies exposed to high stress and thermal cycling.

Rather than acting as a transactional metal supplier, Prince & Izant functions as an engineering collaborator—helping OEMs optimize alloy selection, joint design and thermal profiles to extract every bit of performance from each gram of silver.

Global Reach, Local Presence

Headquartered in Cleveland, the company sustains a global network spanning the U.S., Europe and Asia. Manufacturing and technical hubs in Illinois, Wisconsin, Ireland, Germany, China and India ensure regional responsiveness and continuity of supply. Strategic acquisitions in microstampings and clad composites further extend its capability set, aligning with aerospace and electronics supply chains that demand both precision and resilience.

This distributed footprint enables Prince & Izant to provide localized engineering support while maintaining centralized quality oversight—an operational model increasingly vital in a world defined by supply chain complexity.

Managing the Metal: Precious Strategy Meets Practicality

As a precious-metal specialist, the company complements its technical leadership with robust metal management services. Customers can stabilize silver costs through structured price-locking, inventory optimization and scrap recovery programs. These closed-loop systems allow recovered silver-bearing waste to be refined and credited back, reducing both financial exposure and environmental footprint.

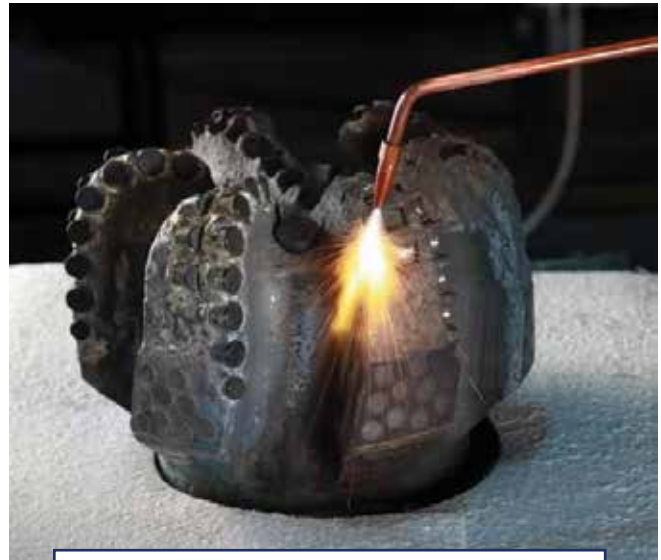
Sustainability now forms a defining pillar of the company's operations. Beyond compliance with global standards, Prince & Izant's commitment to recovery and reclamation reflects a circular-economy approach that ensures precious metals are used efficiently, responsibly and securely.

Innovation Beyond the Alloy

With industrial demand increasingly driven by electrification, thermal efficiency and miniaturization, the company's strategic vision focuses on three growth pillars:

1. Deepened application engineering.
2. Advanced form-factor innovation (preforms, clad materials, composites).
3. Expanded global precious-metal management capability.

The recent foray into clad and composite materials signals an evolution from pure alloy manufacturing toward a broader engineered-materials platform—one that merges metallurgical science with systems-level performance.



Conclusion

In an industry defined by precision and reliability, Prince & Izant Company exemplifies how metallurgy, manufacturing control and financial acumen can converge to create value beyond the ounce. Whether bonding turbine blades or sealing medical assemblies, the company's silver brazing solutions continue to underpin the technologies that move, heal and power the modern world.



For further information on the company, please visit:
<https://princeizant.com/>

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GLOBAL SILVER INDUSTRIAL DEMAND BRAZING ALLOYS & ELECTRONICS

Global Brazing Alloys & Solder Demand (Million ounces)											
Country	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Y/Y
China	24.1	24.5	24.8	25.1	22.5	22.1	19.5	20.4	21.1	21.9	4%
United States	5.9	6.2	6.4	6.5	6	6.5	6.8	6.9	7	7.1	0.70%
Germany	4.3	4.2	4.2	4.1	4.3	4.7	5	5.1	5.4	5.3	-2%
India	2.2	2.2	2.3	2.2	1.7	2.7	3	3.1	3.3	3	-7%
South Korea	2.3	2.4	2.4	2.3	2.1	2.2	2.3	2.4	2.6	2.7	6%
Others	10.5	11.4	11.9	12.2	10.8	12.1	12.6	12.3	10.3	10.3	0.40%
Global Total	49.1	50.9	52	52.4	47.5	50.5	49.2	50.2	49.7	50.5	1%

Source - Silver Institute/ Metals Focus

Global Electrical & Electronics Demand (Million ounces)											
Country	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Y/Y
China/Hong Kong	71	85.2	88.7	88.1	80.8	90	124.4	195.6	211.4	221.8	5%
United States	65	66.9	68.7	65.6	66.6	70.8	73.9	75.6	78.9	82.6	5%
Japan	91	104.2	88.9	94.3	96.6	98.7	83.3	82.6	78.9	53.7	-32%
Germany	17.7	18.3	19	17.1	21.4	25.7	20.6	20.9	21	20.5	-2%
India	13.8	14.3	15.3	13.6	11.7	14.9	17.2	18.2	18.6	17.6	-5%
France	7.4	7.6	8	8.2	7.5	8.6	9.2	9.8	10	10.4	4%
Others	43.3	42.6	41.8	39.7	36.7	42	42.1	41.7	42.1	42.7	1%
Global Total	309	339.1	330.4	326.7	321.4	350.7	370.7	444.4	460.9	449.5	-2%
of which photovoltaics	81.6	99.3	87	74.9	82.8	88.9	118.1	192.7	197.5	186.6	-6%

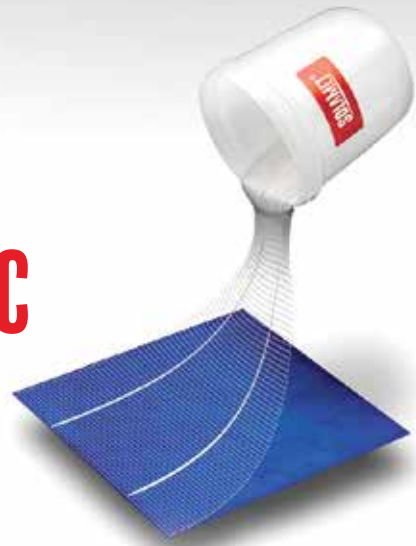
Source - Silver Institute/ Metals Focus

One Million ounces = 31.25 tons



SOLAMET®

SOLAMET ELECTRONIC MATERIALS CO.



Engineering the Contact Layer of the Solar Age

In photovoltaic manufacturing, silver paste is not merely a conductive medium—it is the engineered electrical interface that determines how efficiently sunlight is converted into bankable electricity. Every printed finger on a solar cell represents a balance between conductivity and shading, and every gram of silver directly influences cost per watt. Within this specialised discipline stands Solamet Electronic Materials Co., a focused global leader dedicated exclusively to photovoltaic silver metallization paste.

Solamet became an independent enterprise in 2021 following the acquisition of the DuPont Solamet photovoltaic metallization paste business, yet its technological lineage dates back to the early industrialisation of crystalline silicon solar cells in the 1980s. This continuity underpins its market credibility. Metallization is not a commodity business—it is a cumulative science shaped by decades of formulation refinement and process optimisation.

Today, Solamet operates as a specialist platform with a singular focus: optimising conductive silver pastes for photovoltaic applications. In the broader precious metals ecosystem, this positions the company as a critical downstream industrial consumer of high-purity silver, transforming refined metal into precision-engineered contact systems for gigawatt-scale solar production.

A Portfolio Aligned to Cell Architecture Evolution

Rather than offering a universal product, Solamet maintains a structured portfolio aligned with the evolving photovoltaic technology roadmap. Its front-side silver pastes are engineered for fine gridline printing, enabling:

- Narrower finger widths
- Higher aspect ratios
- Reduced shading losses
- Stable adhesion and low contact resistivity

Fine-line capability has become a decisive efficiency lever in modern solar cell design.

Back-side and solderable pastes complement this offering, ensuring reliable interconnection and thermal robustness during module assembly.

As the industry has transitioned from conventional cells to advanced architectures, Solamet's formulations have evolved accordingly. Its portfolio supports:

- PERC passivation stacks with controlled fire-through behaviour
- N-type and boron-doped emitters
- Advanced TOPCon structures
- Specialised via-fill and interconnect designs

Each paste is calibrated to firing windows, dielectric compositions and emitter characteristics—reflecting the reality that metallization performance is inseparable from cell architecture.



Manufacturing as a Discipline of Precision

Silver paste manufacturing depends on the integration of three tightly controlled elements: silver powder engineering, glass frit chemistry and organic vehicle systems.

- Particle size distribution influences sintering and conductivity.
- Frit chemistry governs adhesion and contact resistivity.
- Rheology determines print stability at high throughput speeds.

Solamet's competitive strength lies in the precise integration of these domains under strict statistical process control. High-purity silver dispersion, controlled frit synthesis and precision mixing ensure batch-to-batch consistency.

In gigawatt-scale solar manufacturing, even minor paste variability can translate directly into yield and efficiency fluctuations. Manufacturing discipline, therefore, is inseparable from financial performance.

Global Positioning and Customer Proximity

Photovoltaic manufacturing remains concentrated in Asia, with strategic capacity in Europe and North America. Solamet operates as a global supplier with facilities and technical capabilities positioned close to major solar manufacturing clusters.

This positioning enables:

- Reduced logistics risk
- Faster qualification cycles
- On-site technical collaboration
- Supply chain resilience

Proximity to customers is not merely logistical—it is strategic, enabling rapid adaptation to technology transitions.

Design-In Collaboration & Silver Thrifting

Silver paste is never "plug-and-play." Its performance is co-optimised with screen parameters, drying profiles and firing curves. Solamet's operating model centres on close collaboration with process engineering teams to fine-tune:

- Firing windows
- Adhesion performance
- Contact resistivity
- Silver laydown per cell

Silver represents the dominant cost component of metallization paste, making silver-thrifting innovation central to competitiveness.

Innovation themes include:

- Lower grams of silver per cell
- Enhanced conductivity at reduced loadings
- Fine-line print capability
- Stable performance at higher line speeds

For the precious metals market, photovoltaic paste remains one of the most structurally significant segments of industrial silver demand, directly linked to global solar deployment.

Sustainability and Compliance

Sustainability extends beyond renewable energy generation to materials sourcing and manufacturing discipline. Solamet aligns with internationally recognised governance frameworks, including OECD-aligned due diligence and electronics supply chain compliance expectations.

Material efficiency remains a dual objective:

- Economic competitiveness
 - Resource optimisation at terawatt deployment scale
- Manufacturing systems align with established quality and environmental management standards, reinforcing traceability and regulatory compliance.

Strategic Outlook in the Terawatt Era

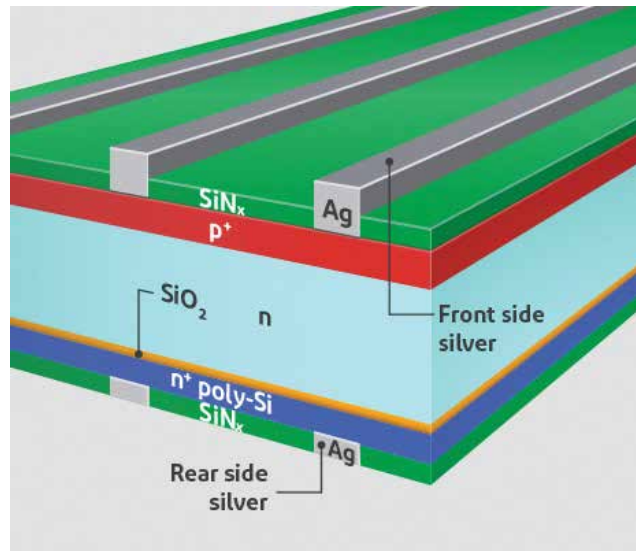
The photovoltaic industry is moving toward terawatt-scale deployment. This transition will intensify pressures around:

- Continued silver reduction per watt
- Compatibility with advanced N-type and TOPCon architectures
- Higher throughput and automation
- Performance stability on thinner wafers

Solamet's roadmap focuses on:

- Fine-line metallization technologies
- Lower-temperature firing compatibility
- Enhanced adhesion at reduced silver loadings
- Print precision for next-generation screen systems

Scaling capacity while maintaining chemistry precision will define leadership in the next phase of solar expansion.



Conclusion

Silver paste may represent only a thin printed layer on a silicon wafer, but its industrial significance far exceeds its physical thickness. It is the engineered boundary where refined silver becomes functional infrastructure in the energy transition.

Solamet Electronic Materials Co. occupies this silver–silicon interface with focused expertise and sustained innovation. For the precious metals community, the company illustrates a powerful reality: silver is not only a store of value—it is a conductor of the global solar economy.

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For further information on the company, please visit:
<http://www.solamet.com/>

Redefining Silver's Role: TANAKA at the Core of Industrial & Energy Innovation



TANAKA Precious Metals: Engineering Silver as a High-Performance Material System

Founded in 1885, TANAKA Precious Metals has evolved from a traditional refining enterprise into a globally integrated materials engineering group, redefining the role of silver from a traded commodity to a critical functional material.

This transformation reflects not only the company's longevity, but its strategic alignment with the increasing material complexity of modern industrial systems-where metallurgical precision directly underpins performance, reliability, and efficiency.

From Refining Heritage to Functional Materials Leadership

TANAKA's trajectory mirrors the broader evolution of the precious metals industry. While its origins lie in refining and trading, its long-term strategic focus has been on downstream integration-developing advanced silver-based materials tailored for high-performance applications.

Today, TANAKA operates at the intersection of metallurgy, electronics, and energy systems, where its materials are not merely inputs but performance enablers.

A pivotal milestone in this journey has been its integration with Metalor Technologies, strengthening its refining capabilities, recycling infrastructure, and global supply chain resilience.

This integration has enabled secure access to high-purity silver, enhanced circularity, and improved management of price volatility-critical in silver-intensive applications.

Manufacturing Technologies & Metallurgical Know-How
At the core of TANAKA's competitive positioning lies its deep metallurgical expertise and tightly controlled manufacturing processes. Its production architecture-anchored in Japan and supported by regional hubs across the United States, Europe, and Asia-ensures consistency, scalability, and traceability.

The company's ability to integrate refining, materials engineering, and fabrication creates a closed-loop system where process control translates directly into product performance-particularly in applications where micron-level variations can impact efficiency.

Product Forms & Integration Capability

TANAKA's silver portfolio reflects both breadth and technical sophistication:

- **Silver Powders:** Ultra-fine, nano-scale, flake, and spherical morphologies tailored for electronics and advanced coatings
- **Silver Pastes:** Front- and rear-side photovoltaic pastes, along with thick-film formulations for electronic circuits
- **Electrical Contact Materials:** Silver-based alloys (AgNi, AgSnO₂, and cadmium-free alternatives), engineered for durability, arc resistance, and switching reliability

What distinguishes TANAKA is not merely its product range, but its ability to align material characteristics with application-specific requirements-bridging the gap between material science and system-level performance.

Application Focus & End-Use Strategy

TANAKA's materials are embedded in critical global industries:

- **Photovoltaics:** High-efficiency silver pastes supporting advanced solar cell architectures
- **Electronics & Semiconductors:** Conductive materials for circuits, packaging, and interconnects

- Automotive & Electrification: Contact materials for EV systems and switching applications
- Industrial Systems: High-reliability components for demanding operating environments

This diversified application base reflects a deliberate strategy to position silver as an enabling material across multiple growth sectors.

Customer Engagement & Design-In Strategy

A defining characteristic of TANAKA's business model is its early-stage engagement with customers. Rather than supplying standardised materials, the company collaborates closely with OEMs to co-develop formulations tailored to specific manufacturing processes and performance requirements.

This design-in approach embeds TANAKA's materials into customer systems at the development stage, creating long-term partnerships and enhancing switching barriers.

Sustainability, Compliance & Circular Economy

Sustainability is integral to TANAKA's operating model.

The company has established robust systems for:

- Recycling and recovery of silver from industrial scrap and end-of-life products
- Closed-loop material flows with customers
- Compliance with global environmental and regulatory frameworks

This circular approach not only reduces environmental impact but also enhances supply security and mitigates exposure to raw material volatility.

Certifications & Global Standards

TANAKA operates at the highest levels of global accreditation:

- ISO 9001 – Quality management
- IATF 16949 – Automotive-grade manufacturing
- ISO/IEC 17025 – Analytical precision
- ISO 13485 – Medical-grade materials (select divisions)
- LBMA Good Delivery Referee (Gold & Silver)
- LPPM Good Delivery Referee (PGMs)

These certifications reinforce its credibility across high-reliability industries and global bullion markets.

Global Footprint & Supply Chain Resilience

TANAKA's operational model combines technological centralisation with geographic diversification. Its integrated value chain-spanning refining, recycling, powder

production, paste formulation, and component manufacturing-ensures resilience in an increasingly volatile global supply environment.

Competitive Differentiation

TANAKA's differentiation is defined by:

- End-to-end vertical integration
- Deep application-specific material expertise
- High consistency and reliability at scale
- Strong customer integration through design partnerships
- Multi-regional, resilient supply chain infrastructure

In contrast to fragmented competitors, TANAKA operates with a system-level understanding of silver as a functional material.

Strategic Outlook

As industries increasingly demand higher efficiency, electrification, and sustainability, the role of silver as an enabling material will continue to expand. TANAKA's strategic positioning-rooted in metallurgical excellence, vertical integration, and application intimacy-places it at the forefront of this transition.

In this context, the company is not merely participating in the evolution of silver markets-it is actively shaping how silver is engineered, integrated, and valued across the global industrial ecosystem.



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