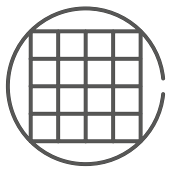
Semiconductor technology



High purity chemistry and equipment

Electronics

Semiconductor technology

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Semiconductor technology at a glance

Leading-edge chemistry, equipment, and process solutions for the semiconductor industry

- Pad metallization
- Pillar plating
- RDL plating
- Damascene filling
- Through via filling
- Through silicon via filling
- Double side plating

ISO 6 clean room production facility for pure and high quality chemistry and ISO 7 for equipment production

Clean room production 2,250 m^2 of equipment production area and 1,500 m^2 for chemistry production

Our products enable customers to reduce their environmental footprint while improving process efficiency

70% energy regeneration during production, using an innovative heat recovery system

Highly trained experts dedicated to the development of semiconductor technologies

Presence in **14 countries** worldwide

383 registered patents in our portfolio for semi-conductor and functional electronic coatings

4 dedicated TechCenters:

- Shanghai, China
- Berlin, Germany
- Yokohama, Japan
- Guanyin, Taiwan

MKS' Atotech's semiconductor technology

Complete wafer metallization

Electroplating solutions for next generation technologies

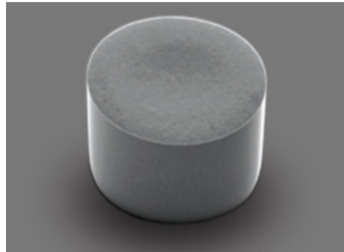
MKS' Atotech's semiconductor portfolio offers leading technology solutions for wafer metallization, for chip interconnects and advanced packaging technologies including dual damascene, redistribution layer, pillar, pad and under-bump metallization, through via filling, and through silicon via applications.

High purity chemistry and equipment

Our high purity chemistries and optimized process solutions for electroless and electrochemical deposition of copper, nickel, palladium, gold, tin, and indium are industry-leading. With the addition of MultiPlate®, an innovative plating tool for both single and double side plating, we now offer a turnkey solution for ECD packaging technologies.

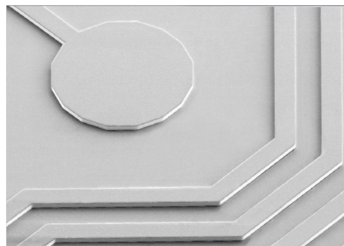
Our broad solutions portfolio

Pillar



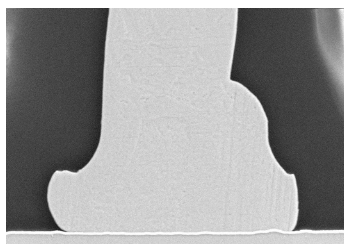
Technology application	Process	Atotech solution
FOWLP, flip chip, capacitors, WLCSP, memory, eWLP, power ICs	ECD Cu through mask process for pillar formation	Spherolyte® Cu
	ECD Ni for diffusion barrier	Spherolyte® Ni
	ECD Sn for solder bump	Spherolyte® Sn
	E'less thin Sn on pillar sidewalls for protection	Xenolyte® Sn
	ECD SnAg for solder bump	Spherolyte® SnAg

Redistribution layer



Technology application	Process	Atotech solution
FOWLP, flip chip, CIS, power ICs, capacitors, WLCSP, bi-polar CMOS DMOS, eWLP	ECD Cu through mask process for RDL formation	Spherolyte® Cu
	E'less deposition of Ni for diffusion barrier	Xenolyte® Ni
	E'less Pd layer for oxidation protection	Xenolyte® Pd
	E'less Au layer for soldering	Xenolyte® Au

Pad metallization

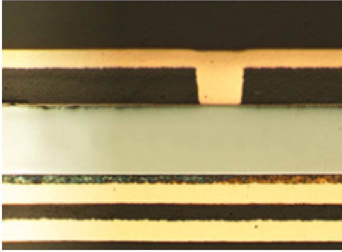


Technology application	Process	Atotech solution
Power ICs, MEMS, display, memory, controllers, sensors, packaging	Al pretreatment	Xenolyte® Zincate
	Cu pretreatment	Xenolyte® Cleaner
	E'less deposition of Ni for diffusion barrier and to protect the underlying interconnects	Xenolyte® Ni
	E'less pure Pd layer for bonding	Xenolyte® Pd
	E'less Au layer for soldering	Xenolyte® Au

Through silicon via

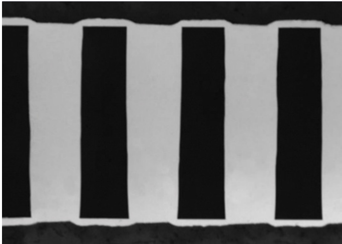
Technology application	Process	Atotech solution
2.5D and 3D WLP, CMOS image sensors	ECD Cu through mask process for conformal filling of TSVs	Cupratech® CP
	E'less Ni layer for diffusion barrier	Xenolyte® Ni
	E'less Pd layer for oxidation protection	Xenolyte® Pd

Double side plating



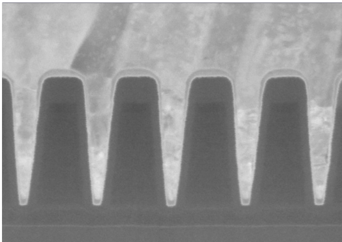
Technology application	Process	Atotech solution
Power ICs, embedding	Simultaneous double side ECD Cu plating	Spherolyte® Cu MD

Through via filling



Technology application	Process	Atotech solution
Interposer	ECD Cu through via filling process	Spherolyte® Cu MTV

Damascene interconnects



Technology application	Process	Atotech solution
Memory, logic	ECD Cu for damascene interconnects	Everplate® Cu Atomplate® Cu

Systems

MultiPlate®

Next generation ECD packaging technologies

Cleanroom capacity for both chemistry and equipment production – ensuring highest quality

1,500 m² cleanroom production area in Neuruppin, Germany

For the semiconductor industry, the quality and purity of the deposited metal and process stability and reliability are of utmost importance. From the point of raw material selection and qualification to chemistry production in our state-of-the-art manufacturing facility, and finally, to finished product quality testing, we control the quality of our chemistries at every production step. In doing so, we are able to manufacture high purity chemistries that comply with the most stringent requirements for semiconductor processing.

With the addition of our ISO 7 cleanroom equipment manufacturing facility, we are now positioned to provide the semiconductor industry with a turnkey solution that delivers optimized plating results, and satisfies the requirements for next generation products.

Production highlights

- Automated systems with advanced filtration
- Closed loop production for maximum process control
- 70% energy regeneration with heat recovery systems
- Waste water reduction and recycling
- Recycling of precious metals, materials, and cleaning chemistries

Spherolyte® Cu UF 3 for high reliable RDL fine line plating and microvoid filling

< 10 ppm

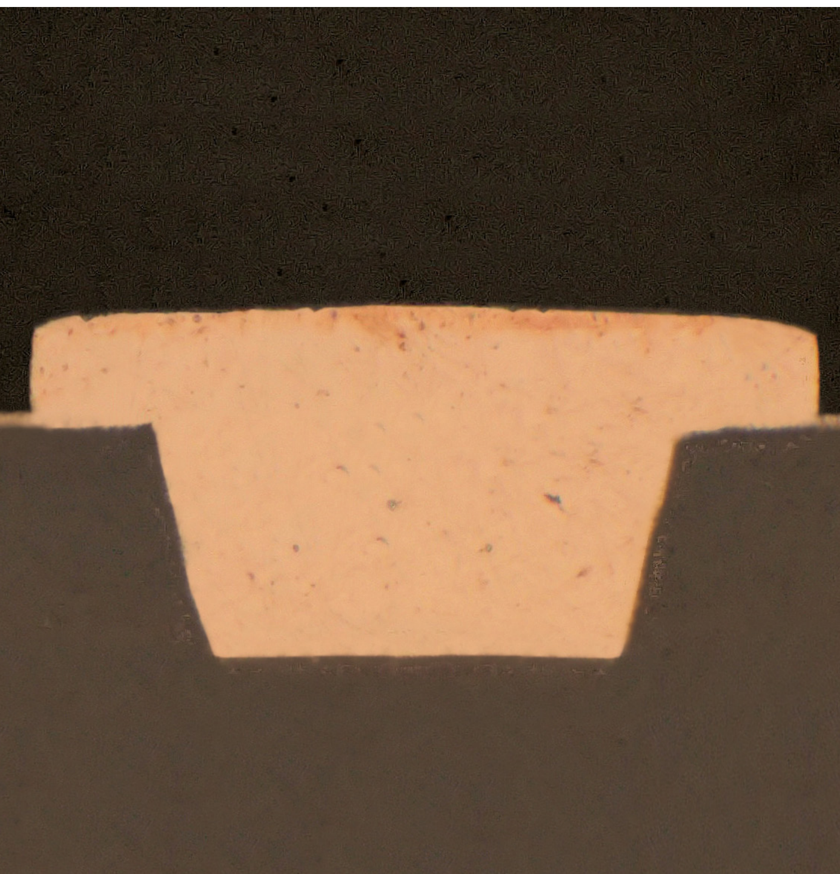
Lowest impurity incorporation, as measured by D-SIMS

29 % Ductility

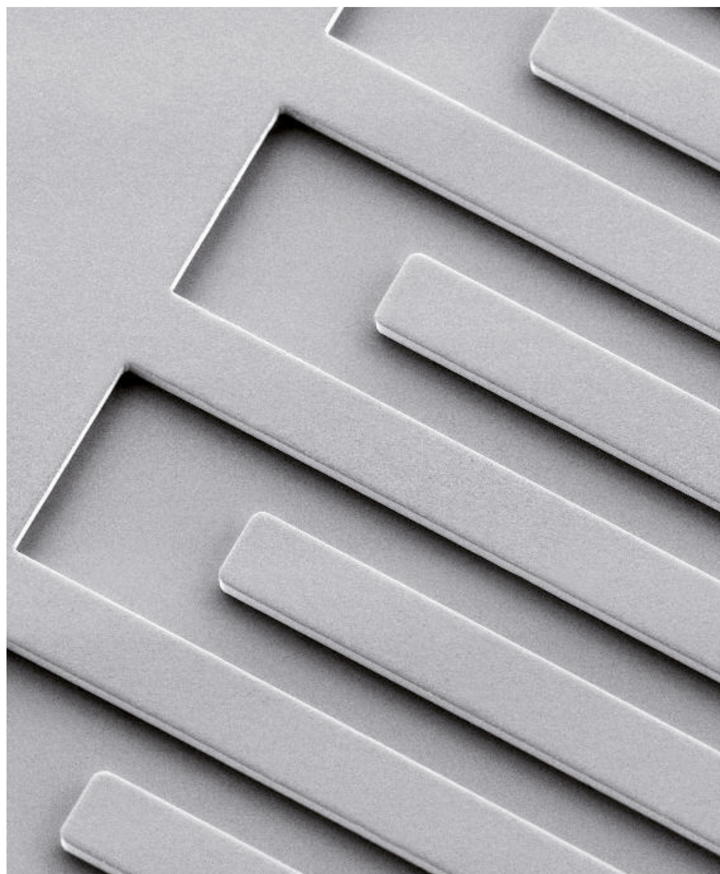
In an ever-evolving industry, MKS' Atotech continues to add value for customers by supplying high performance, top quality, and reliable chemistries that satisfy the plating requirements of redistribution layers for next-generation technologies:

- A single process for both fine line plating and microvia filling
- Low incorporation level of additives, enabling high purity Cu deposits
- Low internal stress, high tensile strength, and high toughness
- Reduction in Cu line breakages after thermal budget

Our Spherolyte® UF3 is a chemistry suite that delivers the highest reliability for dense structures. It enables the next-generation of fan-out technology which is critical for 5G technologies, future smartphones, sensors, and processors.



Microvia filling



Fine line RDL plating

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End markets and industries we serve

Smartphone

Automotive electronics

Computing

Big data infrastructure

Consumer electronics

Communication infrastructure

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Spherolyte® Cu UF 5

Next generation copper pillar plating

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Pure and uniform copper deposits at high deposition speed

High speed pillar plating for advanced packaging

Advanced packaging technologies using copper pillars have emerged as enablers of further miniaturization and enhanced performance. Driven by the increasing demand for faster and better performance, the industry is focused on technologies that provide higher throughput, exceptional reliability performance, and optimal yield. MKS' Atotech Spherolyte® Cu UF 5 process satisfies these requirements with pure and uniform Cu pillar deposits at high deposition speed.

The process is designed for standard pillars for flip chip application as well as new technological requirements such as mega pillar (tall pillar) plating.

Features and benefits

- Purest copper deposit due to lower additive incorporation
- Excellent non-uniformity of < 5% at high speed plating
- Elimination of Ni diffusion barrier
- Excellent adjustable profile shape
- Fully analyzable additive system
- High speed plating capability up to 25 ASD
- Simultaneous processing of different pillar dimensions in one die for next gen hybrid designs

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Spherolyte® Cu UF 5 –
Next generation copper pillar plating

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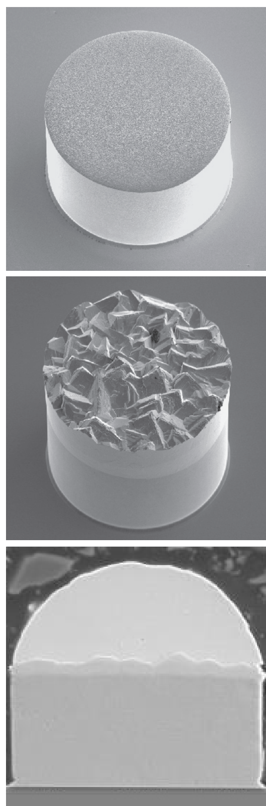

Figure 1-3:
Cu pillar 1) before and 2) after SnAg deposition; 3) cross section of Cu/ SnAg pillar after remelting.

Highest purity, void free copper deposition without a nickel diffusion barrier

The primary feature of the Spherolyte® Cu UF 5 process is the pure copper deposition, which is achieved through a lower incorporation of organic impurities of the additive system. Impurities (e.g. S, Cl) are found to be vastly below impurities of similar processes. Pure copper leads to lower void formation at the intermetallic phase after high temperature storage, and enables the elimination of the nickel-plating step, which is typically used as diffusion barrier to prohibit migration and voiding.

Excellent profile control – adjustable via additive settings

Spherolyte® Cu UF 5 is designed to meet the toughest uniformity requirements at highest plating speed. It shows excellent coplanarity at high-speed plating conditions (< 5% within profile NU).

Additionally, the pillar shape can be adjusted through plating parameters to either flat, concave or convex surface structures – whichever you like and need.

Furthermore, our Spherolyte® Cu UF 5 product suite allows the simultaneous processing of different pillar dimensions (i.e., diameter, height) in one die – making it the electrolyte of choice for plating of next generation hybrid designs.

Adjustable shape via additive control

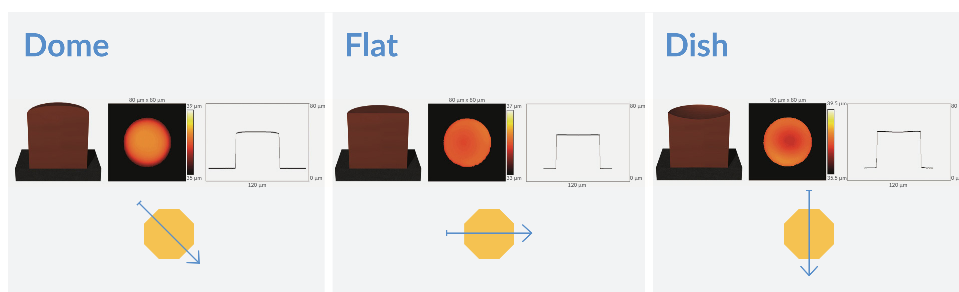

Figure 4-6:
Confocal measurements of 1) dome-shaped 2) flat and 3) dish-shaped Cu pillars.

Spherolyte® Ni

All liquid ECD Ni electrolyte

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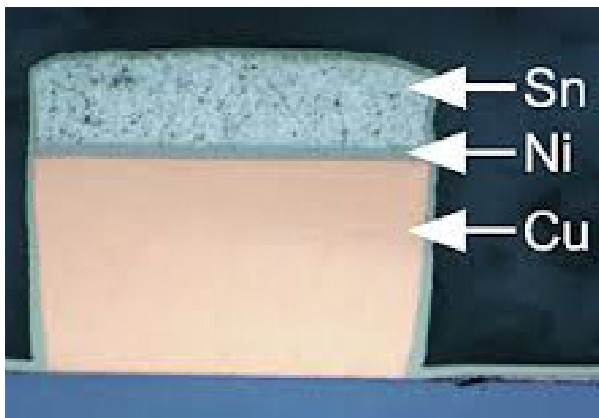
All liquid ECD Ni electrolyte for highly uniform plating

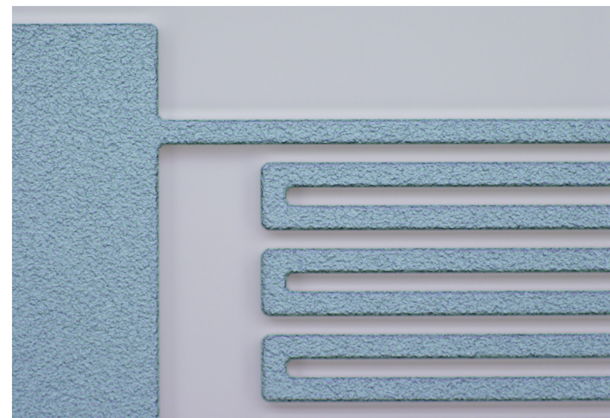
All liquid Ni plating process for various applications

Spherolyte® Ni electrolyte allows the plating of Ni for a broad set of applications such as Ni diffusion barrier, NiFe permalloy, Ni micropillars and Ni TSV. To allow easy handling under clean room conditions, the pH can be adjusted by adding a liquid acid – no powder handling is required.



Excellent uniformity and barrier layer function

Spherolyte® Ni deposits show excellent uniformities and hence allow the controlled deposition of Ni on the substrate. In pillar applications, the deposited Ni barrier prevents the diffusion of Cu into the solder material and therewith the formation of Cu/Sn alloys. As these intermetallic phases are known to grow uncontrollably, the use of Spherolyte® Ni significantly enhances the device reliability.



Features and benefits

- All liquid product – no powder handling necessary
- Excellent diffusion barrier for Cu
- Usable for NiFe alloy-permalloy-plating / Ni TSV application
- Excellent uniformity / throwing power performance
- Long bath life / good stability
- Easily analysable and maintainable plating system
- Wide operating window

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Spherolyte® Ni – Wide operating window and long batch life

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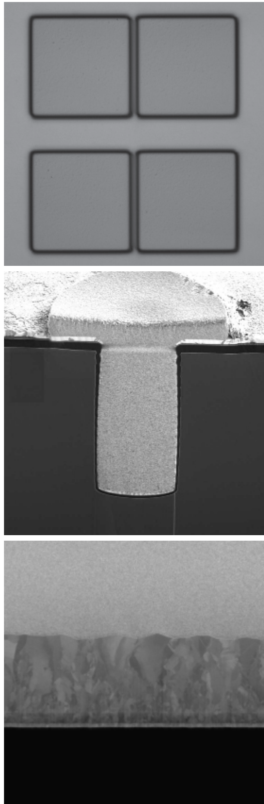

Figure 1-3:
Spherolyte® Ni plated –
1) NiFe pads (top view);
2) Ni TSV (FIB cross section);
3) Ni layer (FIB cross section)

Robust process and outstanding properties of the deposits

Spherolyte® Ni allows a wide operating window with regards to general plating conditions such as pH and temperature. The chemical composition enables a long batch life and good stability. Additionally, the system is easy to analyse and maintain, thus allowing the precise deposition of pure Ni layers which act as excellent diffusion barriers.

Extended additive suite for a broad variety of applications and parameter adjustments

To allow the broad applicability of the Ni electrolyte, a broad range of additive exists that allows the tuning of the process to the required needs. As such, next to leveler and accelerator, which allow to tune the via filling capabilities, a broad range of additives exists. For example, the Spherolyte® Ni Additive reduces internal stress in the deposits, while the Spherolyte® Ni Solution promotes nickel anode dissolution and prevents anode passivation, and the Spherolyte® Ni Iron Additive acts as Fe source to allow NiFe alloy plating.

Contact us to get to know more about the available additives.

Basic conditions

- Current density: 0.5 – 10 ASD
- Plating efficiency: 95 – 98% (at 2 ASD)
- pH: 4.0 (3.5 – 4.5)
- Temperature 50 °C (45 – 65°C)
- Deposition rate: 0.4 µm/min (at 2 ASD)
- Ni anodes: (S*-round or –pellets) / Ti basket
- Filtration: PP or HDPP filter (mesh size 1 µm)
- Compatible with fountain and paddle plater

Spherolyte® Cu DB

Next generation Cu-to-Cu direct bonding

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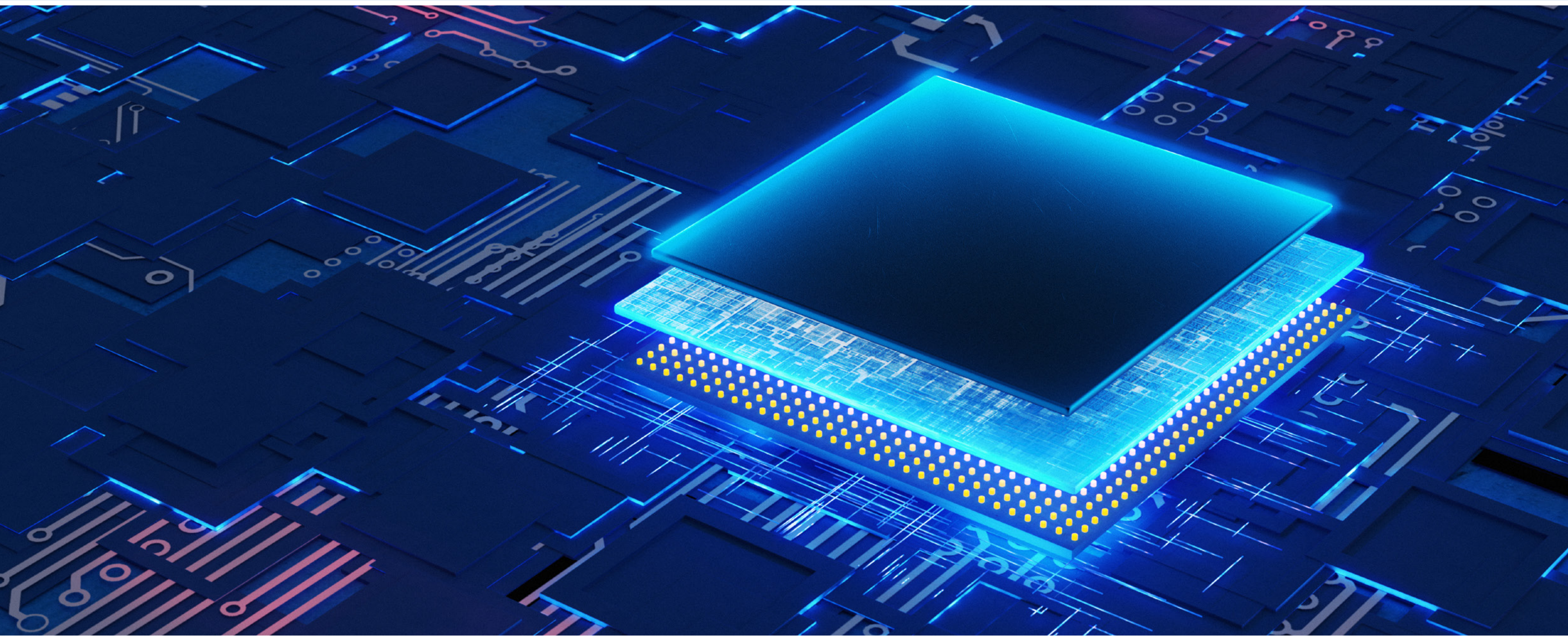

Low temperature annealing Cu for next generation bonding

Copper direct bonding for advanced packaging

Cu-to-Cu direct bonding promises to be one of the key technologies for the manufacturing of next generation semiconductor devices. It allows enhanced device performance due to superior electrical performance and simultaneous smaller form factors and higher reliabilities. Additionally, wafer-to-wafer bonding enables cost advantages and improved production efficiencies.

Spherolyte® Cu DB meets the requirements of next generation Cu-to-Cu bonding, for which relatively low bonding temperatures ≤200 °C are required.

Features and benefits

- Bond formations at low temperatures (≤ 200 °C)
- Deposition of pure copper
- Superior via filling capabilities
- High uniformity
- Good ductility
- Good electromigration performance

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Next generation Cu-to-Cu direct bonding

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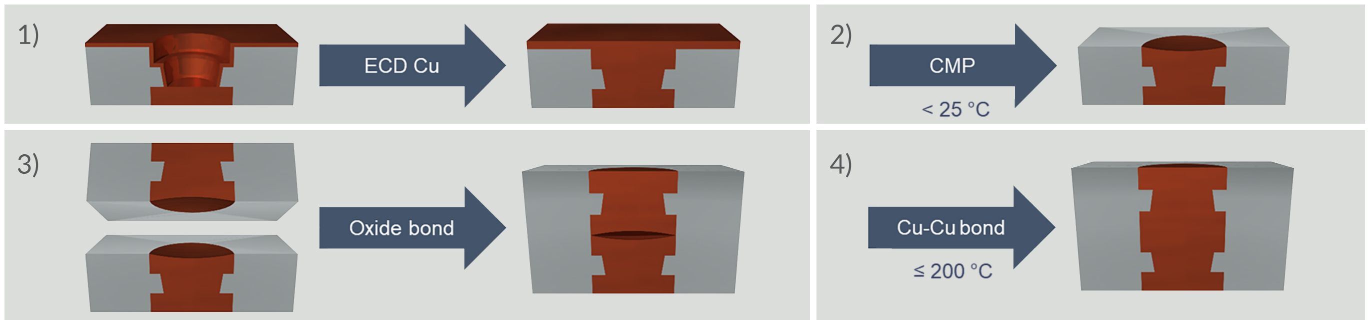
Cu-to-Cu direct bonding sequence based on metastable Cu

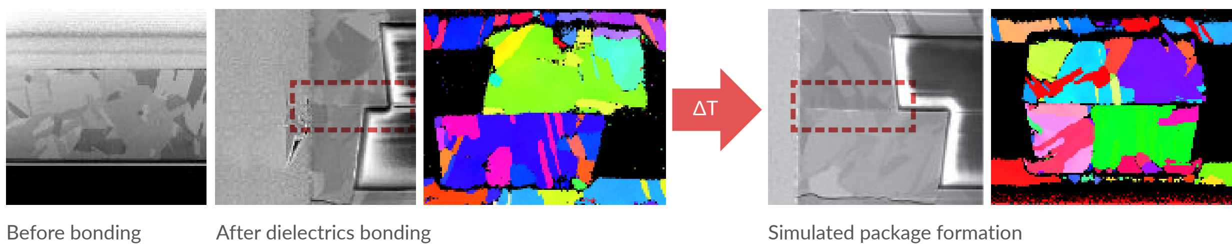


1) Filling of vias with electrolytic metastable Cu; 2) chemical mechanical polishing to remove Cu cover layer; 3) Preliminary dielectrics bonding;
4) annealing step at temperatures ≤ 200 °C to allow Cu-to-Cu bond formation over interface.

Bondformation by metastable copper

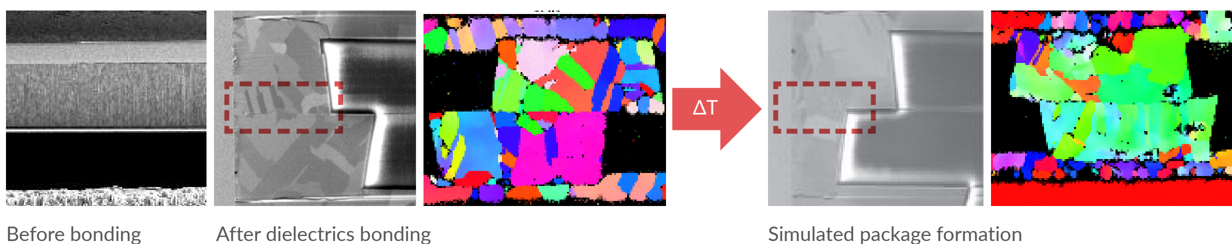
Spherolyte® Cu DB is our new process for the deposition of metastable Cu, which allows to execute Cu-to-Cu direct bonding at low temperatures.
Standard processes deposit coarse grained Cu which under low-temperatures does not change its structures and hence requires higher bonding temperatures. Spherolyte® Cu DB deposits pure, metastable Cu which recrystallizes at temperatures ≤ 200 °C, leading to a grain growth of the Cu interface and hence a firm bonding step.

Non-optimized process (stable, coarse-grained microstructure)

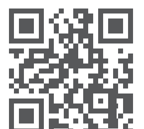


Before bonding | After dielectrics bonding | Simulated package formation

Optimized process (metastable microstructure)



Before bonding | After dielectrics bonding | Simulated package formation



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Xenolyte® Au TG

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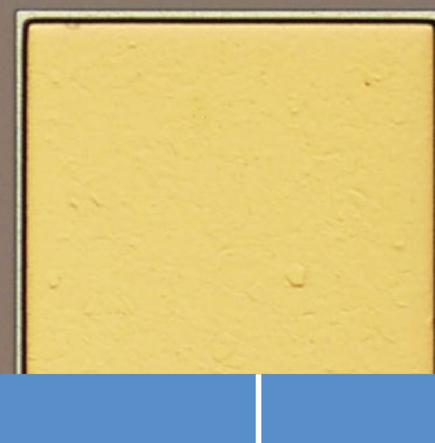
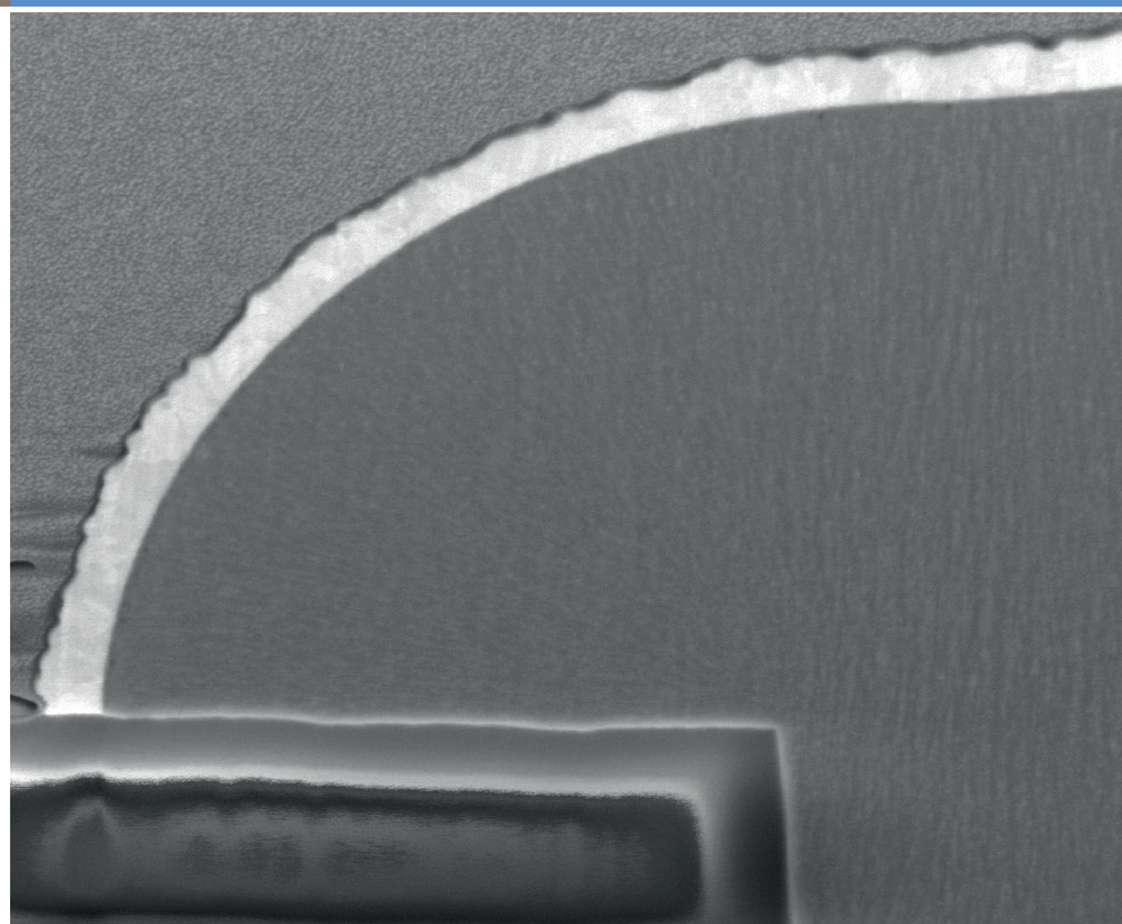
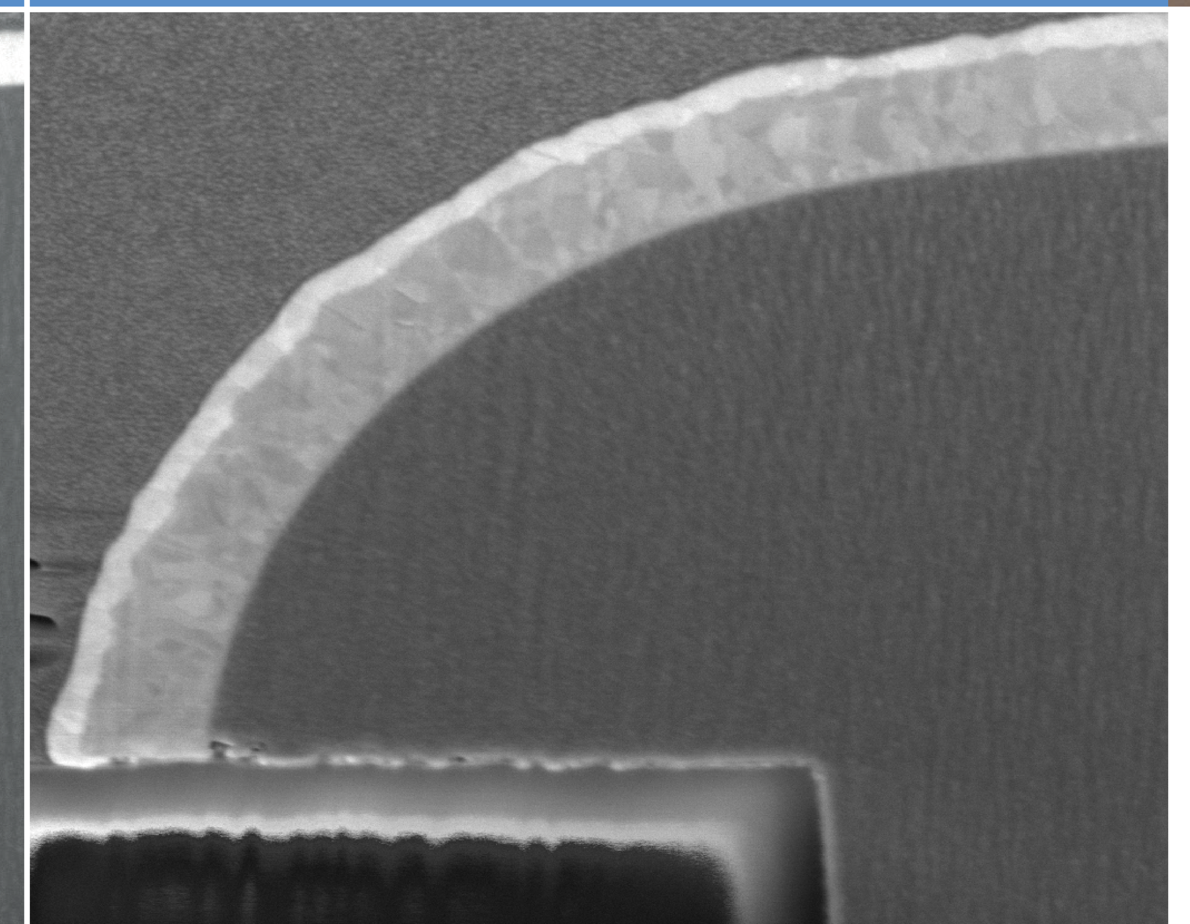
Autocatalytic Au process – A final finish on Ni or Pd for RDL and pad metallisation

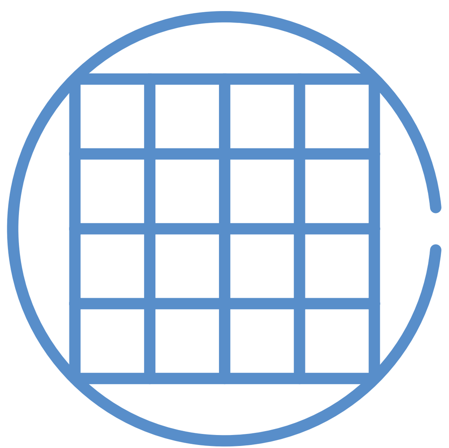


200 nm Xenolyte® Au TG on 3 µm NiP

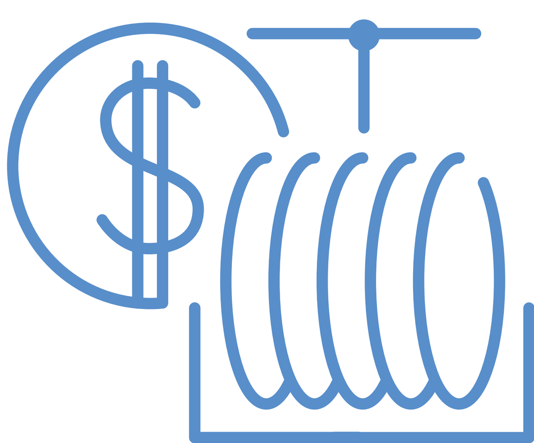


120 nm Xenolyte® Au TG on 400 nm pure Pd and 3 µm NiP





One step autocatalytic Au process for thick Au deposits



Compatible with batch processing in wet bench

Autocatalytic Au for automotive and power IC customers

Our pure autocatalytic Au process Xenolyte® Au TG is the perfect addition to our electroless RDL and pad metallization portfolio. It provides thick and pure gold deposits on electroless nickel and palladium layers. The deposition of thick Au layers from Xenolyte® Au TG does not require an immersion Au strike step and thus reduces corrosion of underlying metal layers to a minimum.

Features and benefits

- Pure gold deposits
- No immersion Au prestrike step required
- Deposition rates between 5-15 nm/min
- Extended bath lifetime
- Applicable to electroless Ni and Pd layers
- Suitable for soldering and wire bonding applications
- Cyanid-, EDTA-, and aldehyde-free