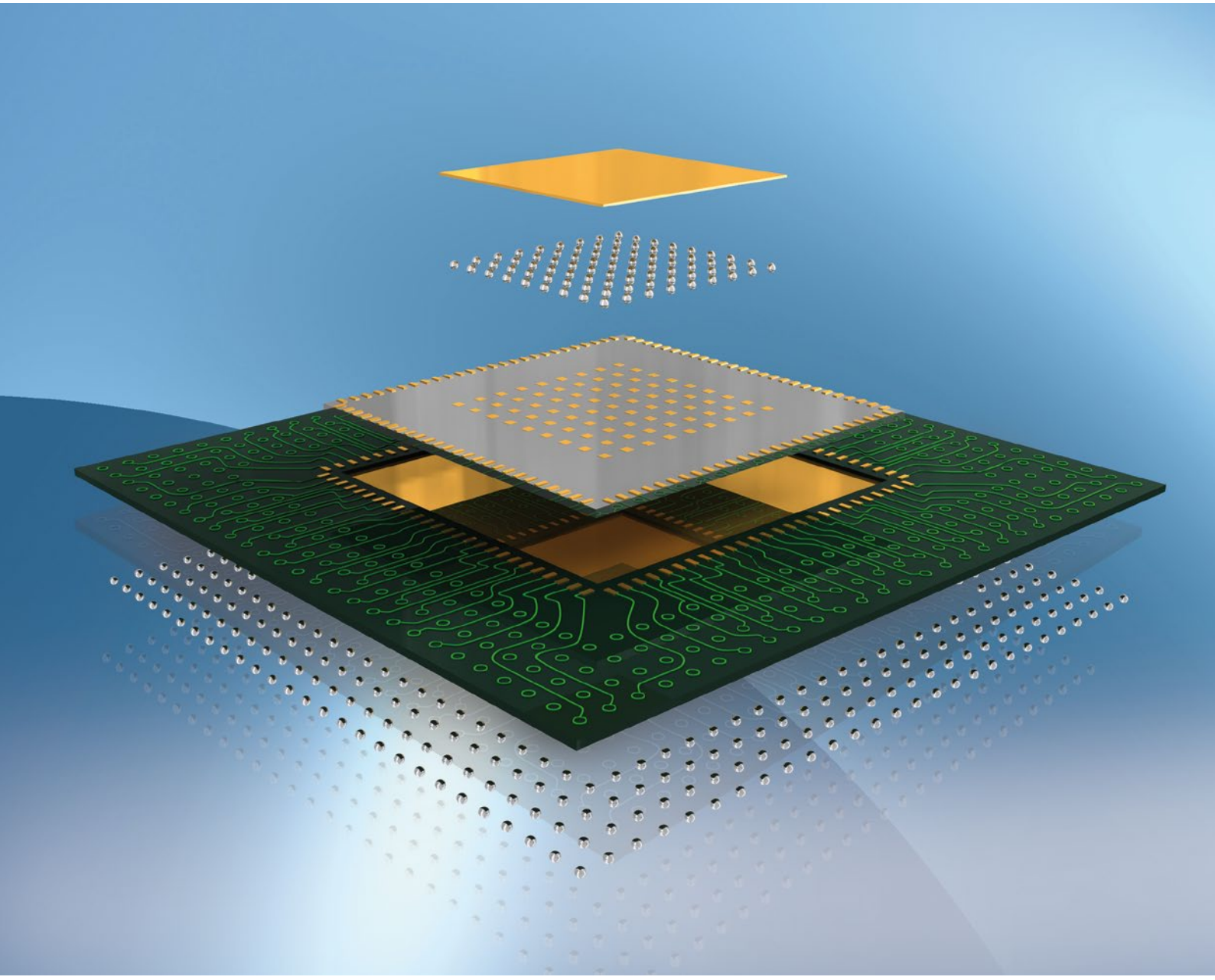
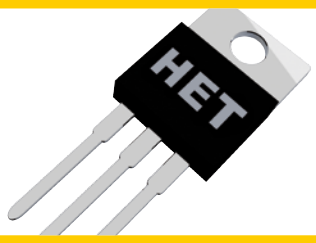
Heraeus

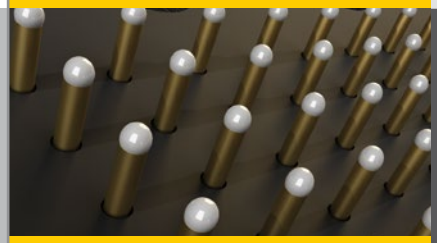


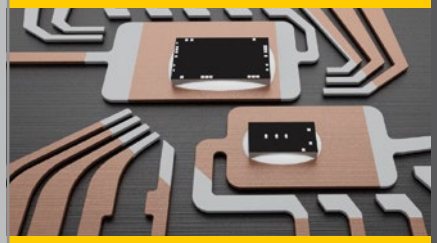
Product Overview

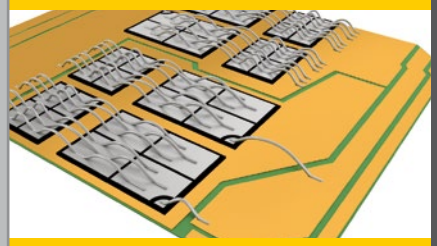
Heraeus Electronics – Assembly Materials
Power & Discrete

Introduction









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Microbond Silver Interconnect

Content

The Global Business Unit, Heraeus Electronics – Assembly Materials is the premier manufacturer of materials for semiconductor assembly / packaging and printed circuit boards. The business focus is on 3 distinct but related product segments:

- **Automotive and Industrial** – Materials for PCB assembly of high reliability electronic circuits
- **Power and Discrete** – Materials for assembly / packaging of Semiconductors and related technologies
- **Powder** – Vertically integrated manufacture of Solder Powders for every application (Low Alpha, Lead Free, Wafer Bumping, etc.).

With production sites located in China, Europe and Singapore, the Assembly Materials Group is ideally situated to support customer's high volume manufacturing operations.

Our state of the art laboratories feature not only the latest in analytical and development tools but also utilize the latest manufacturing assembly equipment so our research and customer application teams can duplicate the customer's process.This laboratories are linked to our production sites and support customers in their region.

The focus of this brochure is the Power and Discrete segment of Heraeus Electronics – Assembly Materials. This segment specializes in materials designed for the assembly / packaging of power and discrete semiconductors as well as related technologies such as Die Attach, DCB (Direct Copper Bonded), SiP (System in Package), Bumping and Flip Chip Attach to name a few.

Key products in this segment include: Solder Wires, Solder Pastes, Conductive and Non Conductive Adhesives and Fluxes. Additionally, the revolutionary SmartFluxes and mAgic Sinterpaste and Adhesive are featured.

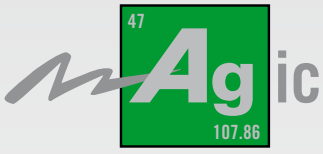
mAgic Sinter Materials

Heraeus Lead Free Die Attach Technology

As a leading supplier of Die Attach materials to the power electronics market Heraeus recognized the need for high performance materials. Our research and development team created a new class of Die Attach materials to meet this requirement. This novel material technology, utilizing silver sintering technology, is branded as mAgic (**M**icro-bond **Ag** **I**nter**c**onnect). The product platform consists of silver sintering pastes and silver sintering adhesives that contain micro-scaled silver particles, which allow a wide process and application window. Due to their exceptional electrical and thermal performance sinter pastes are suitable for high power density modules. The newly developed sinter adhesives, which are processed as easily as conventional adhesives, can replace solders in low to medium power density modules. Compared to lead free solder joints, sinter adhesives joints exhibit similar electrical and thermal properties and, at the same time, provide increased reliability performance at high operation temperatures. mAgic materials are currently in high volume production and demonstrate their outstanding performance in high power modules and converters daily.

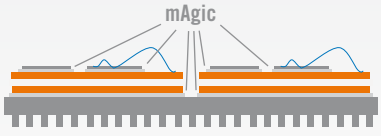
Thanks to their excellent thermal performance and ability to withstand elevated operating temperatures, mAgic materials allow for increased power densities and higher operating temperature in packages. mAgic has allowed for a breakthrough in the design of cheaper, lightweight and more robust devices.

Series	Conventional Conductive Adhesive	mAgic Adhesive	mAgic Paste	Solder
Process Temperature	120 – 175 °C	180 – 200 °C	200 – 280°C	200 – 350 °C
Max. Operation Temperature	150	200	> 250	150
Electrical Resistivity (mΩ·cm)	≤ 0.1	≤ 0.05	≤ 0.008	0.01 – 0.03
Thermal Conductivity (W/mK)	2 – 7	> 30	> 100	20 – 50
CTE (ppm/K)	40/100	50/110	≤ 23	25 – 30
E-Modulus @ 25 °C (GPa)	1 – 4	4	> 35	~ 30



Microbond Silver Interconnect

	mAgic Adhesive	mAgic Paste		
	No Pressure ASA	Pressure Assisted ASP043	Pressure Assisted ASP131	No Pressure ASP295
Application				
Die Attach	+	+	+	+
Component Attach	+	n/a	n/a	+
Process				
Dispensing	+	n/a	n/a	+
Printing	+	+	+	+
Properties				
Halogen Free	+	+	+	+
Lead Free	+	+	+	+
Recom. Sinter Pressure	0 MPa	20 MPa	10 MPa	0 MPa
Sinting in Air	+	+	+	+
Sintering in N_2	+	n/a	n/a	+
Cleaning	not needed	not needed	not needed	not needed
Metal Content after Processing (by weight)	89%	100%	100%	100%
Compat. Surface Finishes				
Ag	+	+	+	+
Au	+	+	+	+
Pd	+	+	+	+



Solder Wires for Die Attach

The Die Attach process remains a key step in the manufacture of power packages to ensure product reliability. With the automotive and aerospace industries setting ever higher reliability requirements, the demands on Die Attach materials are becoming more and more stringent.

Thermal and mechanical fatigue defects in electronic components are caused primarily from successive on/off cycling. To maximize reliability, engineers must identify the optimum combination of material performance and properties. This is where Microbond material technology makes the difference.

To illustrate this advantage we will examine the Die Attach process. The Die Attach joint has three main functions. In the first place it ensures the mechanical connection of the die onto the lead frame. Secondly, it enables heat dissipation from the die to the heat sink and lastly permits electrical contact and transmission.

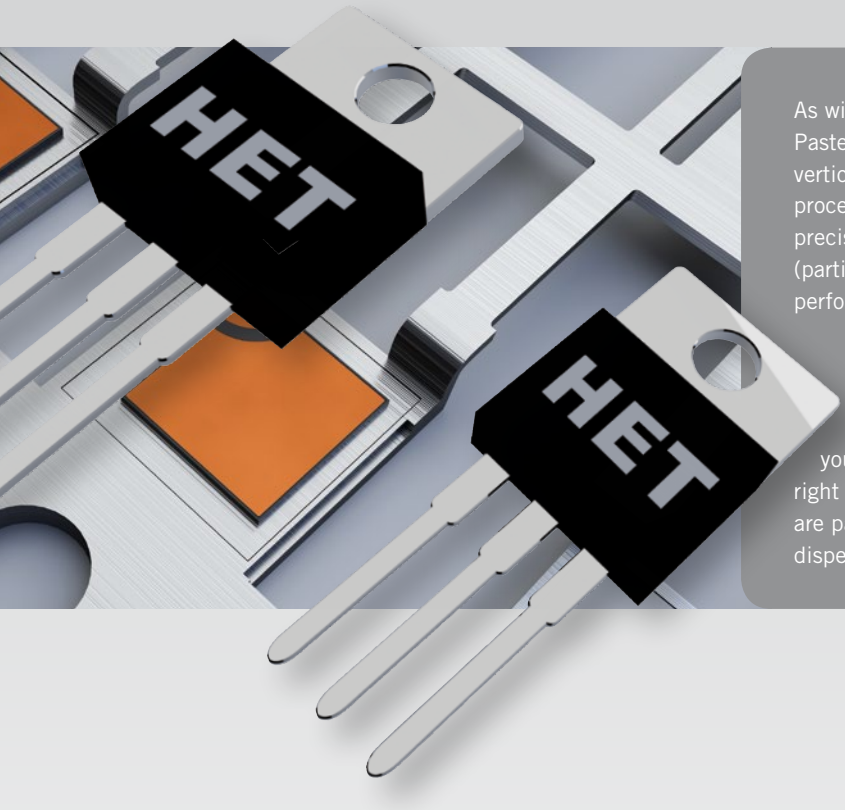
High melting point solder alloys are required for high operating temperature of devices. The Microbond advantage is in a complete portfolio of alloys and materials that are suited to a wide range of temperature requirements.

Specifically doped solder material involves the addition of a minimal amount (ppm range) of wetting enhancing elements. The controlled addition of these substances significantly improves the wetting and flowing properties of the alloy. It provides a higher production yield and reliable results.

Standard Alloys	PbSn1Ag1.5	PbSn2Ag2.5	PbSn5	PbSn5Ag1.5	PbSn5Ag2.5	PbSn10Ag2	PbIn5Ag5	SnAg25Sb10
Application								
Die Attach	+	+	+	+	+	+	+	+
Process								
Wire Dispensing (WD)	+	+	+	+	+	+	+	+
Patterning with Motorized Pre-Press Module (MPPM)	+	+	+	+	+	+	+	+
Wire Dispensing with Soft Solder Dispenser (SSD)	+	+	+	n/a	+	n/a	n/a	n/a
Properties								
Pb Free	n/a	n/a	n/a	n/a	n/a	n/a	n/a	+
Flux Free	+	+	+	+	+	+	+	+
No Cleaning	+	+	+	+	+	+	+	+
Void rate < 5 %	+	+	+	+	+	+	+	+
Excellent Wetting	n/a	+	++	+	++	++	n/a	n/a
Superior Reliability	++	+	n/a	n/a	+	n/a	++	n/a

Standard wire diameters are in the range of 10 to 40 mil (0.254 – 1.01 mm). The Microbond advantage is the ability to control extremely tight wire diameter tolerances thru a sophisticated wire extrusion process. This state of the art process ensures a wire surface that is free of organic contamination and oxides in order to provide perfect wetting and the lowest void rate possible. Microbond Solder Wires guarantee a consistent bondline thickness (BLT) and a very low tilt rate.

Solder Pastes for Die and Clip Attach



As with the Microbond Solder Wire, Microbond Solder Pastes come in a wide variety of solder alloys. In addition, vertical integration of the solder powder manufacturing process provides the Microbond advantage. The ability to precisely control alloy purity and achieve the tightest PSD (particle size distribution) ensures the outstanding performance and high yields that customers demand.

The table below illustrates standard Die Attach Solder Paste available. In addition, Microbond products are available for special applications and your Microbond contact can assist in choosing the right product for your process. Die Attach Solder Pastes are packaged in easy to use syringes for a variety of dispensing systems and provide the following benefits:

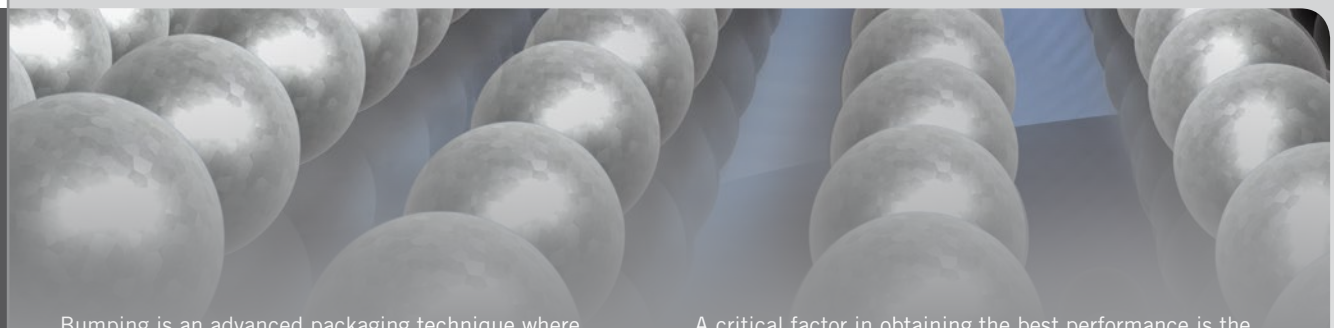
- **Excellent dispensing behavior**
- **Good Tackiness & superior soldering properties**
- **Low Voiding**

	No Clean						Water Soluble
Series	**F367**	**RM210**	**RM212**	**RM218**	**DA444**	**DA447**	**CL30-7386**
Application							
Die Attach	+	+	+	+	+	+	+
Clip/Bridge Attach	+	+	+	+	+	+	+
Passive Component Attach	+	+	+	+	+	+	n/a
Process							
Dispensing	+	+	+	+	+	+	+
Printing	+	n/a	n/a	+	n/a	n/a	n/a
Pin Transfer	n/a	+	n/a	n/a	n/a	n/a	n/a
Properties							
Halogen Free (IEC)	+	+	n/a	+	+	+	+
Activation	L0	L0	M1	L0	L0	L1	H1
Superior Wetting	n/a	n/a	+	+	n/a	n/a	+
Reflow in Air	n/a	+	+	+	n/a	n/a	n/a
Reflow in Nitrogen / Forming Gas	+	+	+	+	+	+	+

No Clean
Owing to good surface-insulation resistance properties, No Clean solder pastes do not require cleaning, however cleaning with compatible solvents is also possible if desired.

Water Soluble
These pastes feature optimized flux systems that ensure aggressive wetting while maintaining ease of cleanability. Optimum cleaning performance is achieved using hot DI water promptly after reflow.

Solder Pastes for Bumping



Bumping is an advanced packaging technique where substrates or wafers are bumped with Solder Pastes. Spezialized Fluxes are utilized to produce very uniform bumps with the highest accuracy and reliability after reflow.

The solder paste bumping process is a more flexible, faster and cost effective production process compared to conventional plating or sputtering methods.

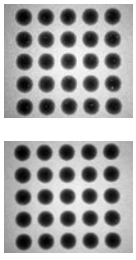
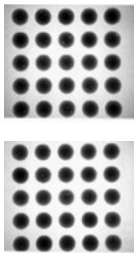
A critical factor in obtaining the best performance is the solder powder as it composes 85 – 90 % by weight of the bumping paste. Heraeus solder powders for bumping pastes have exceptional particle size distribution. Achieved by a patented in house technology which produces ultrafine powders at a very high yield, Heraeus is the leading producer of sophisticated powders.

Series	Bumping Pastes	
	Water Soluble	
	F510	F590
Application		
Wafer Bumping	+	+
Substrate Bumping	+	+
Stencil Printing	+	+
Properties		
Halogen Free (IEC)	n/a	+
Superior Wetting	++	+
Cleanability	+	+
Typical Alloys		
SnAg3Cu0.5	+	+
SnCn0.7	+	+
Powder Types*		
Type 5 (10 – 25 µm)	+	+
Type 6 (5 – 15 µm)	+	+

Low Alpha and Ultra Low Alpha grades are available on request.

* Powder types smaller than type 6 are available on request.

Void rate performance

Series	F510 T6	F590 T6
OSPCu		

Comparable void rate achieved using the same Heraeus lead free reflow profile

Fluxes and SmartFluxes for Ball and Flip Chip Attach

Tacky fluxes are widely used in electronic assembly. One of the main applications is the Ball Attach process which uses mainly water soluble Fluxes. The primary function of the material is to hold the ball in place during the reflow and provide improved wetting performance. After this they will be removed completely from the circuit with a water cleaning process.

Another application is Flip Chip Attach. For this application water soluble or no clean fluxes are used. Both material providing the same basic functionality but the no clean fluxes will remain on the circuit. Key to no clean flux performance is outstanding SIR performance and excellent compatibility with the underfill process.

The SmartFlux, created by the Heraeus development team, improve sicnificantly the missing ball yield. Missing ball appears due to warpage of the substrate during the reflow process.

This new material is a combination of high tacky fluxes and special solder powders. The addition of the powder prevents the movement of the ball and improves the wetting to the substrate surface at the same time.

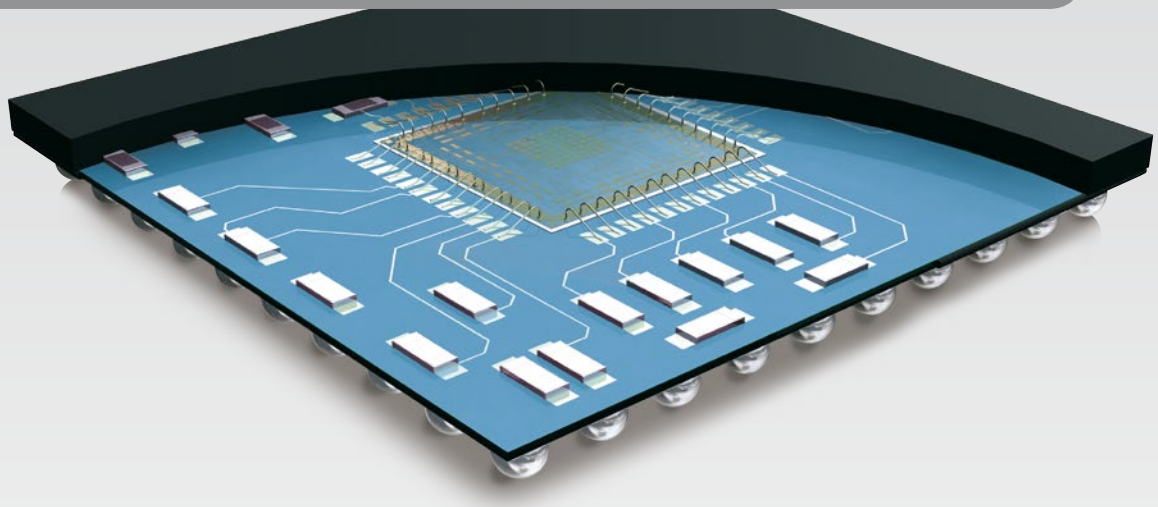
SmartFlux allows for significantly improved yields especially for high value packages and devices in utilizing copper or tin metallizations.

Series	Tacky Fluxes				SmartFlux	
	No Clean		Water Soluble		No Clean	Water Soluble
	NC 5070	TF 38	WSD 3892	WSD 3810-CFF	BD 72	FLX 89131
Application						
Ball Attach	+	n/a	+	+	+	+
Flip Chip Attach	+	+	+	+	+	+
Process						
Printing	+	+	+	+	+	+
Pin Transfer	+	+	+	+	+	+
Ball Dip	+	+	+	+	+	+
Dispensing	+	+	+	+	+	n/a
Properties						
Halogen Free (IEC)	+	+	+	+	+	n/a
Flux Activity (J-STD)	L0	L0	H1	H0	L0	H1
Clear Color of Flux Residues	+	++	n/a	n/a	+	n/a
Cleanability with DI Water	n/a	n/a	++	++	n/a	++
Superior Wetting	+	++	+++	++	n/a	++
Tackiness	++	+	++	++	+	++
Typical Alloys						
SnAg3Cu0.5	n/a	n/a	n/a	n/a	+	+
Powder Types						
Type 5* (15 – 28 µm)	n/a	n/a	n/a	n/a	n/a	+
Type 5 (15 – 25 µm)	n/a	n/a	n/a	n/a	+	+
Type 6 (5 – 15 µm)	n/a	n/a	n/a	n/a	+	+

* Type 5 with upper powder size of 28 µm

Water Soluble Solder Pastes for System in Package (SiP)

System in Package (SiP) is an established technology to provide reasonable costs for the semiconductor miniaturization. This system integrates active and passive components with standard Surface Mount Technology to achieve complex circuits. Continued miniaturization and the incorporation of 3D integrated modules increase the complexity of these packages as well as the functionality. As capabilities and sophistication increases material selection will play a key role not only in package performance but manufacturing yield as well. Heraeus is a major supplier to the SiP Industry and provides a full range of Solder Paste, Tacky Fluxes and Adhesives. Due to their industry leading performance, Heraeus products enable high yields and wide process windows which offer potential cost savings to manufacturers.

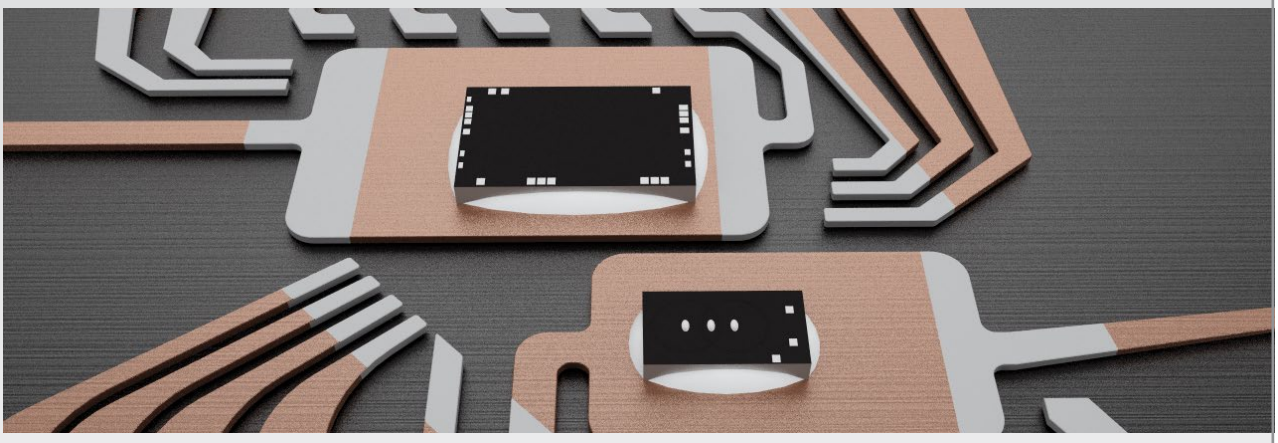


	Water Soluble			
Series	F541 HBF	F590	WL449	F510
Application				
Die Attach	+	+	+	+
Component Attach	+	+	+	+
Process				
Printing	+	+	+	+
Properties				
Halogen Free (IEC)	n/a	+	+	n/a
Flux Activity (J-STD)	H1	M1	M0	H1
Superior Wetting	++	+	+	++
Reflow in Nitrogen	++	++	++	++
Typical Alloys				
SnAg3Cu0.5	+	+	+	+
SnSb5	+	+	n/a	n/a
SnCu0.7	+	+	n/a	+
Powder Types				
Type 3 (25 – 45 µm)	+	+	+	n/a
Type 4 (20 – 38 µm)	+	+	+	n/a
Type 5 (15 – 75 µm)	+	+	n/a	+
Type 6 (5 – 15 µm)	+	+	n/a	+

Adhesives for Die Attach

Die Attach Adhesives have a long tradition in the semiconductor industry. The flexibility of this material makes them ideal for attaching different sized die on a variety of substrate materials. The Heraeus portfolio of Die Attach Adhesives provides a wide range of ready to use, single component systems.

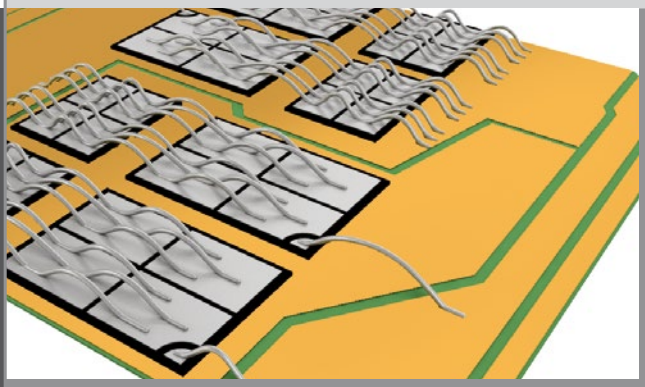
Heraeus Die Attach Adhesives can improve the production yield due to their long pot life, wide process window, fast cure, high thermal conductivity and outstanding temperature stability. One special characteristic is less bleed-out which enables our customers to decrease the space between bond pads and work with maximum die sizes. Excellent dispensing properties lead to maximum throughput and the lowest cost of ownership.



	Conductive Adhesives					Non Conductive Adhesives			
Series	PC 3000	PC 3070	PC 3230	PC 3430	PC 3600	NCA 2	NCA 5	NCA 6	NCA 11
Application									
Die Attach	+	+	+	+	+	+	+	+*	+
Flip Chip Attach	n/a	n/a	n/a	n/a	n/a	n/a	n/a	+	n/a
Component Attach	+	n/a	n/a	n/a	n/a	+	+	+	+
Process									
Dispensing	+	+	+	+	+	+	+	+	+
Printing	+	+	n/a	n/a	n/a	+	+	n/a	n/a
Curing, Conditions and Properties									
Recommended Curing	10 min @ 150°C	10 min @ 150°C	5 min @ 120°C	10 min @ 150°C	5 min @ 80°C	10 min @ 150°C	5 min @ 150°C	10 sec @ 170°C	10 min @ 80°C
Fast Curing	n/a	n/a	+	n/a	n/a	n/a	+	++	+
Flexible	+	+	+	++	+	+	+	n/a	++
Pot Life	+	+	++	+	+	+	++	++	+
Low Warpage	+	+	+	++	+	+	+	n/a	++
High Thermal Conductivity	+	++	+	+	+	n/a	n/a	n/a	n/a

* max. 5 x 5 mm

Solder Pastes for Direct Copper Bonding (DCB)



DCB is the traditional technology used for high power applications were currents of 30 A up to several thousand amperes are commonly experienced.
DCBs consist of a ceramic core, typically Al2O3, that acts as an insulation layer and thick copper tracks to provide an electric path on the top side of the device. In addition, a copper layer is found on the back side of the device. The copper layers usually have a minimum thickness of 300µm to ensure a high current carrying capacity.

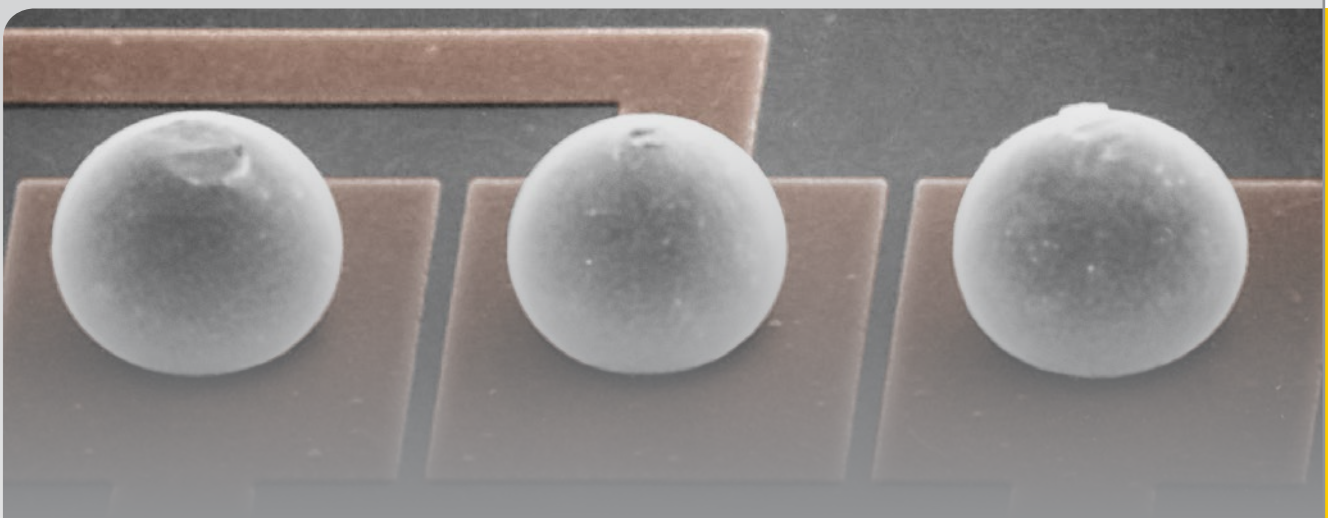
MOSFETs, IGBT and diodes are typically soldered to the top side of the DCB. The back side may be soldered to a so called base plate which supports the heat spreading and heat transfer to a passive or active cooling system. The majority of DCB modules are used in DC-DC or AC-DC converters. Those converters are typically used in the field of e-mobility and renewable energy. Heat is generated due to the high power handled by the modules. This heat has to be dissipated efficiently or reduced product life cycles will be the result. Voids, which hinder good heat dissipation, will be minimized by using a vacuum soldering process. To further minimize voiding and also to guarantee a low level of die tilt, the solder paste needs to be capable of being printed on large areas of > 100 mm^2 uniformly and without holes.

To ensure a good bondability of the circuit in later manufacturing steps the flux residues have to be easily to removed. As one of the market leaders of solder paste for DCB application Heraeus has many years of developing high performance materials for DCB applications.

Our materials are compatible with the vacuum soldering process, provide a outstanding print to print consistency and are easy to clean.

	No Clean				Water Soluble
Series	**F360**	**F360 C20**	**F825**	**F645**	**WL449**
Application					
Die Attach	+	+	+	+	+
Component Attach	+	+	+	+	+
Process					
Printing	+	+	+	+	+
Properties					
Halogen Free (IEC)	n/a	n/a	+	n/a	+
Flux Activity (J-STD)	L0	L0	L0	L0	M0
Min. Die Tilt	+	++	+	+	+
Control of Bond Line Thickness	+	++	+	+	+
Reflow in Nitrogen	+	+	++	++	+
Typical Alloys					
SnAg3.5	+	n/a	+	n/a	+
SnAg3.5Cu2.0	n/a	+	n/a	n/a	n/a
SnAg3Cu0.5	n/a	n/a	n/a	+	n/a
Powder Types					
Type 2.5 (25 – 75 µm)	+	+	n/a	n/a	+
Type 3 (25 – 45 µm)	n/a	n/a	+	+	+

Welco®– Ultra Fine Solder Powder

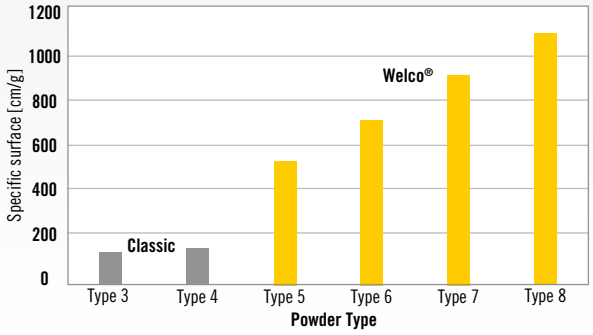


Heraeus has developed Welco-powders for ultra-fine pitch solder paste in various printing applications. The capabilities are ranging from dry film (patented by FCI) to stencil printing. The results of these processes are high quality flip chip or pre-soldered flip chip substrates. These solder powders enable pitches down to 60 µm, whereas the printing process represents a more cost effective and flexible bumping method compared to conventional sputter or plate methods. Advantages of the Welco technology include a very narrow and adjustable particle-size-distribution, controlled by speed, process time and geometry of the dispersing tools, as well as very low oxygen contents in each powder types.

Welco® – only registered in USA

Powders	Lead free			Lead containing
	Sn96.5 Ag3.0 Cu0.5	Sn95.5 Ag4.0 Cu0.5	Sn99.3 Cu0.7	Sn63 Pb37
	217 – 219 °C	217 – 225 °C	227 °C	183 °C
Type 5 [10 – 25 µm]	x	x	x	x
Type 6 [5 – 15 µm]	x	x	x	x
Type 7 [2 – 11 µm]	x	x	x	x
Type 8 [2 – 8 µm]	x	*	*	–
Low Alpha [< 0.02 cph/cm²]	x	–	x	x

x = Alloys available * = under RnD
Other alloys and low alpha qualities on request. Purity of all material > 99.9 %



Comparison – Powder Particle Sizes and Specific Surfaces

The specific surface of the Welco powder is 3 to 6 times higher versus classic powders.

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