Heraeus

Silver Sintering in Diversified Applications

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Agenda

- Introduction of Heraeus
- Why sintering is needed
- Materials and Processes
- Sintering in Power Electronic Modules
- Sintering in Discretes
- Sintering in Power Amplifiers
- Summary

Who We Are

- A globally active material technology Group
- Family-owned for over 160 years
- We create high value solutions for our customers and substantially strengthen their competitiveness
- We are organized in 11 Global Business Units
- Over 12,591 employees at over 100 sites in 38 countries
- 2014 product revenue: €3,4 billion
- 2014 precious metals trading revenue: €12,2 billion

Headquarter Hanau

Regional Headquarter Shanghai

Buford USA

The Markets

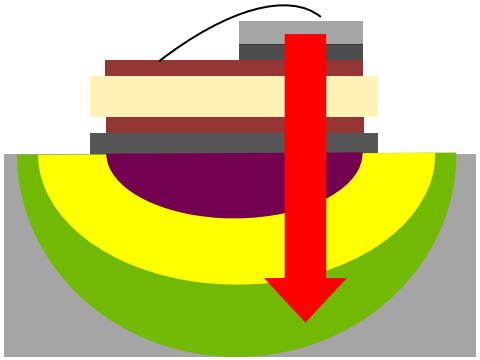
We are active in global markets characterized by a clear differentiation lasting growth and attractive returns

Our ideas are focused on themes such as:

Why sintering is needed?

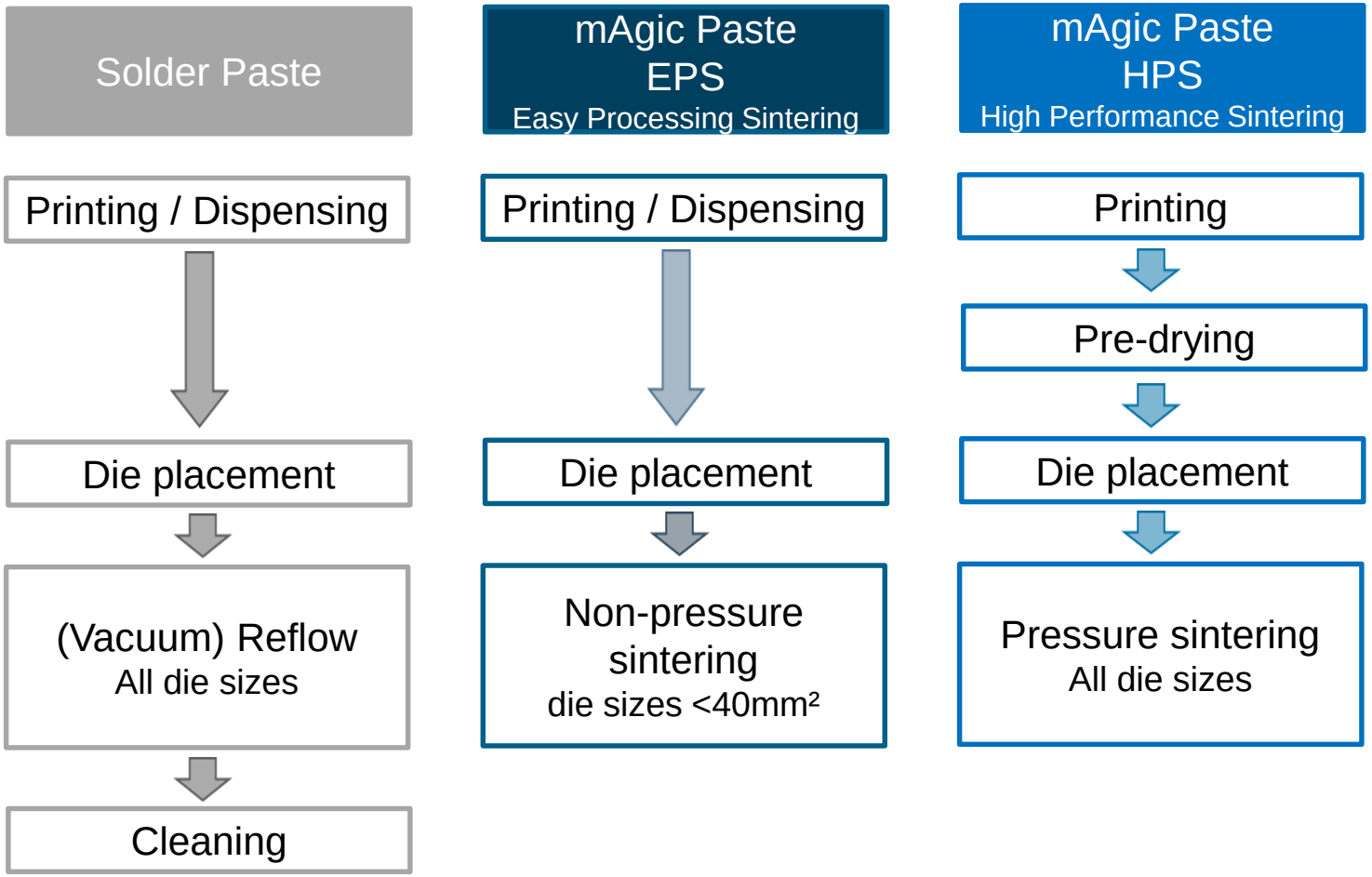
Trends in Electronic Packages

- **Longer Lifetime**
  - Automotive electronics; Systems, difficult to access
- **Miniaturization**
  - Restricted installation volume
  - Cost reduction (reduction of die and substrate size)
- **Increase of power density and operation temperature**
  - Accelerated aging of die contact materials
- **Reduction of manufacturing Costs**
  - Minimize process costs (no cleaning after processing)
  - Lower material costs (by increase of power density)
- **Lead Free Electronics**



mAgic Sintering Materials, Processes, Applications

Processes


Solder Paste
Printing / Dispensing
Die placement
(Vacuum) Reflow
All die sizes
Cleaning
mAgic Paste
EPS
Easy Processing Sintering
Printing / Dispensing
Die placement
Non-pressure
sintering
die sizes <40mm²
mAgic Paste
HPS
High Performance Sintering
Printing
Pre-drying
Die placement
Pressure sintering
All die sizes

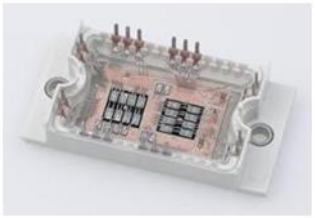
Heraeus

Comparison of Material Properties

mAgic Microbond Silver Interconnect

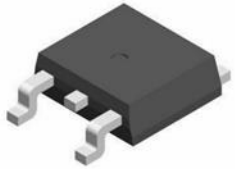
Material properties	SnAg3.5 Solder	mAgic Paste LTS295-Series EPS	mAgic Paste ASP016/043 HPS
Electrical resistivity [mΩ·cm]	**0.01 - 0.03**	**≤ 0.008**	**≤ 0.008**
Thermal conductivity [W/m·K]	**20 - 50**	**>100**	**> 200**
CTE [ppm/K] (below/above T_g)	25 - 30	19	19
E-Modulus @ 25°C [GPa]	~ 30	~ 25	~ 50
Shear strength [N/mm^2]	~ 40	≥ 10	≥ 10
Process temperature [°C]	**230-260**	**≥ 230**	**≥ 230**
Residue free	**No**	**Yes**	**Yes**

mAgic Sinter Applications



Power Modules

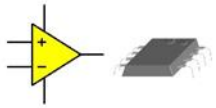
- **Highest Life Time**
- **High Operation Temperature**



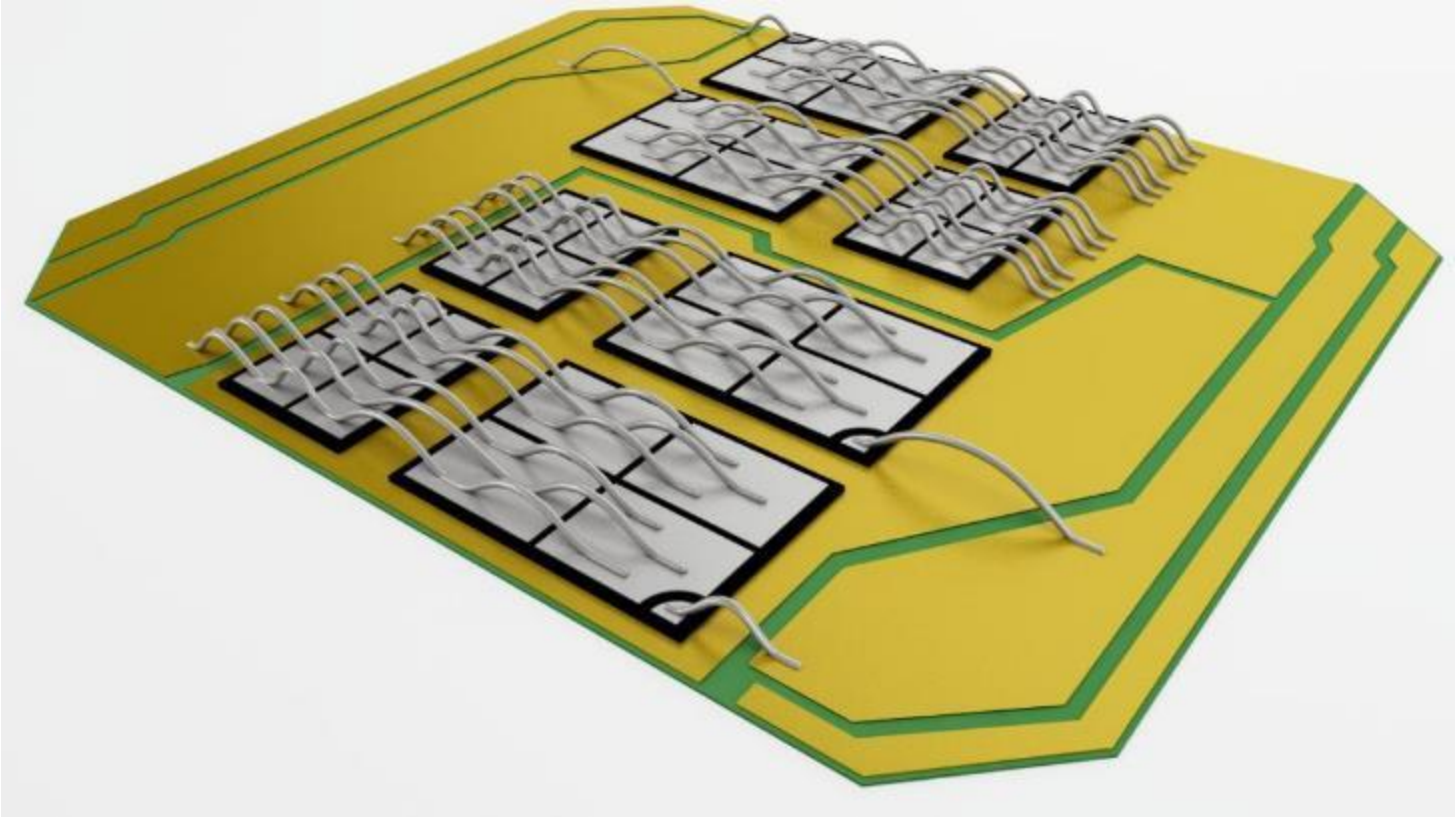
Discretes

- **Lead Free**
- **Melting Point >260°C**
- **MSL 1 Proven**

Power Amplifier

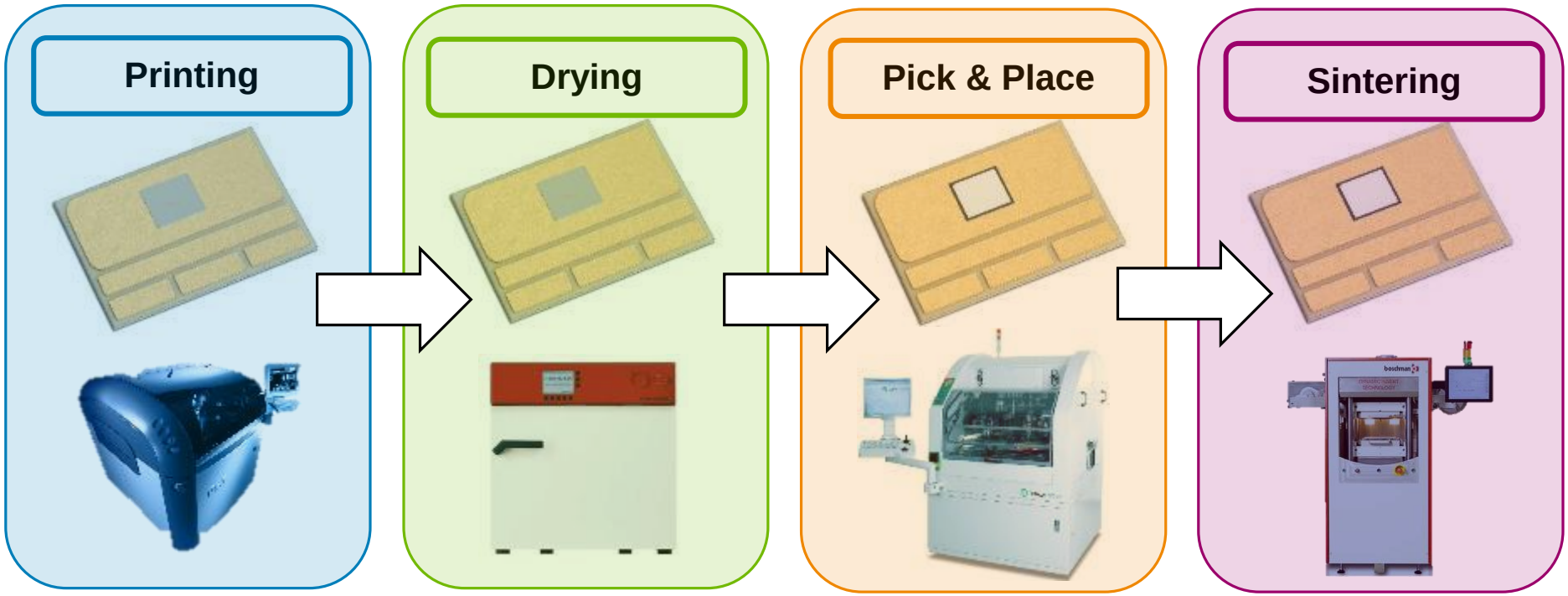


- **High Thermal Concuctivity >100W/mK**
- **High Electrical Conductivity >10MS**
- **Low Processing Temperature ≤ 200°C**



mAgic Sinter Materials in Power Electronic Modules

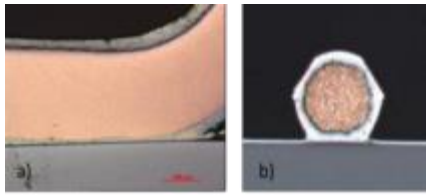
HPS Process



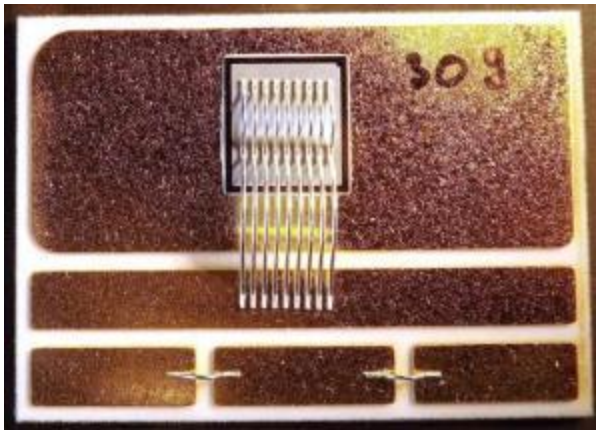
Benchmark Wire Bonding and Die Attach Material – Power Cycling Test Package

- Conventional **DCB package**:
  - DCB : bare Cu for solder, NiAu metallization for mAgic product
  - Diode: Infineon: 8.15 mm x 9 mm diode, NiAg backside metallization, thickness: 120 µm

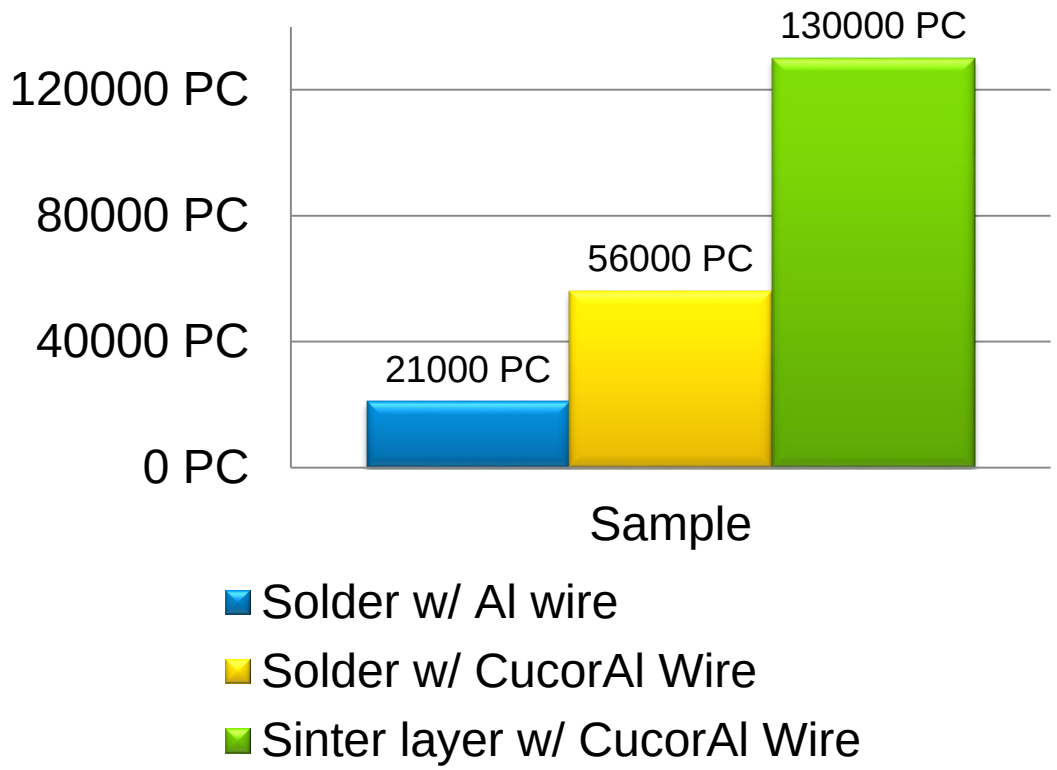
- **Tested Materials**
  - Wire Bond Materials Al-Wire, 300µm vs. AlCu-wire, 300µm
  - Die Attach Material SnAg3.5 Solder vs. mAgic Sinter Paste



- **Active power cycle test Parameter**
  - $t_{on}=t_{off}=15s$
  - $T_{min}=40°C$
  - $\Delta T=110°C$



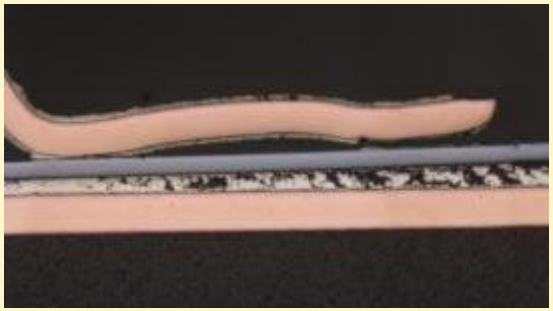
Power Cycling Capabilities



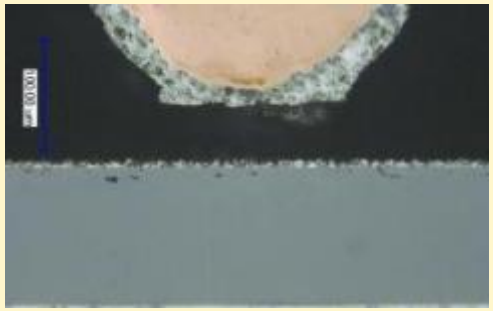
- Soldered module failed after 56,000 cycles
- Test of sintered module stopped after 130,000 cycles
- Improvement of life time >2.5 times

Soldered Modules Bonded using AlCu Wires at End of Life

Soldered Module with AlCu-Wire after 56.000 Power Cycles

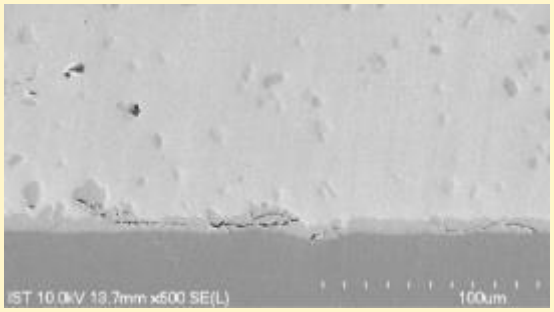


Overview Picture

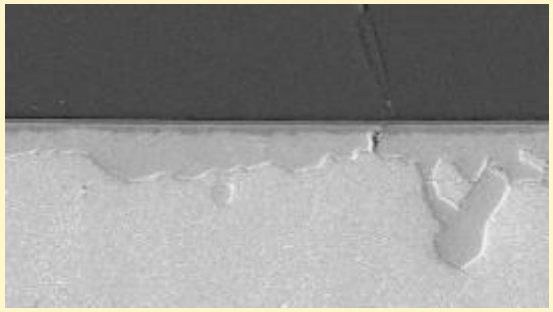


Bond Lift on Chip

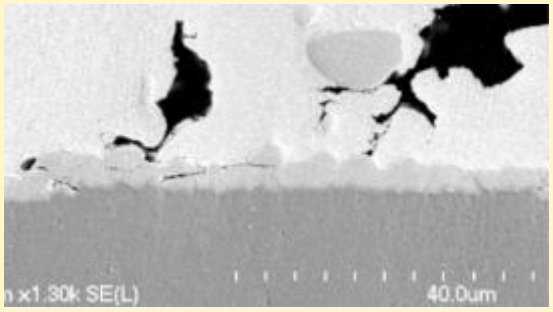
Die Attach Layer Center



SEM DA Layer Center

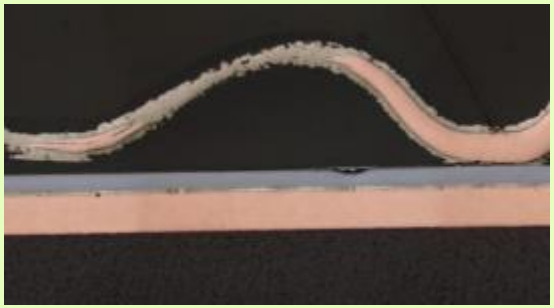


SEM DA Layer Center



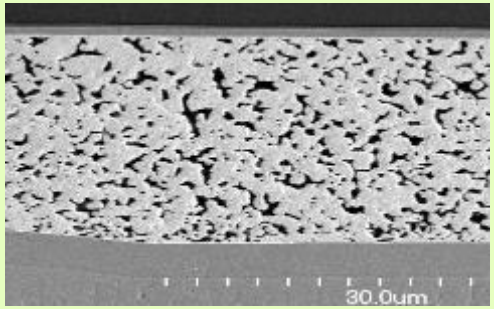
SEM DA Layer Corner

Sintered Modules Bonded using AlCu Wires at 130000 Power Cycles

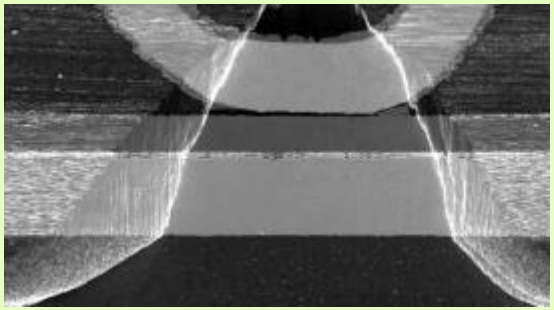


Overview Picture

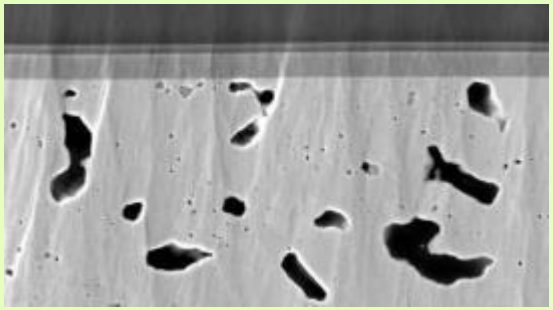
Bond Lift on Chip



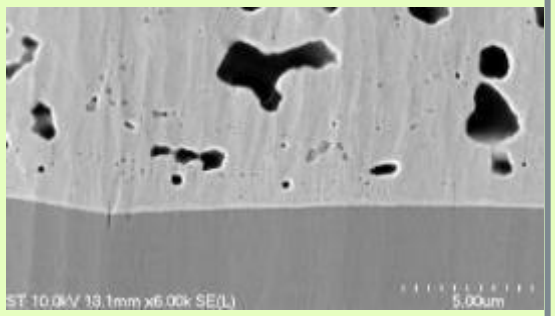
Die Attach Layer



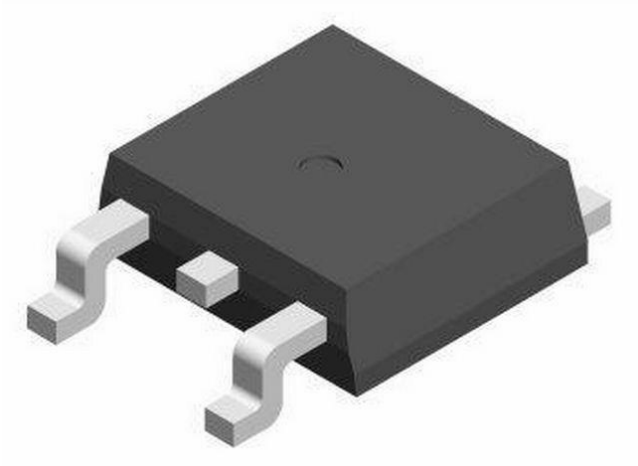
SEM DA Layer Center



SEM DA Layer Corner

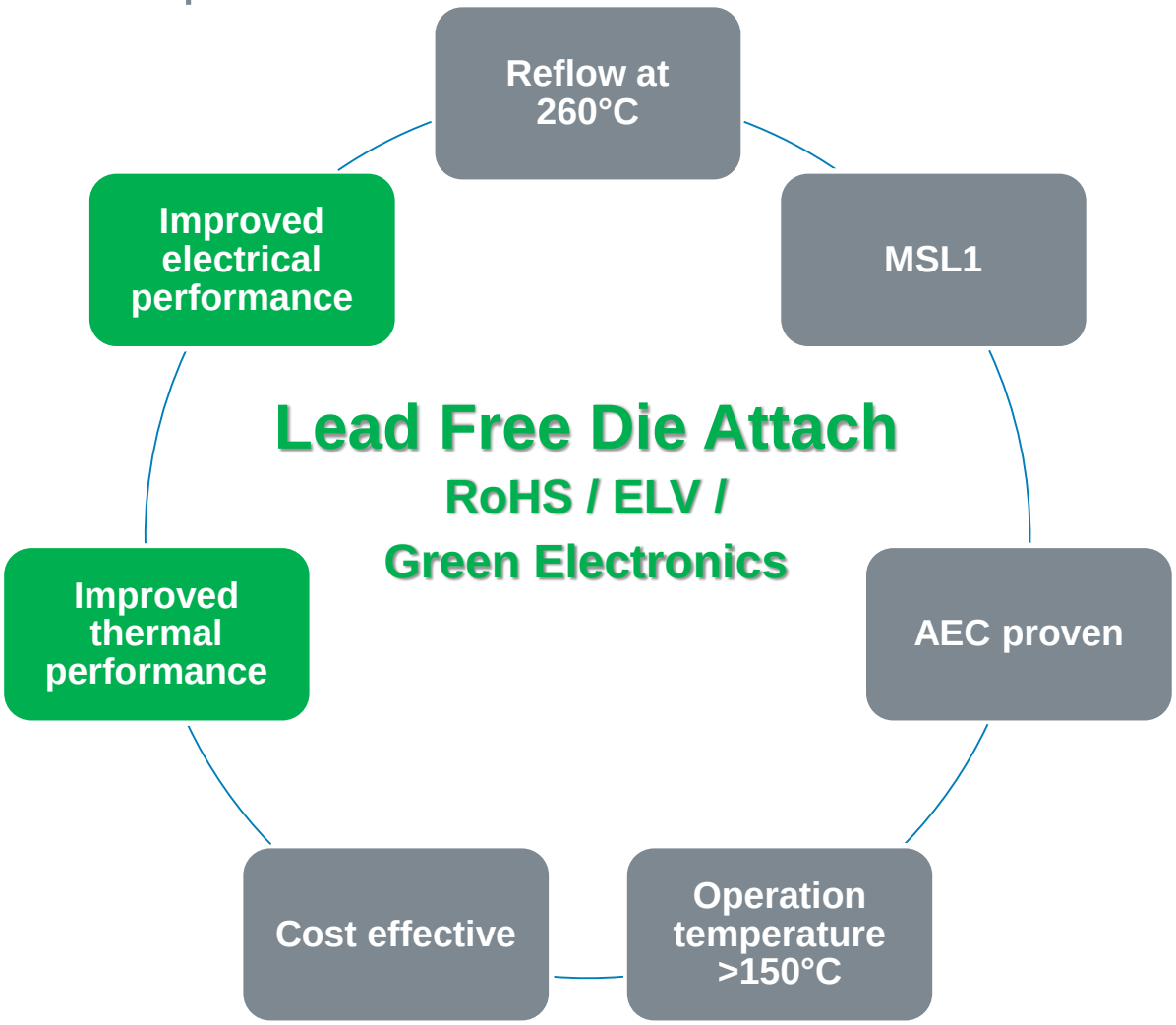


SEM DA Layer Corner



mAgic Sintering Material in Discretes

Sintering as Die Attach Technology
Motivation and Requirements



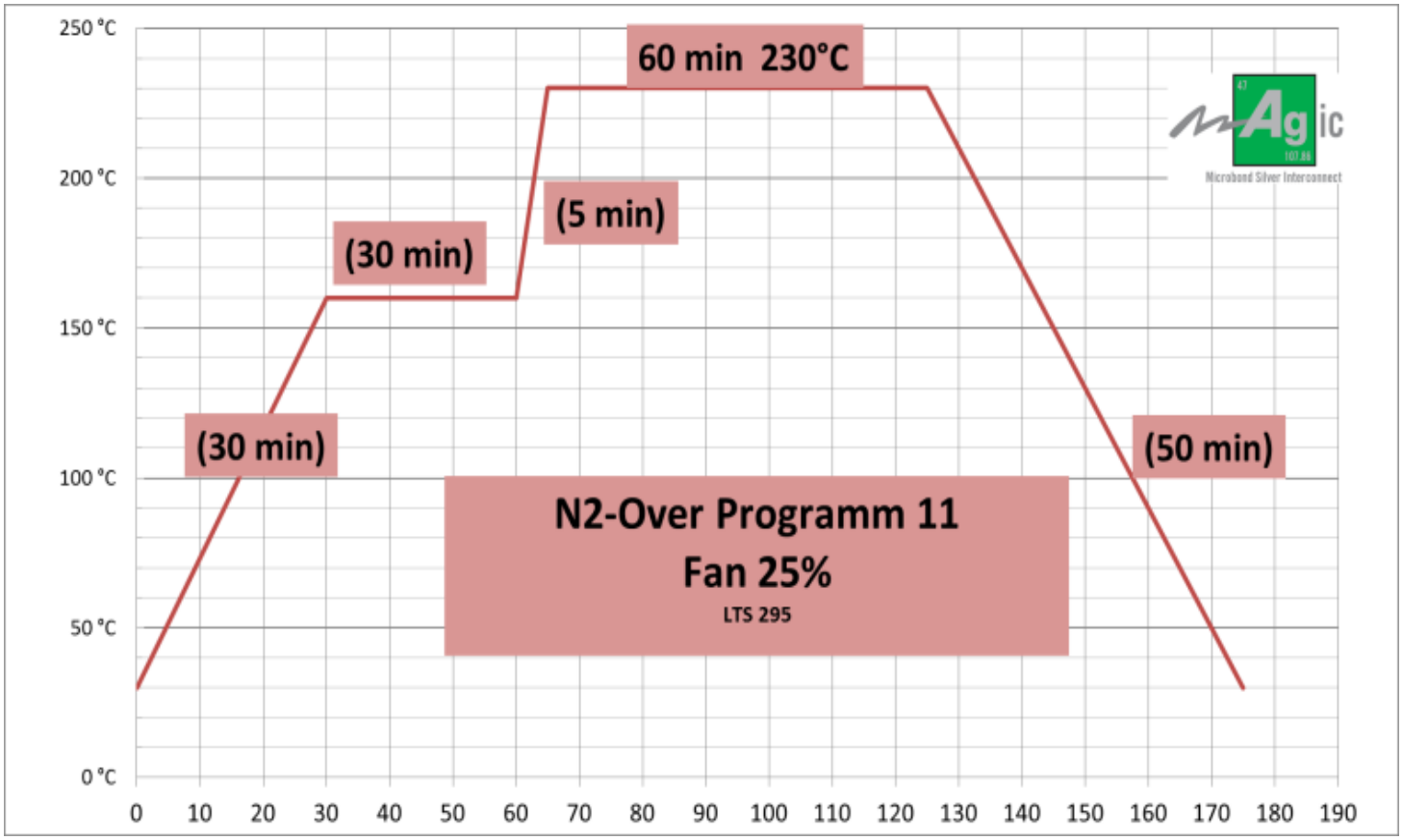
Pressure - Free Sintering Process

Dispensing

Pick & Place

Sintering

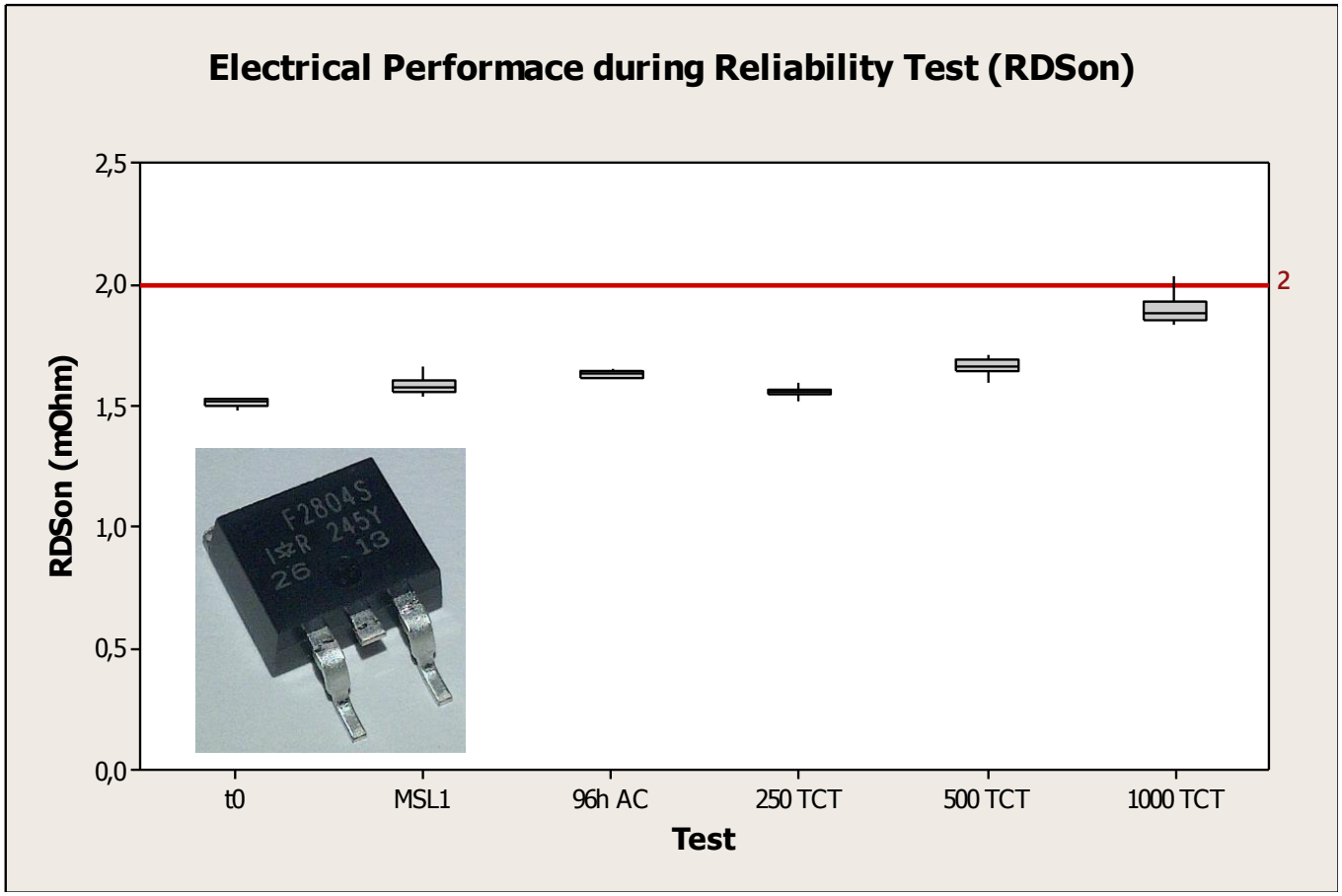
Example of Sintering Profile



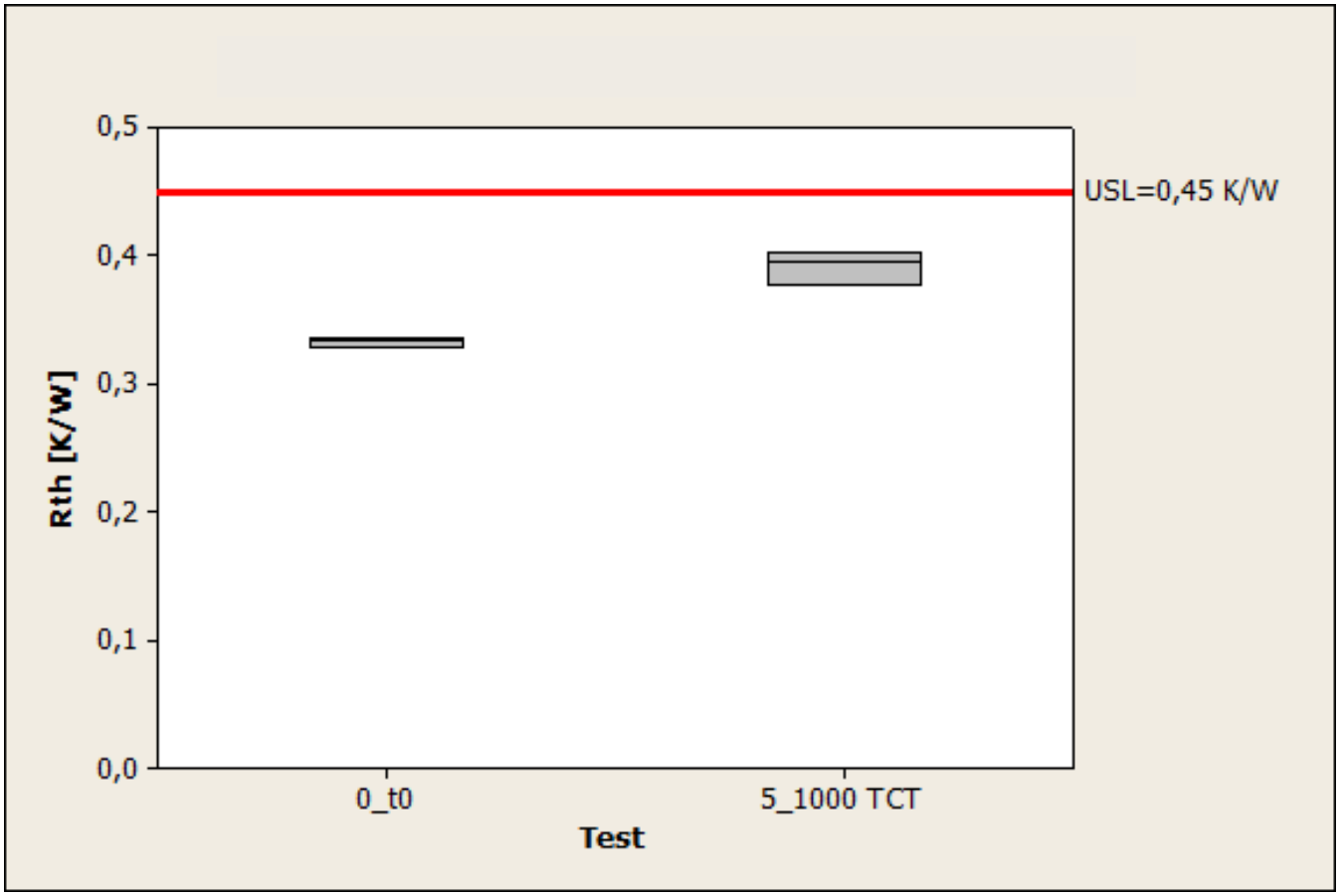
Reliability Test on D2Pak
Setup

- D2Pack Power MOSFET package (automotive part)
  - Die Size is 4.3mm x 6.1mm
  - Paddle size is 8.53 mm x 5.10 mm; Ag Spot Plating for paste
  - Die Attach materials: Sinter Paste ASP295
- Reliability tests performed
  - MSL1 — 3 times reflow after 168h 85/85 storage
  - Auto Clave — 96h @ 121°C, 1 bar and 100% r-h.
  - Temperature Cycle Test — -55/+150°C
- Test methods
  - R_{DSon} measurement
  - Inspection of X-section

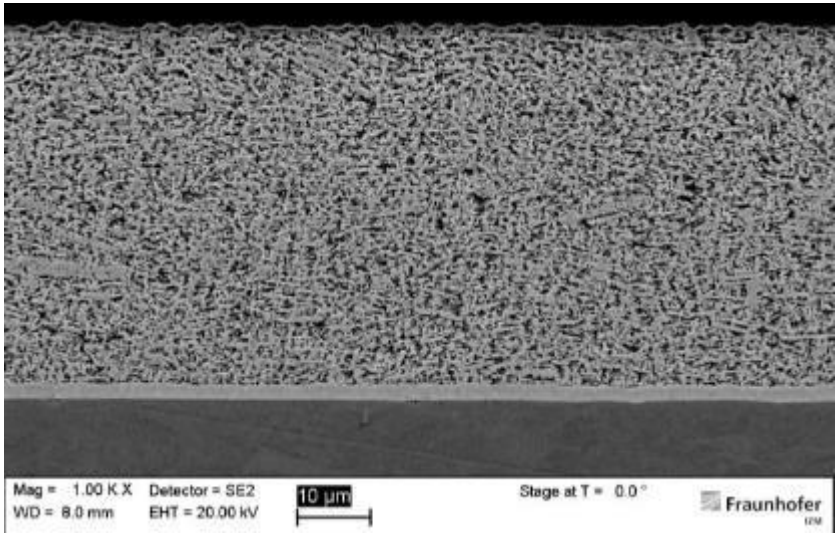
ASP 295 in D2Pak
R_{DSon} Test Result

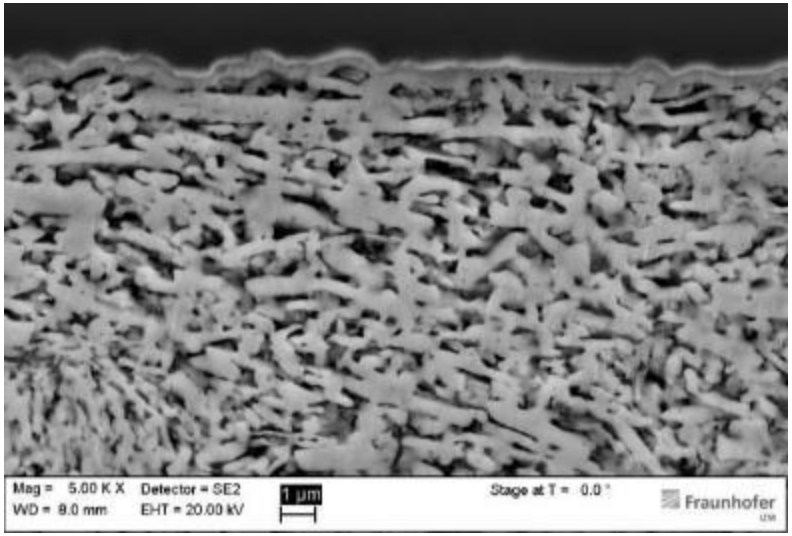


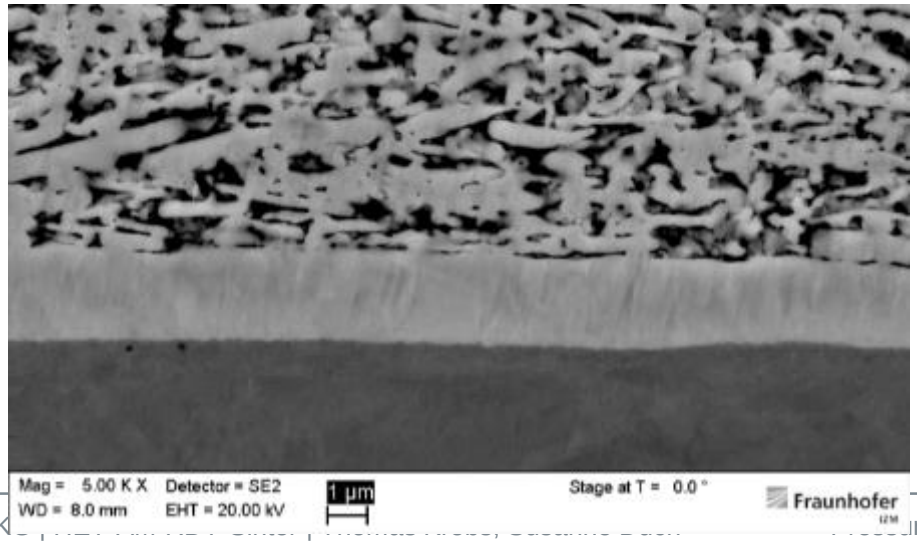
ASP 295 in D2Pak
R_{th} Test Result



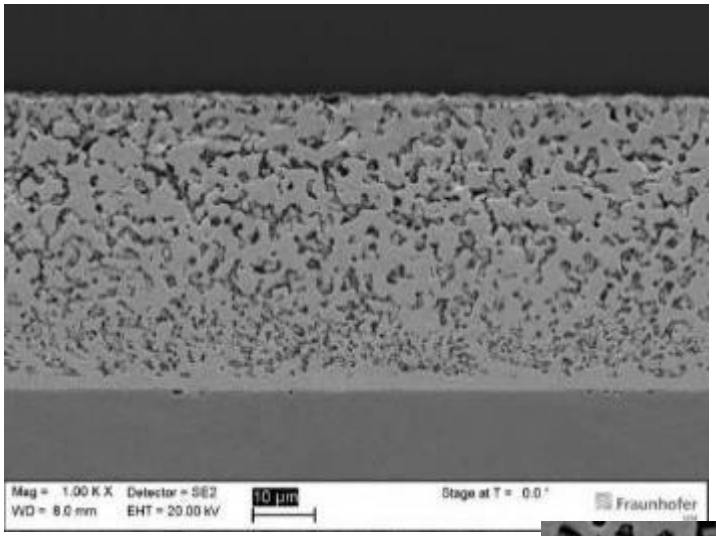
LTS295-01P2 Initial

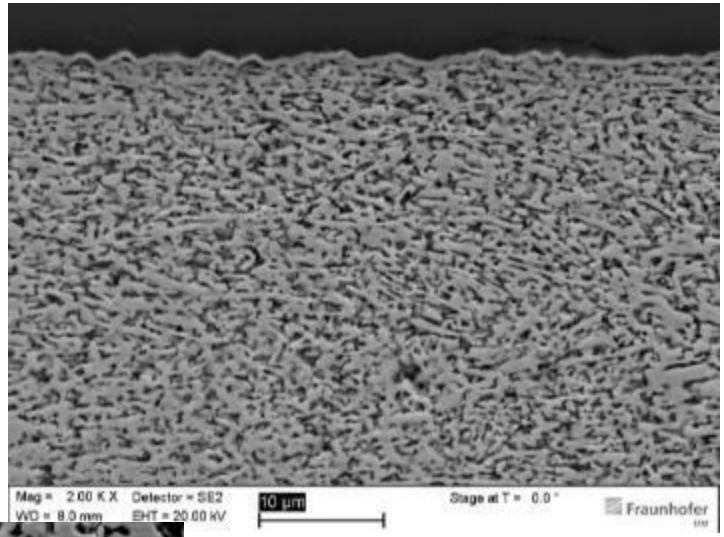


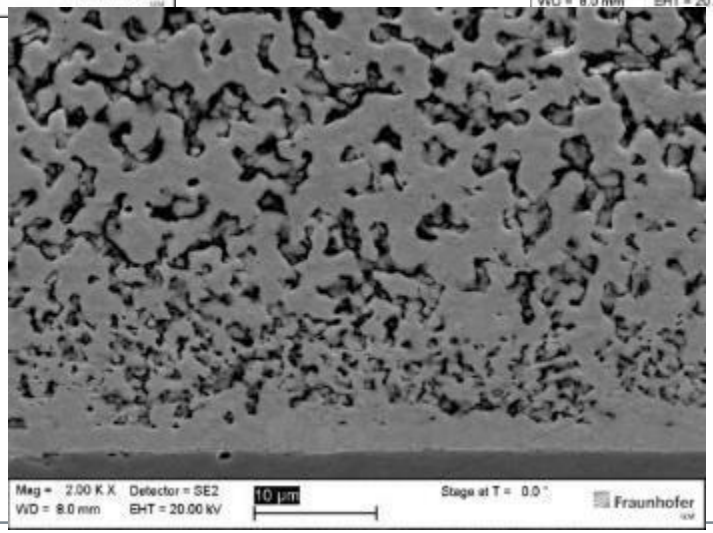


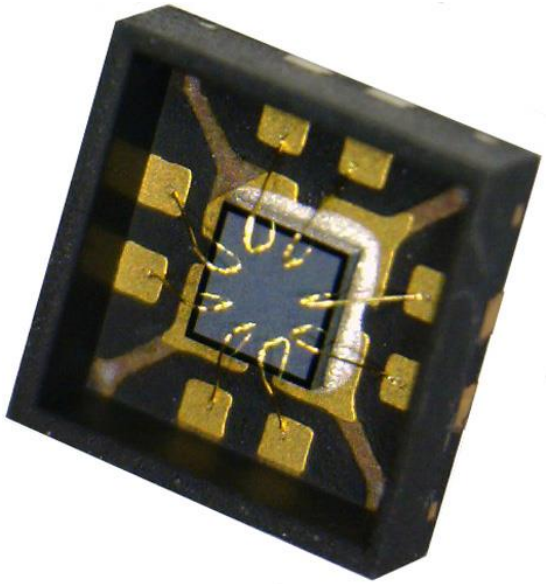


LTS295-01P2 1000 TCT -55/+150°C





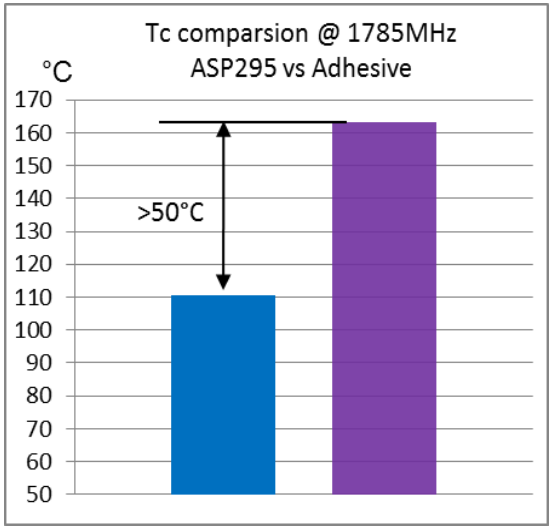


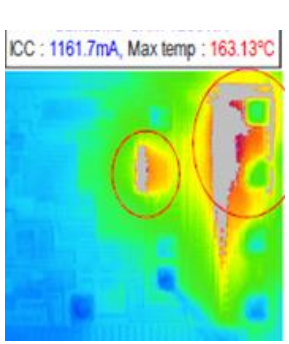


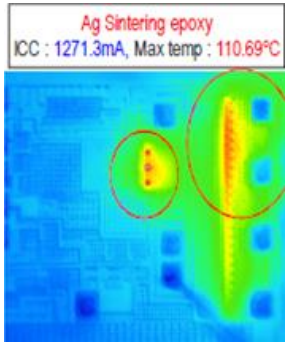
mAgic Sintering Material for Power Amplifier on Organic Substrates

Power Amplifier

- PA Chips generating a lot of heat but getting less efficient if they are getting hotter
- This drives the need for higher thermal conductivity die attach materials
- mAgic sinter paste provides outstanding thermal conductivity between die and substrate
- Improved thermal conductivity of die attach material enable
  - Lower chip temperatures
  - Less power loss and longer battery life
  - Improved performance

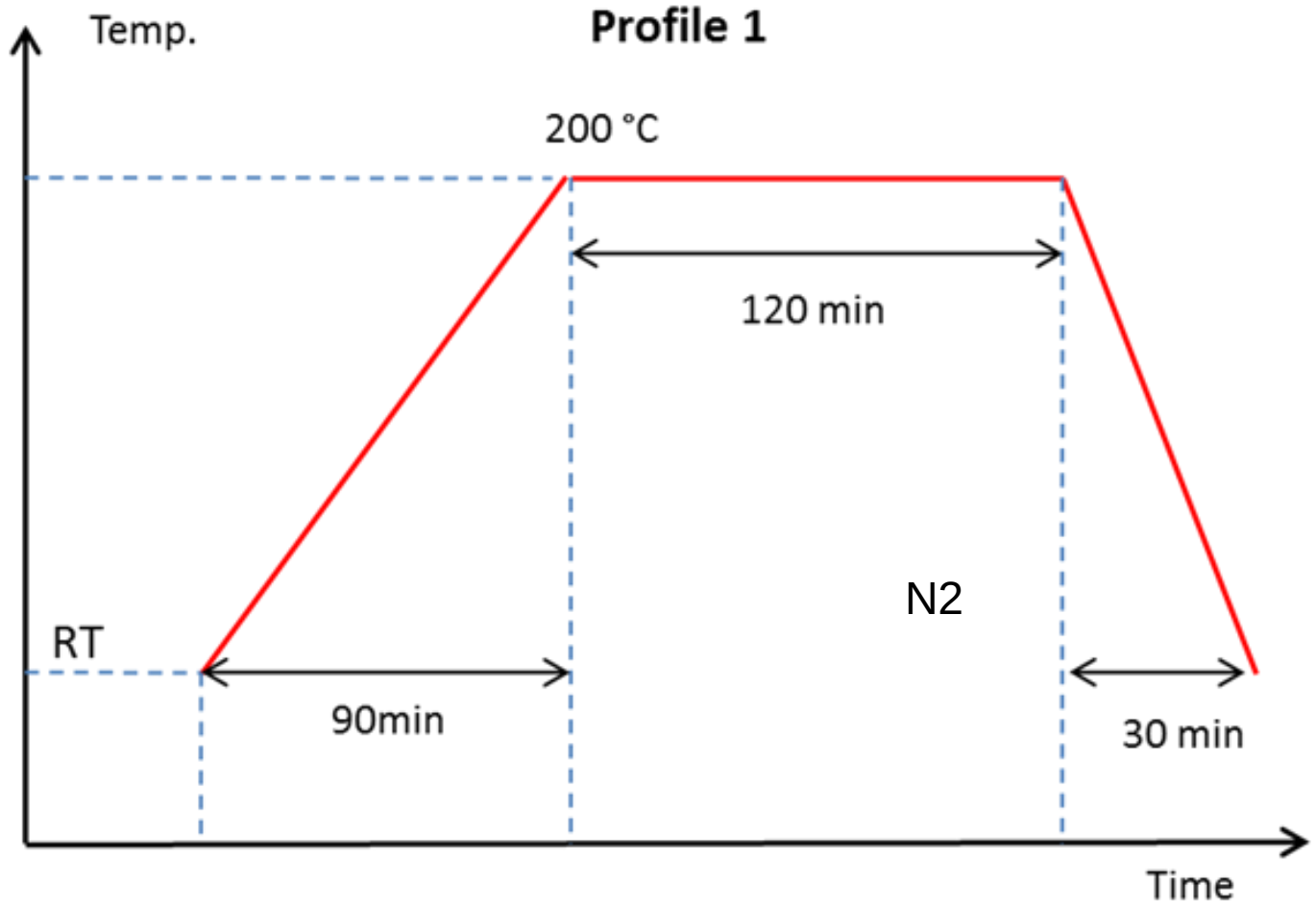






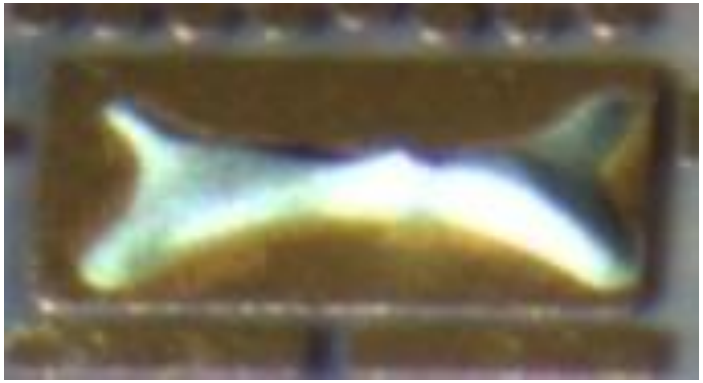
	therm. enhanced Adhesive	ASP 295 (mAgic sinter paste)
Tc @848MHz	153,9	115,61
Tc @1785MHz	163,13	110,69

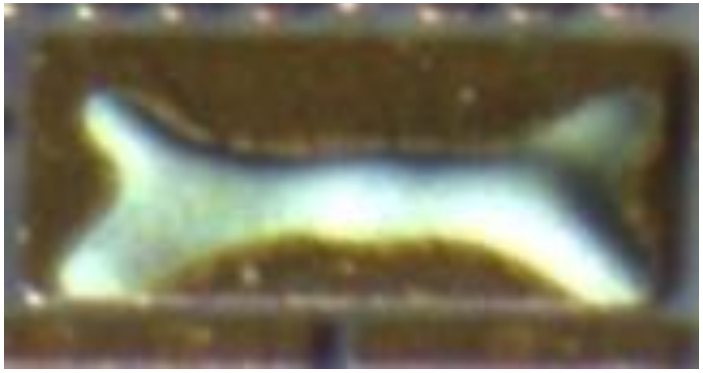
Sinter Profile
Pressure Less Sintering EPS



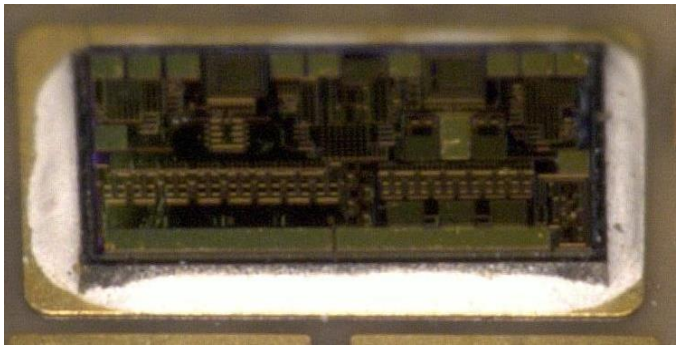
Workability Results

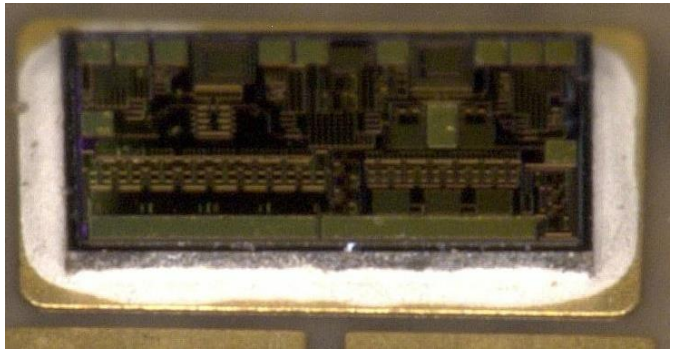
Dispensing



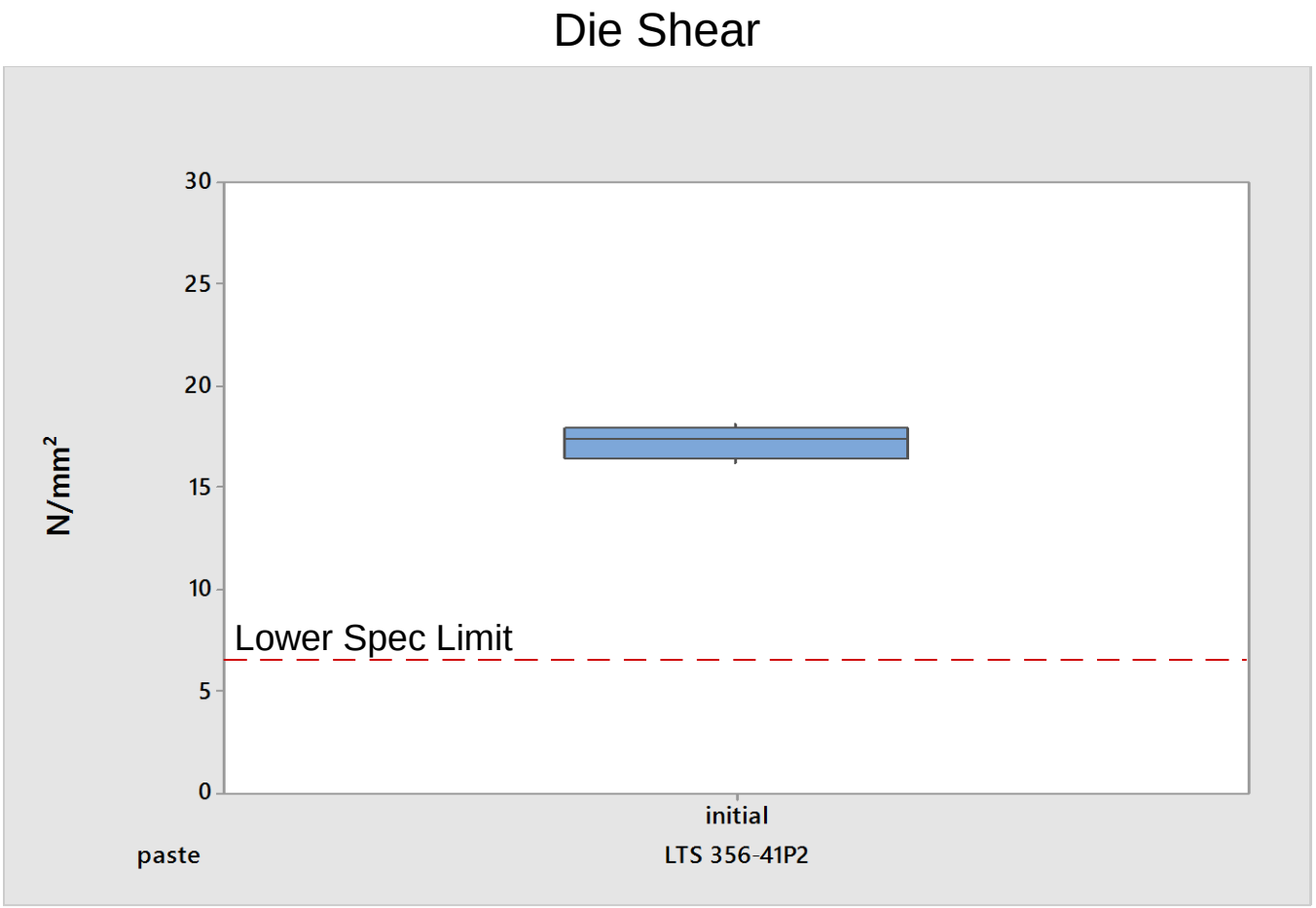


Die Attach





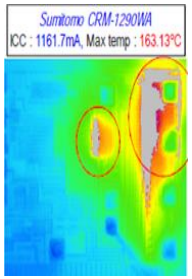
Workability Results

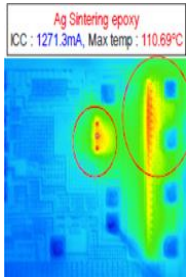


Summary

Summary

- Based on its unique properties and processing silver sintering allows a usage in different applications
- Due to its material performance, thermally, electrically and mechanically it works as enabler and booster if the system is matched
- Compared to solders a makeable increase in life time for of interconnects in power electronics modules will be achieved based on its mechanical stability and thermal conductivity
- For discrete power electronics it can be used as lead free die attach solution, easy in processing and providing the required thermal and mechanical stability for 2nd level interconnect
- In high power density application like power amplifier it allows a further increase of power density or increase in life time due to its exceptional thermal conductivity





Thank You!