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Nano-filled solder paste for highly dissipative power electronic assemblies

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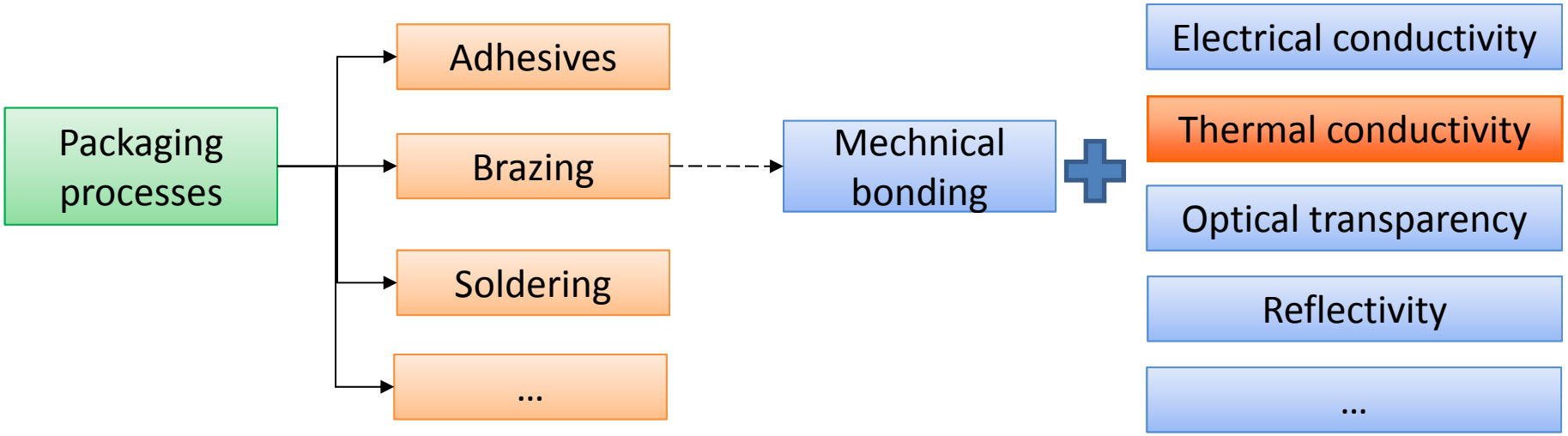
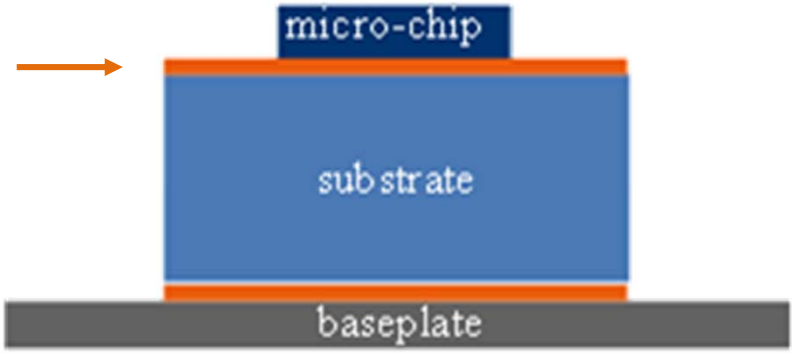
Context: need for new packaging solutions



- Recent development of high power devices: power X 10, up to 180W

AuSn: k=58W/m.K

Filled adhesives: k~1W/m.K



Need:

* thermal conductivity > AuSn

* compatible with hybrid technologies (CTE: 7-10ppm/K, process, etc)

Interest of metals as new brazing materials

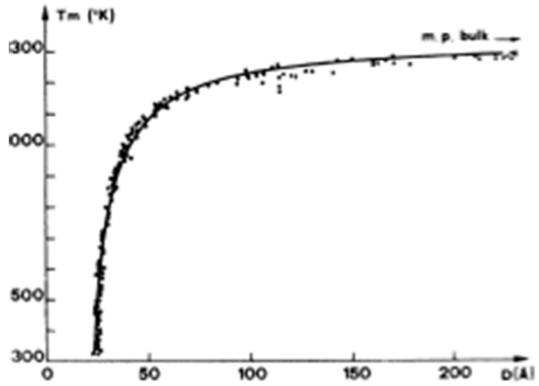
- Possible solutions: Cu, Ag, Au, alloys…

- Silver = best thermal conductor after carbon diamond (thermal conductivity: 429 W/m.K)

- Driving idea: take benefit of the strong decrease of the melting point with particle size

Process:

* short (few minutes)
* low pressure (<10MPa)
* moderate temperature (<300°C)



Ph. Buffat, J.P Borel, Phys. Rev. A 13, 6, (1976) 13.

- Bulk silver (melting point: 961.93°C)

~~incompatible~~

- Silver particles <10nm

compatible

Use of nanoparticles: health and security issues

Use of a new precursor

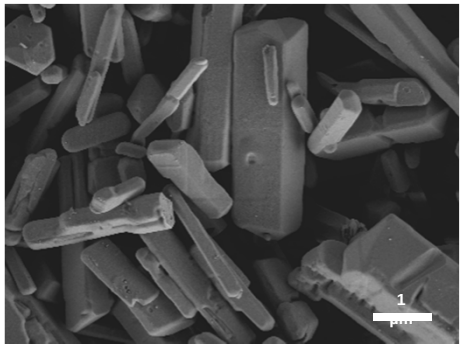
Use of a new precursor

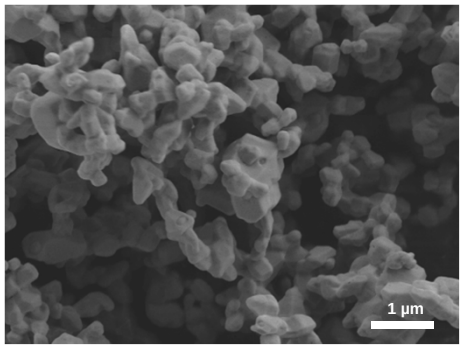
Patent granted

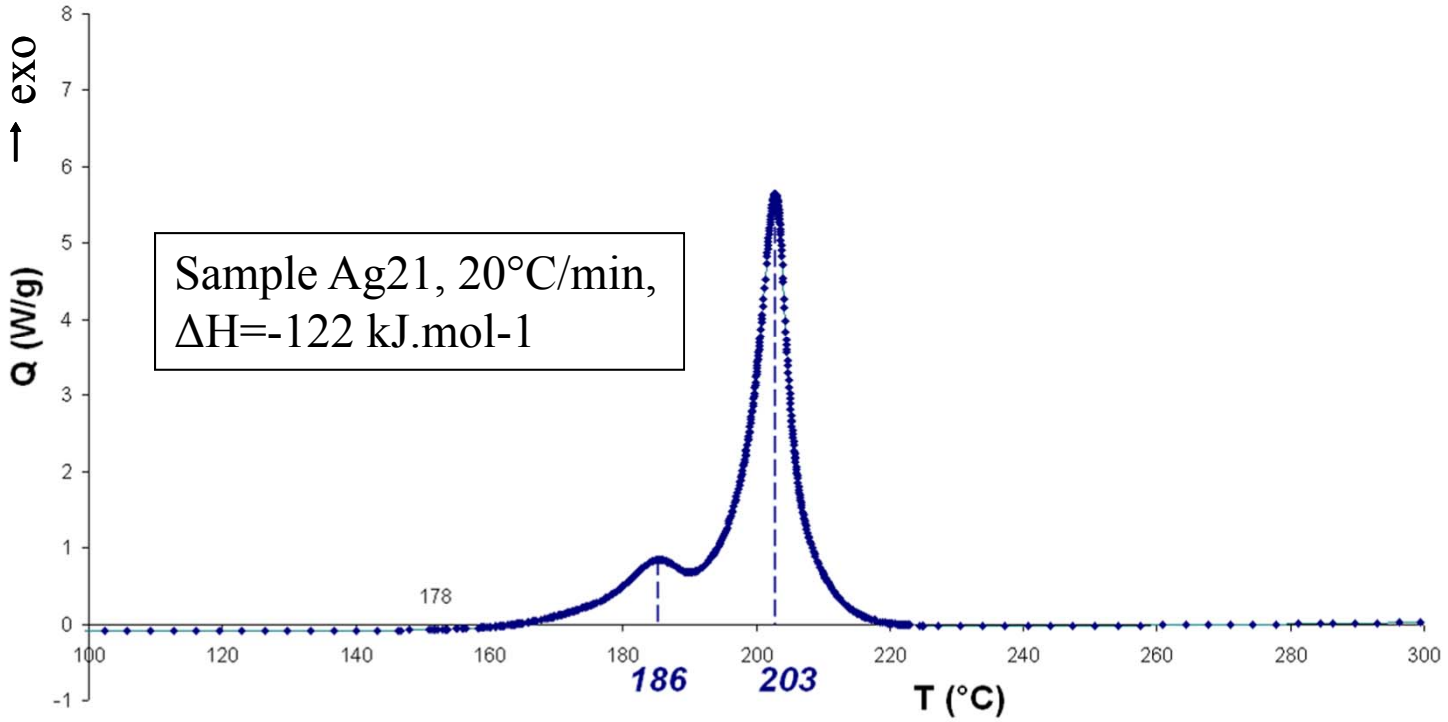
Nano-Ag <10 nm

+

Highly exothermal reaction





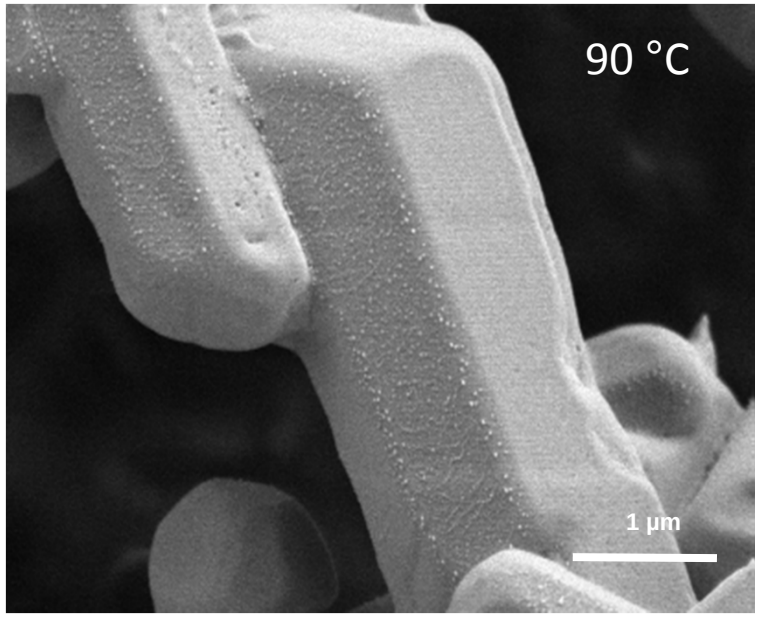


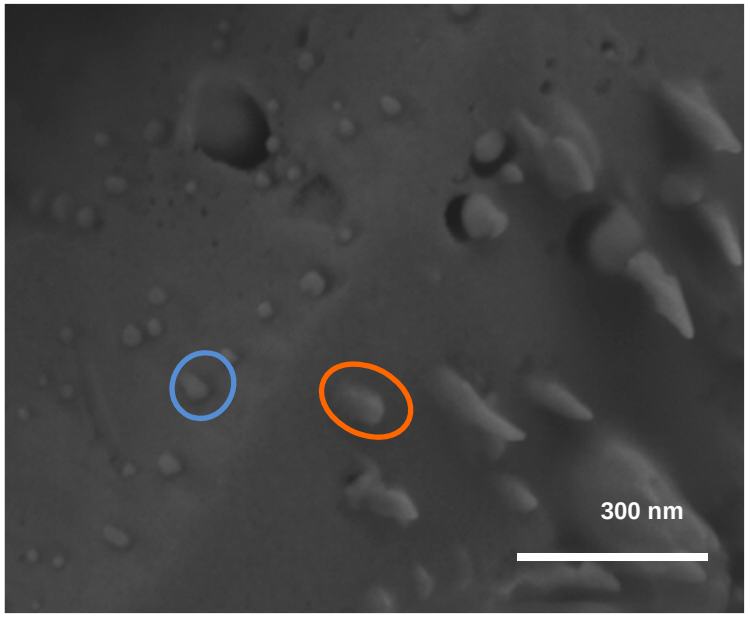
Sample Ag21, 20°C/min,
ΔH=-122 kJ.mol-1

Particle surface transformations: isothermal study

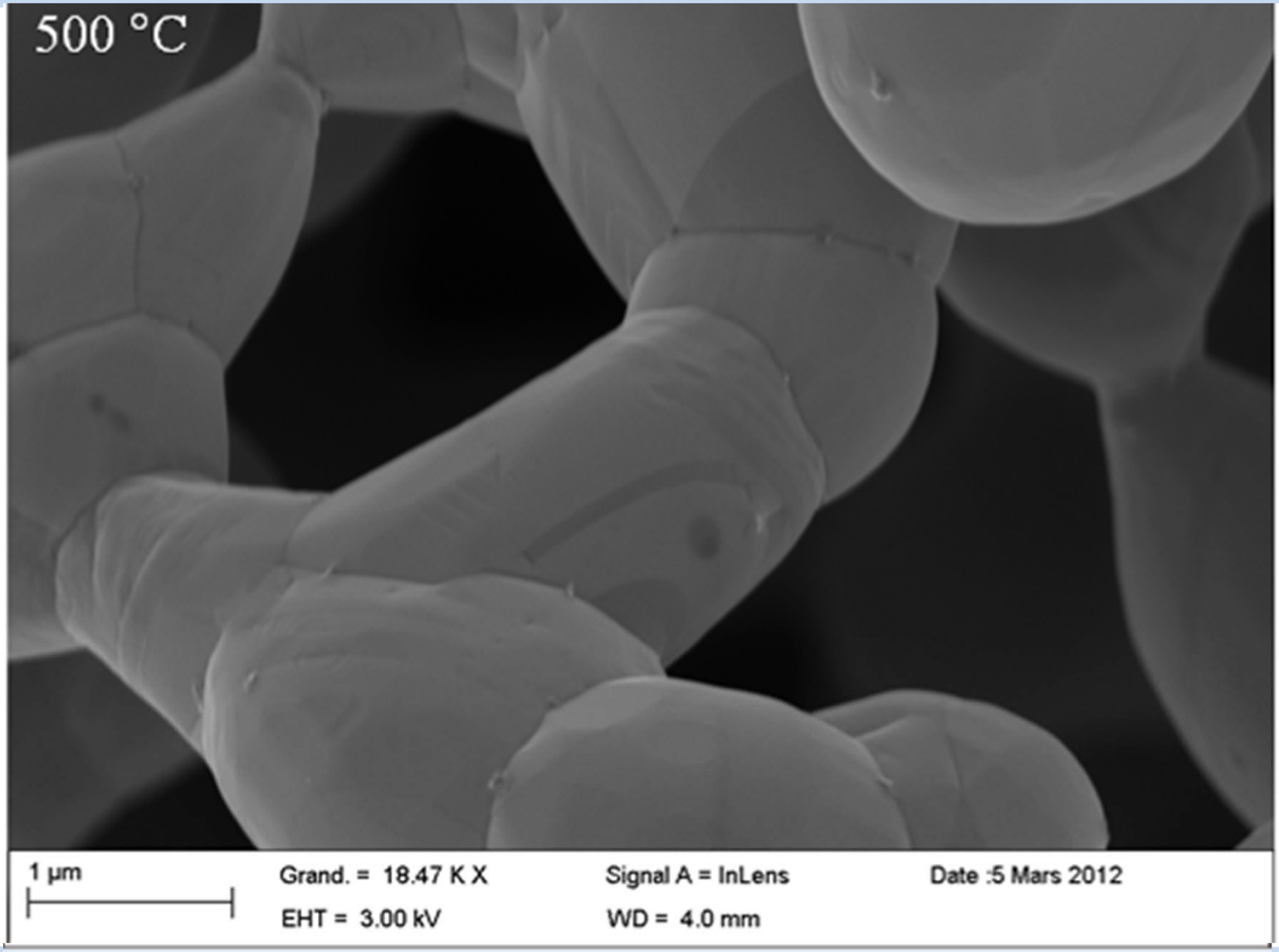
Investigation of the phenomena occurring at the particle surface:

- Decomposition by isothermal holdings (10h) every 10 °C to better separate the exothermal phenomena
- Constant heating rate (5 °C/min)

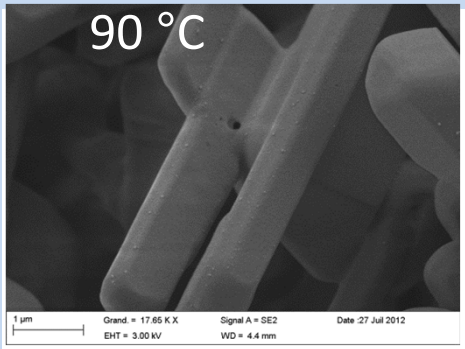


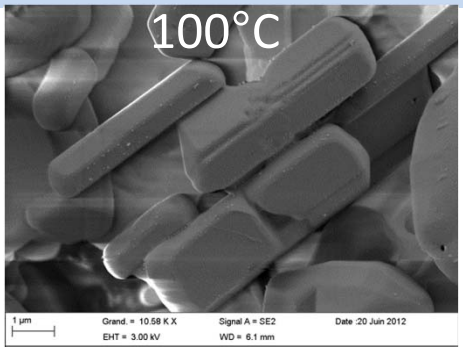


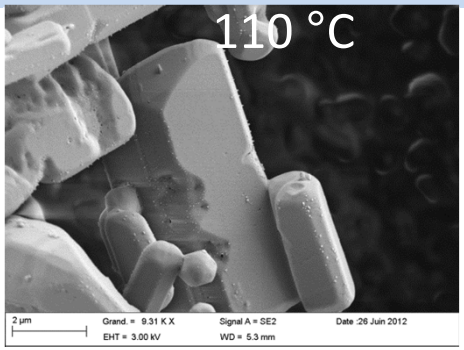
Particle surface transformations: isothermal study

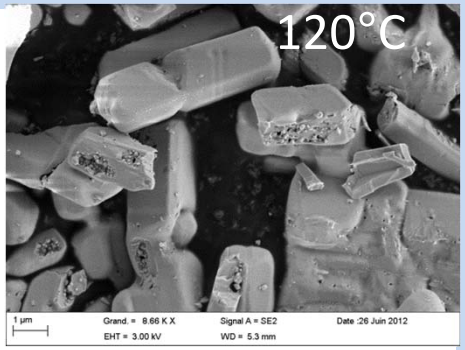


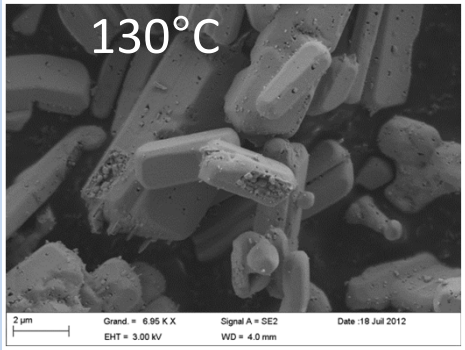
Particle surface transformations: isothermal study

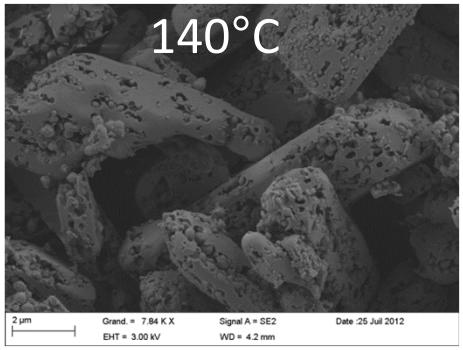


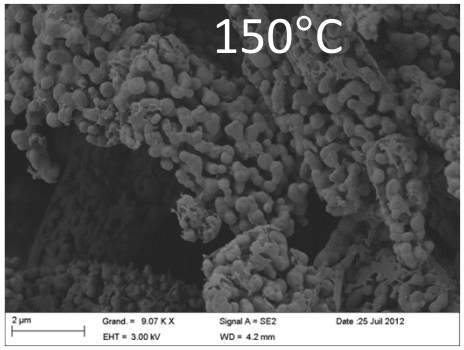


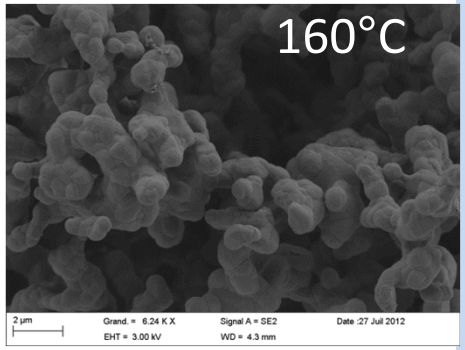


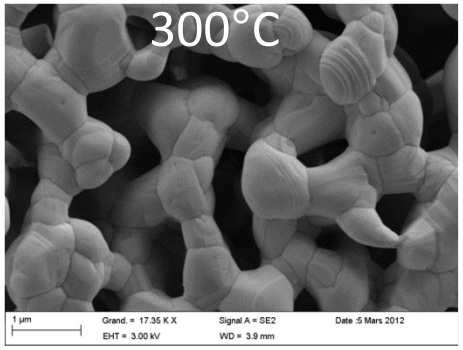


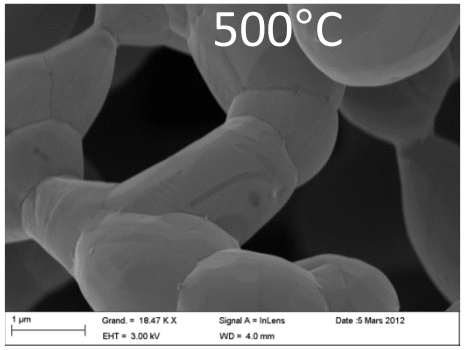


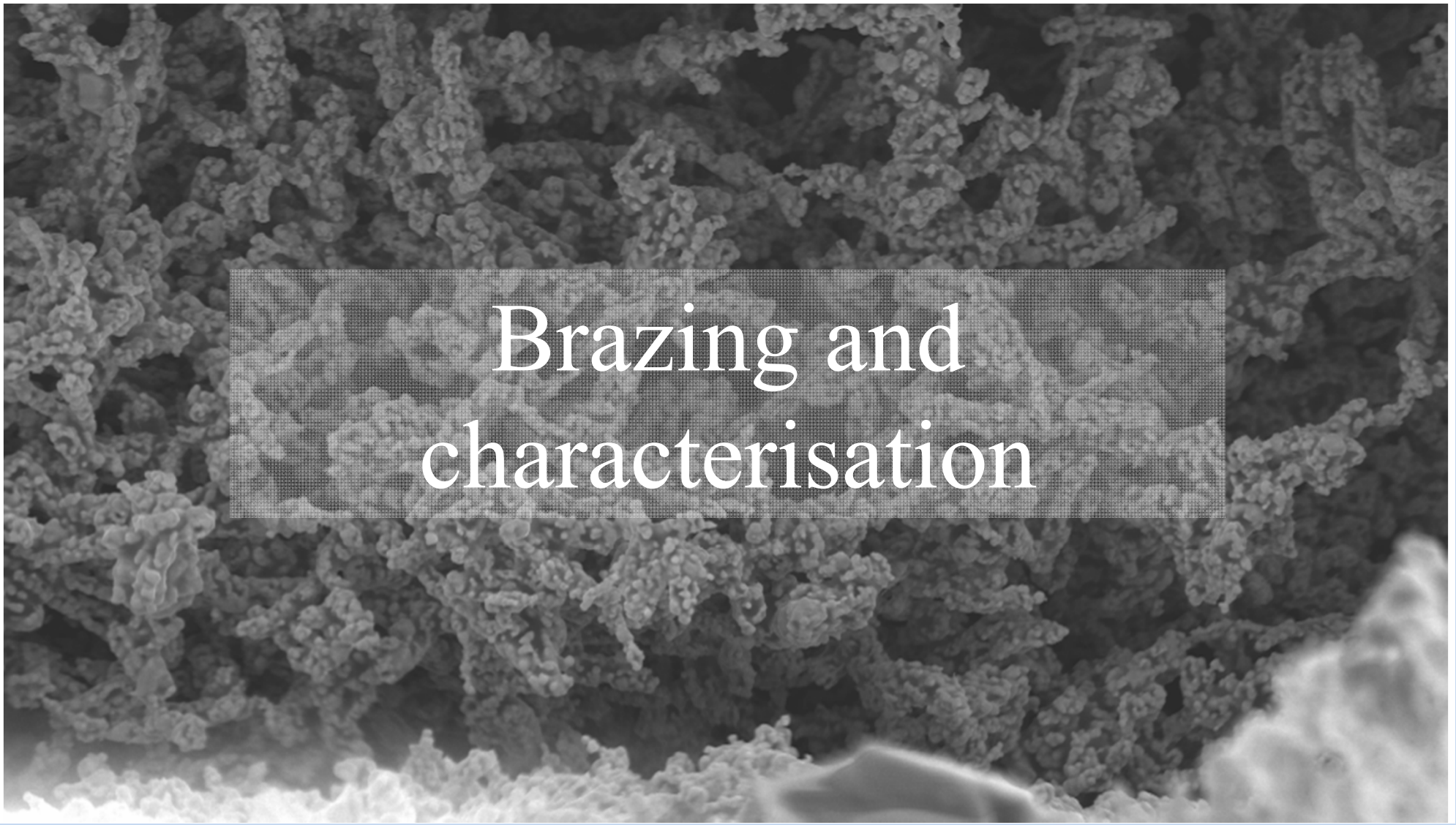






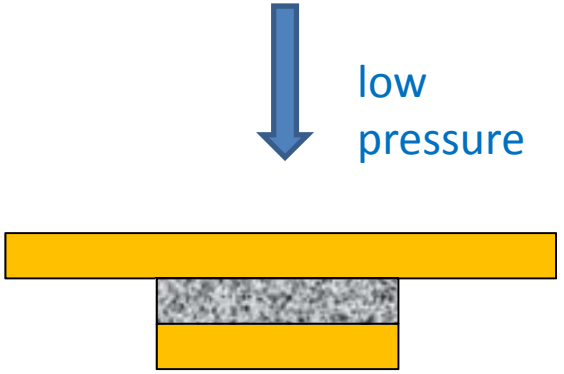


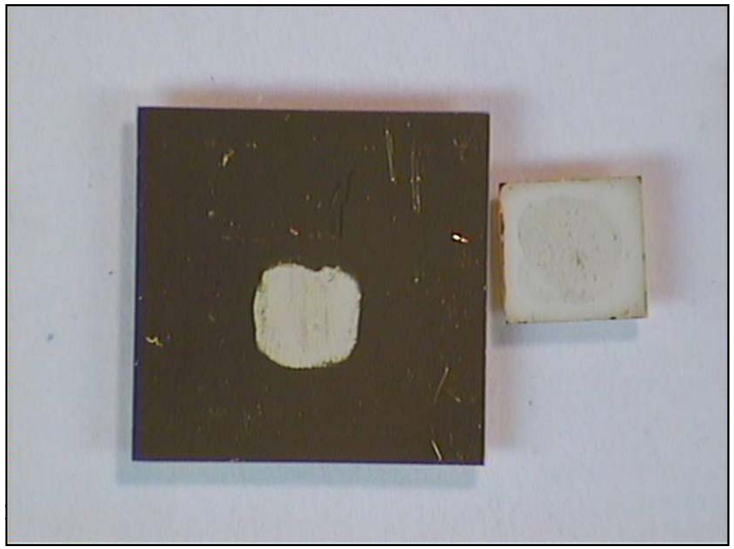



Brazing and
characterisation

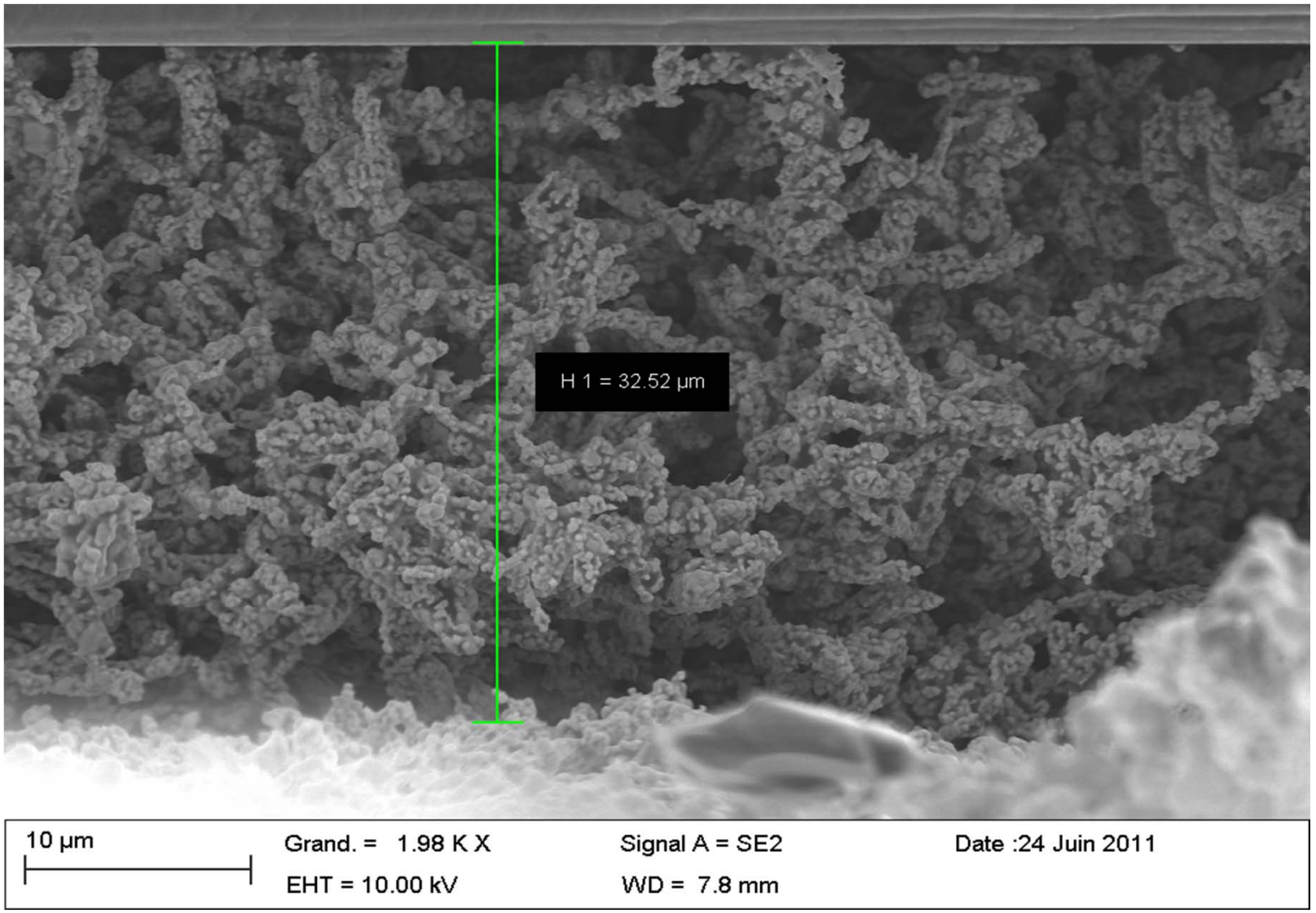
Suspension preparation and brazing process

- Dispersion of the powder in pure ethylene glycol
- Dispense on a 4 x 4 mm^2 alumina substrate
- Drying under primary vacuum to remove the solvent
- Covering with a 10 x 10 mm^2 alumina substrate
- Heating to 300 °C, then cooling at room temperature
- Control by Scaning Accoustic Microscopy (SAM), Scanning Electron Microscopy (SEM) shear tests (MIL Std 883)





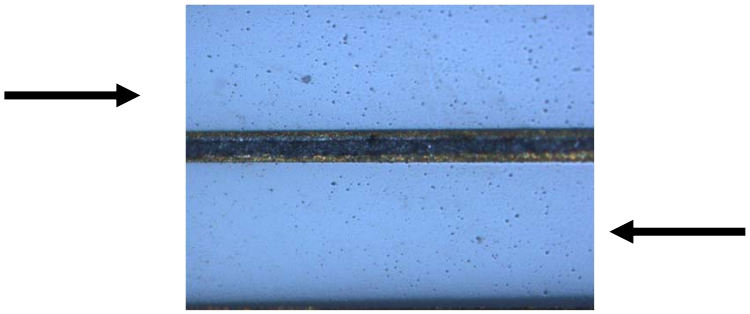
Suspension preparation and brazing process



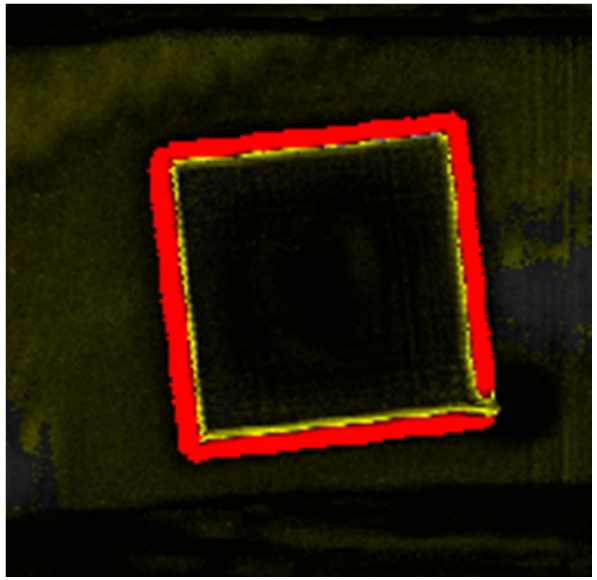
Mechanical joining characterization

- Shear tests:

all the samples meet the minimal requirement of 5 kg shear force



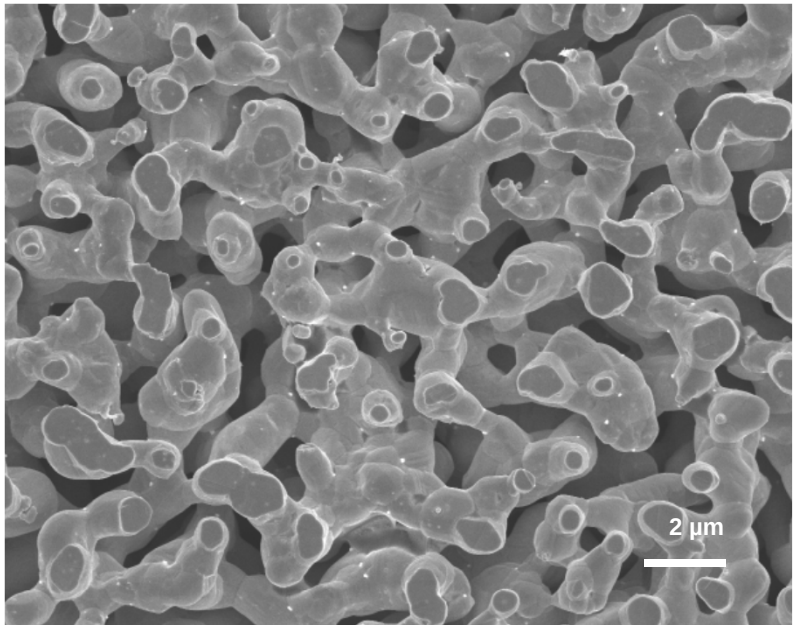
S1	7,5 kg
S2	15,2 kg
S3	5,6 kg
S4	10,9 kg



- SAM characterisation:

homogeneous interface

Porosity estimation

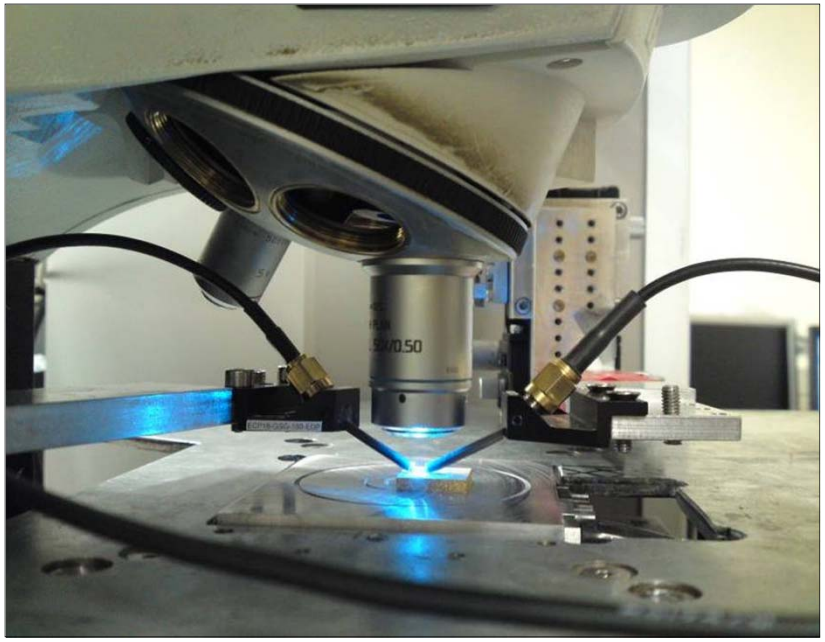


Interface aspect after brazing a glass plate with an alumina substrate. After the sintering the glass was easily removed.

- CO_2 release during the reaction: the sintering can't be complete
- Image analysis → 80 % porosity
- Estimated thermal conductivity: 85 W/m.K

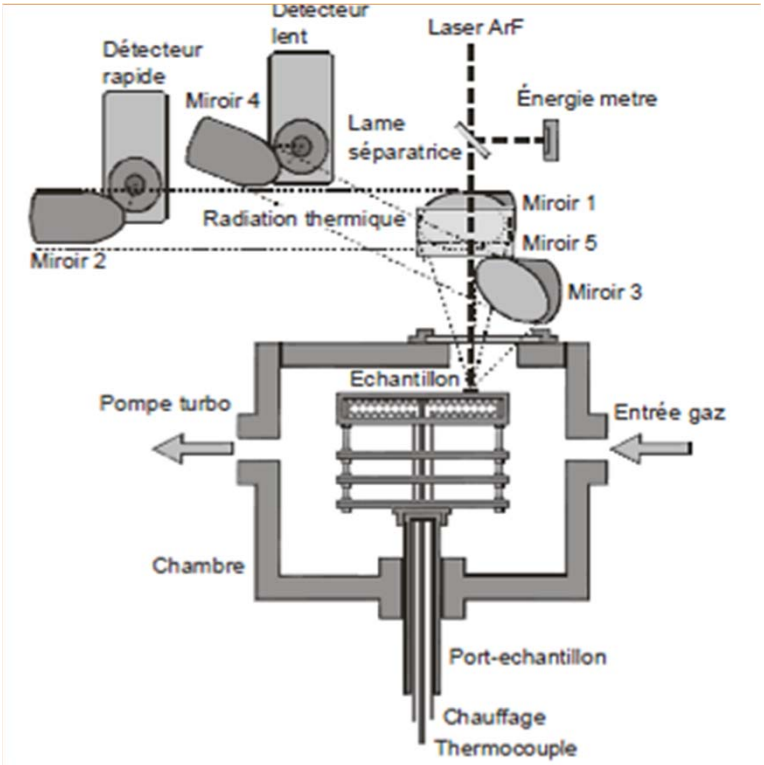
Thermal conductivity measurements

Micro-Raman IR thermography
(active assemblies)



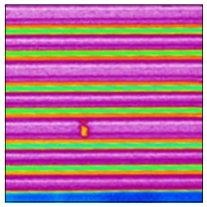
(Center for Device Thermography and Reliability
H. H. Wills Physics Laboratory, University of Bristol)

Impulsional photothermal radiometry
(passive assemblies)



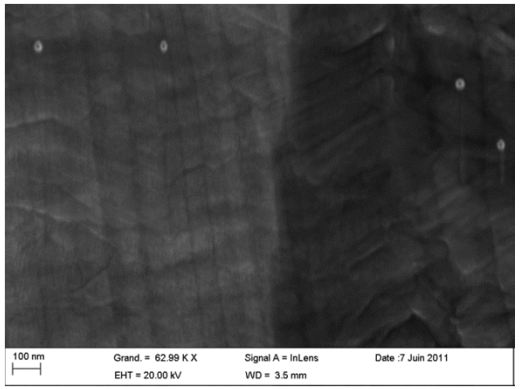
Thermal conductivity measurements

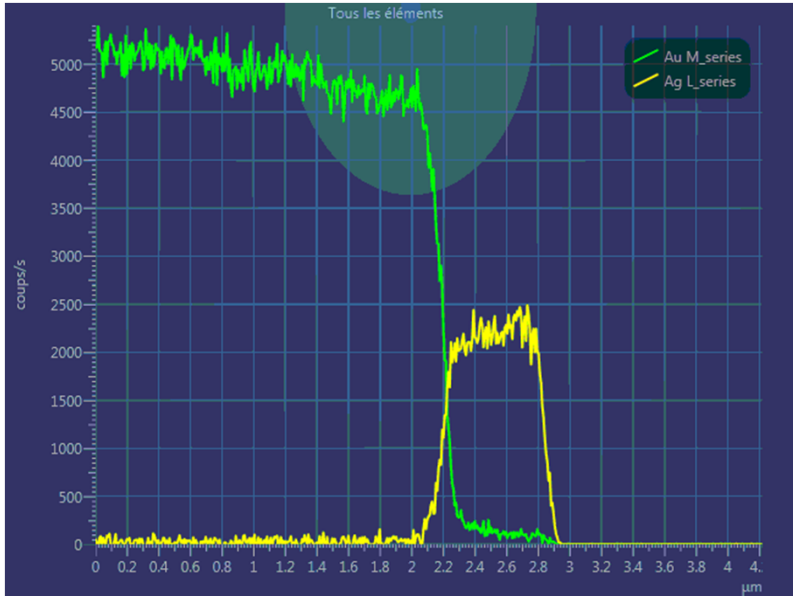
Micro-Raman IR thermography	90 W/m.K
Impulsional photothermal radiometry	Up to 120 W/m.K

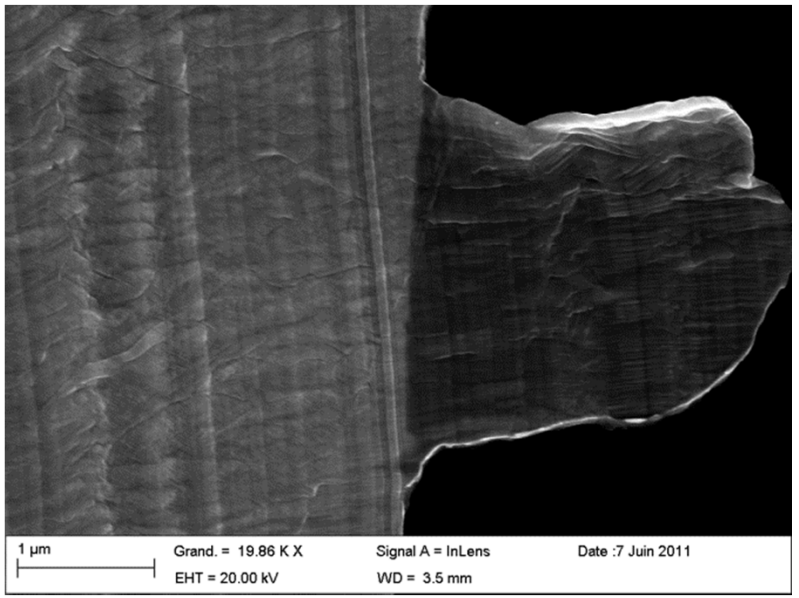


Interface compatibility

- Good metallurgical compatibility with gold-plated surfaces: interdiffusion on 1 µm







Conclusion

- Interest of a new silver precursor as new brazing material for high thermal conductivity electronic interfaces (low pressure, moderate temperature)

- Creation of very reactive small nanoparticles: intermediate step

- Perspective:

compatibility with space requirements, long term performance?

  - mechanical tests
  - temperature storage (125°C)
  - thermal chocks (-55/+125°C)
  - Ag electromigration (under electrical bias)


Thank you for your attention