WEBINAIRE

13 JUIN 11h - 12h

Les poudres fonctionnalisées au service de l'industrie

AU PROGRAMME

> Définition d'une poudre fonctionnelle

> Les domaines d'applications

> Les procédés de fabrication

> Exemples d'applications

> Questions / réponses en direct

ireis

Sébastien Bucher
Responsable R&D

France Innovation

France Innovation (by ASRC) fédère

– Les entreprises innovantes réalisant des prestations de recherche et de développement technologique ;
– Les entreprises proposant des produits, procédés ou services innovants ;
– Les entreprises de type sous traitance industrielle ;
– Les entreprises du conseil et de l'accompagnement de l'innovation, etc.

Dans le cadre de sa plateforme communautaire France Innovation, **investisseurs, collectivités/clusters, etc ou encore organismes de recherche** sont acceptés.

France Innovation

Représentation à double sens

Information Newsletters, Webinaires

Mises en lumière Annuaire, Magazine 360°R&D et réseaux sociaux, Webinaires, etc.

Mises en relation Recherches de compétences, Plateforme communautaire, France Innovation Meetings, etc.

+685 membres avec fiche active

+9 000 inscrits à nos webinaires/an

+28 000 contacts

+2 900 mises en relation

0° R&D
Technologies pour l'industrie
n° 29 TRIMESTRIEL

argeur autonome

France Innovation asrc

360° R&D
Innovations et Technologies pour l'industrie
n° 31 TRIMESTRIEL

L'expertise vibro-acoustique pour fiabiliser des robots industriels

p.6

France Innovation asrc

360° R&D
Innovations et Technologies pour l'industrie
n° 30 TRIMESTRIEL

Les pneus connectés prennent la route

p.6

France Innovation asrc

Vous êtes une entreprise ?

	MEMBRE	MEMBRE PREMIUM	MEMBRE SUPER PREMIUM
Référencer la fiche profil de votre entreprise	✓	✓	✓
Utiliser le logo membre France Innovation	✓	✓	✓
Accepter ou refuser des rendez-vous de membres	✓	✓	✓
Solliciter des rendez-vous aux autres membres	✗	✓	✓
Diffuser des recherches de compétences	✓	✓	✓
Répondre à des recherches de compétences	✗	✓	✓
Participer à des webinaires	✓	✓	✓
Organiser un webinaire	✗	✗	✓
Diffuser du contenu	✗	✗	✓
Tarifs préférentiels sur des évènements partenaires	✗	✓	✓

Au service des entreprises innovantes.

France Innovation est une association professionnelle qui fédère **les prestataires privés de recherche et de développement technologique**, les **entreprises** proposant des **produits, procédés ou services innovants** et les acteurs du **conseil et de l'accompagnement en innovation**.

Vous recherchez une expertise R&D&I ?

Parcourez l'annuaire des membres ou contactez-nous.

Trouver une expertise

CHIFFRES CLÉS

400 membres

+ de 600 mises en relation par an

UN RÉSEAU NATIONAL

- Porter **une vision commune** (prise de position sur le **Crédit Impôt Recherche**, le Transfert de technologies, le financement des projets nationaux et européens, etc.)

Vous souhaitez valoriser votre savoir-faire ?

Rejoignez France Innovation

Comment adhérer ?

France Innovation

LA PLATEFORME COMMUNAUTAIRE

au service des entreprises innovantes

- ✓ **Mots clés**
- ✓ **Structure**
- ✓ **Compétences & Expertises**

Sélectionner

- ✓ **Domaines d'application**
- ✓ **Localisation**

num dpt, ville

Triez par pertinence ou par ordre alphabétique

(622) **TRIER PAR** A - Z **Derniers inscrits**

BA Group

BA Group, expert de la conception et de la fabrication de systèmes robotiques et mécatroniques complexes et programmables pour..

https://www.batechgroup.com/

Voir plus

DEMANDER UN RDV

PME

LMAD

Les robots, véhicules autonomes arrivent pour remplacer, augmenter les métiers manuels et humains en gérant les taches ...

http://www.lmad.eu

Voir plus

DEMANDER UN RDV

PME

AERO CONCEPT ACE ENGINEERING

Experts en aérodynamique, mécanique des fluides et thermique nous proposons des études en soufflerie (2,05x2,3m de section e...

http://www.aero-ce.com

Voir plus

DEMANDER UN RDV

PME

CLHYNN PILE HYDROGÈNE

CLHYNN propose une technologie de pile à hydrogène vert disruptive , qui va accelérer la transition énergétique dans la...

http://www.clhynn.com

Voir plus

DEMANDER UN RDV

DIAMFAB

Diamfab est une start-up spécialisée dans la fabrication de diamant pour des applications d'électronique de puissance et...

https://diamfab.com/fr/

Voir plus

DEMANDER UN RDV

PISEO photonics.innovation.services

Piséo est une plateforme d'innovation spécialisée en optique photonique. Equipé d'un part de son propre laboratoire COFRAC,..

http://piseo.fr

Voir plus

DEMANDER UN RDV

France Innovation

MEETINGS

Les RDV d'affaires des entreprises innovantes

Les participants 2023 :

93% ont identifié de nouveaux partenaires
92% envisagent de participer à nouveau

www.france-innovation-meetings.fr

FRANCE INNOVATION MEETINGS 2024 : 5 CONVENTIONS D'AFFAIRES 100% EN LIGNE

www.france-innovation-meetings.fr

Attention, de nouveaux webinaires peuvent venir s'intercaler entre les dates ci-dessous.

https://www.france-innovation.fr/webinaire/

20 juin	Valoriser la PI lors d'une levée de fonds (HAUTIER IP)
27 juin	L'Accélérateur EIC Horizon Europe : jusqu'à 17,5M€ (Focus étape 2-full application)
27 juin	CIR/CII : Conclusions de l'enquête de la DGE (Bercy)
10 sept	L'Accélérateur EIC Horizon Europe : jusqu'à 17,5M€ (Focus étape 2-full application)
03 oct	Software, IA : quelle protection par brevet ? (HAUTIER IP)
14 oct	L'Accélérateur EIC Horizon Europe : jusqu'à 17,5M€ (Focus étape 1-short application)
17 oct	La texturation et la découpe par laser ultra court, au service de l'industrie (IREIS)

**En cours de programmation* | *AAP Décarbonation dans l'industrie France 2030 (ADEME)*

www.france-innovation.fr

contact@france-innovation.fr

https://www.linkedin.com/in/france-innovation-67607a166/

https://twitter.com/Fr_Innovation

France Innovation

ireis

institut de recherches
en ingénierie des surfaces

HEF® GROUPE

Surface materials engineering

Functionalized powders & applications

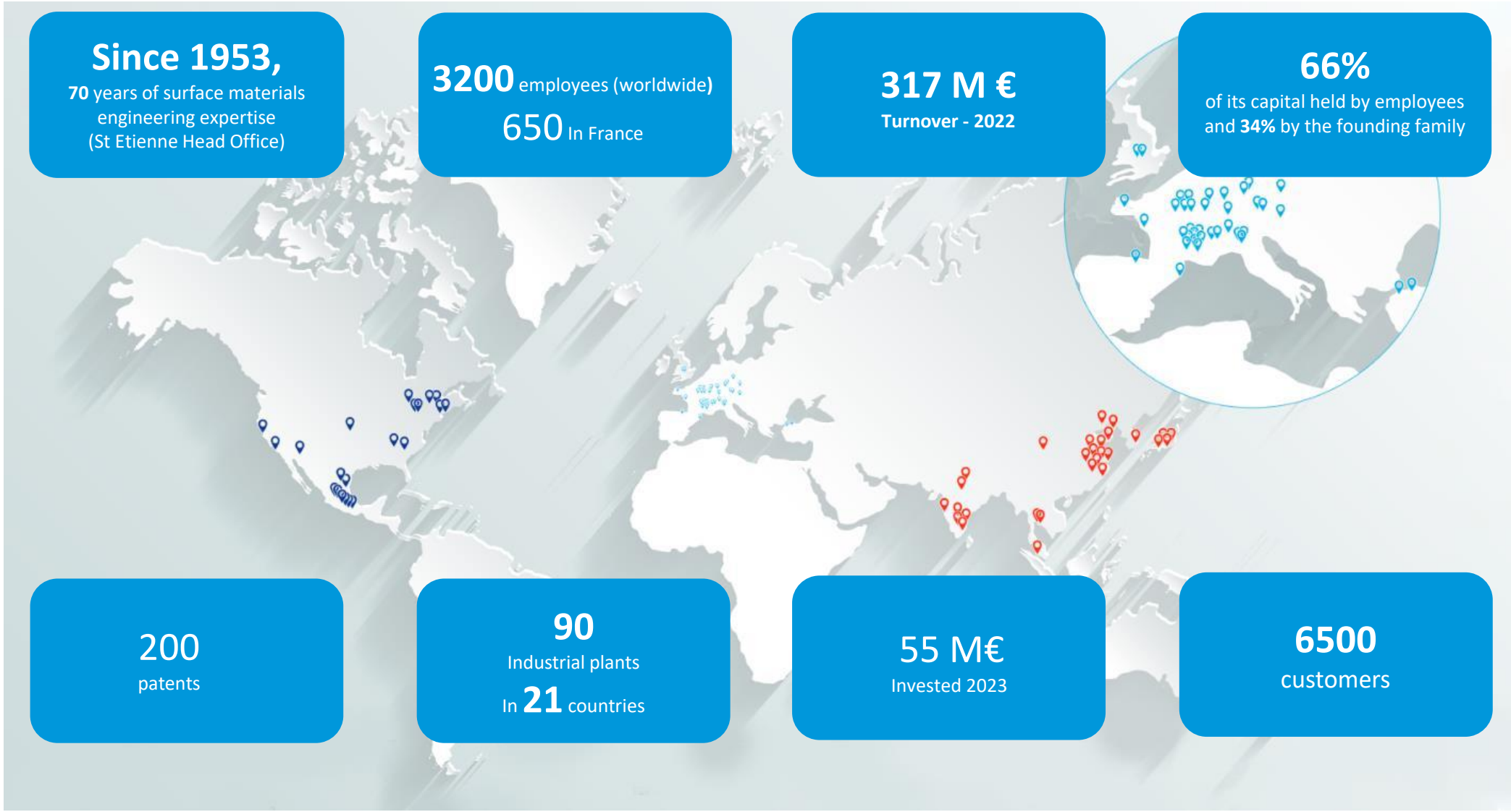
Webinaire– June 2024

Sébastien BUCHER

OUTLINES

- Presentation of the HEF group
- Production and use of Fonctionalized powders
- The Superball project: Production of innovative Solder Balls

HEF in Figures



5 key technologies for developing surface materials

THERMOCHEMISTRY

World leader in ionic liquid nitriding.

PVD - PECVD

World leader in carbon-based tribological deposits.

FRICTION COMPONENTS

Specialty player for severe environments.

FEMTOSECOND LASERS

This technology enables cutting, etching on a micron scale and the functionalisation of all materials surfaces.

FUNCTIONALIZED POWDERS

Our technologies enable the manufacture of multi-material functionalised powders.

3 areas of surface materials engineering

TRIBOLOGY

Understanding and mastering of friction and wear mechanisms.

PHOTONICS

Understanding and control of surfaces, interfaces and optical components.

HYDROGEN TECHNOLOGIES

Understanding of the surface phenomena related to the electrolysis/fuel cell and hydrogen engine

HEF® GROUPE

The group’s key areas of activity

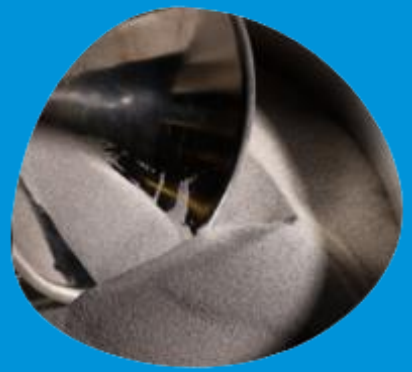
CONSTRUCTION

MOBILITY

MEDICAL

AEROSPACE & DEFENSE

GREEN ENERGIES



FUNCTIONALIZED POWDERS

Our technologies enable the manufacture of multi-material functionalised powders.

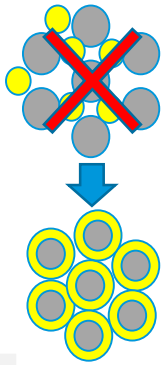
Developing solid materials (3D printing) or coating (thermal, electrical properties), etc.

- General description of functionalized powders
- Production processes and fields of applications
- Example of applications

HEF® GROUPE

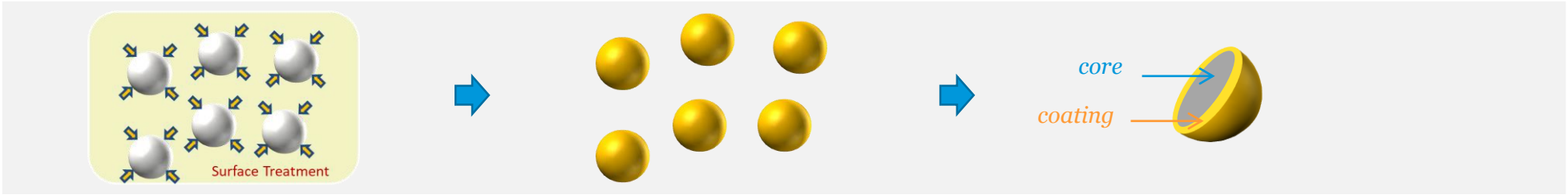
FUNCTIONALIZED POWDERS

General description



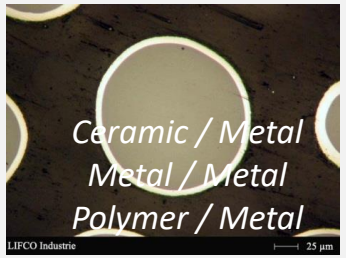
Functionalized powders are multimaterials powders produced by surfaces modifications of commercial powders to improve their properties. This core/shell powder design deliver number of benefits compared to standard powders for many applications:

- ✓ Efficient alternative to blended powders
- ✓ Add tunable surface properties like hardness, lubrication, conductivity, diffusion barrier, corrosion resistance or even wettability

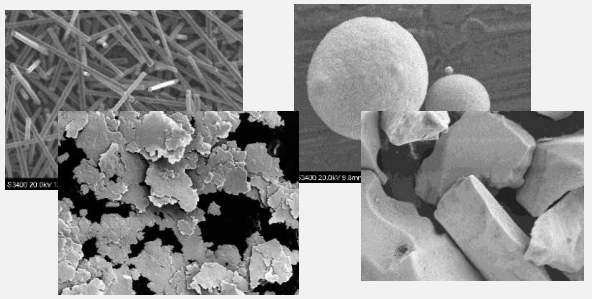


HEF is able to produce multi-core/coatings design at the particle scale with control over the size and morphology of the grains.

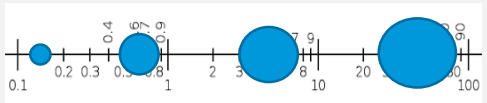
Multi core/coating design



Any kind of morphology



Wide range of grain size

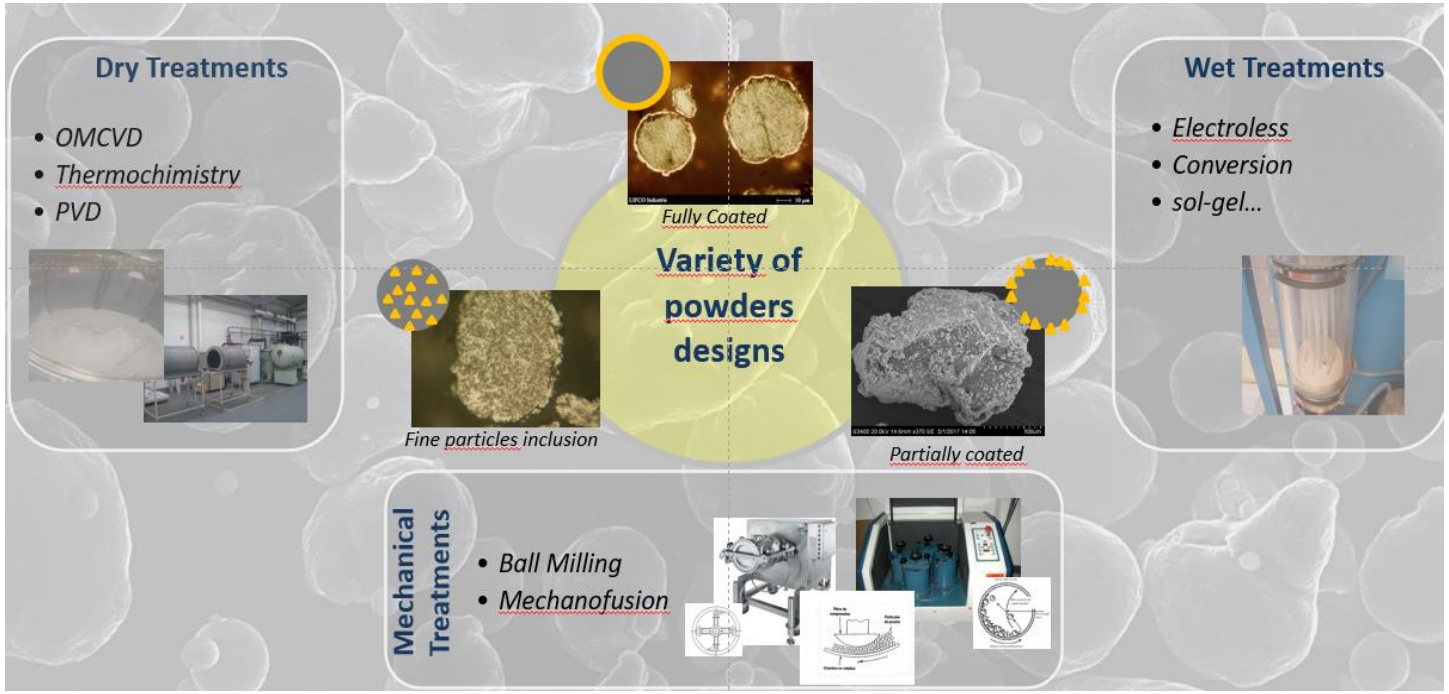


From 500nm to 1mm

FUNCTIONALIZED POWDERS

Production processes & fields of applications

A wide range of multimaterial powders designs are obtained by using complex technologies like dry, wet and mechanical treatments of core particles.



Mutimaterial powders find applications in many fields

Production of Sintered components

- Powder metallurgy
- Additive manufacturing
- Injection molding (PIM, MIM)

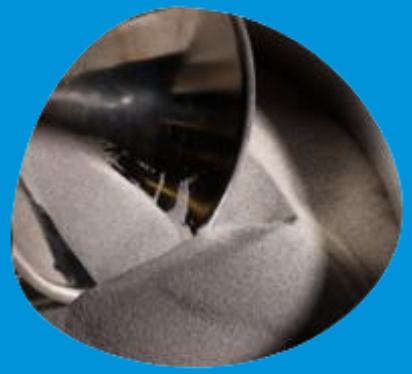
Production of Coatings

- Thermal spray
- Cold spray

Production of Composite materials

- Charged polymers
- Smart fillers

Example of applications



FUNCTIONALIZED POWDERS

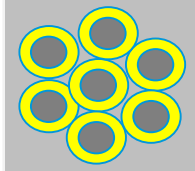
Our technologies enable the manufacture of multi-material functionalised powders.

Developing solid materials (3D printing) or coating (thermal, electrical properties), etc.

Production of sintered components by Compacting / Sintering

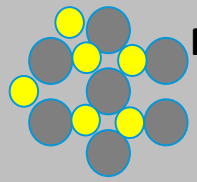
Impact on the microstructure of sintered materials

Case of a Iron Copper alloy: comparaison between a coated powder and a blended powder

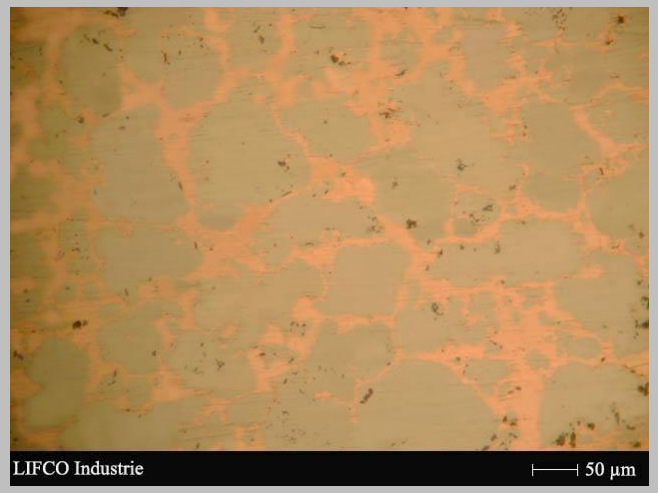


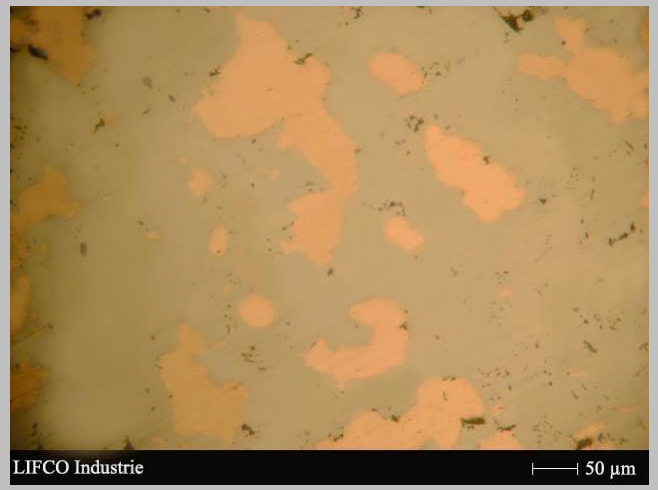
Iron Copper coated powders

Vs



Mix of powders Fe+ Cu

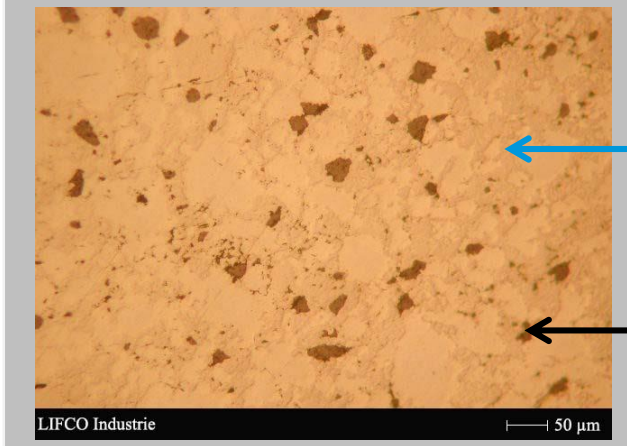




✓ *The use of coated powders improve homogeneity and provide specifics microstructures*

Use of coated powders as diffusion barrier

The coated powder is added by mixing with a metal matrix and shapped by compacting/sintering



✓ *The coating on the lubricant particle avoid its diffusion during sintering*

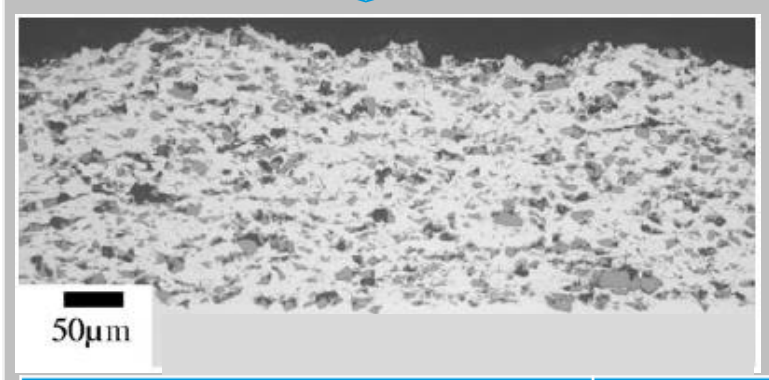
Production of Multi-materials coatings by Cold Spray

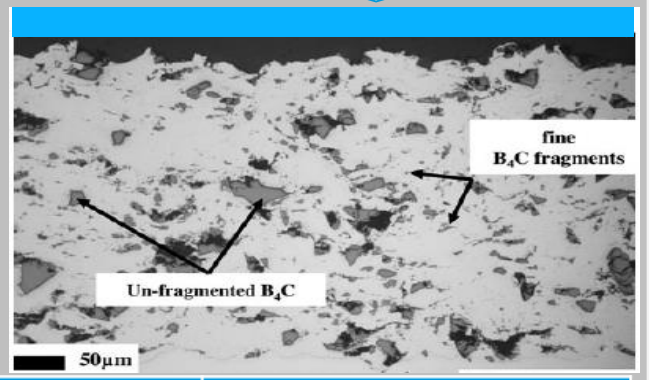
Boron carbide nickel composite coating

B_4C / Ni coated Powders

Vs

Mix of powders
B4C+ Ni



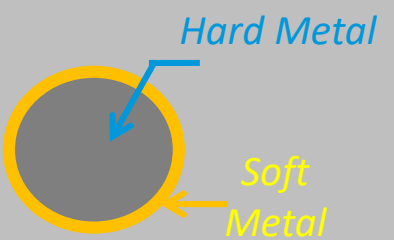


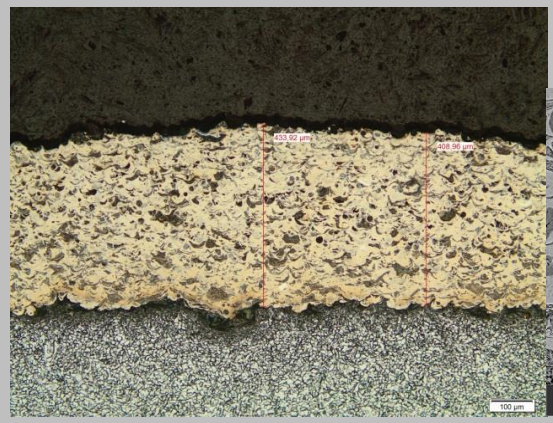
Coatings properties	Coated powders	Mix of powders
[ ]° ceramic particles (B_4C vol.%)	*32,7*	*10,5*
Micro Hardness ($HV_{0,5}$)	*429*	*290*

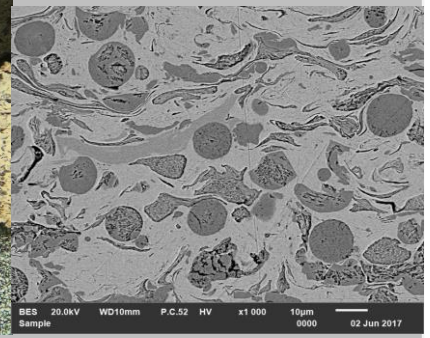
✓ The use of a coated powder greatly improve homogeneity and coating properties

B4C/Ni Composite Coatings Prepared by Cold Spray of Blended or CVD-Coated Powders – Journal of Thermal Spray Technology – April 2012

Metal/Metal composite coating







Cold Sprayed coating

✓ **Coated powders are a efficient alternative to obtain multi-materials coatings with controlled microstructures and compositions**

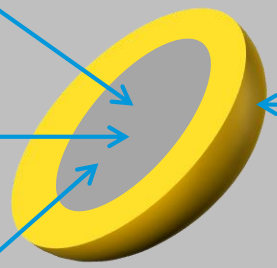
Coated powders for additive manufacturing (SLM)

Case of some « hard to build materials » by SLM

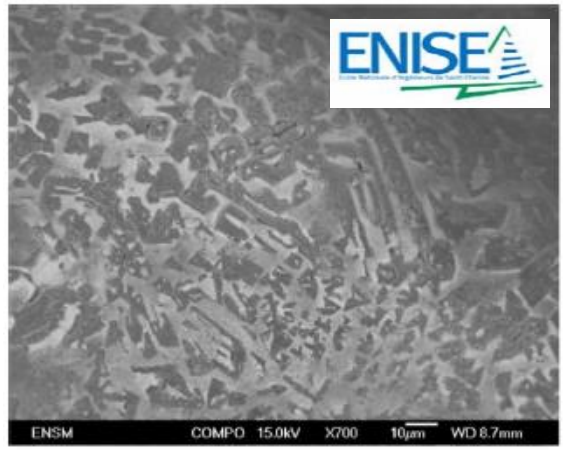
Copper
High laser reflectivity

Aluminium
High laser reflectivity
Oxidation sensitive

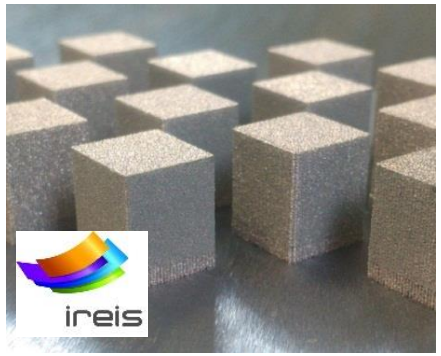
Ceramiques
High melting point
Cracking



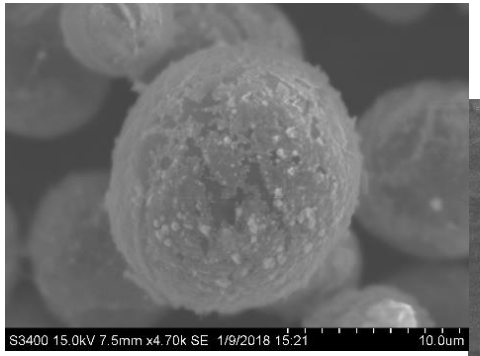
Coatings
Reduced Laser reflectivity
Oxidation resistance
Weldability
Alloying element



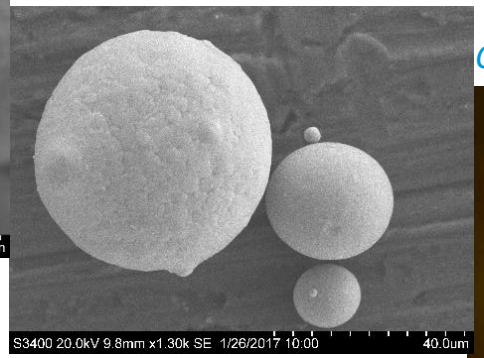
Selective laser melting of boron carbide particles coated by a cobalt-based metal layer - *Journal of Materials Processing Technology - March 2016*



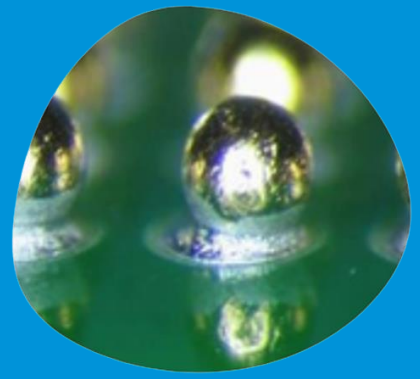
Coated aluminium powder



Coated copper powder



Coated spherical ceramic powder



SOLDER BALLS

Our polymer core solder balls, offering improved mechanical strength and thermal conductivity, make BGA (Ball Grid Array) technology more efficient and reliable.

- Solder Balls Background
- New challenges in solder balls applications
- The SUPERBALL project issues
- Solder Balls synthesis and results

HEF GROUPE

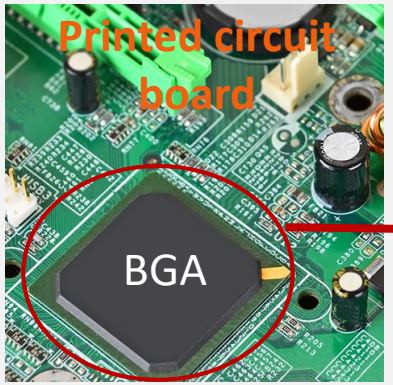
Solder Balls background

Solid Beads usually made of Sn/pb alloys

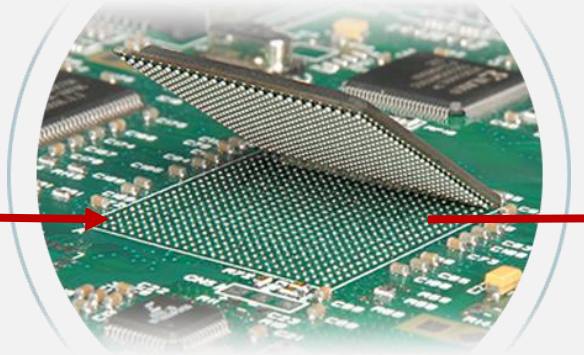
Available in different diameters with a narrow size distribution (+/- 5%)

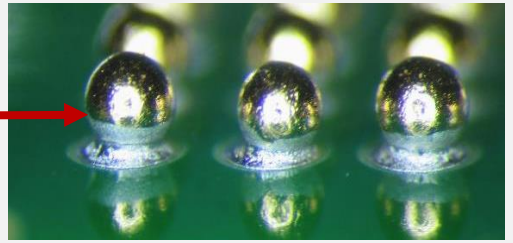
Spherical morphology with a very high rate of sphericity

Electrical Contact function in Integrated circuit packaging



Electronic assembly

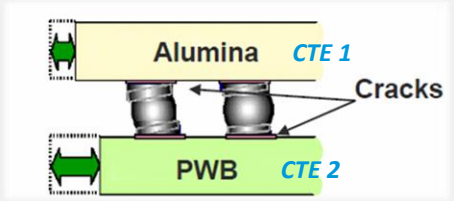




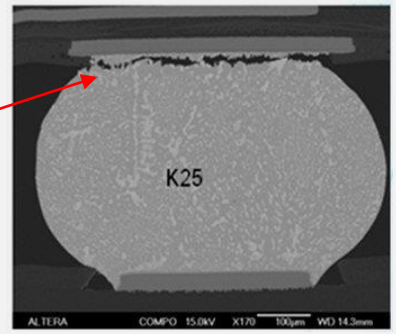
BGA component soldered with beads

New challenges in solder balls applications

High reliability & high performance assembly for severe applications (aeronautics, spatial, armament…)



Thermo-mechanical stress generated in operation

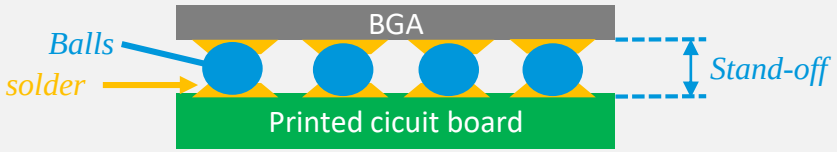


Sodered ball cross section

Temperature variations are the main factor in electronic components failure

Controlled Stand-off for accurate assembly design, miniaturization and high density interconnections (HDI)

No deformation during soldering operations



Controlled « Stand-off »

Upgrated beads properties

Corrosion resistance

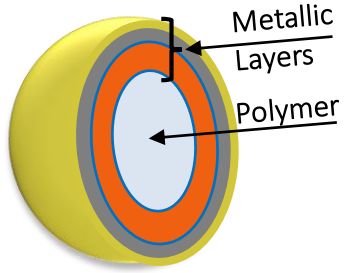
Mechanical resistance

Weight saving

Lead free

Low cost

Development of multimaterials solder balls called « Polymer Core Solder Balls »



polymer core

Upgrated Thermo-mechanical resistance

SUPERBALL R&D project

The superball project issues

Manufacture of Innovative solder balls for high performance and high reliability electronics assemblies

Performance and reliability

Made in France

Sovereignty with the development of a national supply chain & industrial network.

MADE IN FRANCE

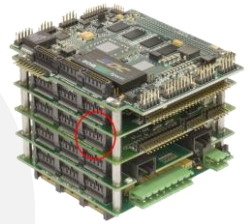
Effective solution to the EU directives on the restriction of the use of lead in the electronic devices in 2026.

Compatibility RoHS

SUPERBALL

New markets

Acces to the global solder balls market. Development and marketing of new generation and top level electronics assemblies.



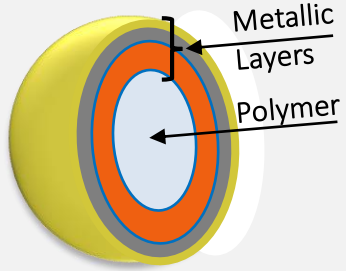
Partnership THALES NICOMATIC LGF

Financier bpifrance La Région Auvergne-Rhône-Alpes SÉM SAINT-ÉTIENNE la métropole

PCSB Synthesis & results

PCSB design & production steps

PCSB design



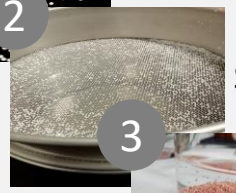
Porous polymer core	*Thermo-mechanical stress absorber*
1st layer of copper (15-20µm)	*Electrical & thermal conductivities*
2nd layer of Nickel (4-6µm)	*Corrosion resistance/diffusion barrier*
3rd layer of Gold (50-100nm)	*Wettability / oxidation resistance*

PCSB synthesis

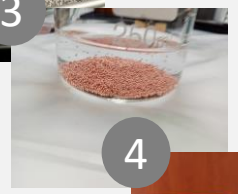
PCSB are produced by a multi-step electroless process

1. Polymer beads

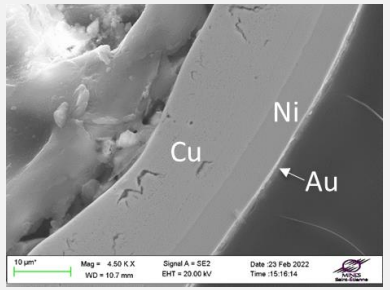
2. Sieving of polymer beads



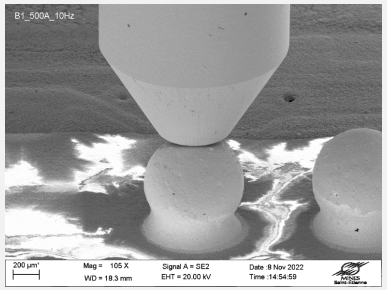
3. Metallizations by electroless plating



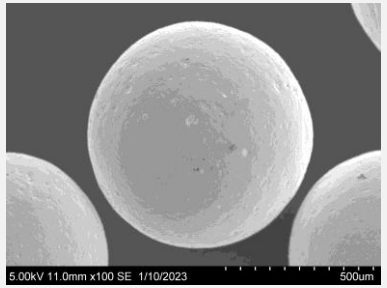
4. Analysis and controls



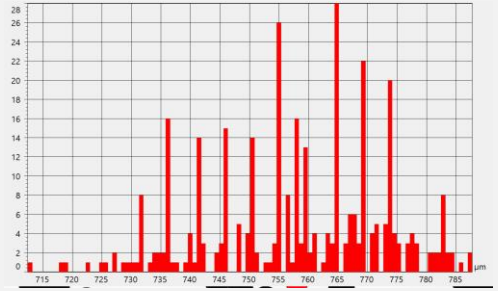
Layer thickness on cross section



Mechanical properties



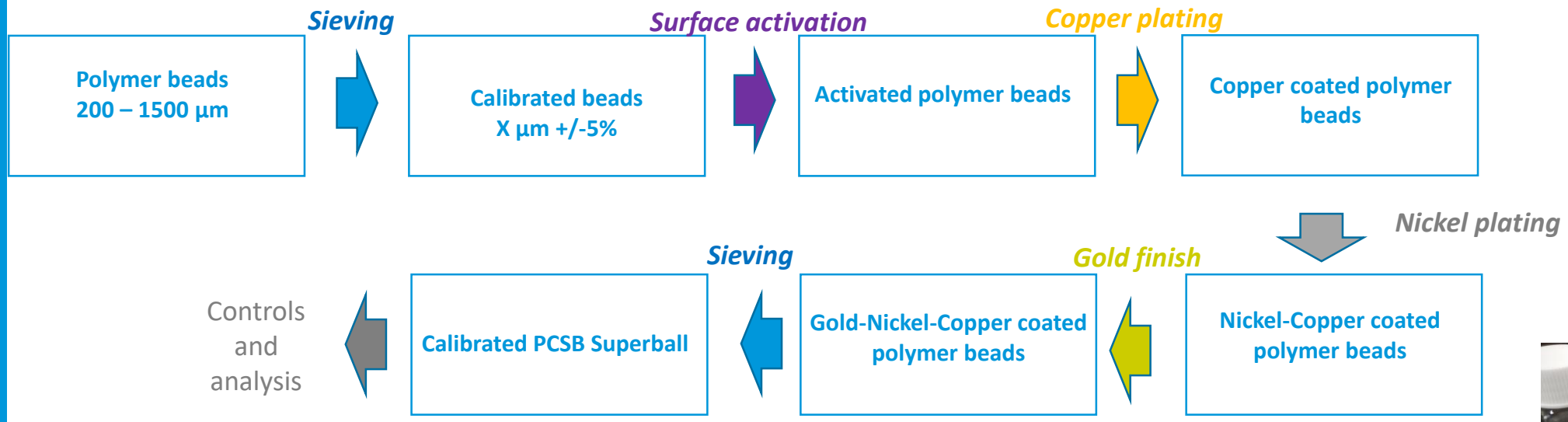
Surface finish & Morphology by SEM



Beads size by image analysis

PCSB Synthesis & results

Plating process: simplified synoptic of the coating steps



Beads after each coating step

Bath chemistry

Plating step	Process	Chemical reactions	Plating rates	Formulation
Polymer activation	Proprietary	Silver NPs grafting	***	IREIS
Copper plating	Electroless	$HCHO + Cu^{2+} + 3OH^- \rightarrow \mathbf{Cu} + HCOO^- + 2H_2O$	~ 10µm/h	IREIS
Nickel (P) plating		$H_2PO_2^- + Ni^{2+} + H_2O \rightarrow H_2PO_3^- + \mathbf{Ni} + 2H^+$	~ 15µm/h	ATOTECH
Gold finish	Galvanic displacement	$Ni + 2Au^+ \rightarrow Ni^{2+} + \mathbf{2Au}$	~ 50nm/5min	ATOTECH

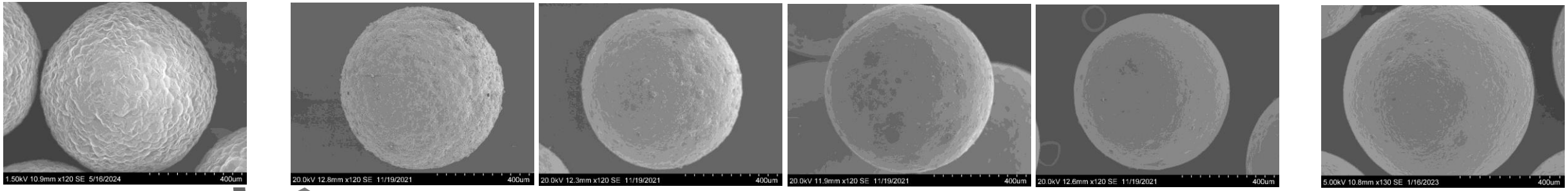
PCSB Synthesis & results

Evolution of the bead's surface finish during plating steps

1- Starting polymer beads

2- Copper plating

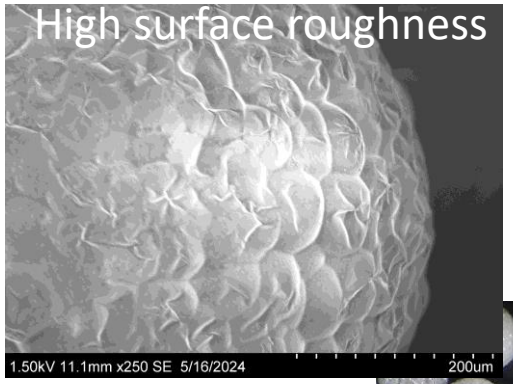
3- ENIG finish



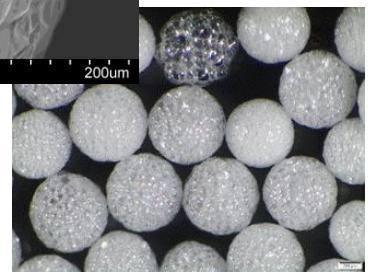
Cu

Plating duration

Ni/Au



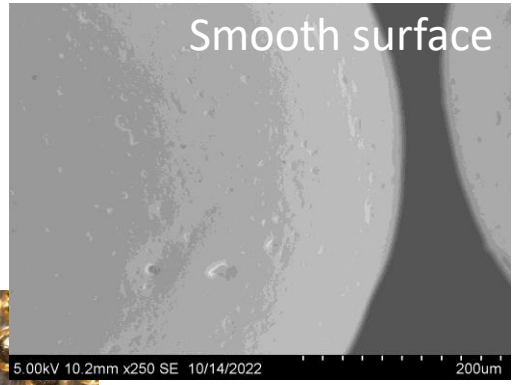
« Soccer ball » like surface



Levelling effect of the electroless copper plating

Main parameters affecting the levelling effect

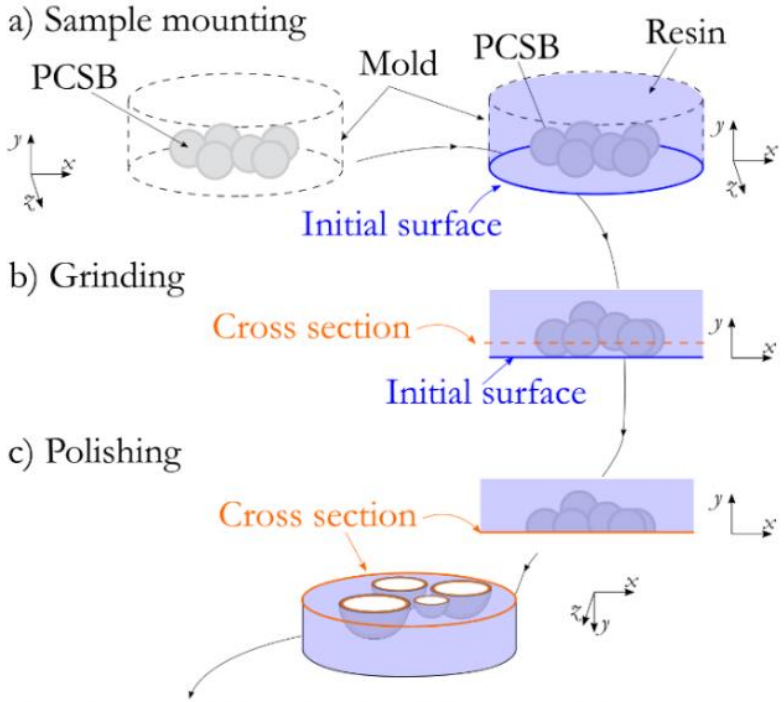
- Bath formulation (reagents []°, additives, stabilizer…)
- Bath temperature / stirring parameters
- Plating time / Layer thickness

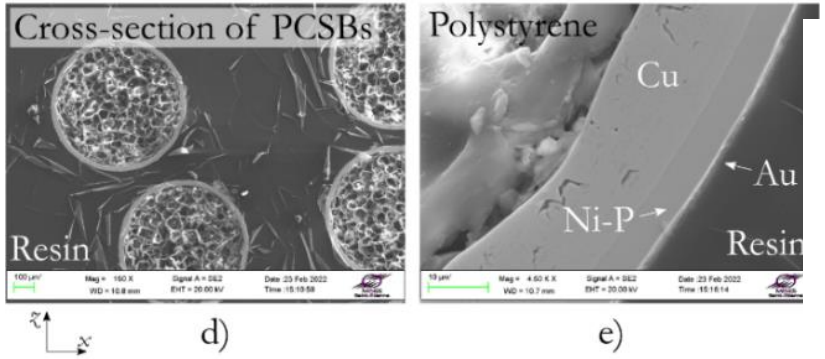


PCSB Synthesis & results

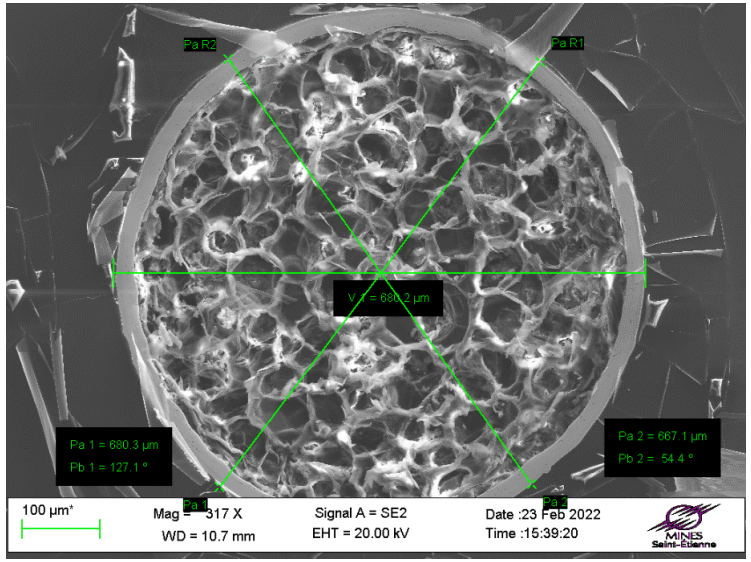
Layers thickness measurment by cross section analysis*

1-Sample preparation

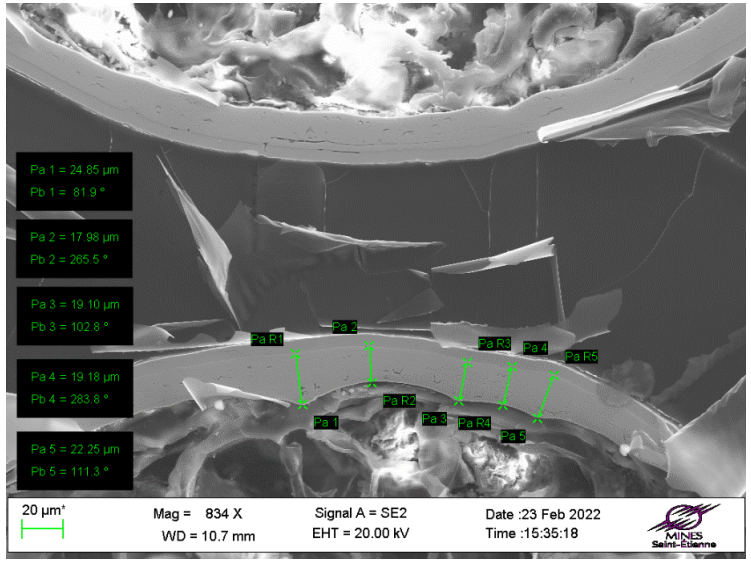


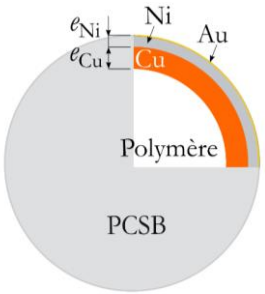


2-diameter measurment



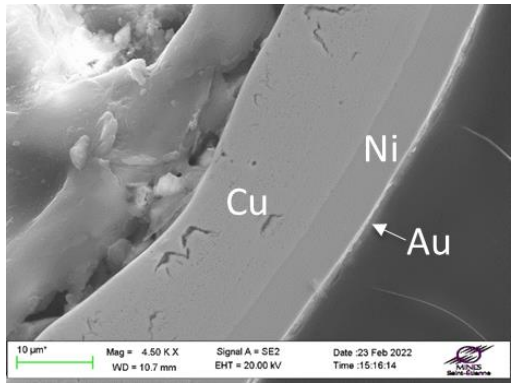
3-Layers thickness measurment





Compliance with layers thickness Specifications:

- ✓ 1st layer of copper (15-20µm)
- ✓ 2nd layer of Nickel (4-6µm)
- ✓ 3rd layer of Gold (50-100nm)



« Multi-scale in-situ micro-mechanical characterization of polymer core sloder ball (PCSB) coatings for BGA interconnections », Microelectronics Reliability, volume 148, september 2023

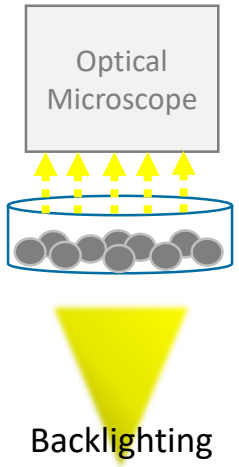
PCSB Synthesis & results

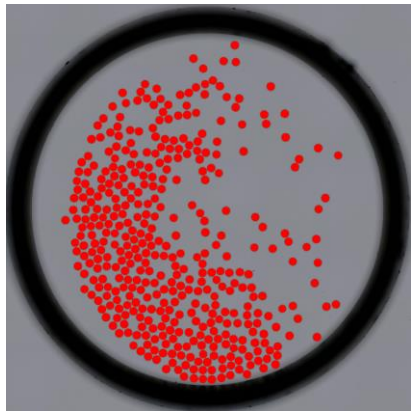
Beads size & sphericity controls by optical analysis

1-Sample preparation

Beads size & sphericity are Analysed by the « Chinese shadows » principle

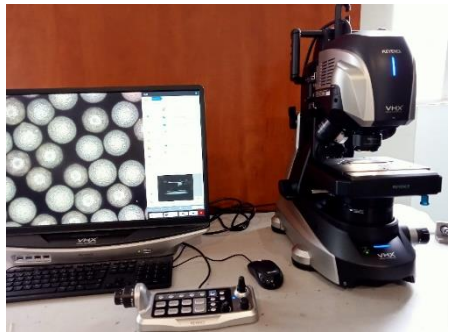
Sample holder



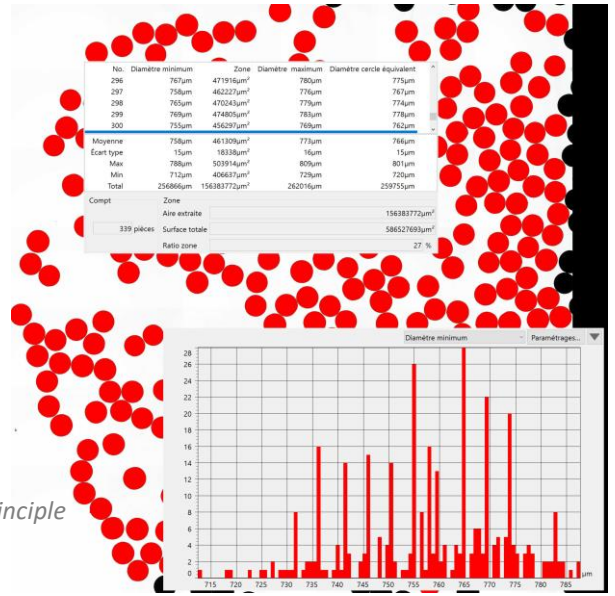


View of the beads by « chinese shadows » principle

2-diameter & sphericity measurment by image analysis

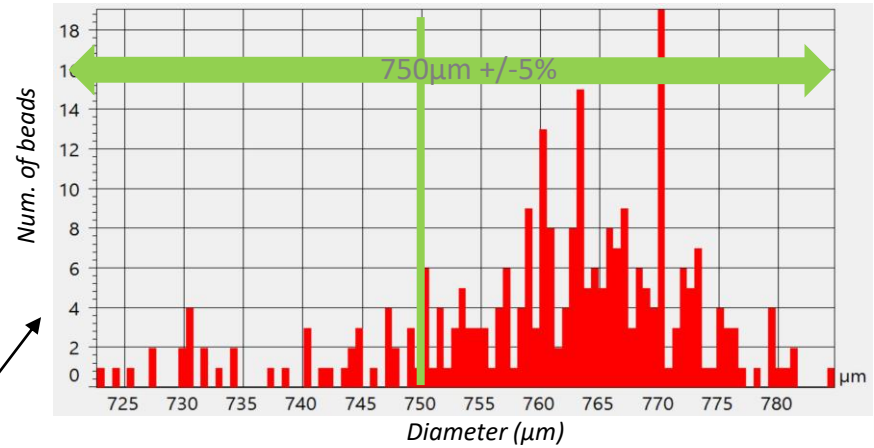


Keyence VHX optical microscope

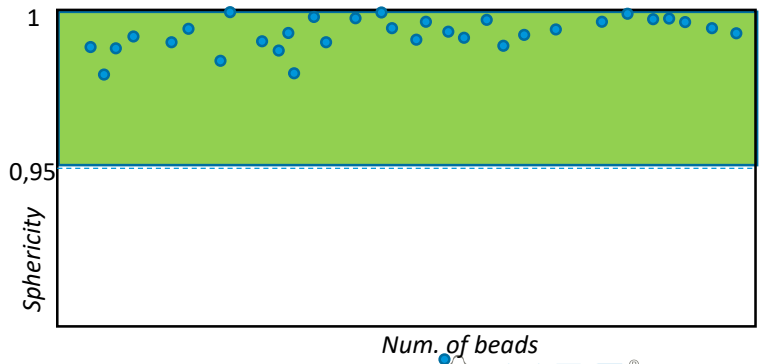


3-Specifications Compliance review

Diameter tolerance +/- 5%



Sphericity tolerance 0,95 to 1



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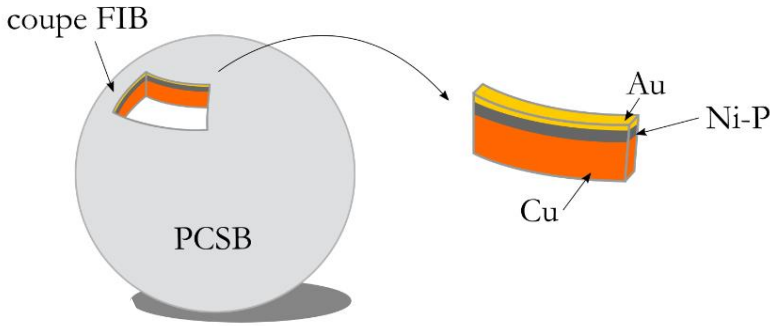
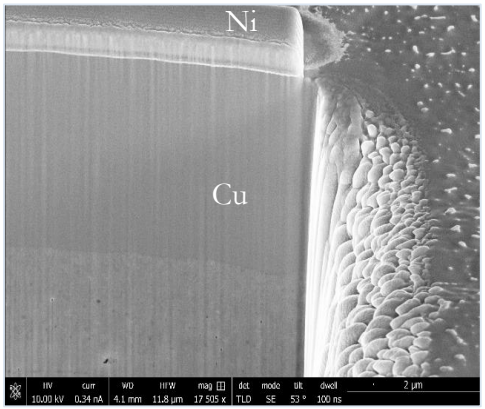
PCSB Synthesis & results

Microstructure analysis on FIB Foil*

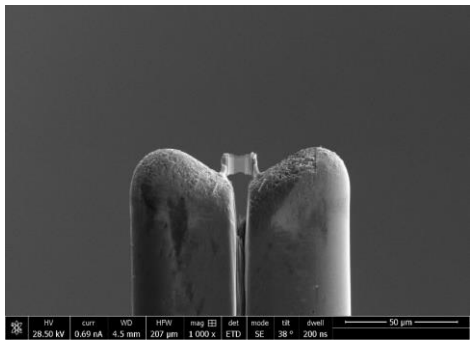
1- Foil fabrication by FIB micromachining

A foil (e<100nm) of the metallic stac is taken by FIB



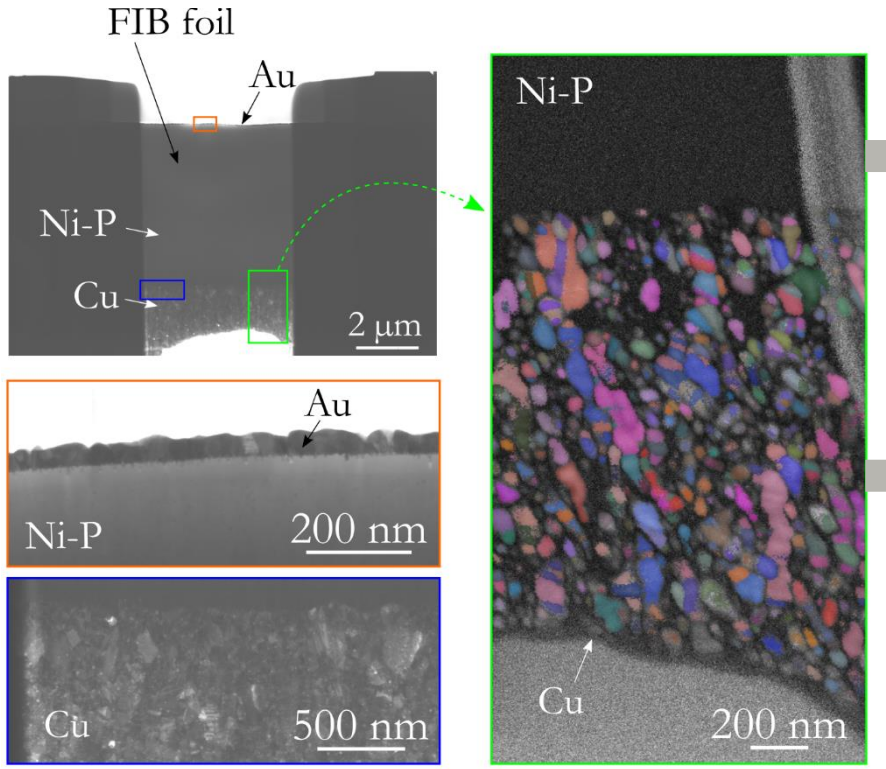


Micromachined metallic stac



Sample holder

2- Foil analysis by SEM (Transmission Kikuchi Diffraction) → *Informations on the crystal structures of coatings*



→ Amorphous

→ Nanocristallin

Specific crystal structures linked to the plating process

Coatings properties ≠ Bulk materials (Bibliography)

**« Multi-scale in-situ micro-mechanical characterization of polymer core sloder ball (PCSB) coatings for BGA interconnections », Microelectronics Reliability, volume 148, september 2023*

Sébastien BUCHER

PCSB Synthesis & results

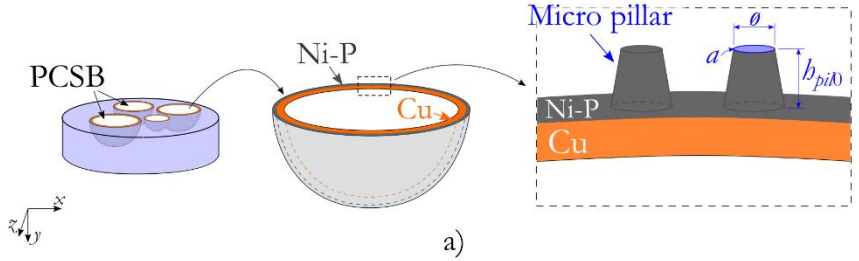
Mechanical properties characterizations by micro pillar compression*

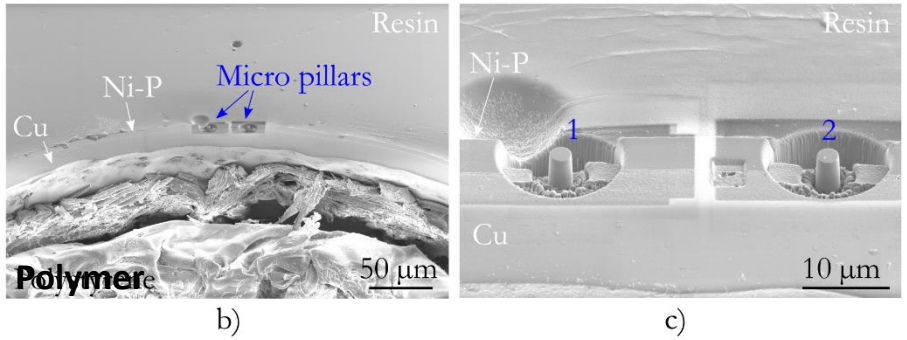
1- Micropillar fabrication by FIB micromachining

Pillar fabrication:

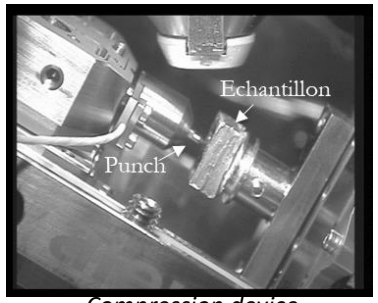
Micro machining FIB (Focus Ion Beam)

Pillar size on Ni-P/Cu coatings: Ø=2 µm, h=4 µm

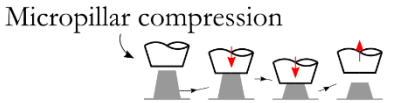


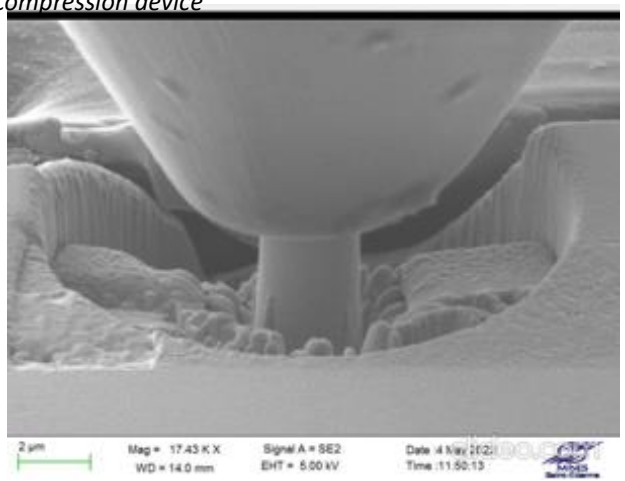


2- Micropillar compression

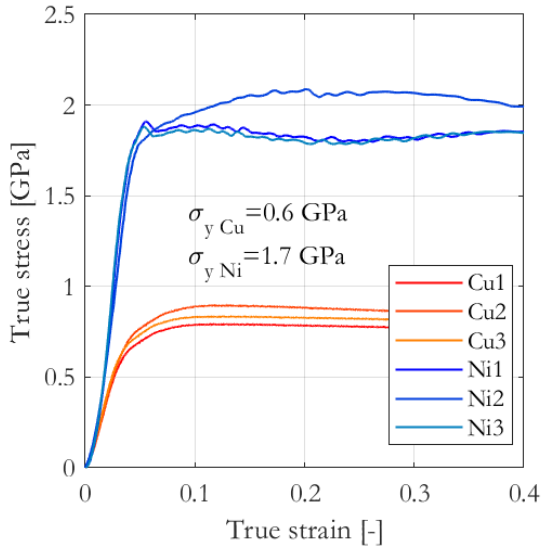


Compression device





3- Stress/strain curves for copper and Nickel



	Yield stress (σy) [MPa]	
Material	Biblio.	Meca.
Cu	30	600
Ni-P	500-1000	1700

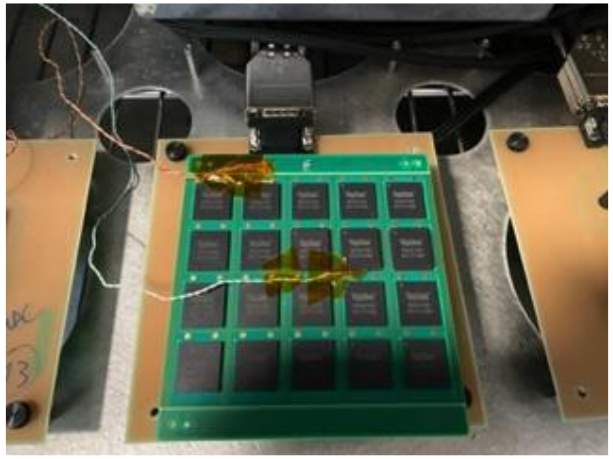
Due to the specific microstructures, Yield stress of Copper and Nickel(P) are higher than « bulk materials »

➡ Positive effect on mechanical properties of the beads

**« Multi-scale in-situ micro-mechanical characterization of polymer core sloder ball (PCSB) coatings for BGA interconnections », Microelectronics Reliability, volume 148, september 2023*

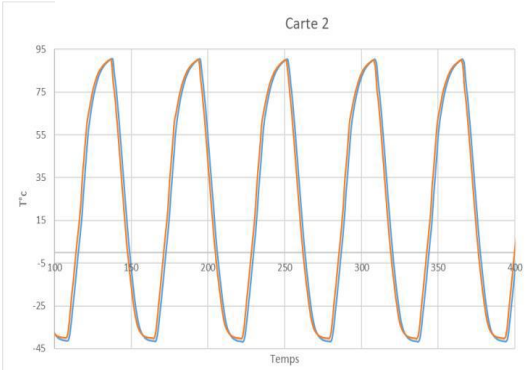
PCSB Synthesis & results

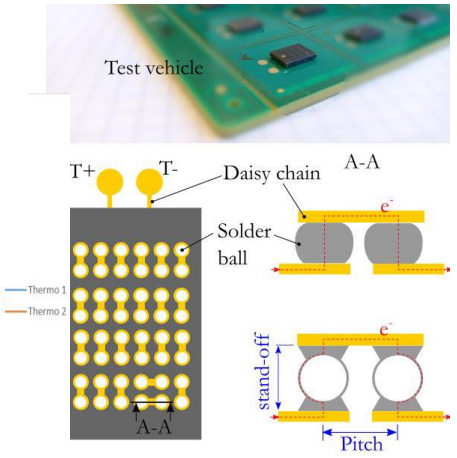
Reliability tests on test vehicle



Test vehicle for reliability test

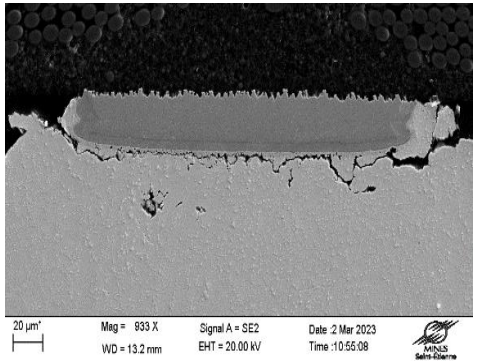
Thermal aging cycle (-40 / +90°C)



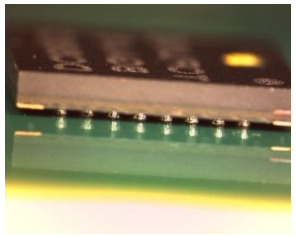


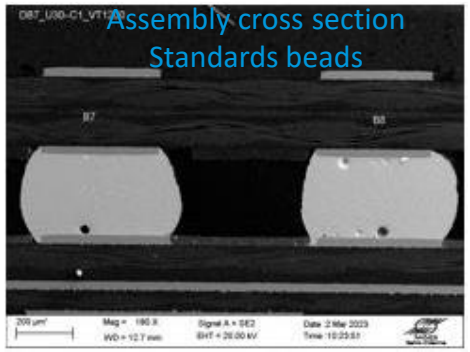
Resistivity measurment during thermal aging

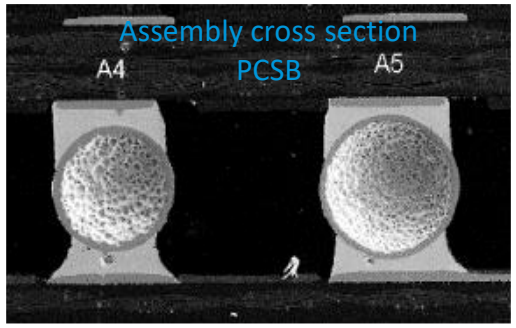
Crack propagations analysis in the solder pad area



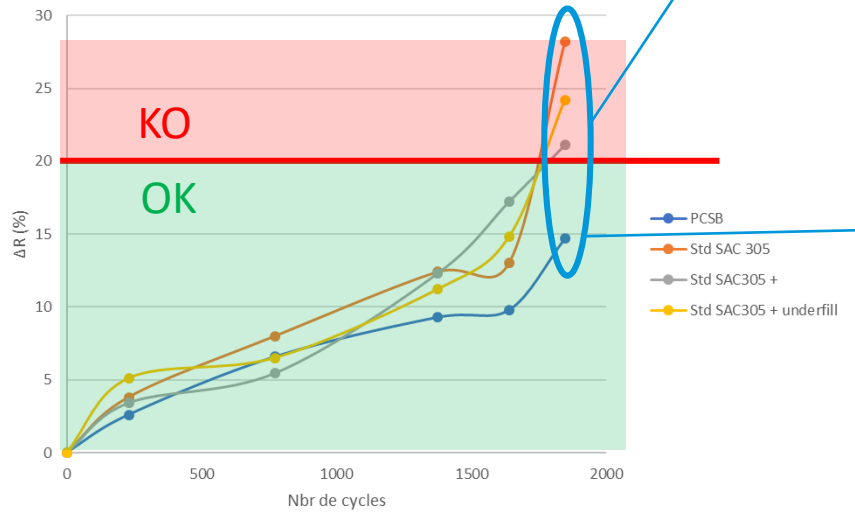
Crack propagation in standard assembly

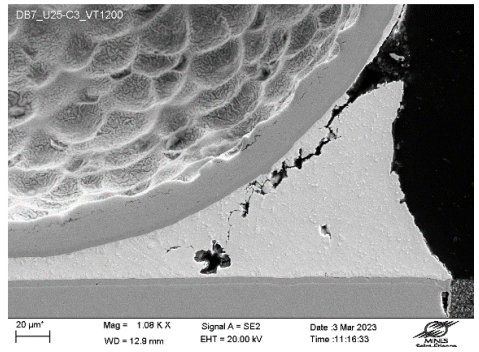






Resistivity variation during thermal aging (If Δ R> 20% => KO)





Crack propagation in PCSB assembly

After 2000 cycles, the crack propagations and the electrical resistance variation are less important for the PCSB than the standard assembly

PCSB Synthesis & results

For more details…

Microelectronics Reliability 148 (2023) 115135

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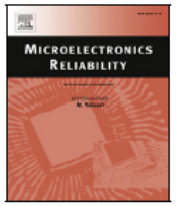

Review paper

Multi-scale in-situ micro-mechanical characterization of Polymer Core Solder Ball (PCSB) coatings for BGA interconnections

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ARTICLE INFO

Keywords:
PCSB
Electroless copper
Electroless nickel
Microstructure
In-situ micropillar compression
FEM

ABSTRACT

In the field of electronic packaging, the manufacturing processes involve electroless plating. The microstructure of these materials differs from bulk materials, so do their mechanical properties. However, bulk material properties are commonly attributed to them. This paper is focused on the characterization of the mechanical properties of a multilayer coating of copper and nickel–phosphorus deposited on a Polymer Core Solder Ball (PCSB) used for BGA (Ball Grid Array) connections. In this coating, the copper is nanocrystalline, while the nickel–phosphorus is amorphous. In order to understand the influence of these microstructural differences on the mechanical properties of the PCSB, a multiscale study is performed. First, at the microscopical scale, the characterization of the mechanical properties (Young modulus (E) and Yielding strength (σ)) of two coatings (Cu, Ni-P) is conducted. For this purpose, insitu micro-mechanical tests (Micro pillar compression and nanoindentation) are carried out. Then, at the mesoscopical scale, the previous properties are validated by applying a compressive loading to a PCSB solder ball. A correlation between the numerical and experimental approaches is performed and revealed that the coating properties are different from those of the bulk material.

Thank you for your attention

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Powders department

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Questions / Réponses

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