KEYNOTE – CHEMNITZER SEMINAR »MEMS Technologies and Applications«

Quality and Reliability Testing of Wirebonds Limitations and new Opportunities

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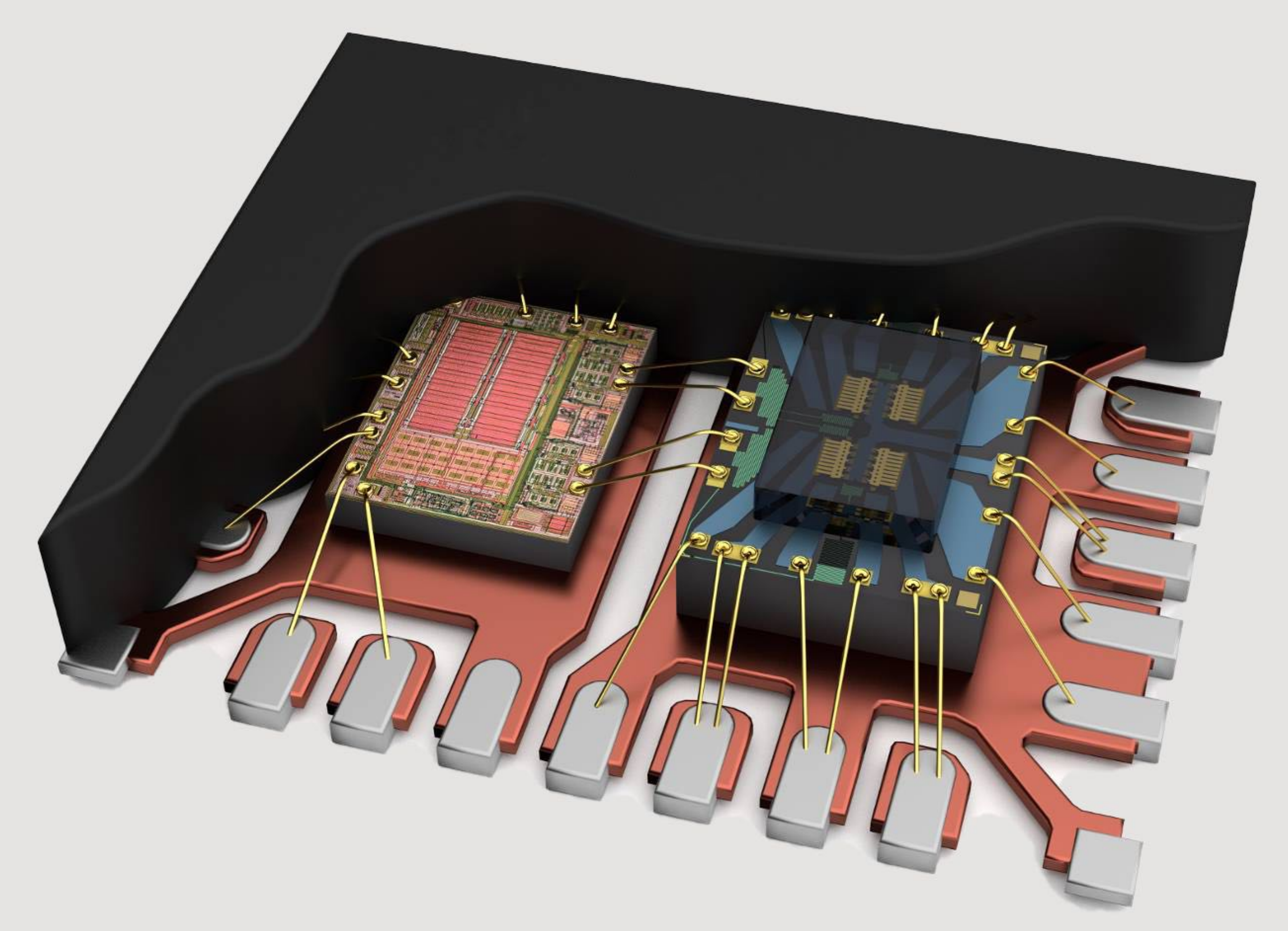
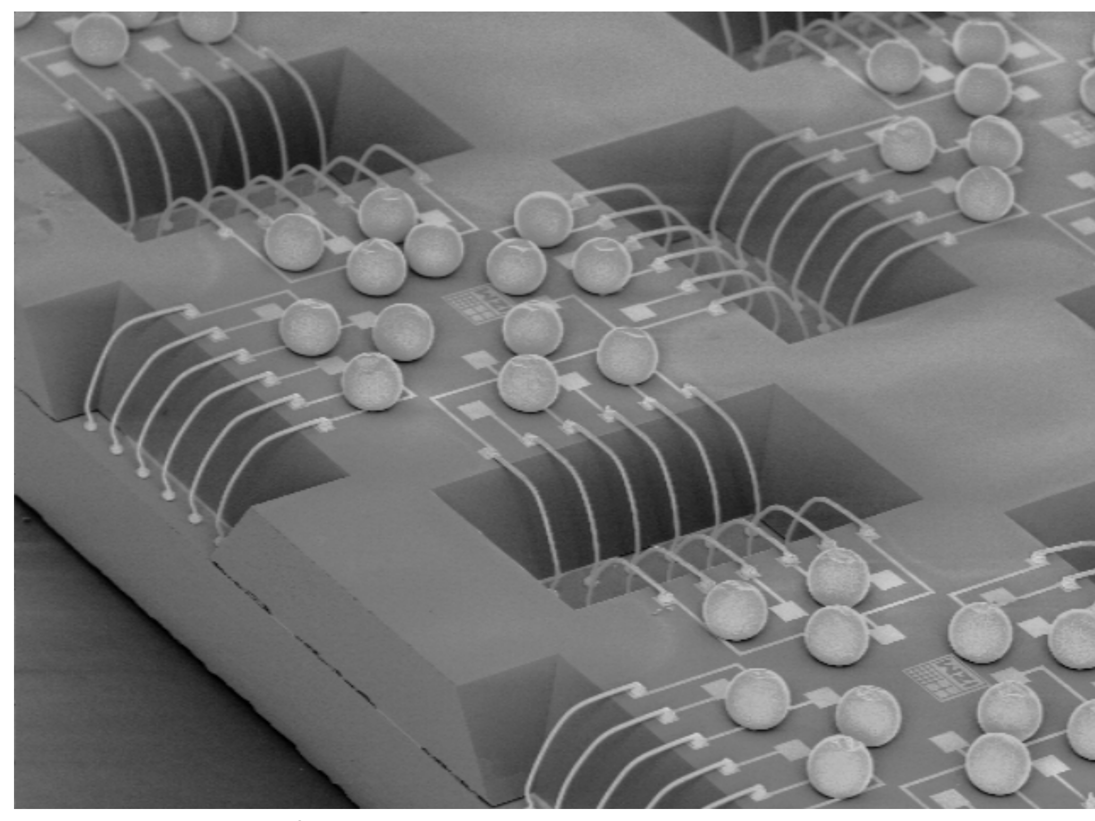
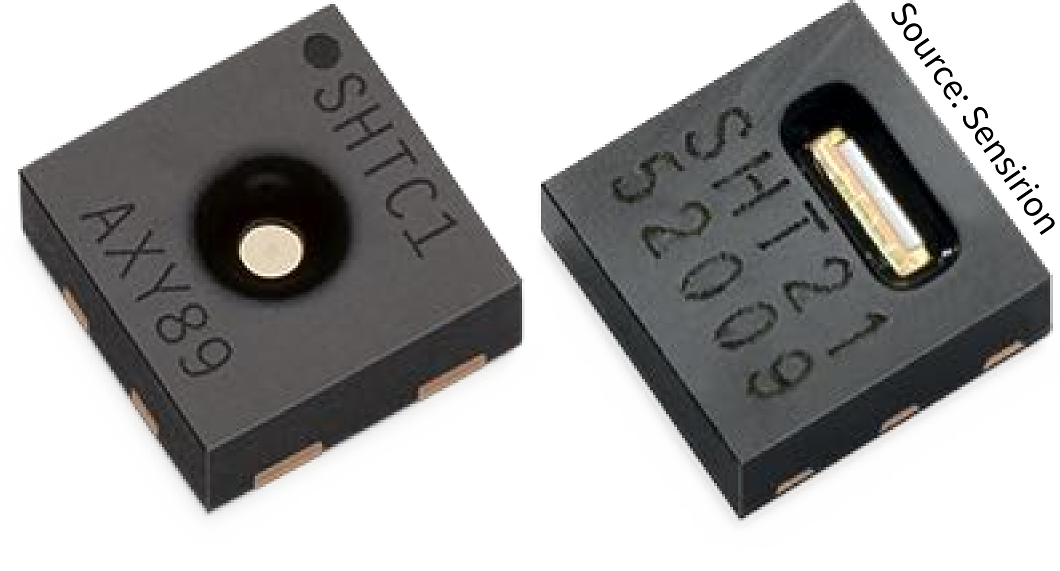
ENHANCE WIRE BONDING



Source: ez.analog.com/switches_multiplexers/w/documents/9760/mems-switch-technology-faq-s (What is the ADI MEMS switch technology?)



Source: Fraunhofer IZM Berlin



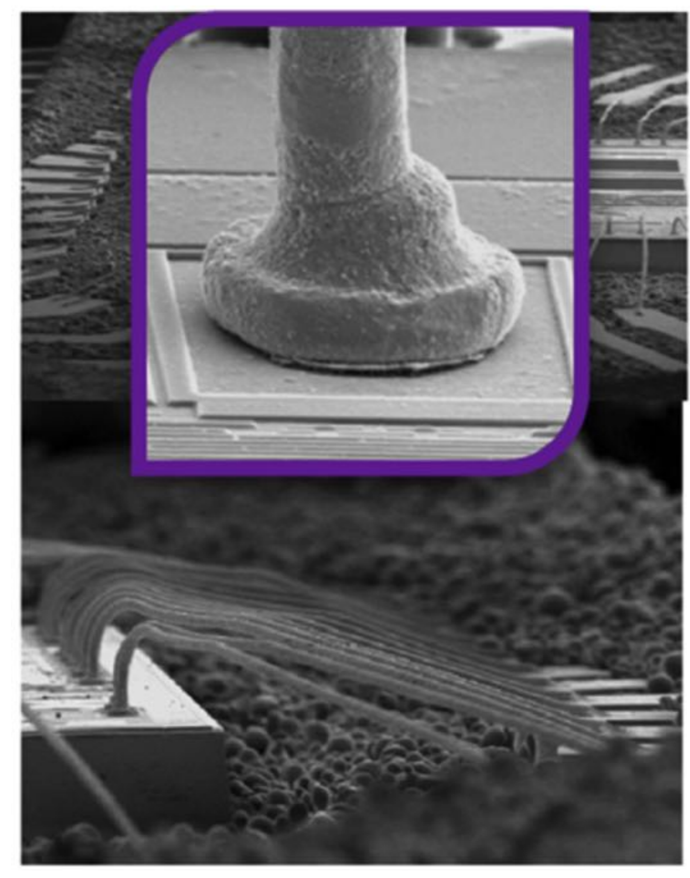
Wire bond testing in production

Open package = no problem

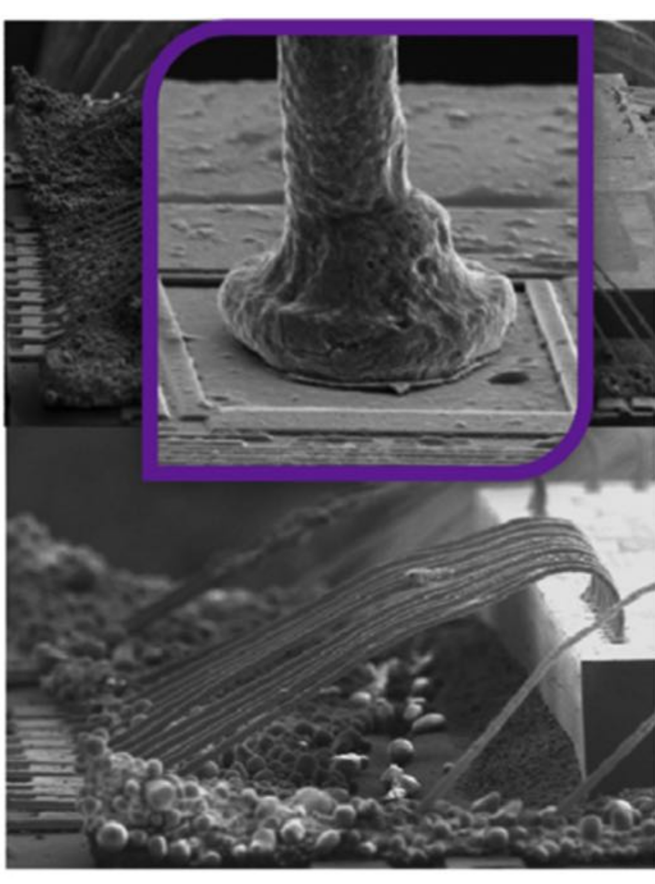
Wire bond testing of a finished product

...

Decapsulation – HNO3 etching (+laser)



TSSOP

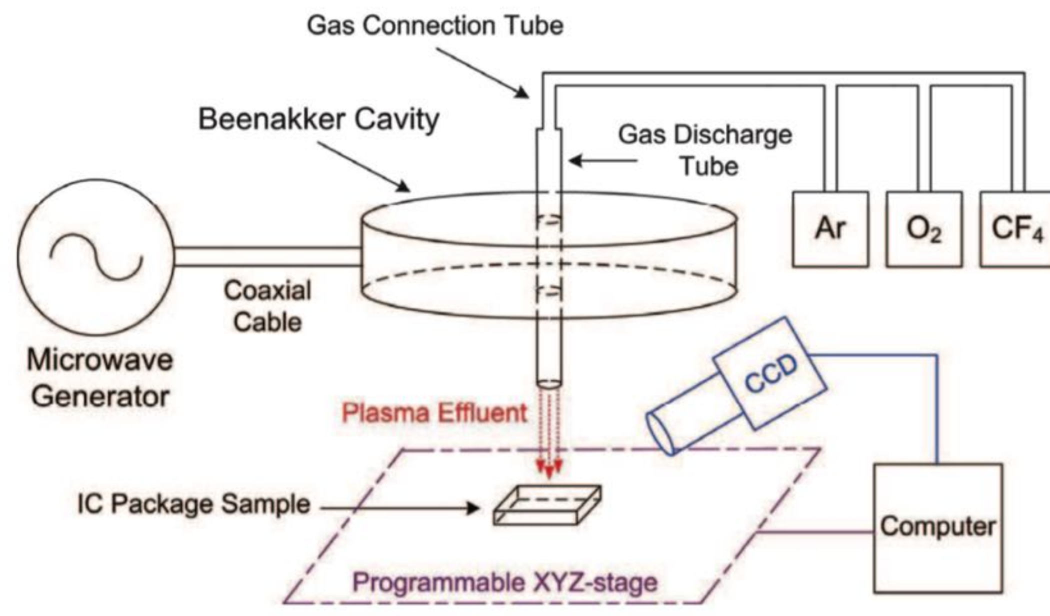


BGA

2:1 nitric 90% fuming to sulfuric mix at 40 °C

Source: Liu, C.-P., Liu, Y.-F., Li, C.-H., Cheng, H.-C., Kung, Y.-C., & Lin, J.-Y. (2012). A novel decapsulation technique for failure analysis of epoxy molded IC packages with Cu wire bonds. *Microelectronics Reliability*, *52*(4), 725–734.

Decapsulation – Plasma (MIP*) decapsulation (+laser)



*microwave induced plasma

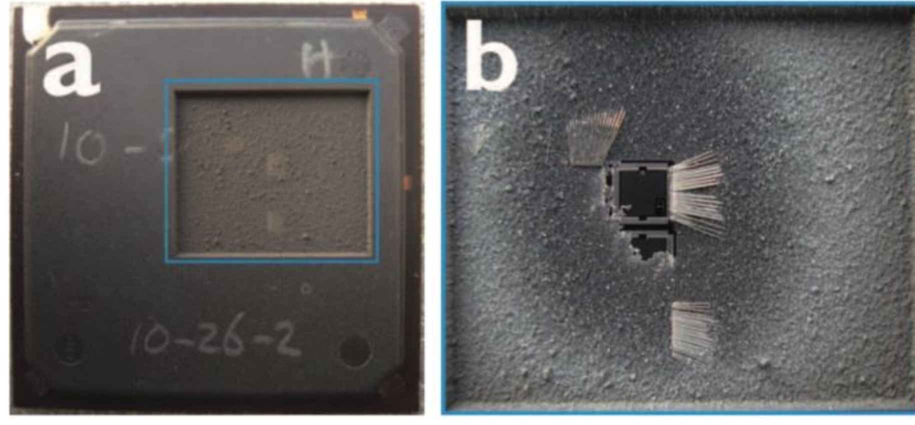
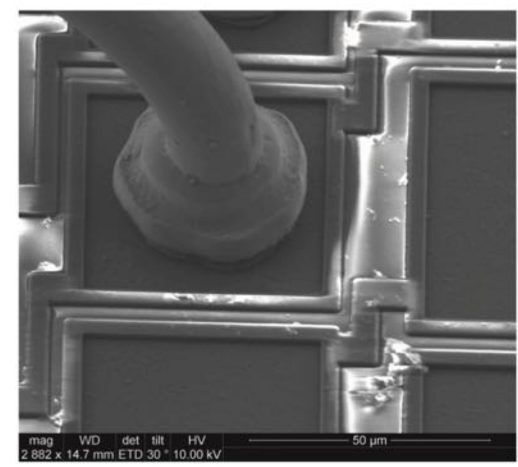
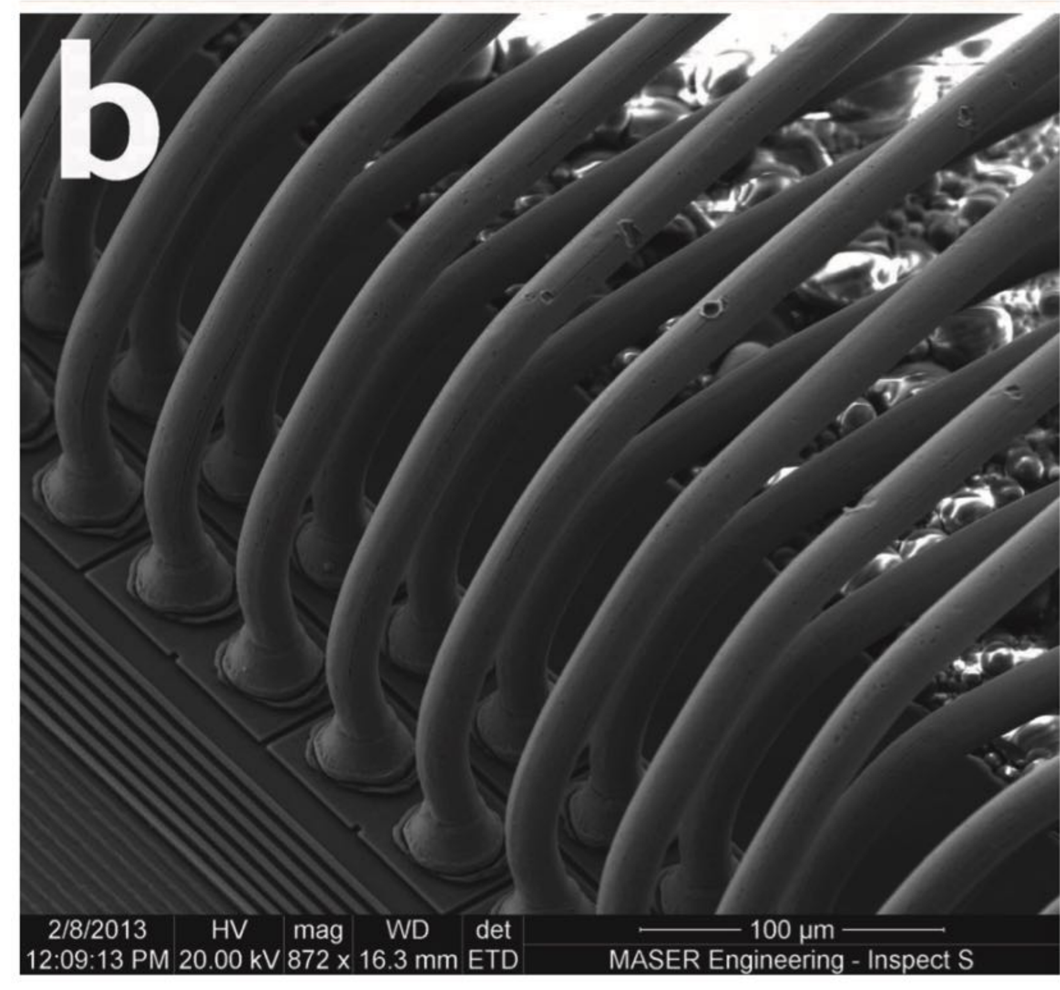


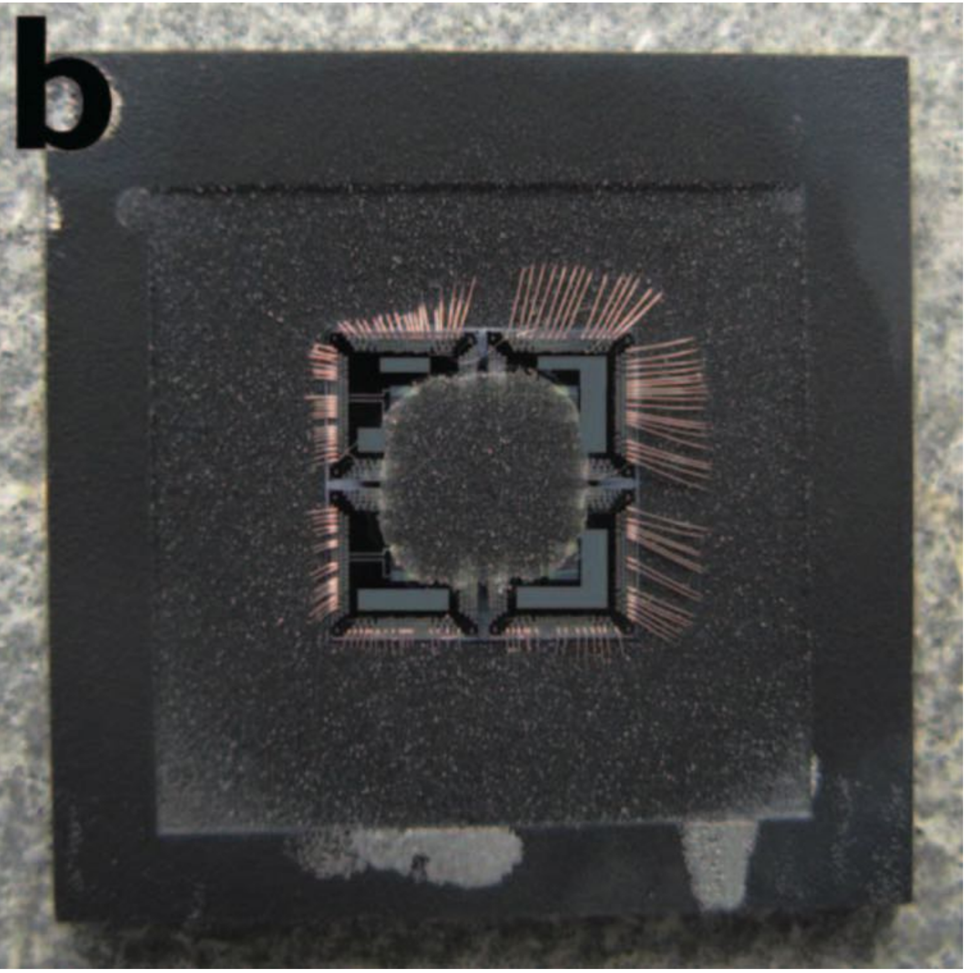
Fig. 3. HTS IC package sample with palladium-coated copper wires (a) after laser ablation; (b) after the following MIP afterglow decapsulation.



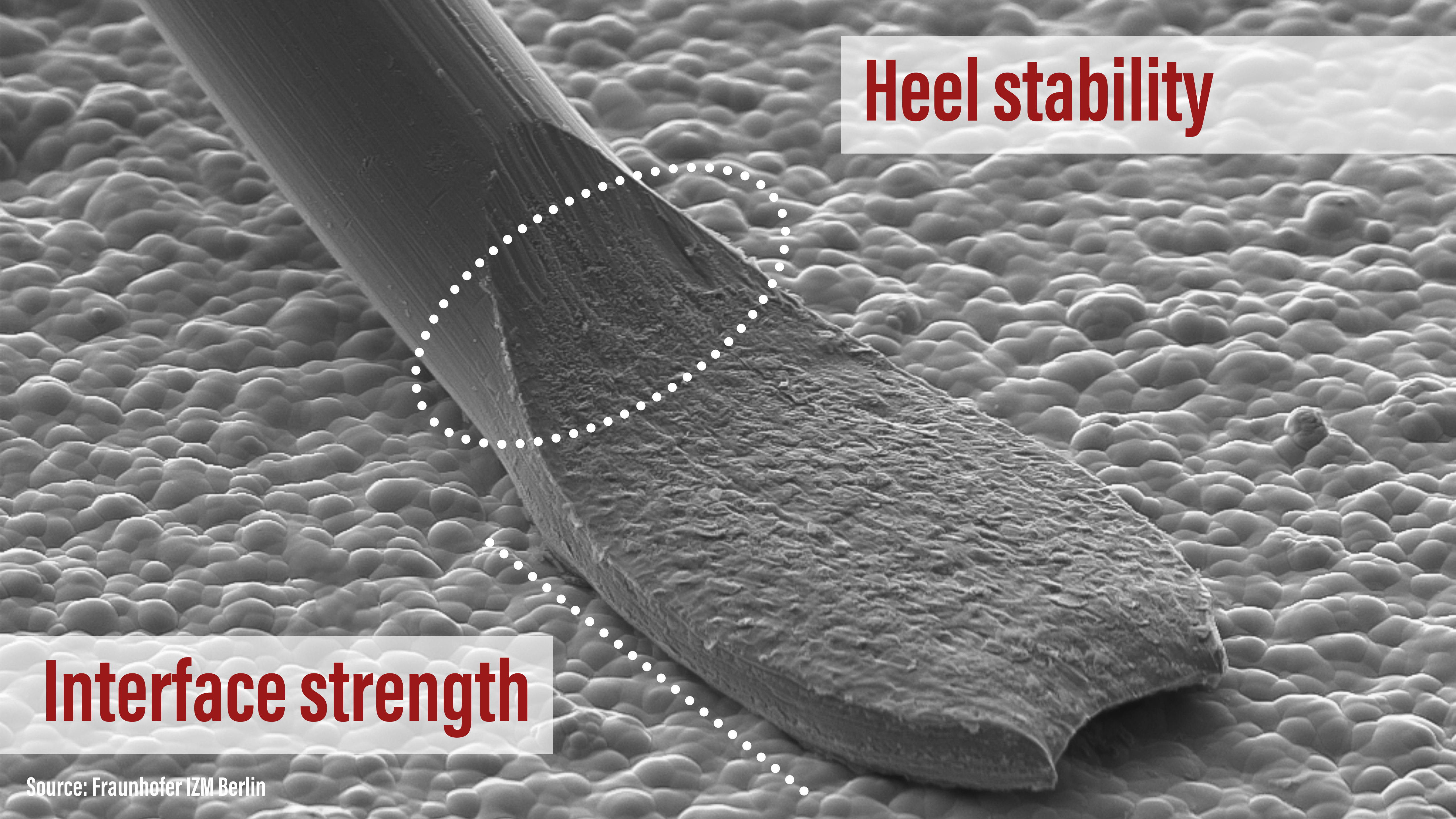
Tang, J., Knobben, A. R. G. W., Reinders, E. G. J., Revenberg, C. T. A., Schelen, J. B. J., & Beenakker, C. I. M. (2013). Microwave Induced Plasma decapsulation of thermally stressed multi-tier copper wire bonded IC packages (pp. 981–986). Presented at the 2013 14th International Conference on Electronic Packaging Technology (ICEPT), IEEE.

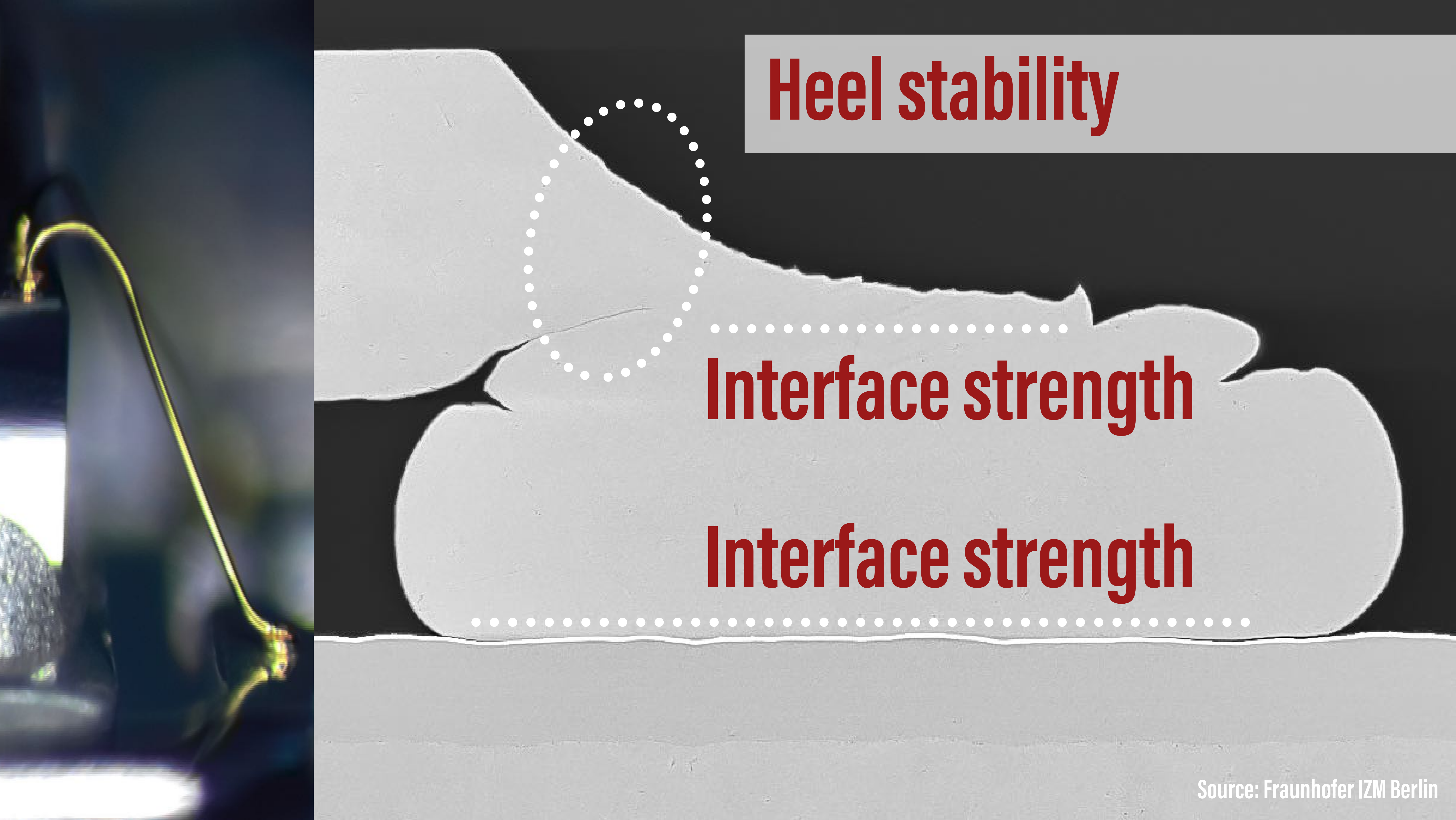
Decapsulation – Plasma (MIP) decapsulation (+laser)





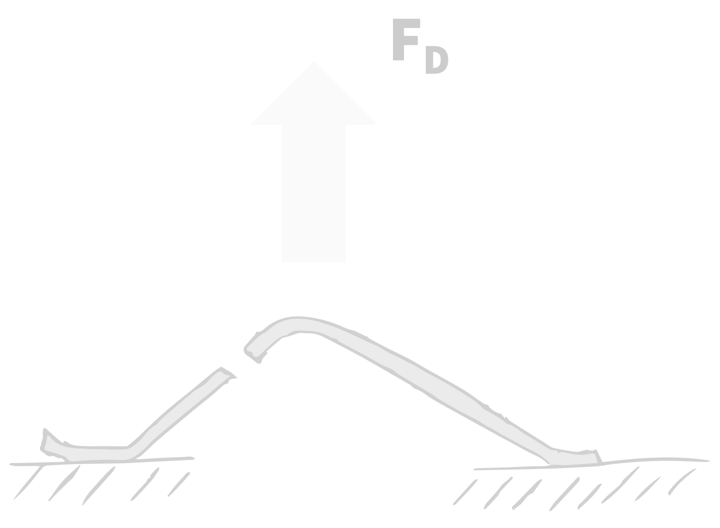
Tang, J., Knobben, A. R. G. W., Reinders, E. G. J., Revenberg, C. T. A., Schelen, J. B. J., & Beenakker, C. I. M. (2013). Microwave Induced Plasma decapsulation of thermally stressed multi-tier copper wire bonded IC packages (pp. 981–986). Presented at the 2013 14th International Conference on Electronic Packaging Technology (ICEPT), IEEE.


Heel stability
Interface strength
Source: Fraunhofer IZM Berlin

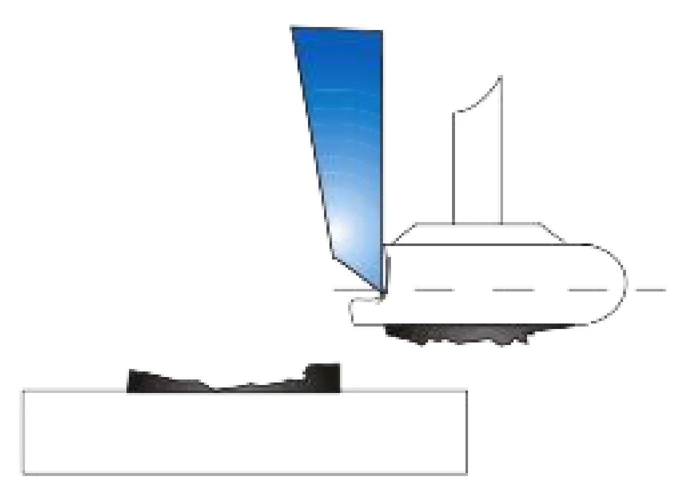

Heel stability
Interface strength
Interface strength
Source: Fraunhofer IZM Berlin

Testing methods for wire bonds

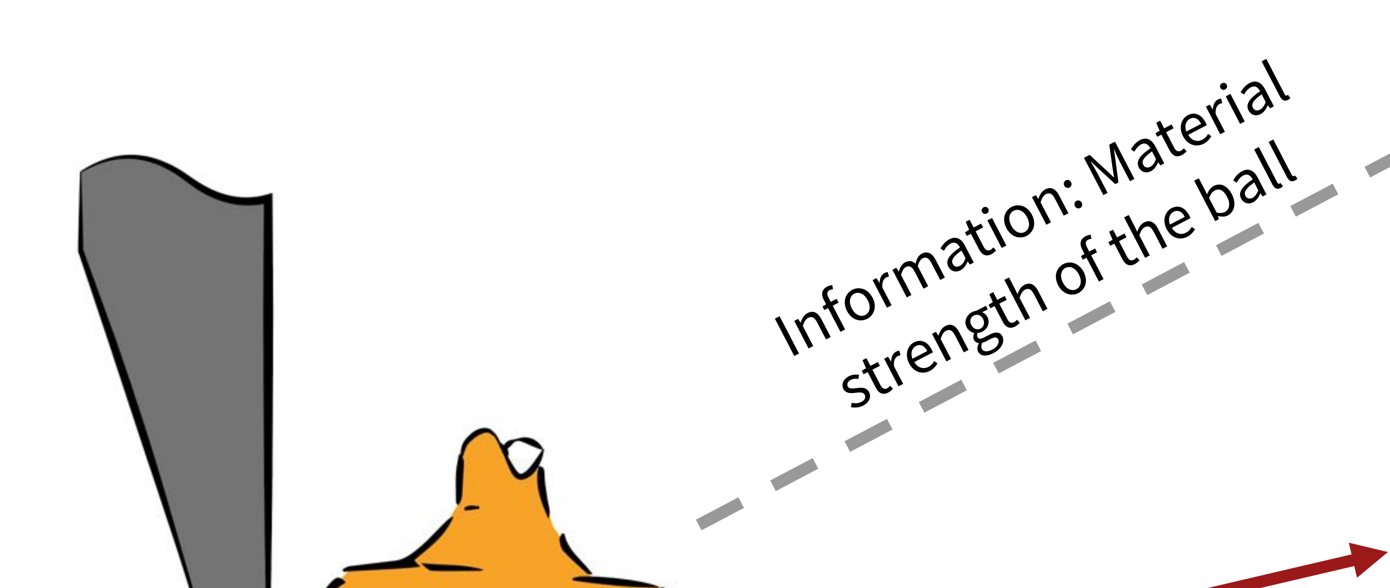
Visual inspection

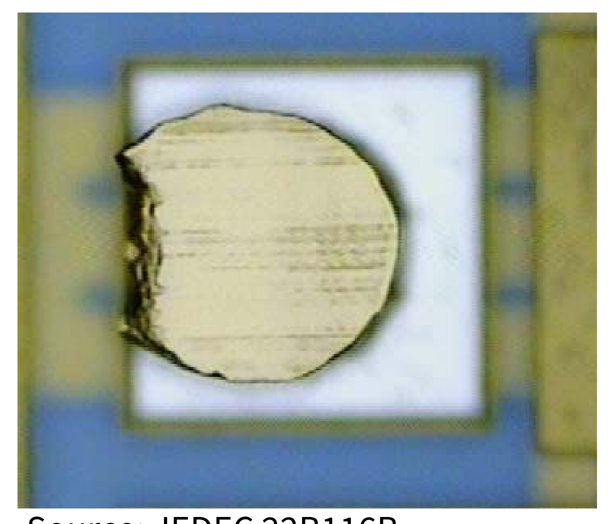


Pull test (destructive and non-destructive)



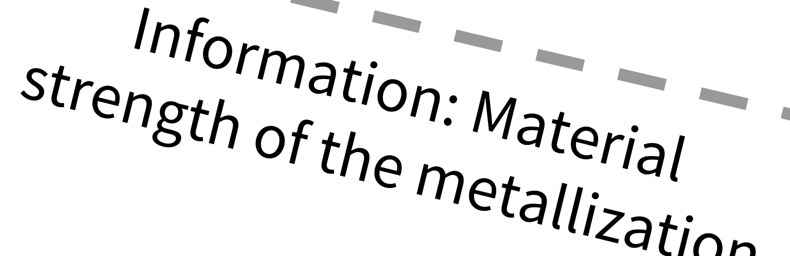
Shear test (destructive and non-destructive)

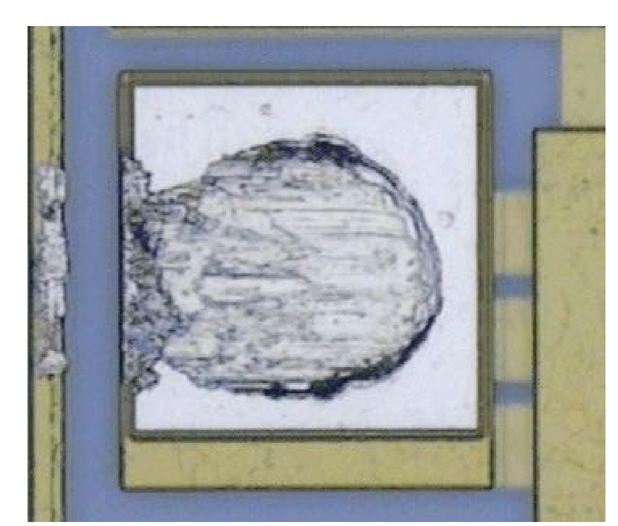




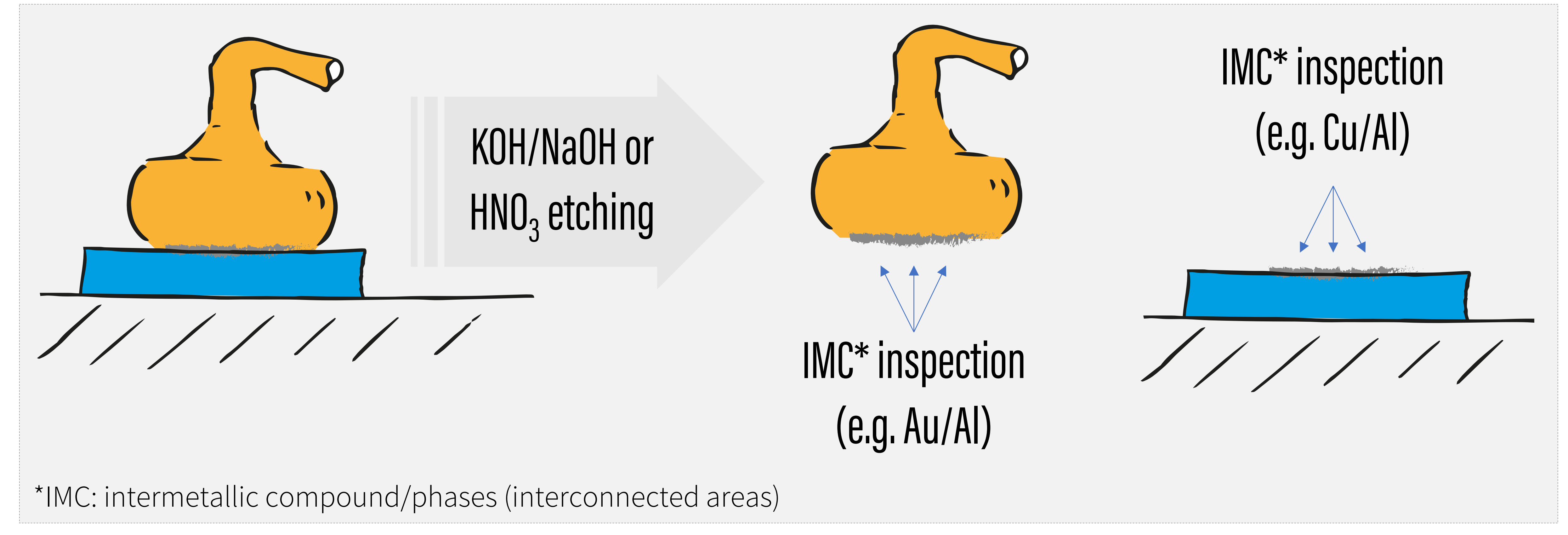
Source: JEDEC 22B116B

What is the quality of the interface?





Source: JEDEC 22B116B


KOH/NaOH or
HNO_3 etching
IMC* inspection
(e.g. Au/Al)
IMC* inspection
(e.g. Cu/Al)
*IMC: intermetallic compound/phases (interconnected areas)

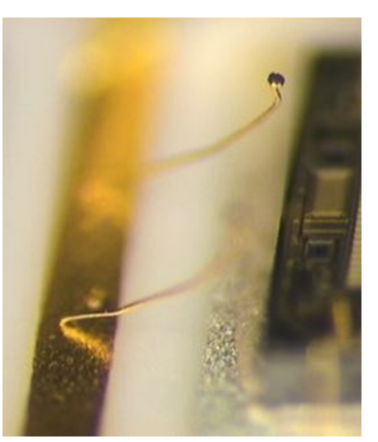
Determining the coverage with intermetallic phases – Au wire

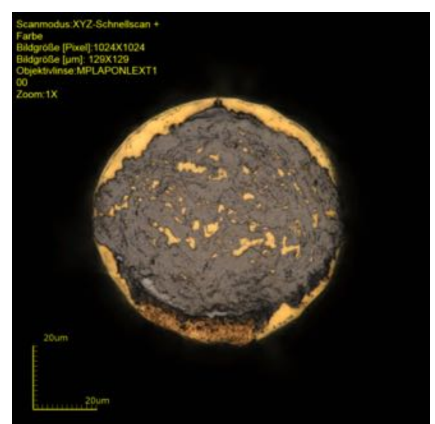
- Removing the Al metallization with 20% NaOH or 20% KOH

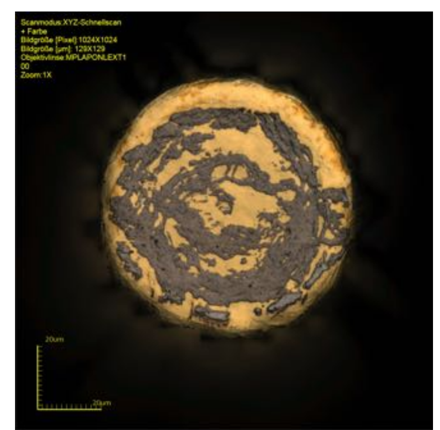
- Rotating the ball bond, using e.g. tweezers

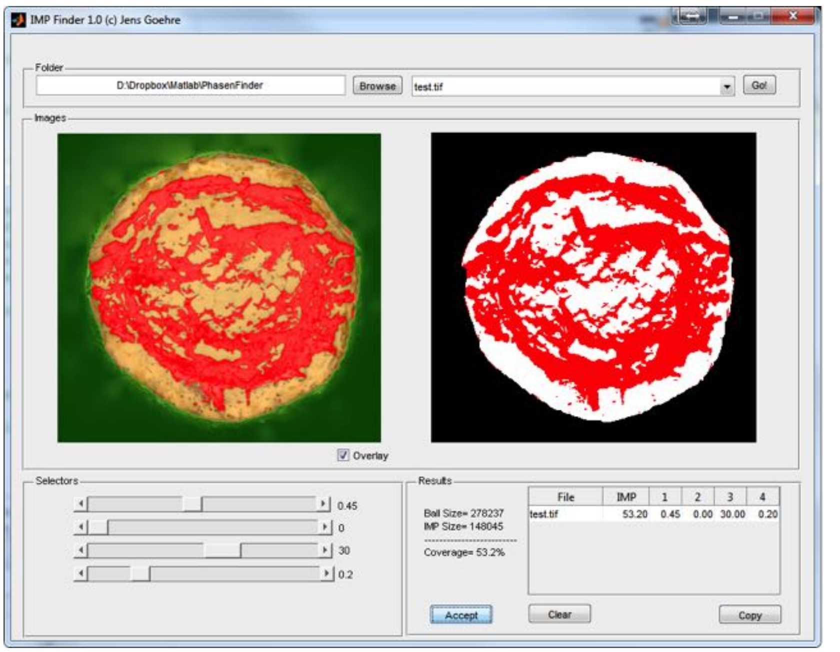
- Inspecting the bottom of the ball with a light microscope, confocal microscope or with SEM

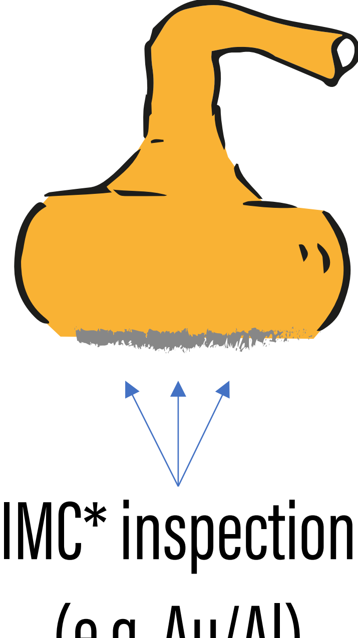
- Determining the surface area of the intermetallic phases using applicable software







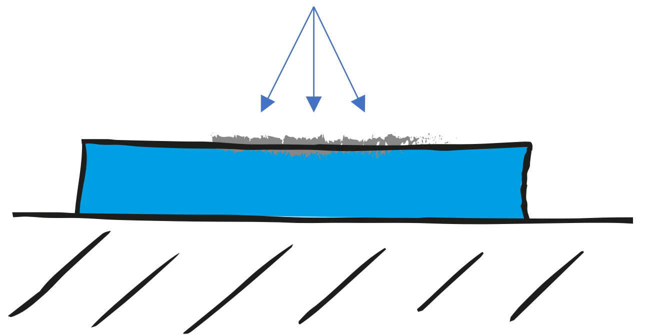




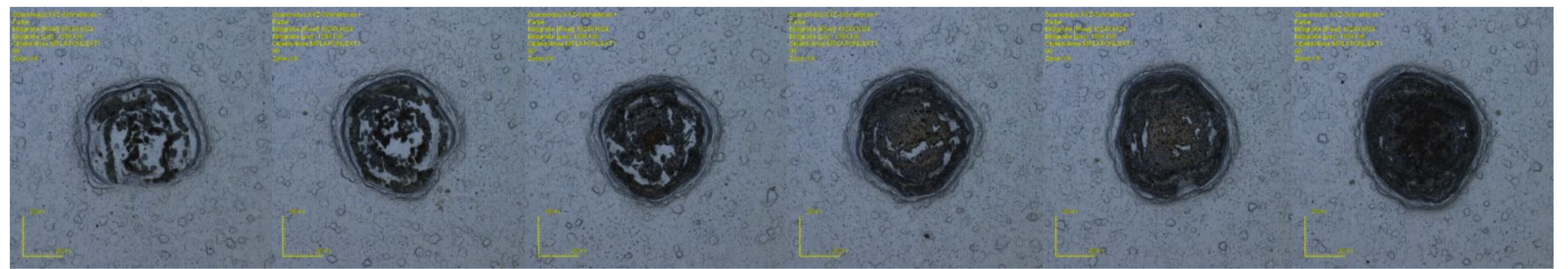
Cu/Al-intermetallics (IMC)

- Cu etching solution 50 ml DI-water and 50 ml 65% nitric acid (at room temperature, 90-120 s exposition time, no ultrasonic).
- Pre-conditioning of bonded contacts at 200°C for 24-40 h to increase IMC growth

IMC* inspection
(e.g. Cu/Al)

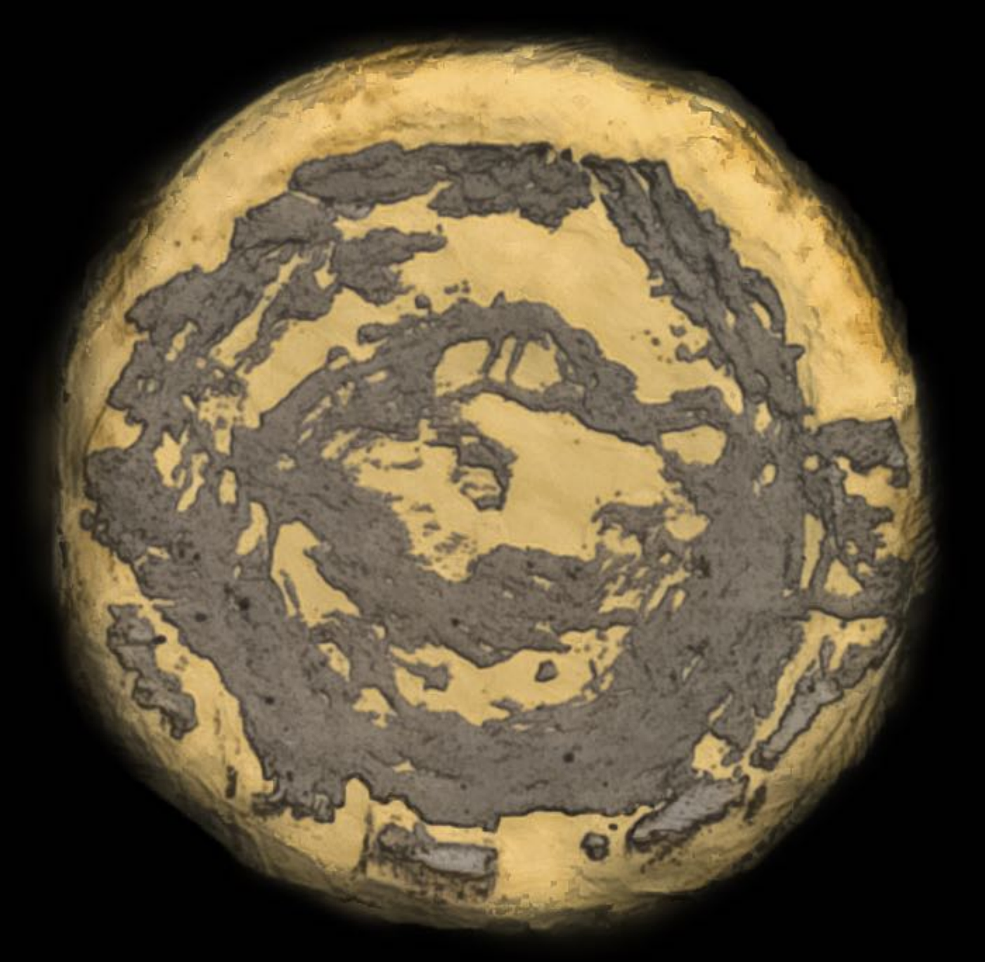


IMC: 70 % **80 %** **90 %** **~95 %** **~97 %** **~100 %**



Recommended IMC coverage

>75 %



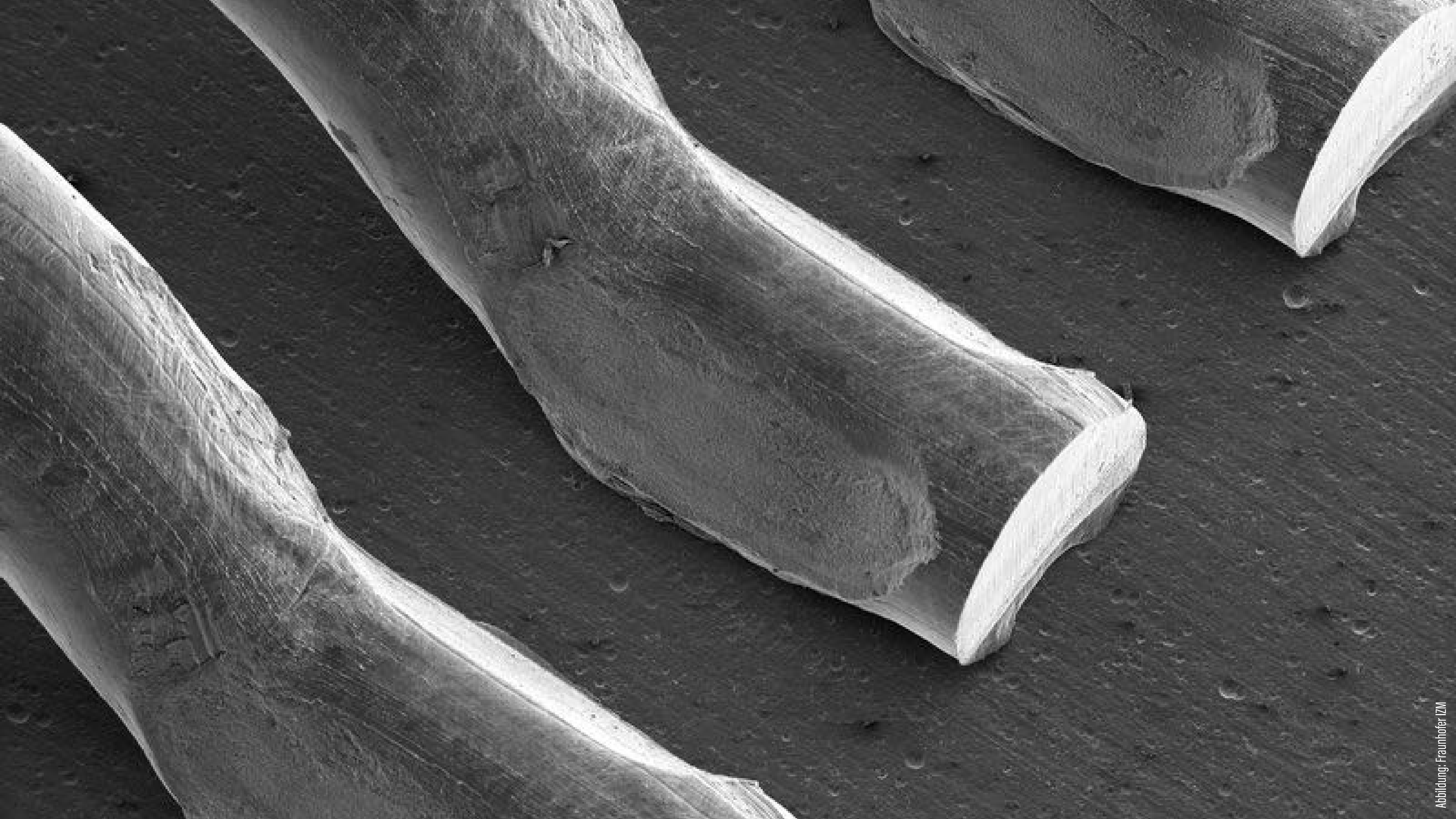


Abbildung: Fraunhofer IZM

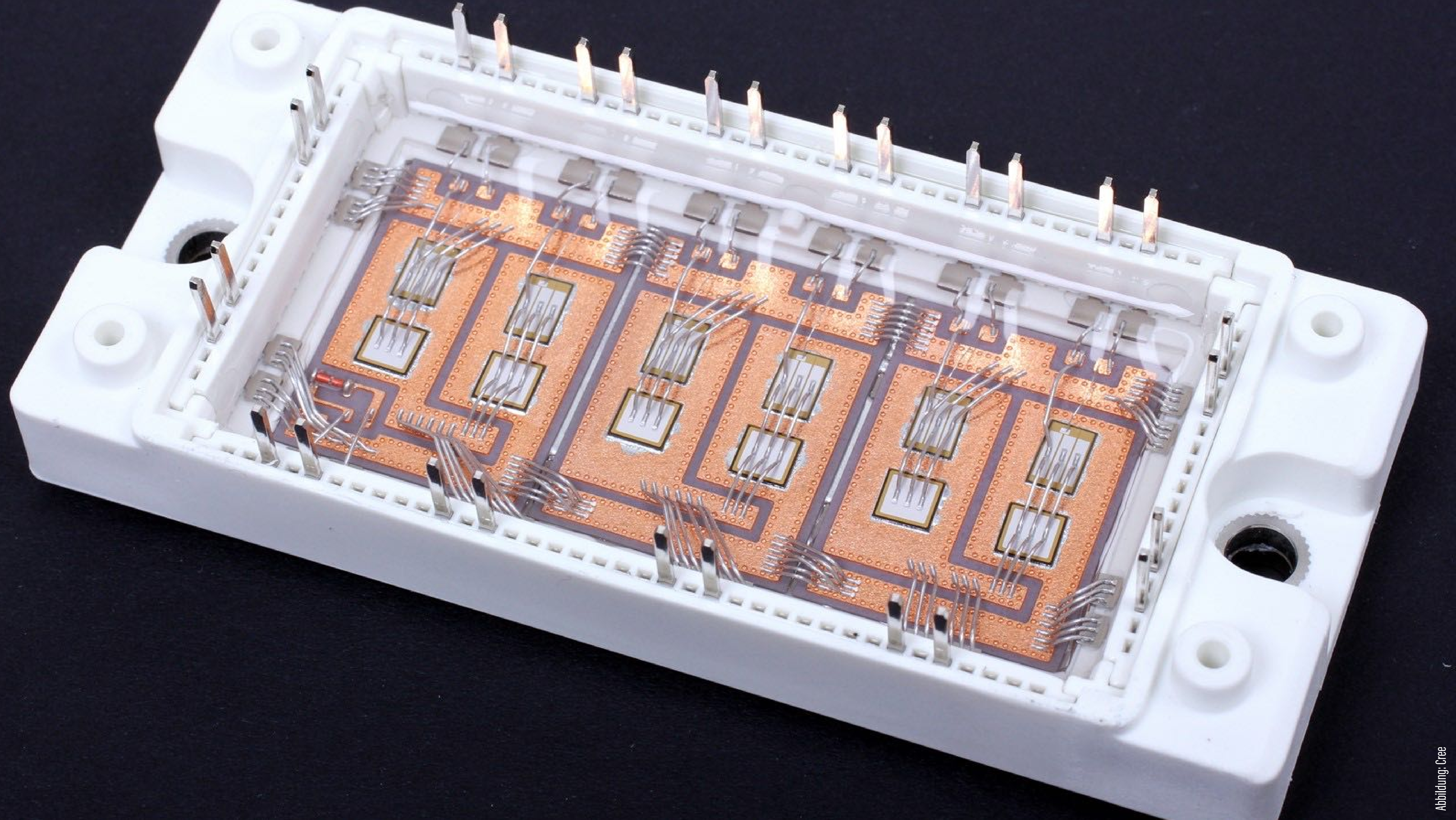
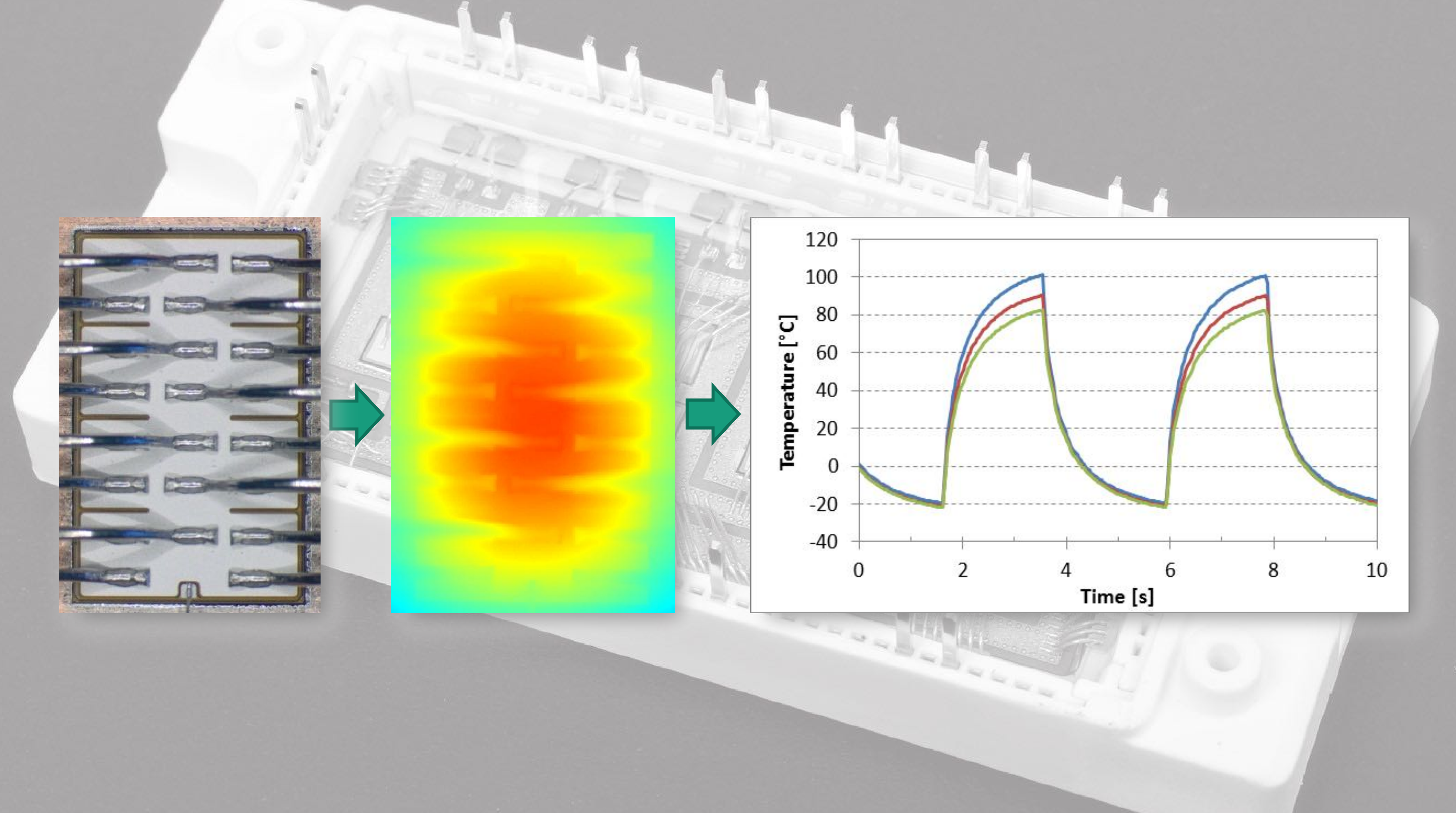


Abbildung: Cree



120
100
80
60
40
20
0
-20
-40
Temperature [°C]
0
2
4
6
8
10
Time [s]

Crack propagation during Active Power Cycling (heavy wire)

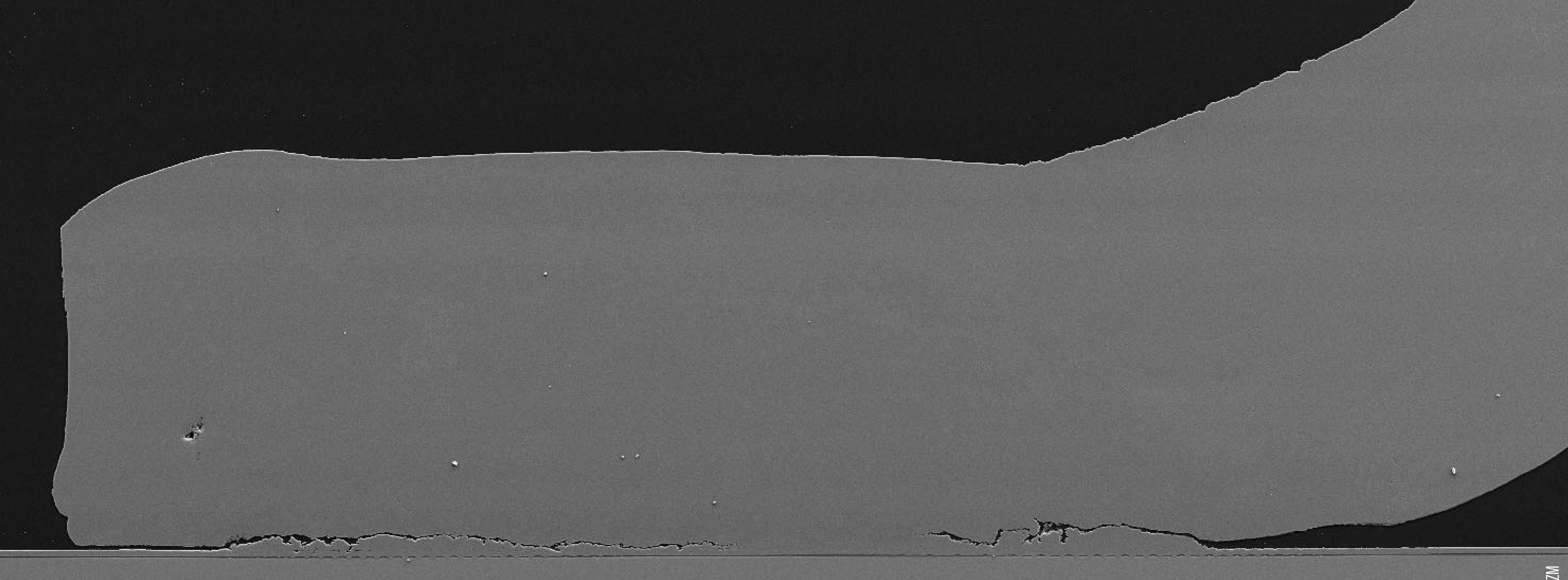


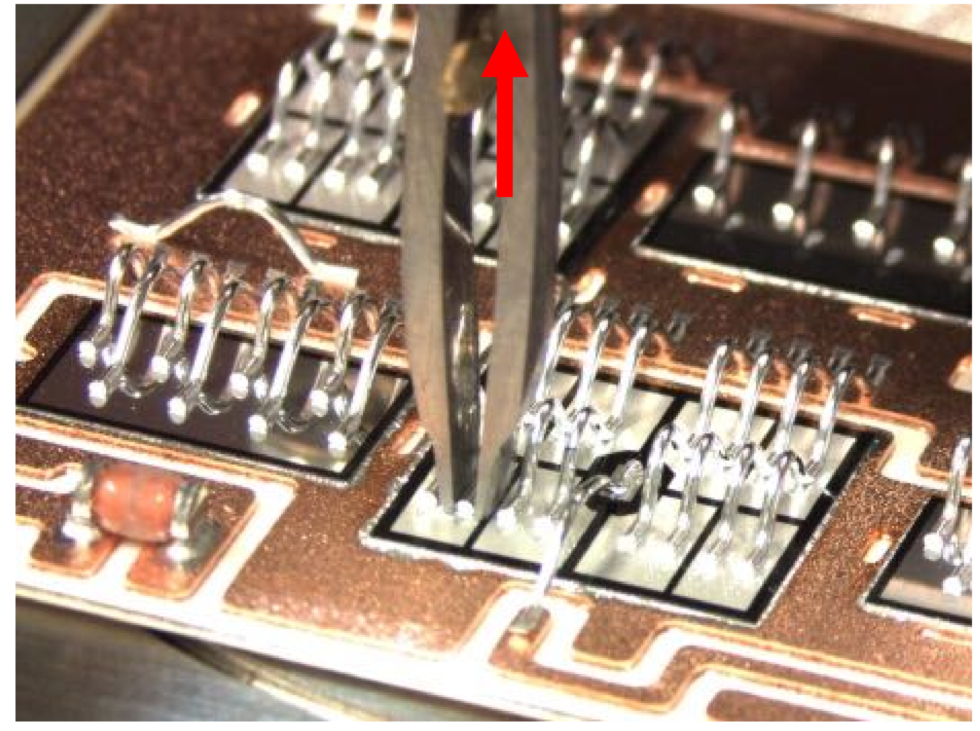
Abbildung: Fraunhofer IZM

BAMFIT

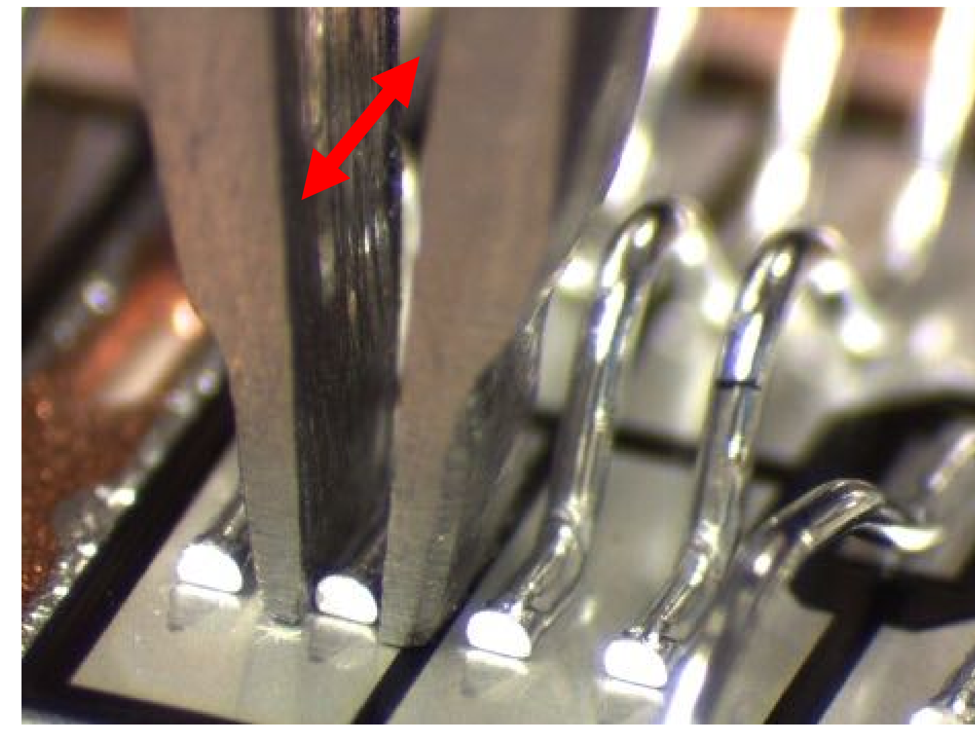
Bondtec
Accelerated
Mechanical
Fatigue
Interconnect
Testing

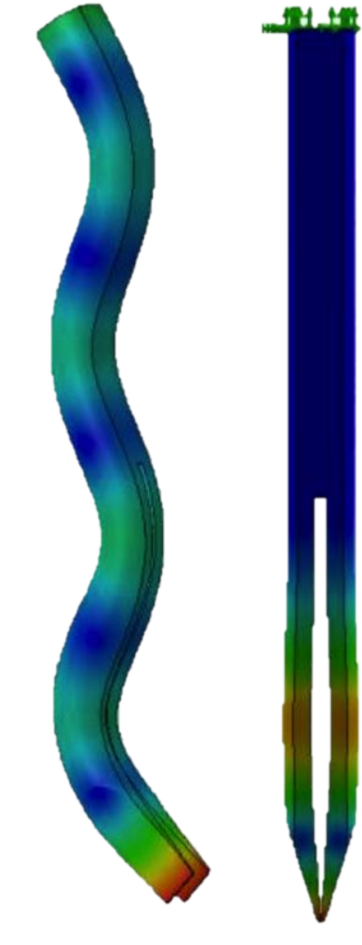
B. Czerny, G. Khatibi, Patent DE 10 2016 107 028.9

Pre-load (tensional force)



Excitation direction (ultrasonic)





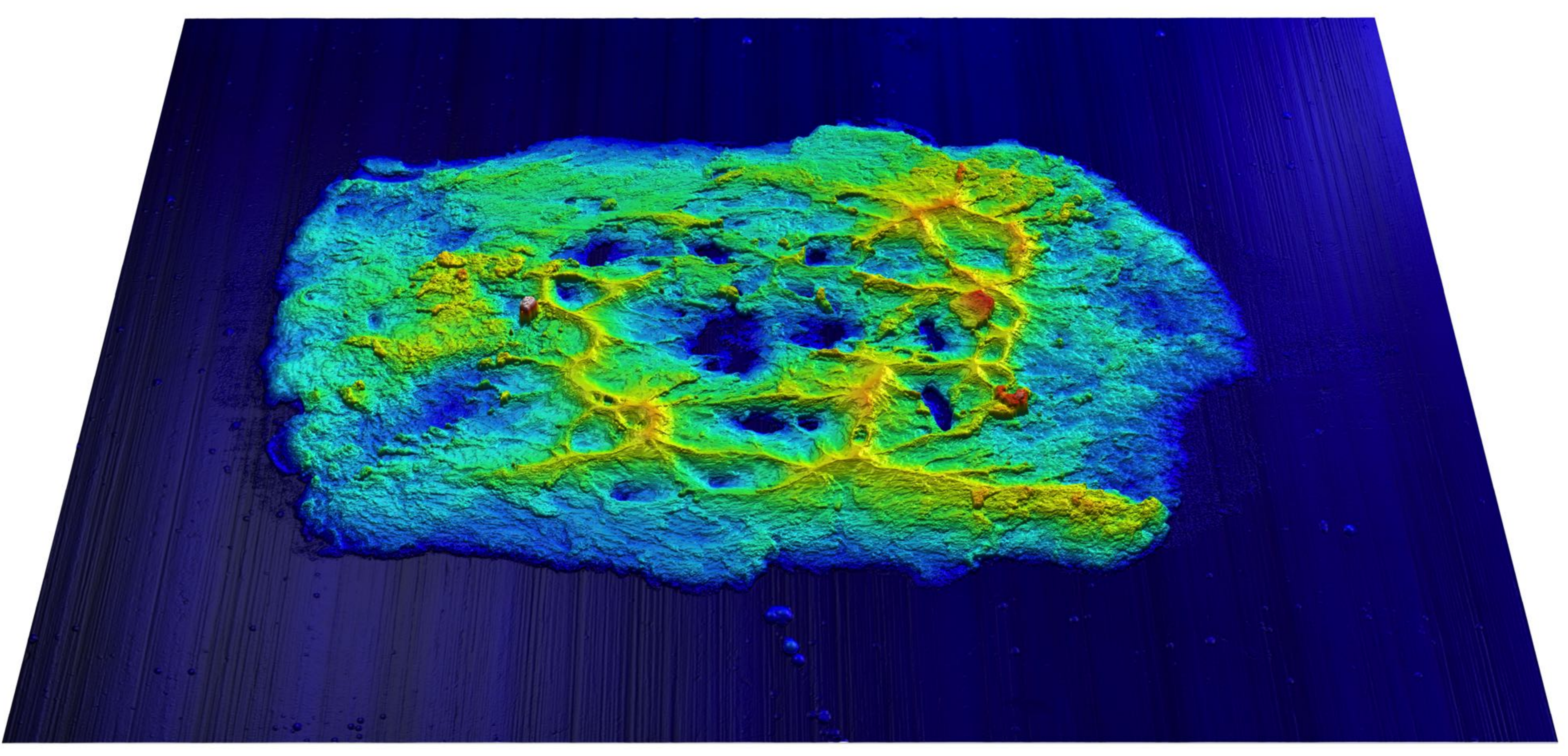
B. Czerny, G. Khatibi, Patent DE 10 2016 107 028.9

Source: B. Czerny, G. Khatibi: BAMFIT – Accelerated Mechanical Fatigue Interconnect Test, PLUS 1/2018

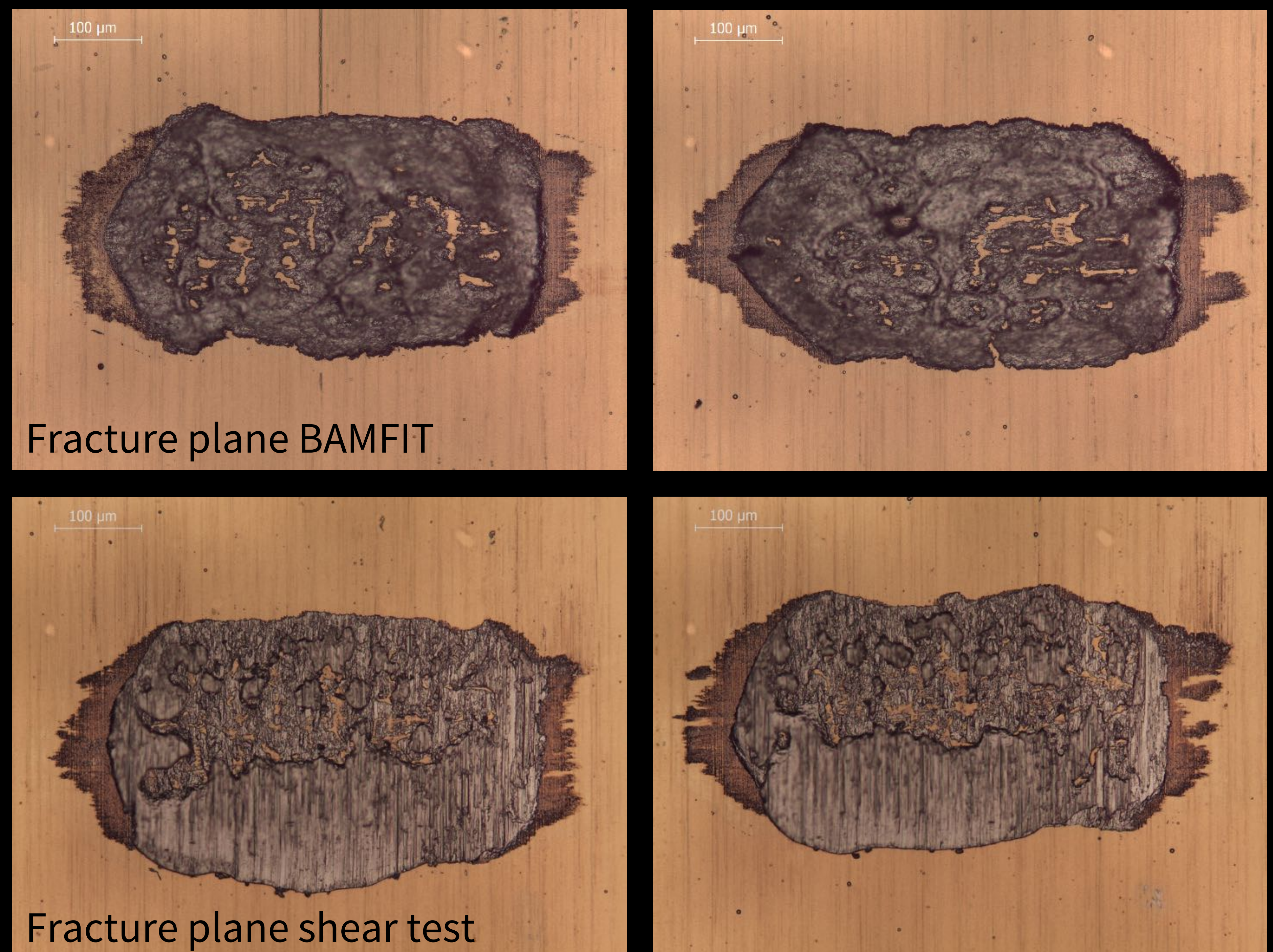
Abbildung: TU-Wien

BAMFIT fracture pattern

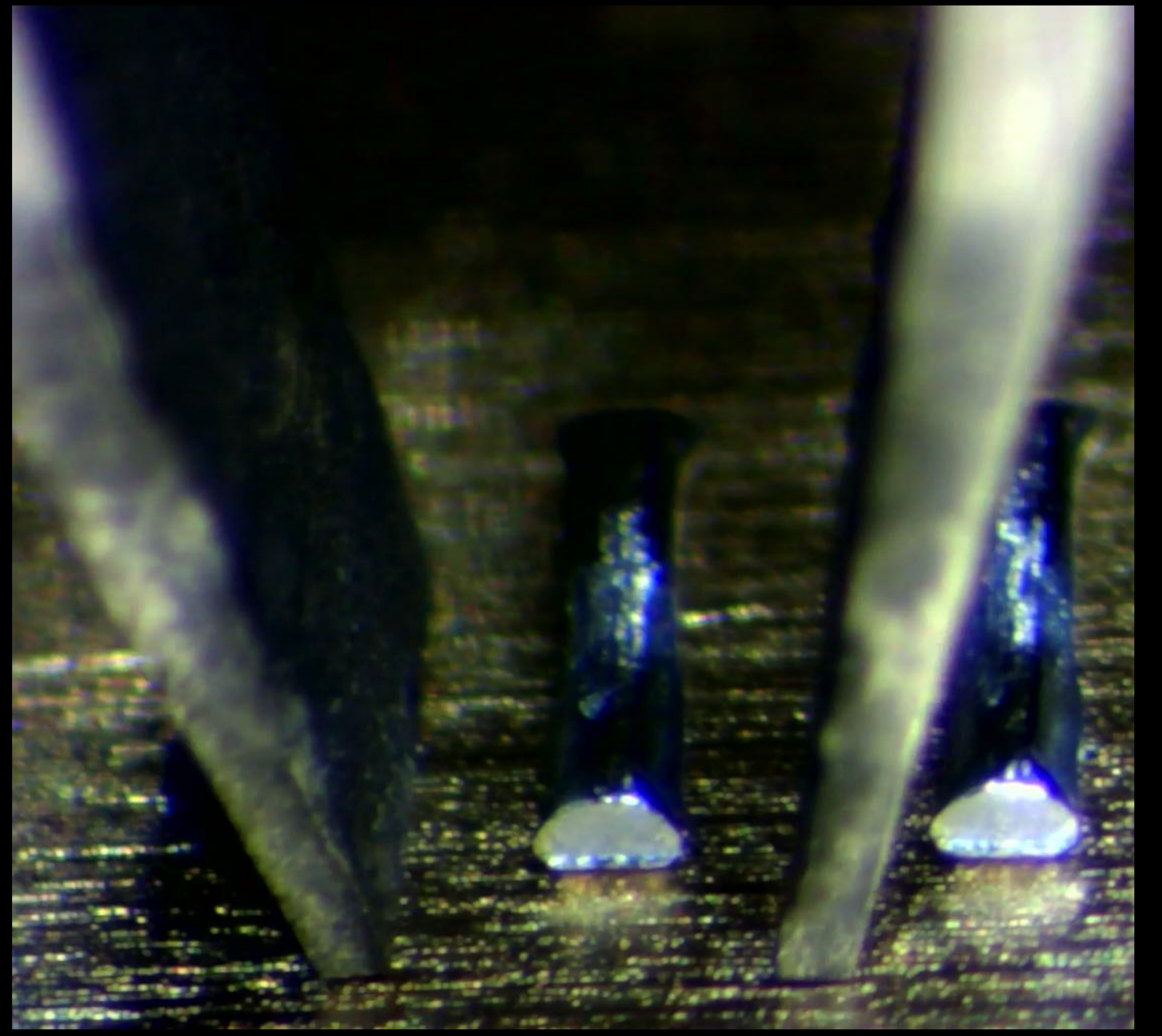
µm
450
400
350
300
250
200
150
100
50
0
0
100
200
300
400
500
600 µm



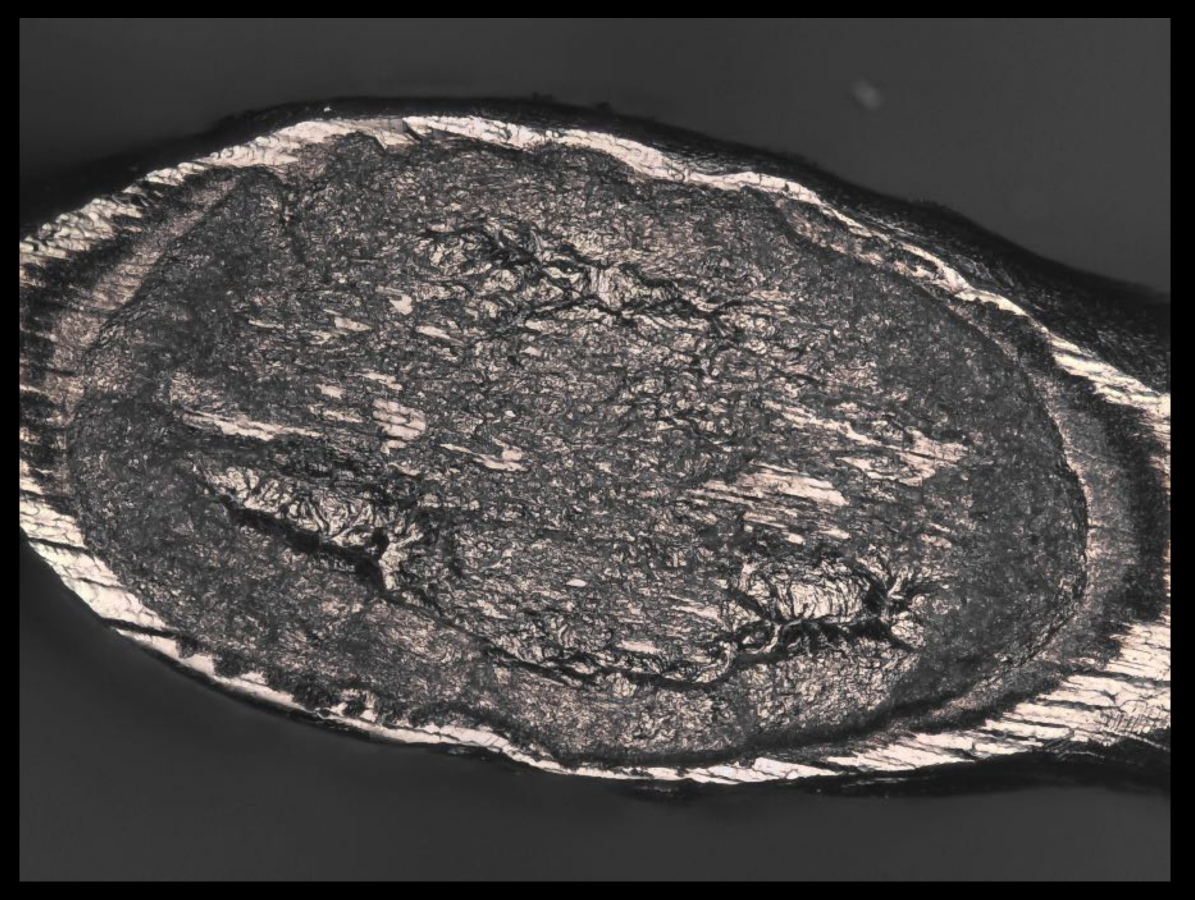
BAMFIT fracture pattern



100 µm
100 µm
Fracture plane BAMFIT
100 µm
100 µm
Fracture plane shear test

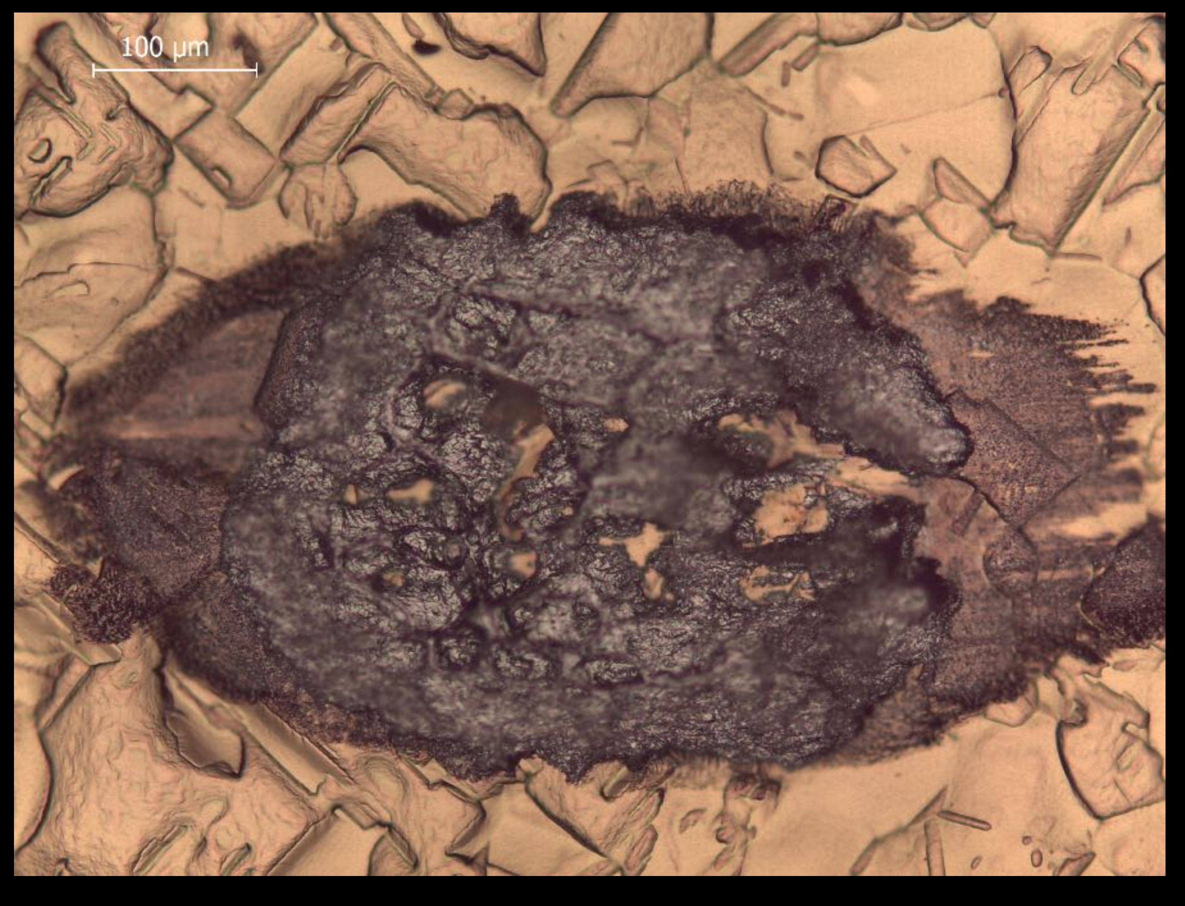


Fracture plane BAMFIT

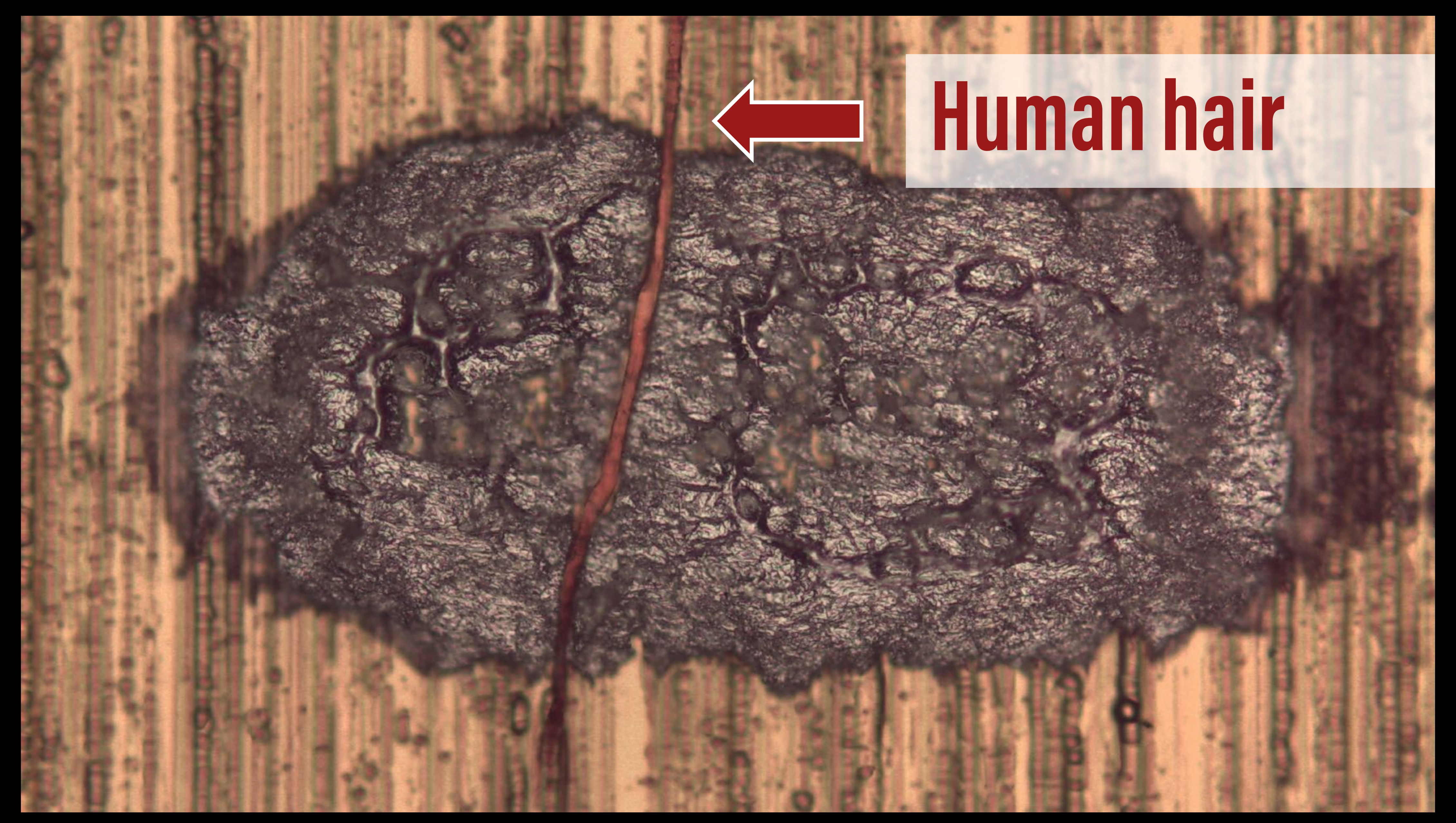


Corresponding wedge bottom

Parameter A



Parameter B


Human hair

SPEEDCYCLE

- **Potential evaluation** of the BAMFIT process applicable for heavy wire bond connections (125 - 500 µm) as an alternative to the shear test
- **Correlation of BAMFIT results to bond quality** and shear test results on different surfaces and different wire materials
- Preparation of a **guideline** for the use of the BAMFIT process with different wire diameters

Project duration: 01.09.2019 – 31.03.2021

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ENHANCE WIRE BONDING