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AAC – Your advanced solution for Space and Beyond

Examples of Failure Analysis Images

Christian Jogl (AAC)

Examinations of a metal rivet

Electron-microscopic assessment of the cross-section

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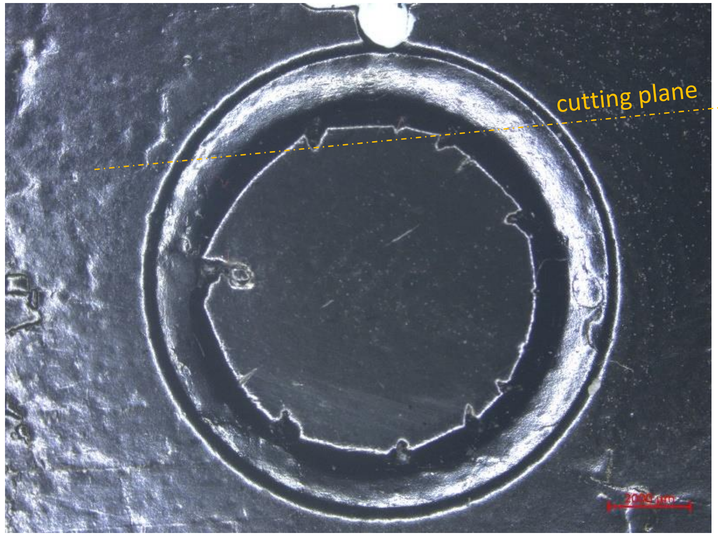
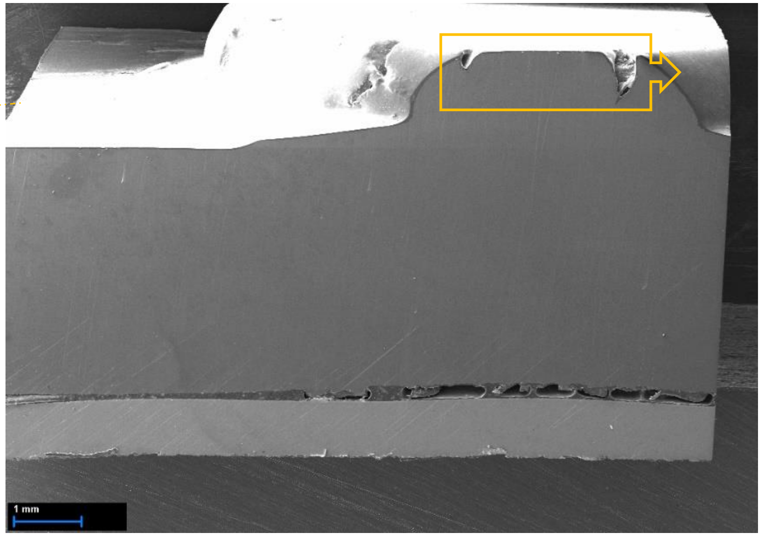
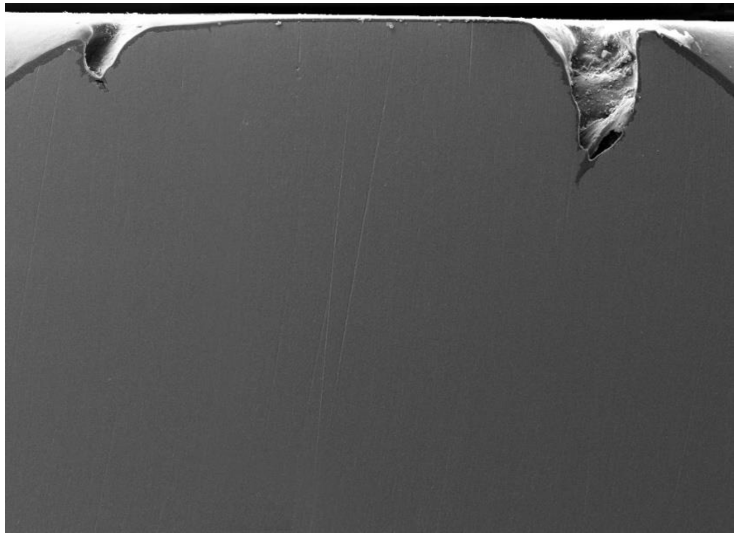
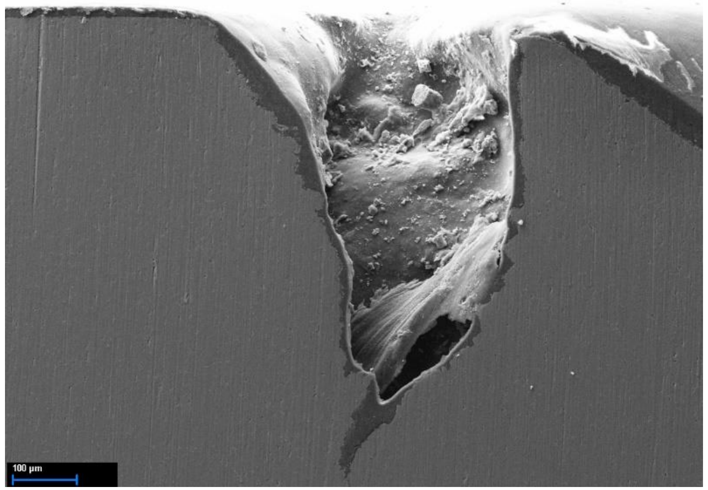








→ 2 cracks (200µm and 600µm deep)

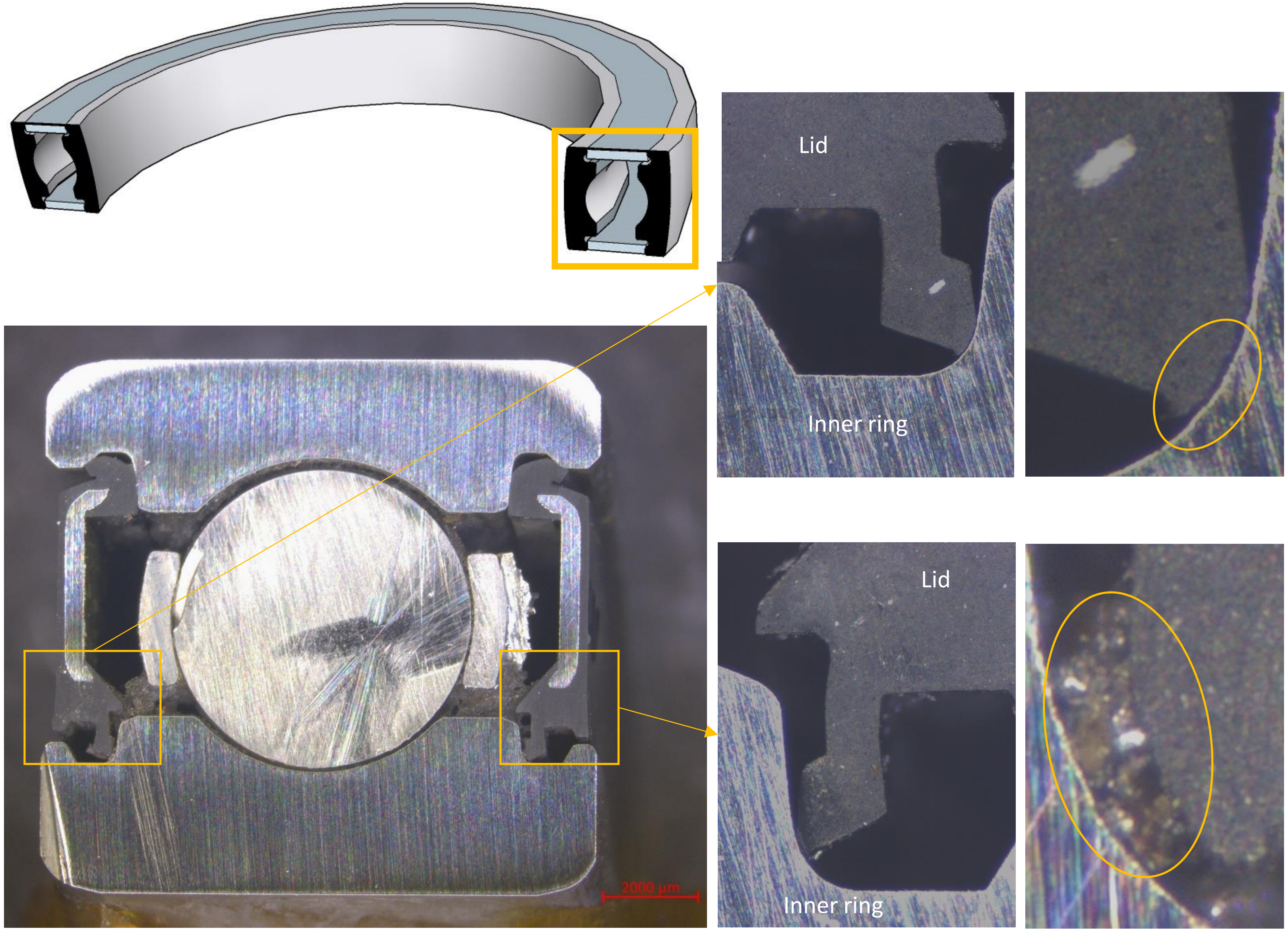
→ Coating detectable inside the rack

→ **Crack formation BEFORE coating process**

→ EDX-analysis inside the crack: found Na and Cl

→ **Corrosion issue**

Investigation on ball bearings
Light-microscopic investigation of the cross section



→ Deformation of the bearing lid in the area of the inner edge
→ Signs of an excessively tight fit
→ Increased torque of the bearing

→ No deformation of the bearing lid
→ Gap filled with grease
→ **Desired condition**

Investigation of Helicoils

Light-microscopic investigation of the cross section

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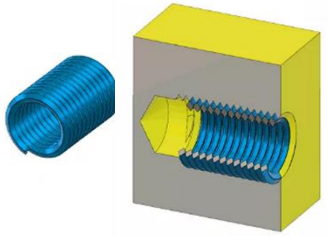
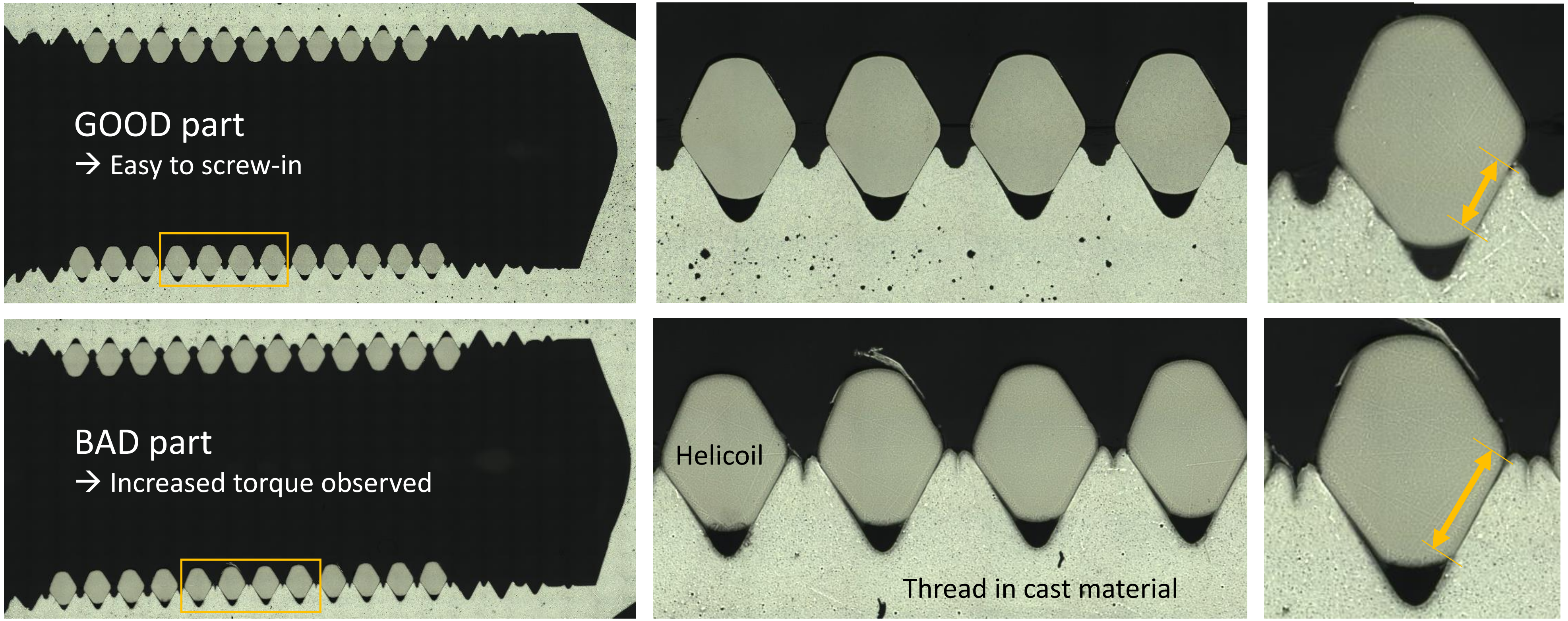
A threaded insert (such as a Helicoil®) is used to create internal threads when the base material does not have the desired properties (e.g., mechanical strength) for a screw connection.





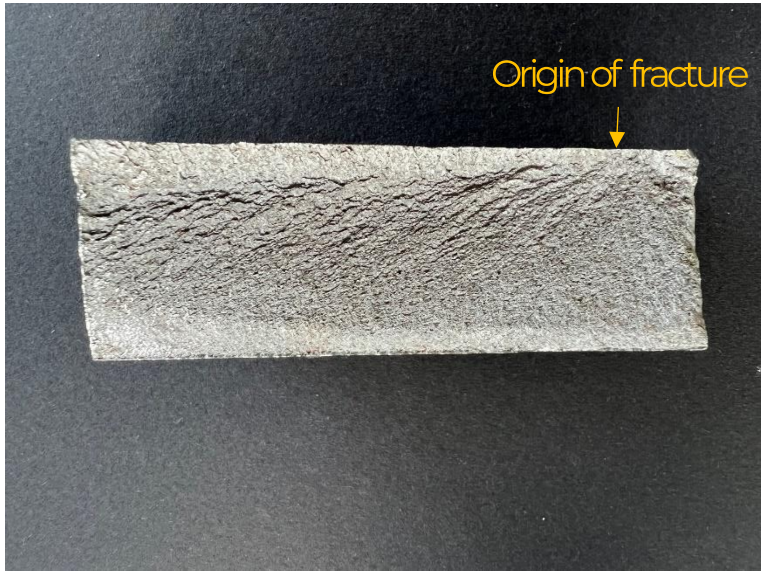
Plastic deformation of the thread in the middle of the screw-in section

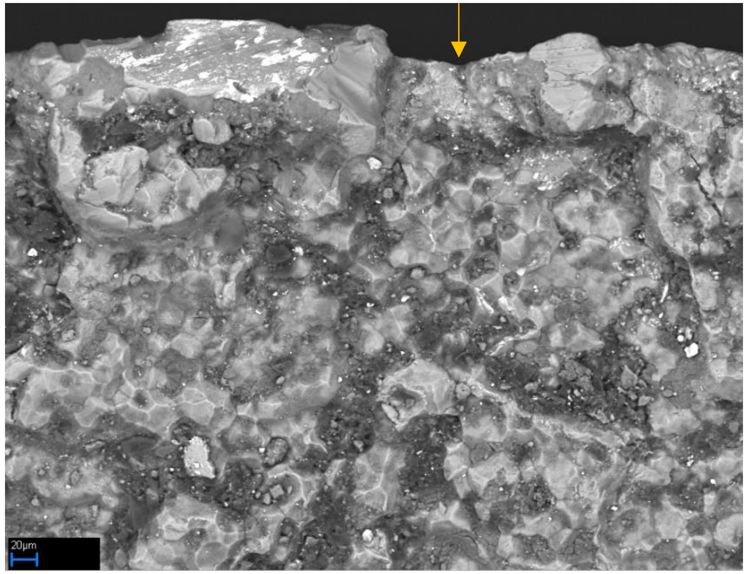
→ Contact area between Helicoil and thread increased

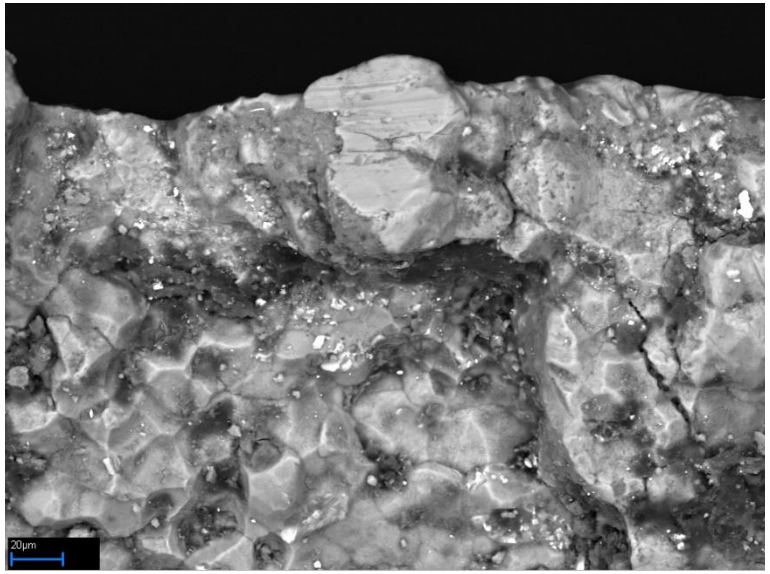
→ Increased friction during screwing

Investigation on a broken component
Electron-microscopic assessment of the fractured surface

Classical failure analysis aims to identify the underlying mechanisms of a damage. This can help to optimize processes and minimize future downtimes.







→ Classification of the fracture pattern as an intergranular brittle fracture due to local mechanical overload.
→ Local plastic deformations in the area of the fracture origin: occur after/during the opening of the crack
→ Oxidic deposits on the surface

→ **From the clear identification of the starting point of the fracture, the underlying cause of the damage can be derived. This provides useful inputs for the optimisation of the mechanism's design.**

3D-measurement of surfaces
Electron-microscopic assessment of the surface

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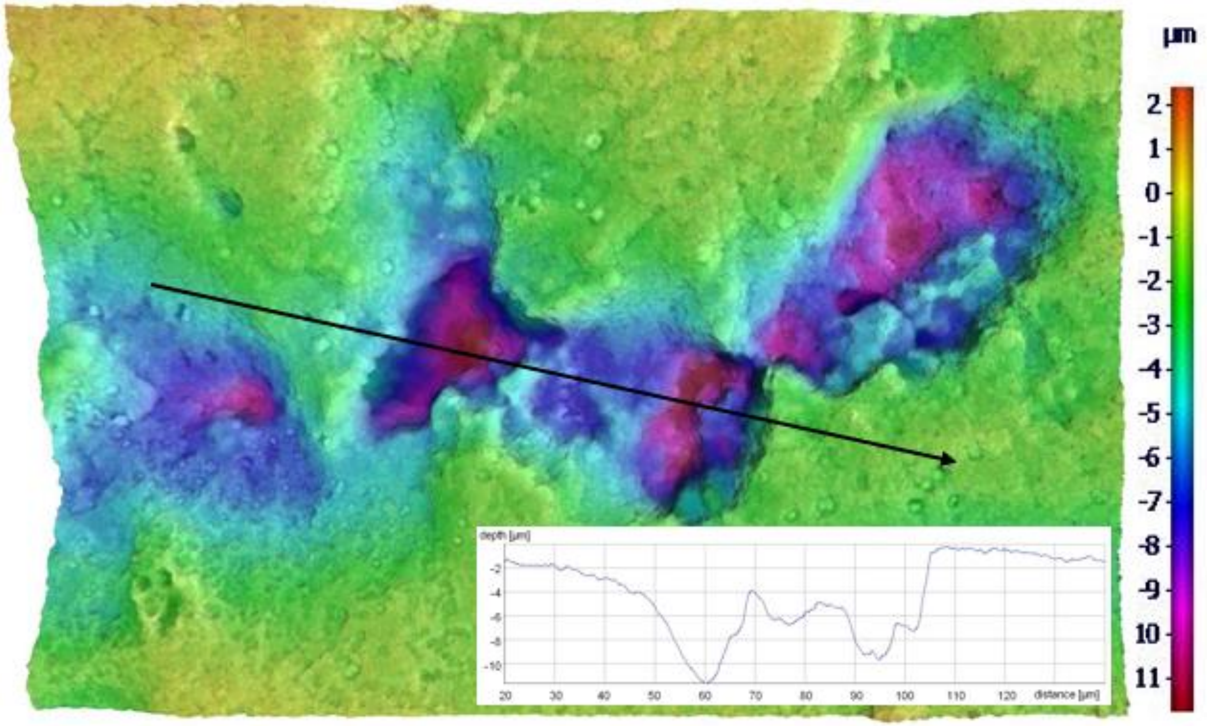
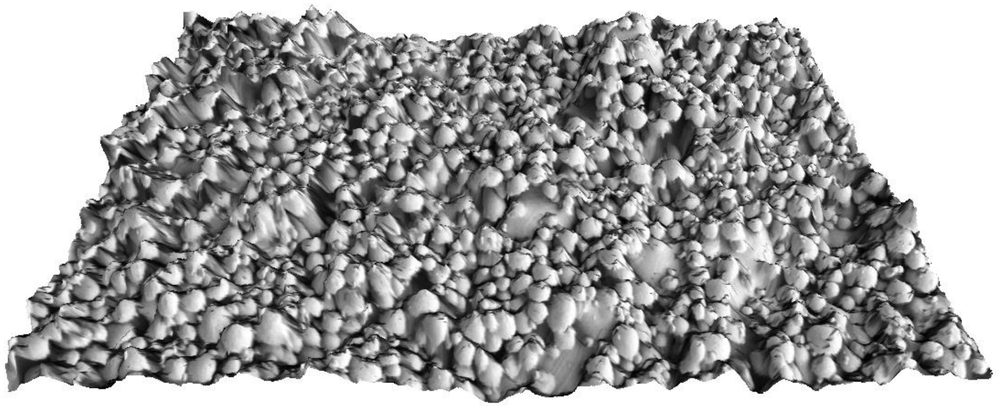
In addition to electron microscopic imaging of the surface and chemical analysis using EDX, it is also possible to display and measure the topography of the surface. To do this, a 3D model is calculated from the SEM images using highly specialized software packages, which can then be measured and quantified. On the one hand, this gives the statistical surface parameters (Ra, Rz, waviness, etc.) and, on the other hand, the dimensions of surface structures can be determined.

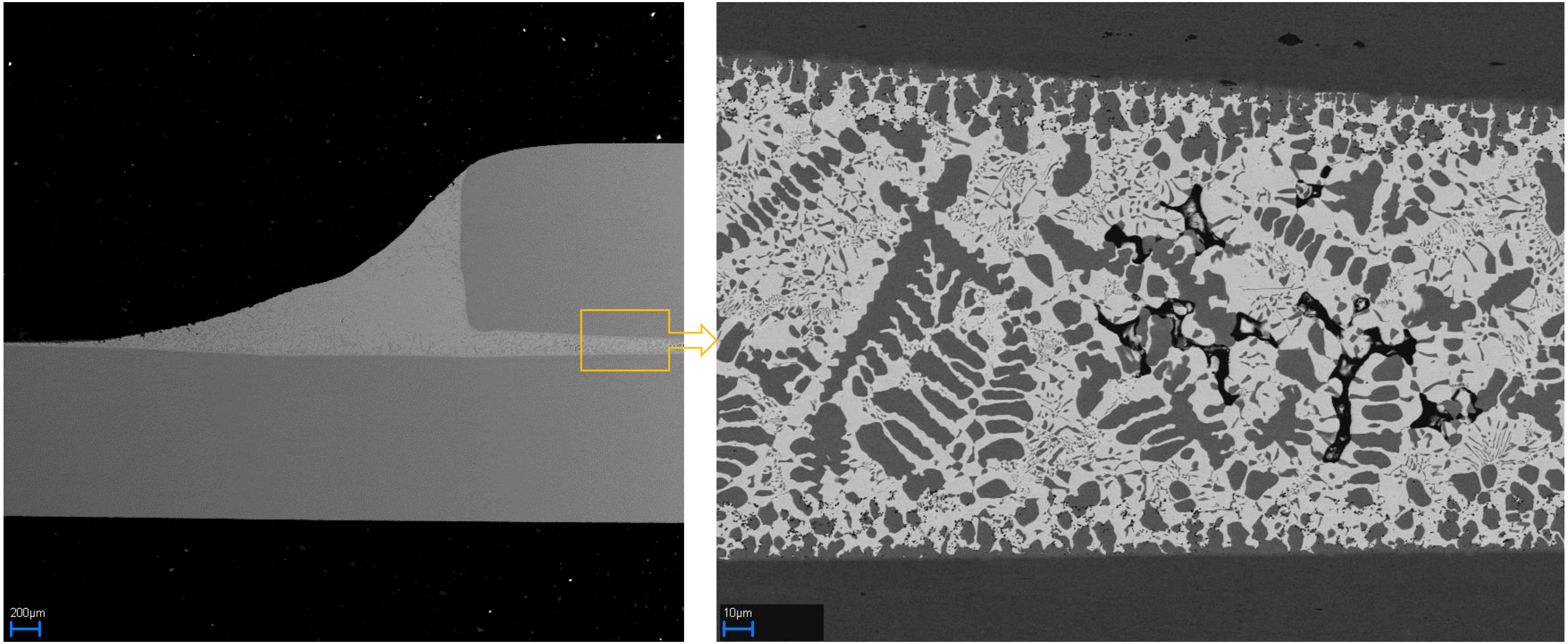


3D-representation and measurement of a damaged area



Representation of a 3D printed surface to determine the roughness parameters

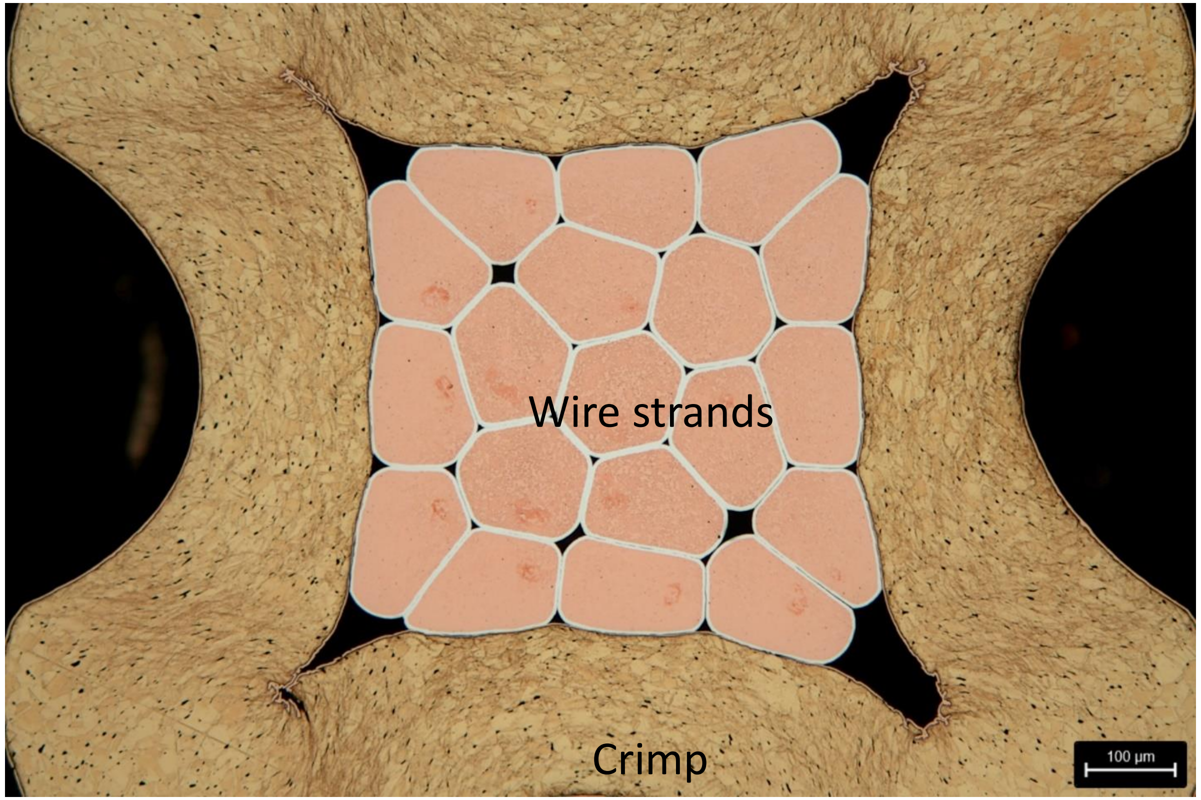
Examination of a solder joint
Electron-microscopic assessment of the cross section



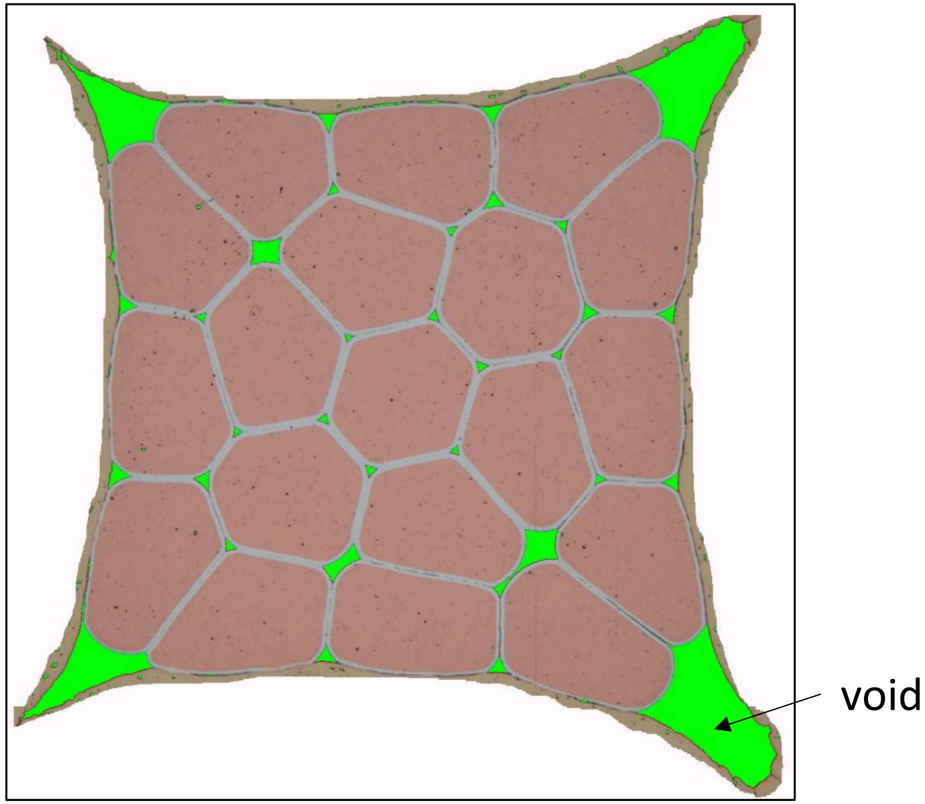
→ Investigating the microstructure of the (Cu / Ag / Zn) - soldering shows **pores and defects**

Investigation of electronic parts
Light-microscopic investigation of the cross section

The metallographic examination of electronic components (such as connectors, resistors, ICs, ...) provides essential information about the quality of the component and can be used to qualify manufacturing processes.



Light-microscopic Image of the cross-section through a crimped contact.

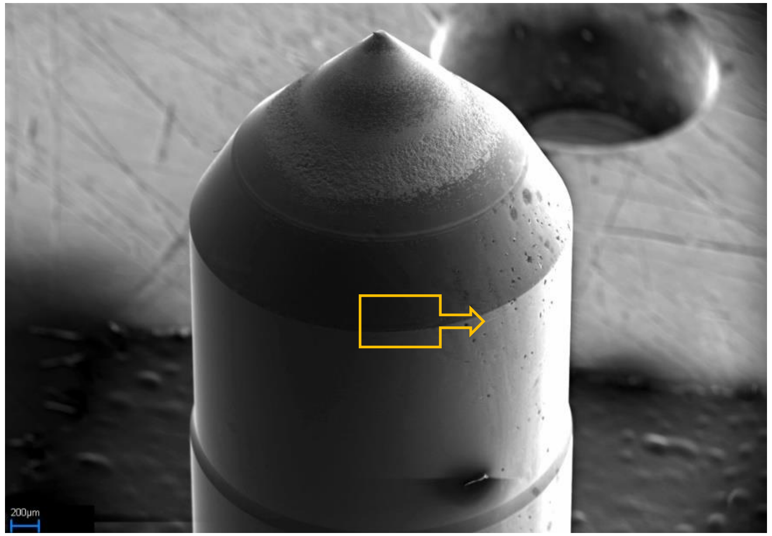


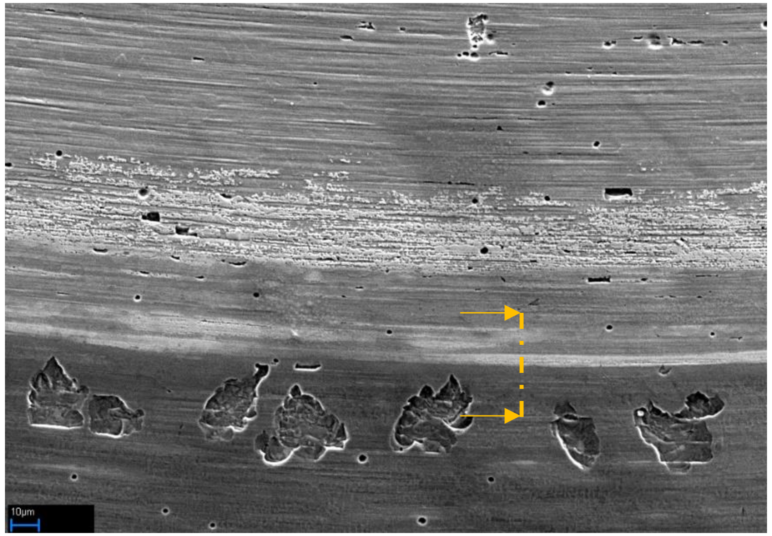
Quantitative determination of the proportion of defects using specific evaluation routines

The quantitative analysis of voids is used to qualify electronic parts for usage under demanding conditions.

Investigation of an valve needle
Electron-microscopic assessment

Failure analysis can also be performed on complex-shaped components and parts.



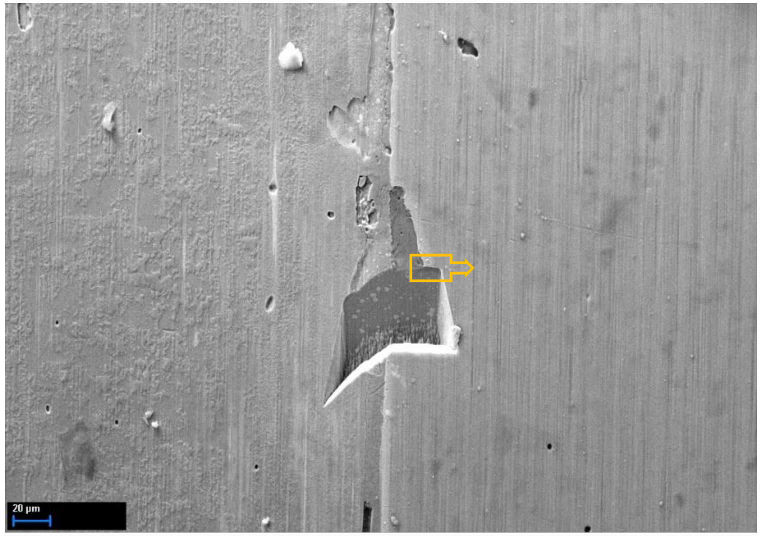


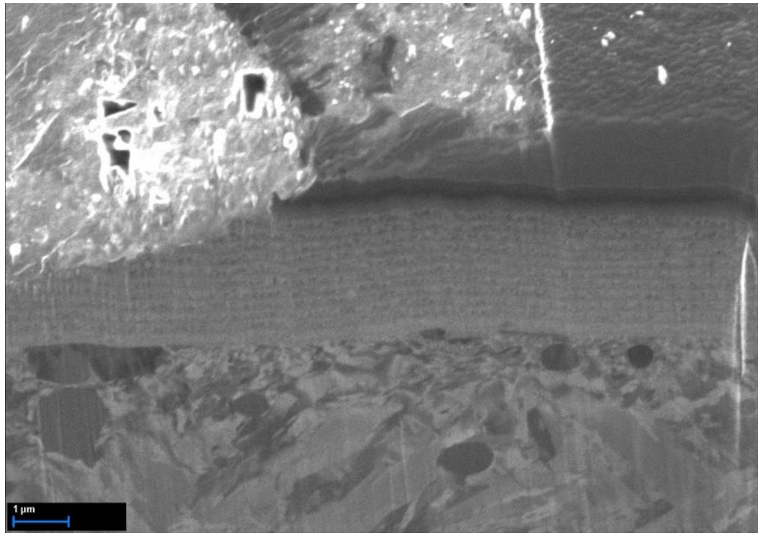
FIB-cut in the contact area:

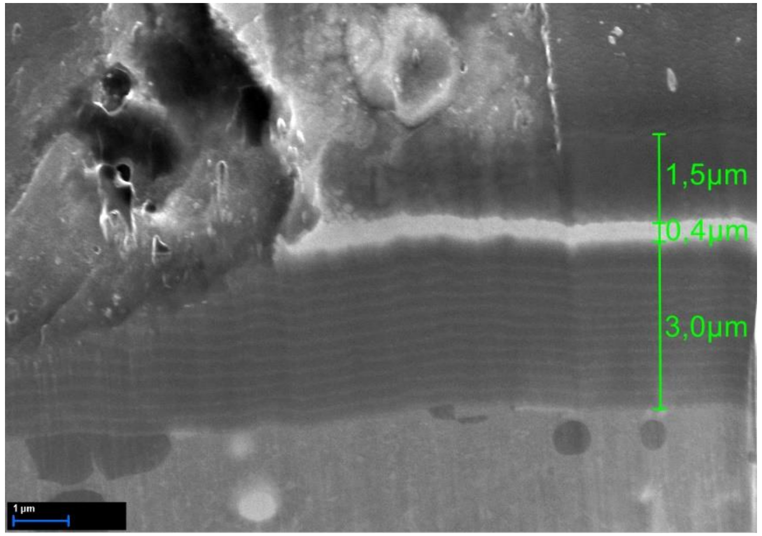
→ **Continuous removal of the coating (no flaking)**

→ **Structure of the coating:**
~3,0µm Multilayer- Basecoating
~0,4µm Interlayer
~1,5µm Functional top layer

→ **Grain structure in the base material**



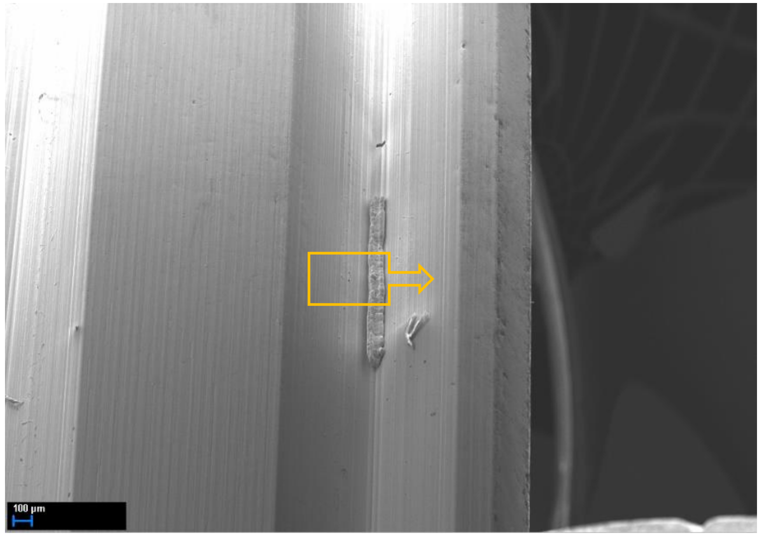


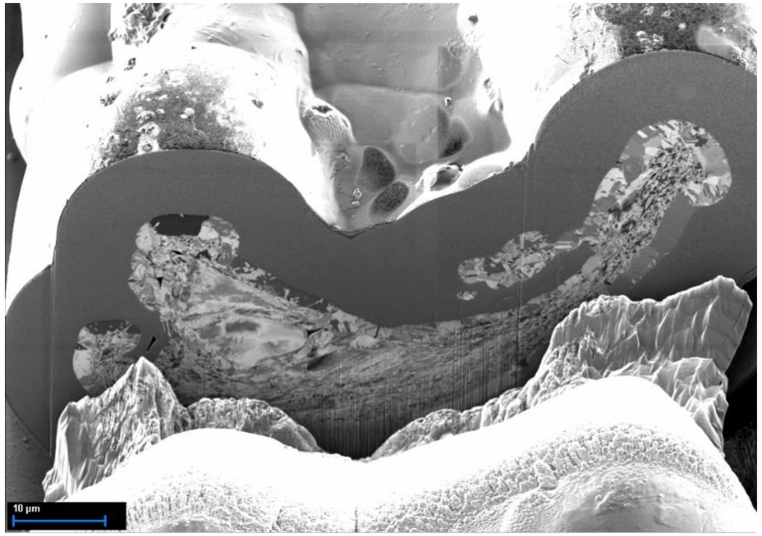


Investigation on a slip-ring assembly
Electron-microscopic assessment

Damage analysis does not just begin after the failure of a component, but can also be seen as part of quality assurance and therefore is an essential step in product development.

→ Analysis on a noticeable contamination in the V-groove of a slip ring:





The FIB-cut into the contamination reveals:

→ Metallic grain structure inside the contamination
→ The contamination is fully covered with coating

→ **No failure during coating process**
→ **Production chip originating from BEFORE the coating process**

Assessment and optimisation of a coil

Light-microscopic investigation of the cross section

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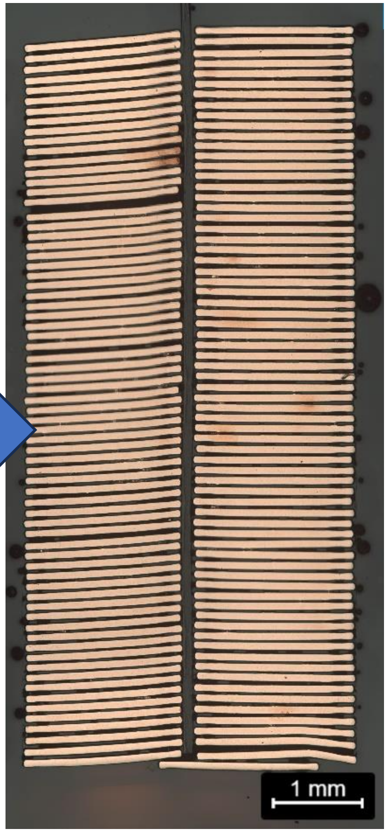
Involving microanalytical methods into the production process can be used to optimise parts and processes

Initial configuration



optimised configuration

→ ***More compact***

→ ***More efficient***

A customer developed a new type of coil with a rectangular wire cross section.

The winding machine used had to be adapted in order to obtain optimal wire layering.

After each adaptation step, a cross section was examined to assess the alignment of the wires.

This enables optimization of the manufacturing process, which leads to a reduction in component size on the one hand and an increase in efficiency on the other.

Evaluation of stress corrosion cracking
Light- and electron-microscopic investigations

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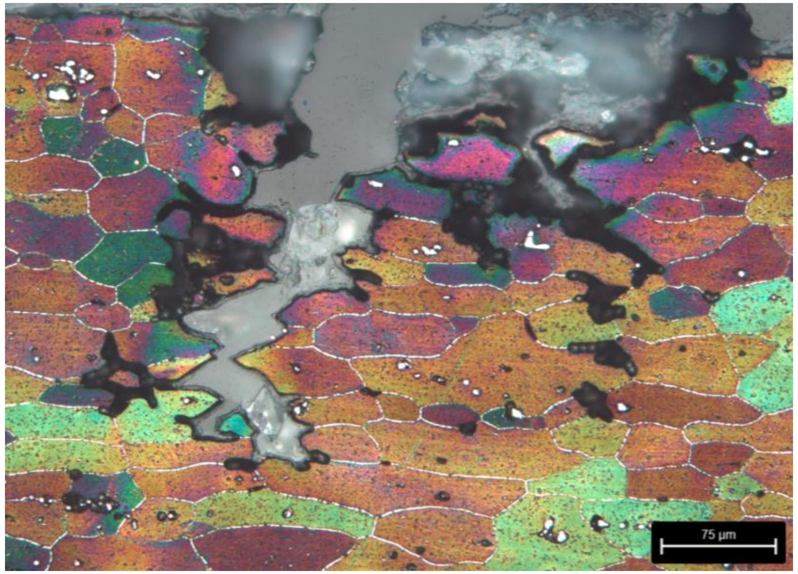
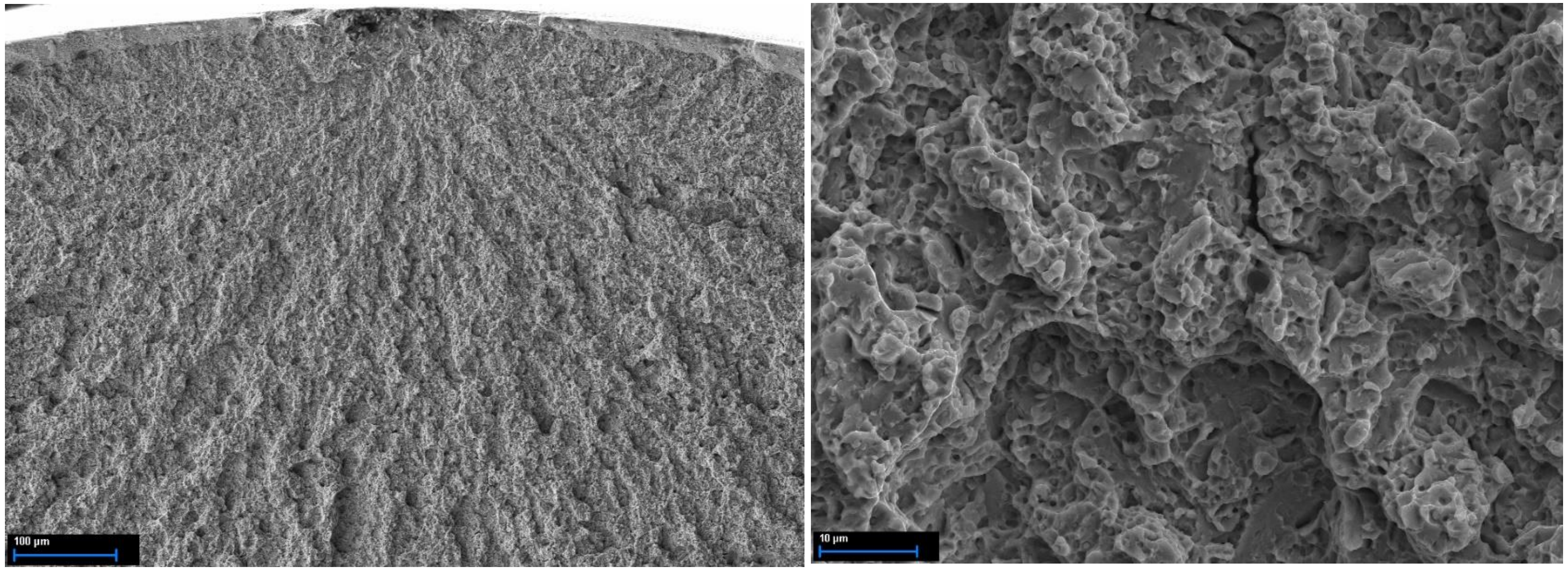
The failure of metal components can be attributed not only to mechanical or chemical overload, but also to a combination of both stresses. The risk of so-called stress corrosion cracking (SCC) is assessed according to the ECSS standard ECSS-Q-ST-70-37, using both light microscopic and electron microscopic methods.

Tensile test sample after SCC test



Light-microscopic image of the cross-section (acc. to ECSS standard)



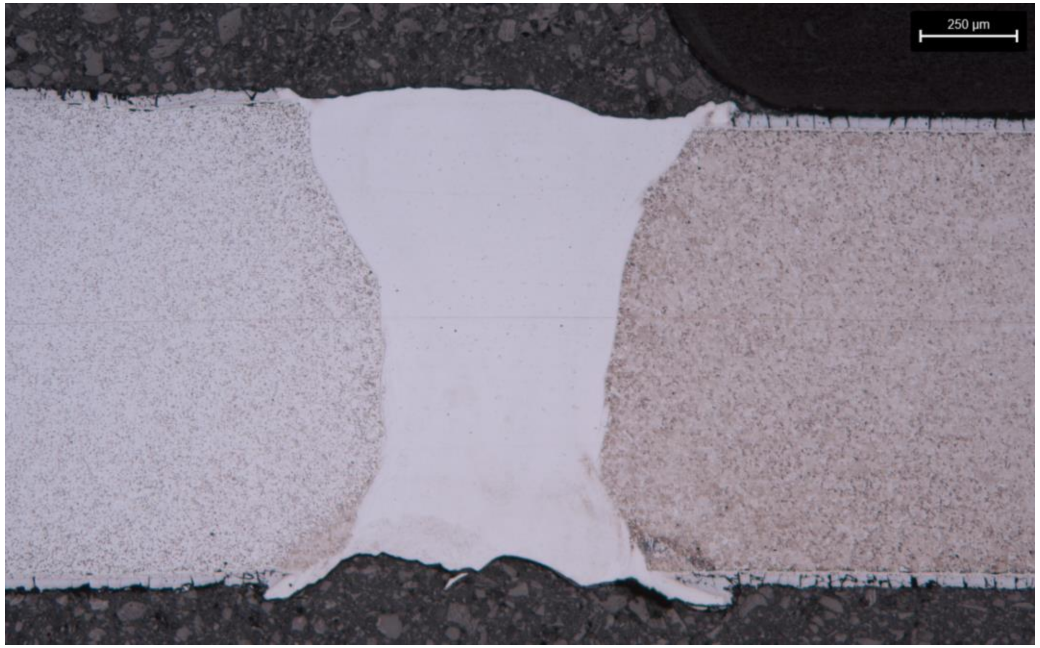
Electron-microscopic image of the cross-section (in addition to the requirements stated in the ECSS standard)

Assessment of weld seams

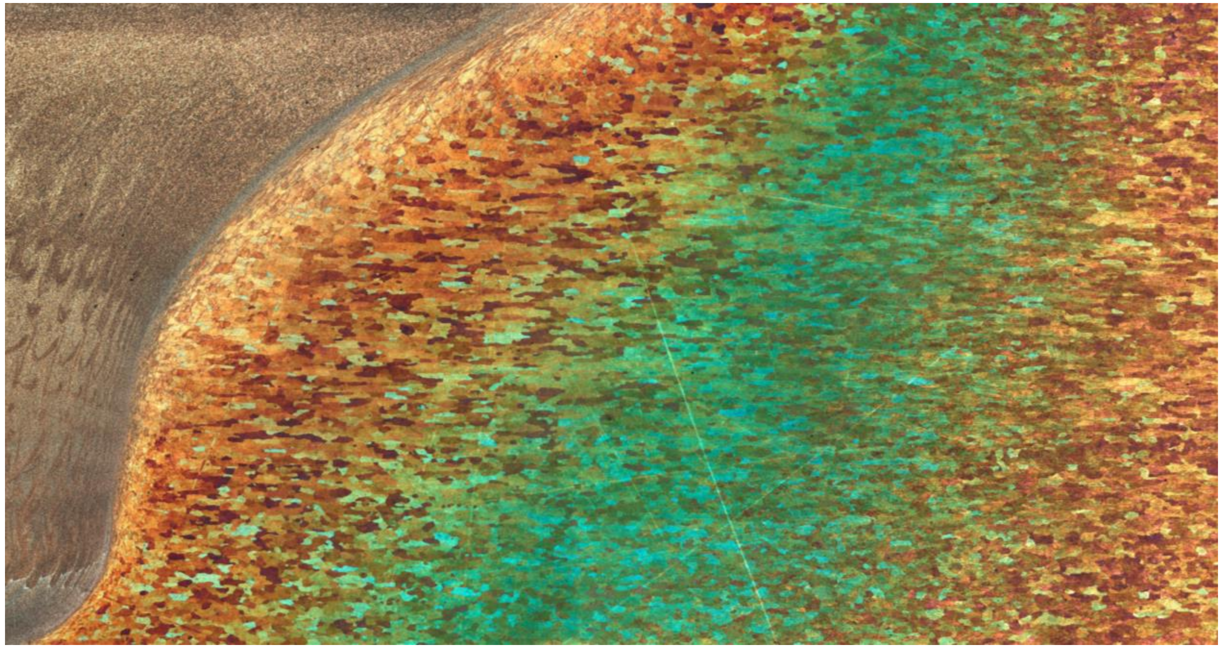
Light- and electron-microscopic investigations

The quality of weld seams is determined in accordance with DIN-EN-10359 by examining welded components after cross-cutting and polishing using a light microscope.

In addition, the heat input during welding leads to changes in the grain structure, which can lead to premature failure under stress. The assessment of the grain structure (e.g. identification of the heat-affected zone - HAZ) is carried out using etched metallographic sections. Also the profile of the hardness curve can be used to identify the heat affected zone.



Light-microscopic image of the cross-section (according to DIN-EN-10359)



Light-microscopic image of the chemically etched cross-section to identify the grain structure

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THANK YOU FOR YOUR ATTENTION

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