

Low-filled Electrically Conductive Adhesives based on Silver-coated Glass and Copper Particles

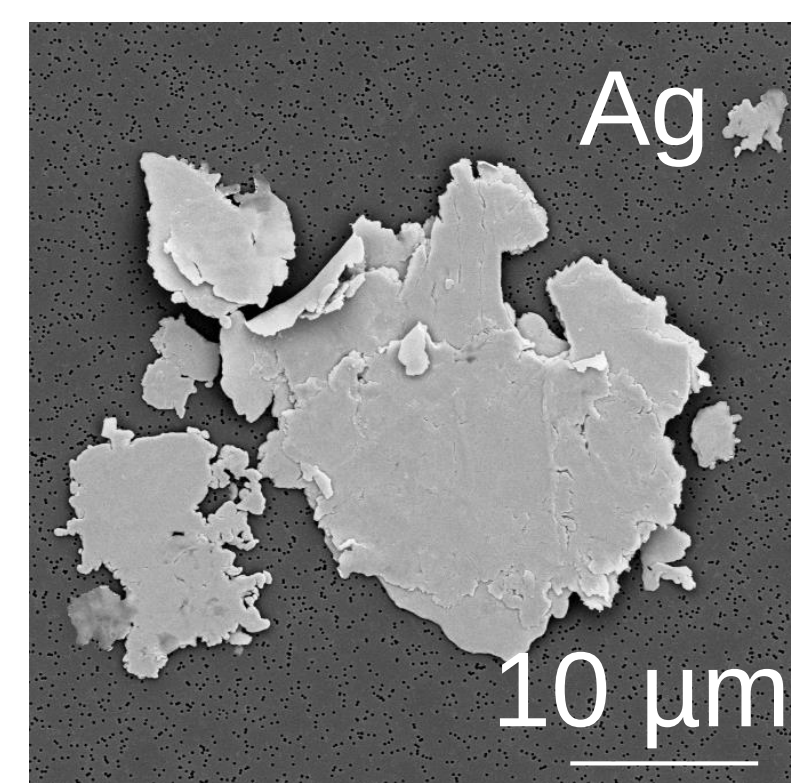
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Motivation

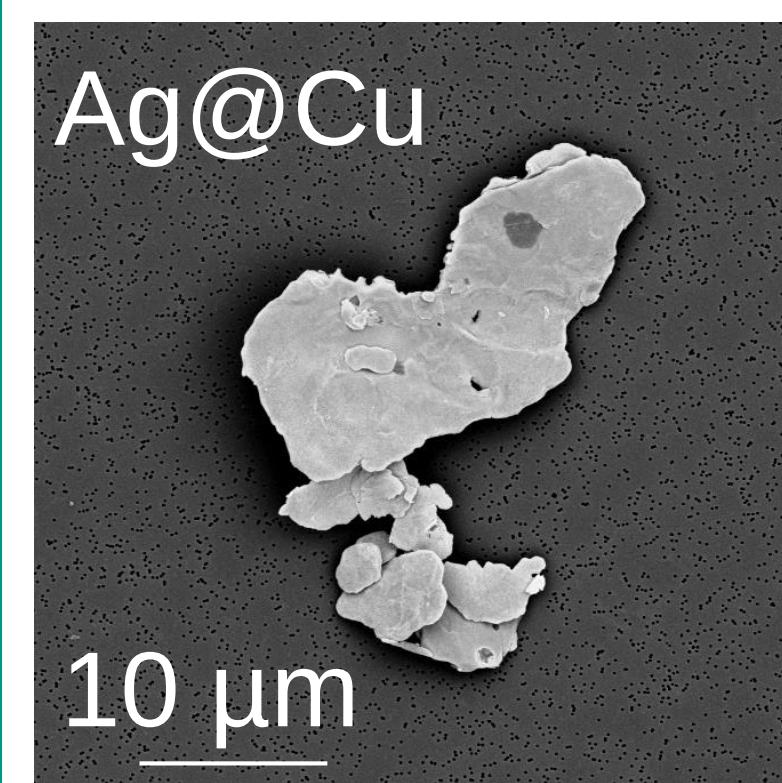
- Saving silver is vital for photovoltaics industry
- ECAs are an additional silver source in solar modules
- Ag particle replacement by shell-core particles
- General reduction of filler content

Material

- Epoxy resin, snap cure
- Different flake-shaped particles with similar size distribution
- Different surface chemistry
- Copper oxidation above 250 °C

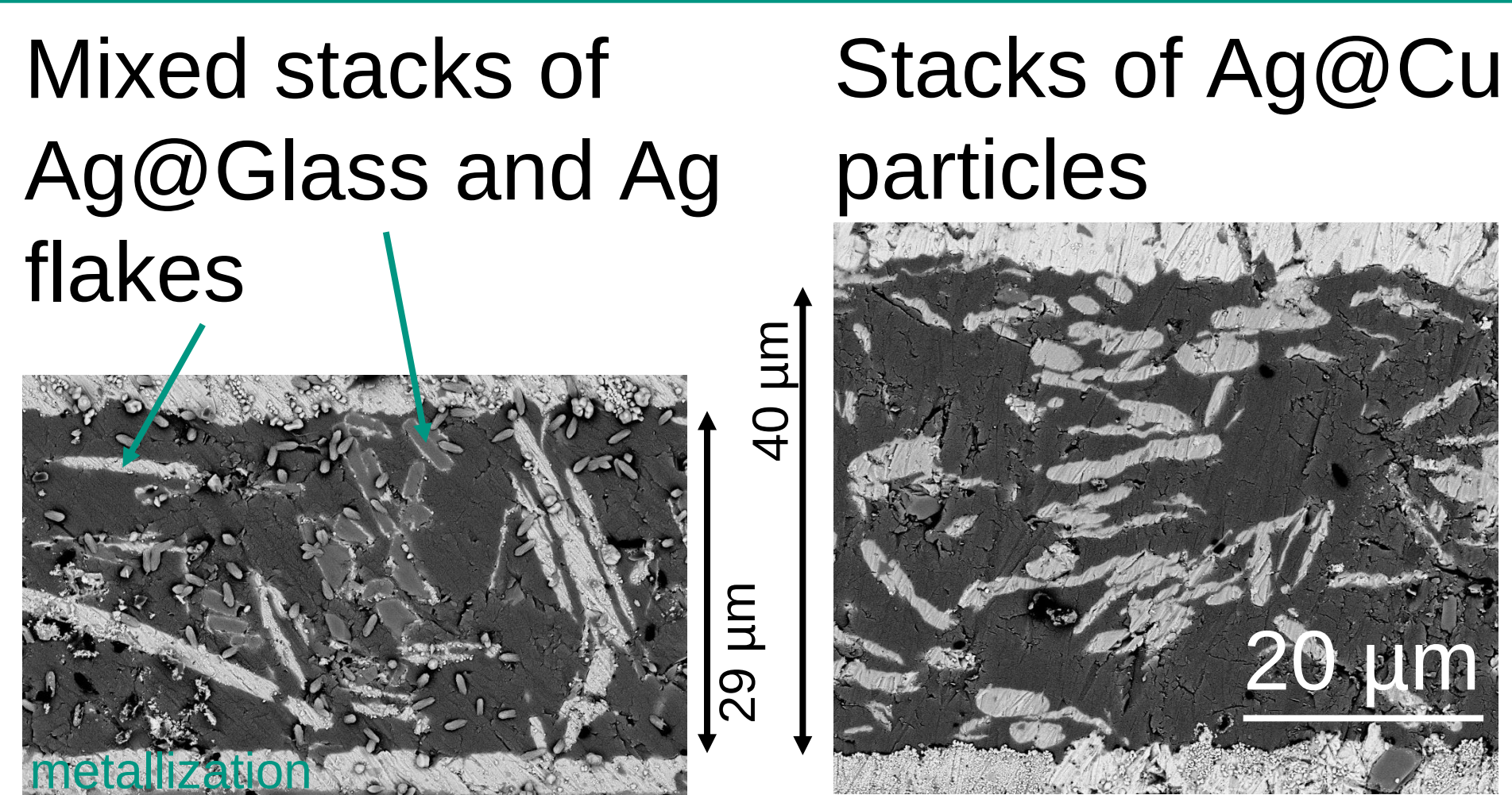


Ag@Cu

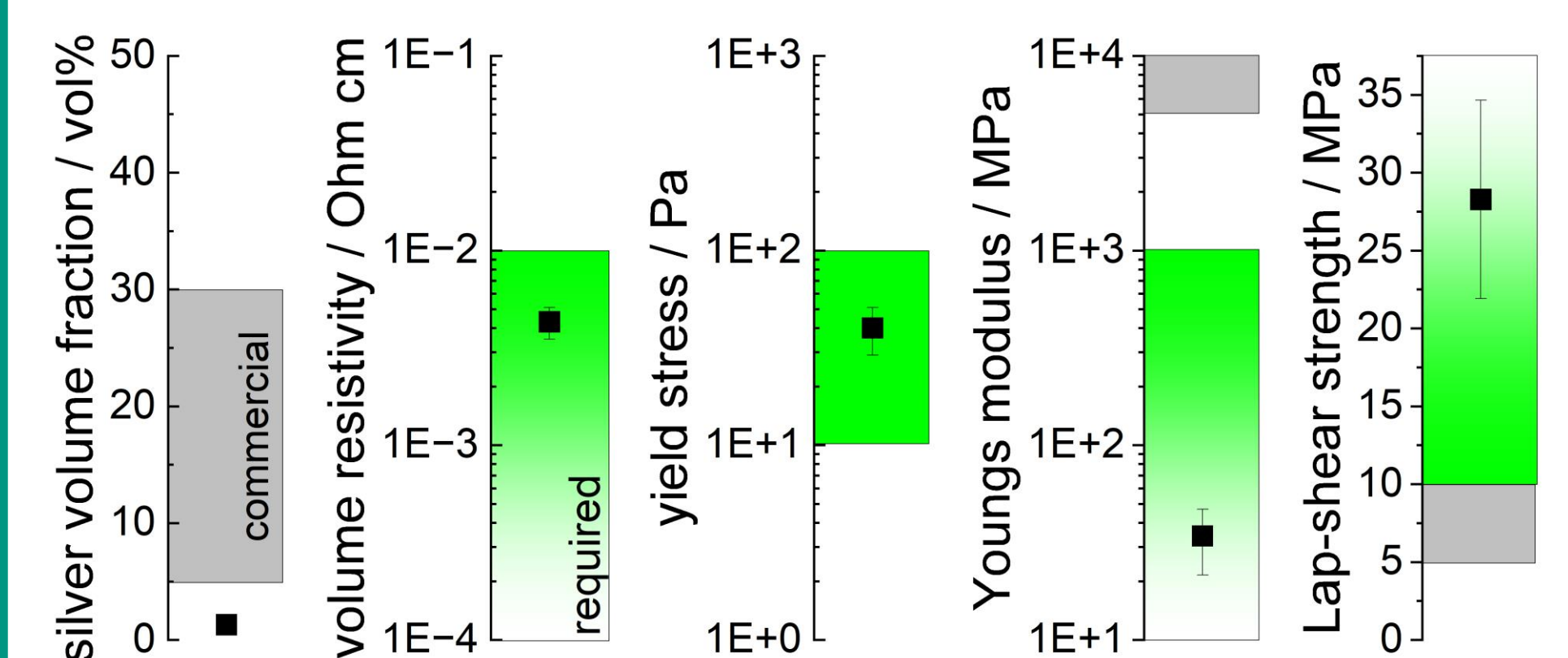
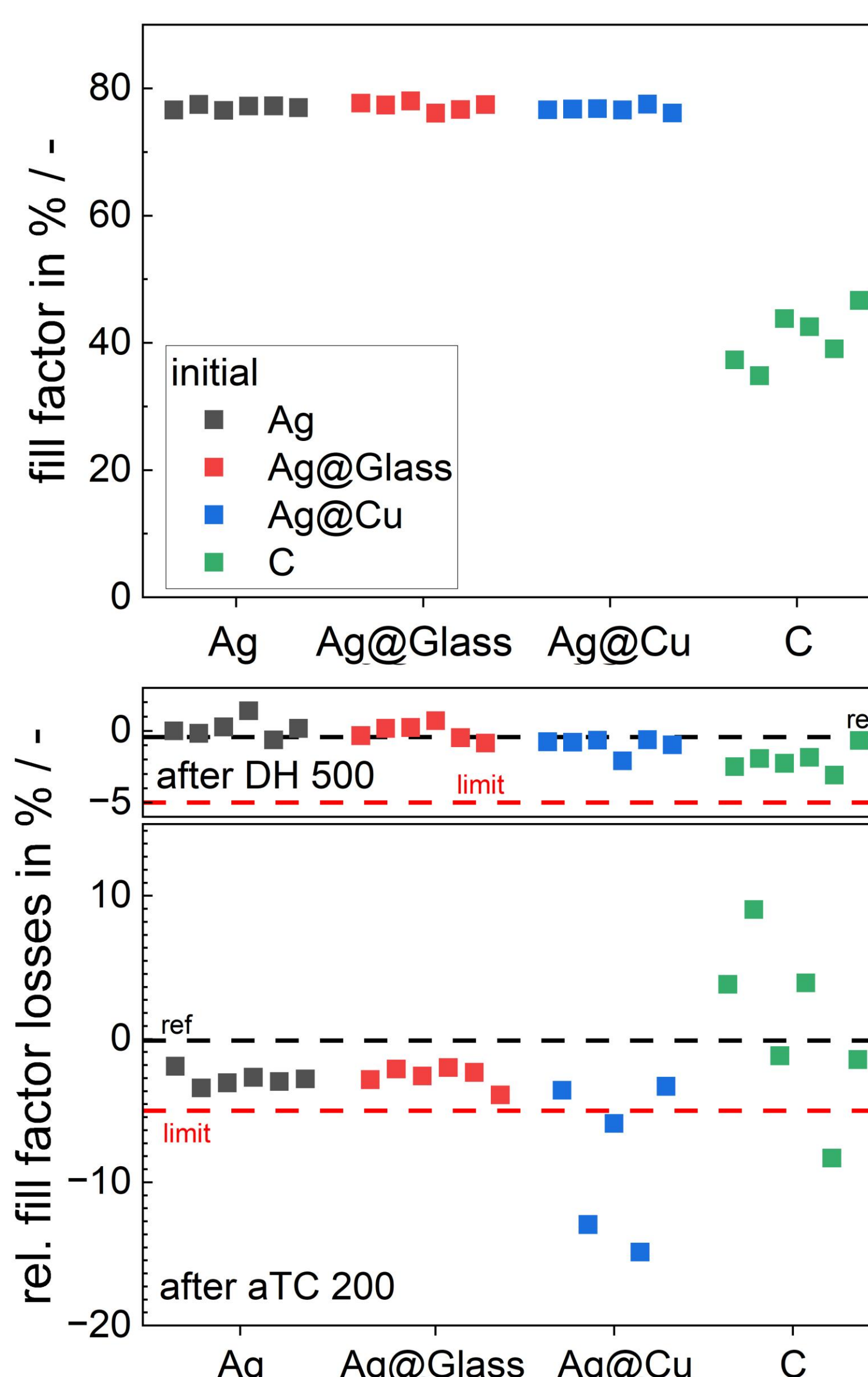


- 15 wt% Silver on Copper
- At least 10 vol% Ag@Cu necessary to achieve $< 0.01 \Omega \text{ cm}$
- Paste stabilization necessary
- Halogen-additive stabilizes ECA
- Ag@Cu particles affect curing, prolonged curing necessary
- Resulting bond is rather soft

Joint Intersection

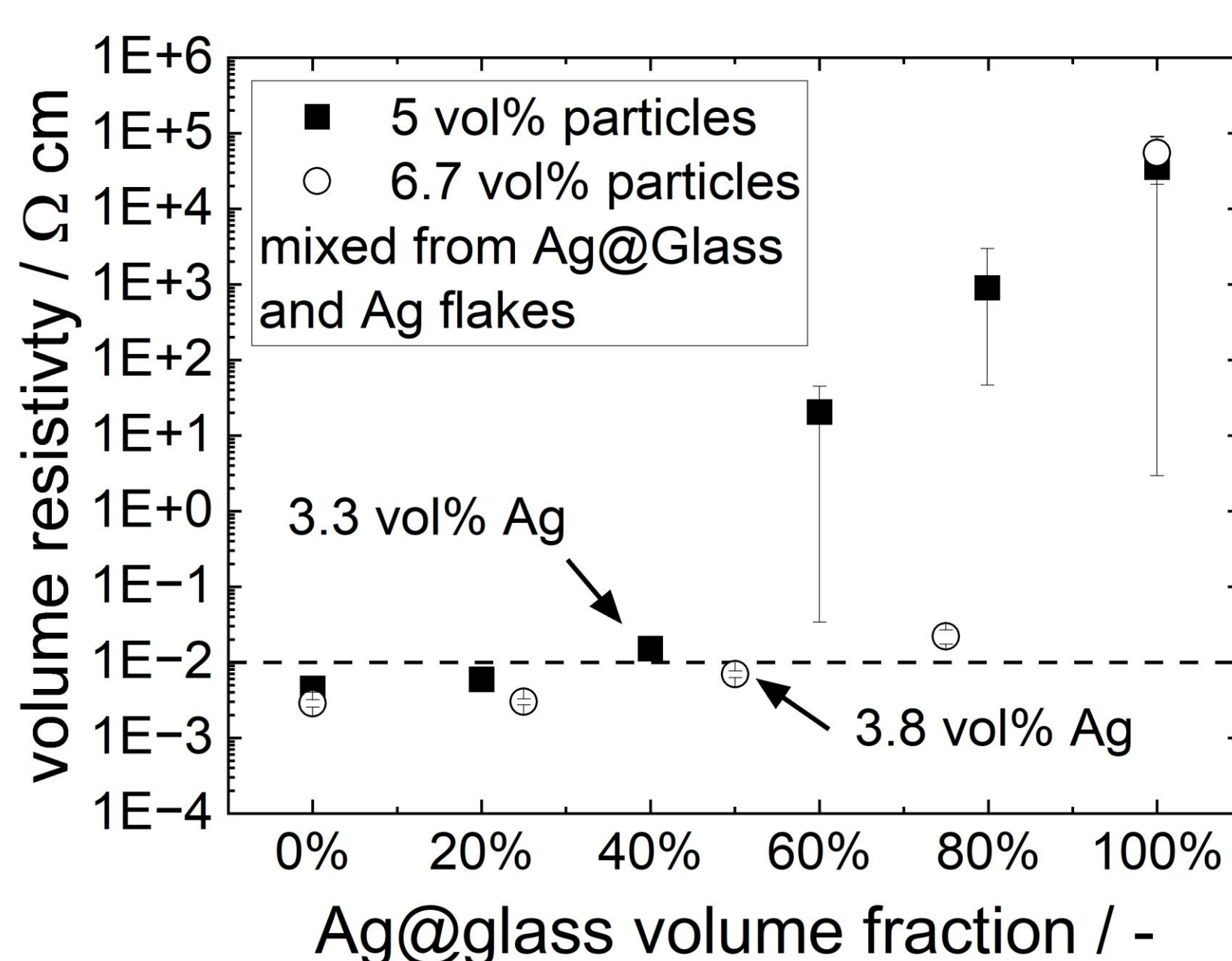


Module performance

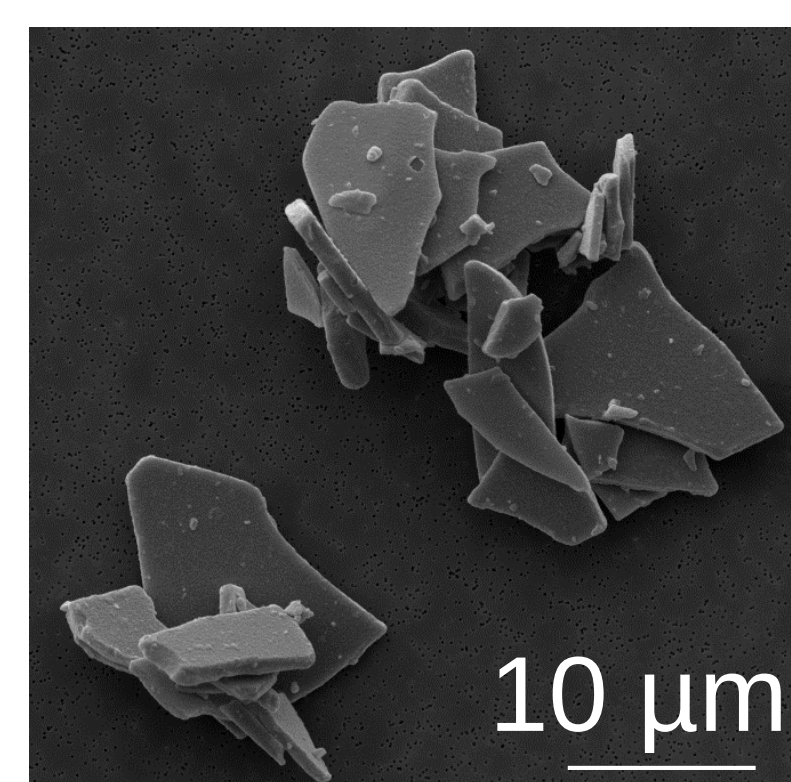


Ag@Glass

- Mixture of Ag@Glass and Ag flakes
- In low-filled ECAs at least 3.5 vol% silver is necessary ($< 0.01 \Omega \text{ cm}$)
- By varying the glass content, paste properties can be individually tuned
- High lap-shear strength $> 20 \text{ MPa}$



40 wt% Silver on Glass



Copper and Carbon

- Pure Copper particles oxidize in air resulting in insulating ECAs
- Carbon ECAs need high fill grades for conductivity which counteracts processability
- Volume resistivity of pure Carbon-filled ECAs is not sufficient

Conclusion and Outlook

- Ag reduction to 7 wt% (+40% Cu) or 25 wt% (w/o Cu)
- Promising module results with Ag@Glass-ECA
- Processing of Ag@Cu particles is more challenging, modules degrade under thermal cycling
- Inert core-particles are favourable, additionally to glass, carbon-based cores could be utilized

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ECA: Electrically Conductive Adhesive

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