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Multifunctional Lightweight
Structures

Low temperature joining of copper using silver nanoparticles

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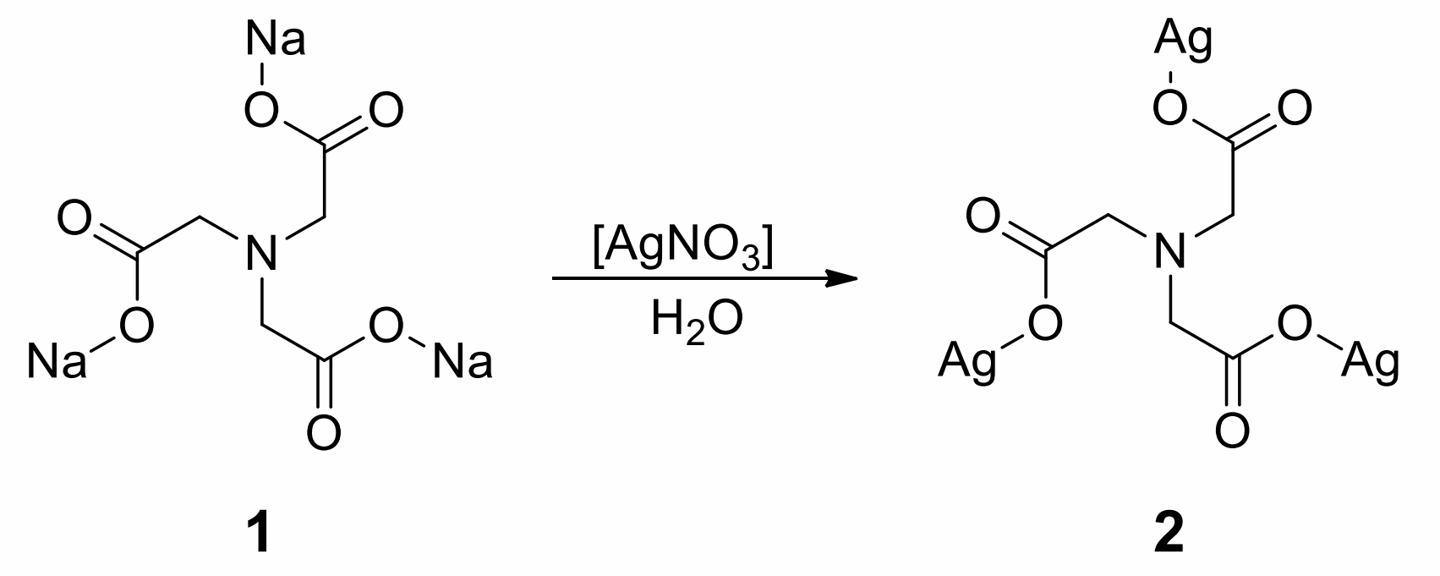
Introduction

Due to the heat sensibility of components in electronic applications, joining at low temperatures is of great interest. Since silver exhibits the highest value for electrical and heat conductivity within all metals, joints with silver as bonding material are most favorable [1]. Based on their capability for a high silver content suspensions of nanoparticles are suited for joining studies. Nanoparticles exhibit a decreased sintering and melting temperature with decreasing particle size [2;3]. A further decrease in temperatures can be permitted using *in situ* generated nanoparticles by transition metal precursors [4;5]. Pastes of silver(I) salts, as done in this work, can easily be produced by dispersing it in a fluid.

Experimental and Results

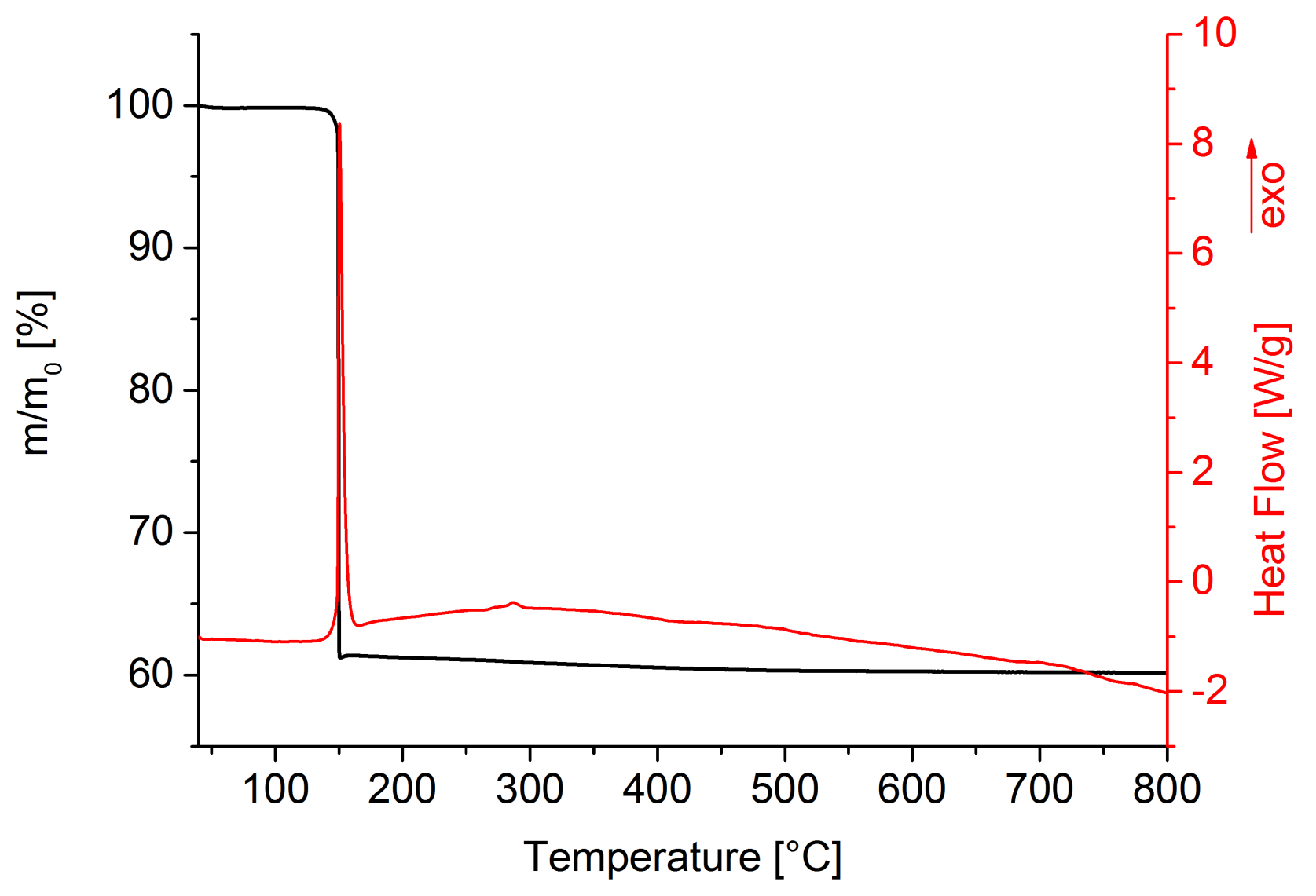
Synthesis and Properties



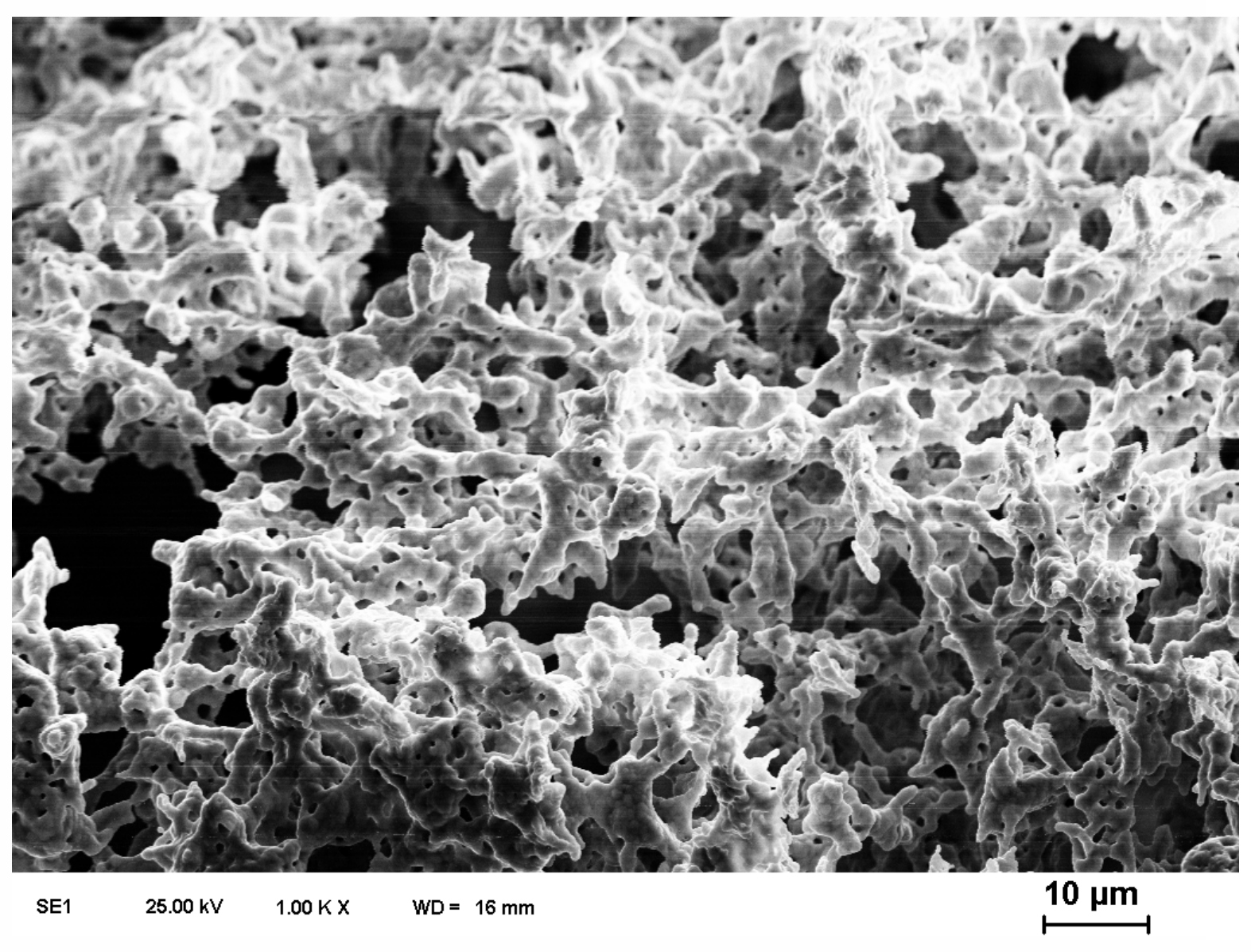
*Synthesis of [(**AgO$_2$CCH$_2$)$_3$N**]*

- Simple and efficient synthesis
- Straightforward purification
- Ambient temperatures
- Exclusion of light
- Characterization via elemental analysis and IR spectroscopy

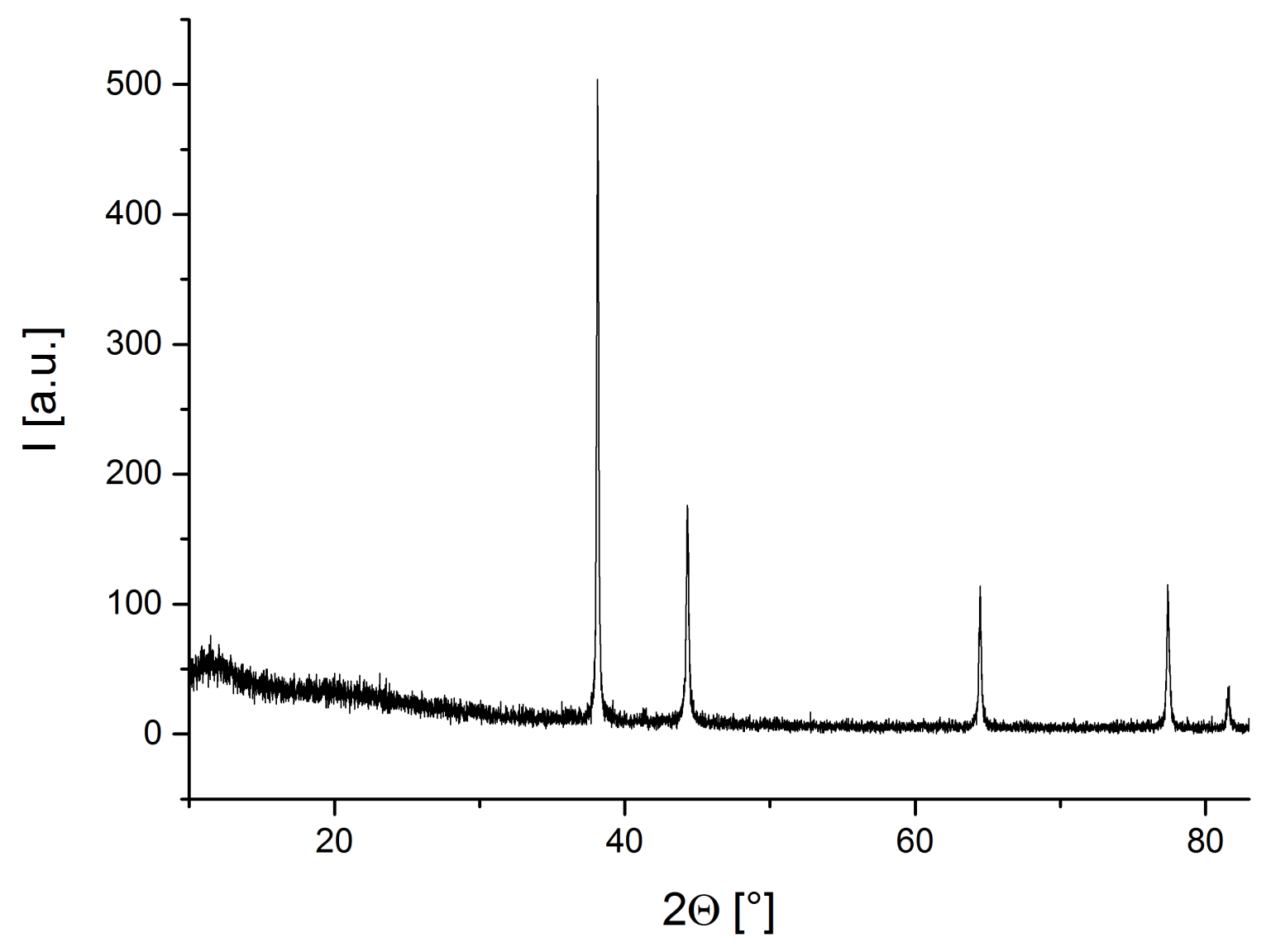
- Thermal behaviour of **2** studied by TG and DSC measurements
- Spontaneous and exothermic decomposition
- Onset temptерature 147 °C
- 60.5 % silver residue
- Silver confirmed by XRPD studies
- *In situ* generated nano-particles sinter together



*TG (black) and DSC (red) traces of **2** (heating rate 10 K/min, argon flow rate of 40 mL/min and oxygen flow rate of 20 mL/min)*



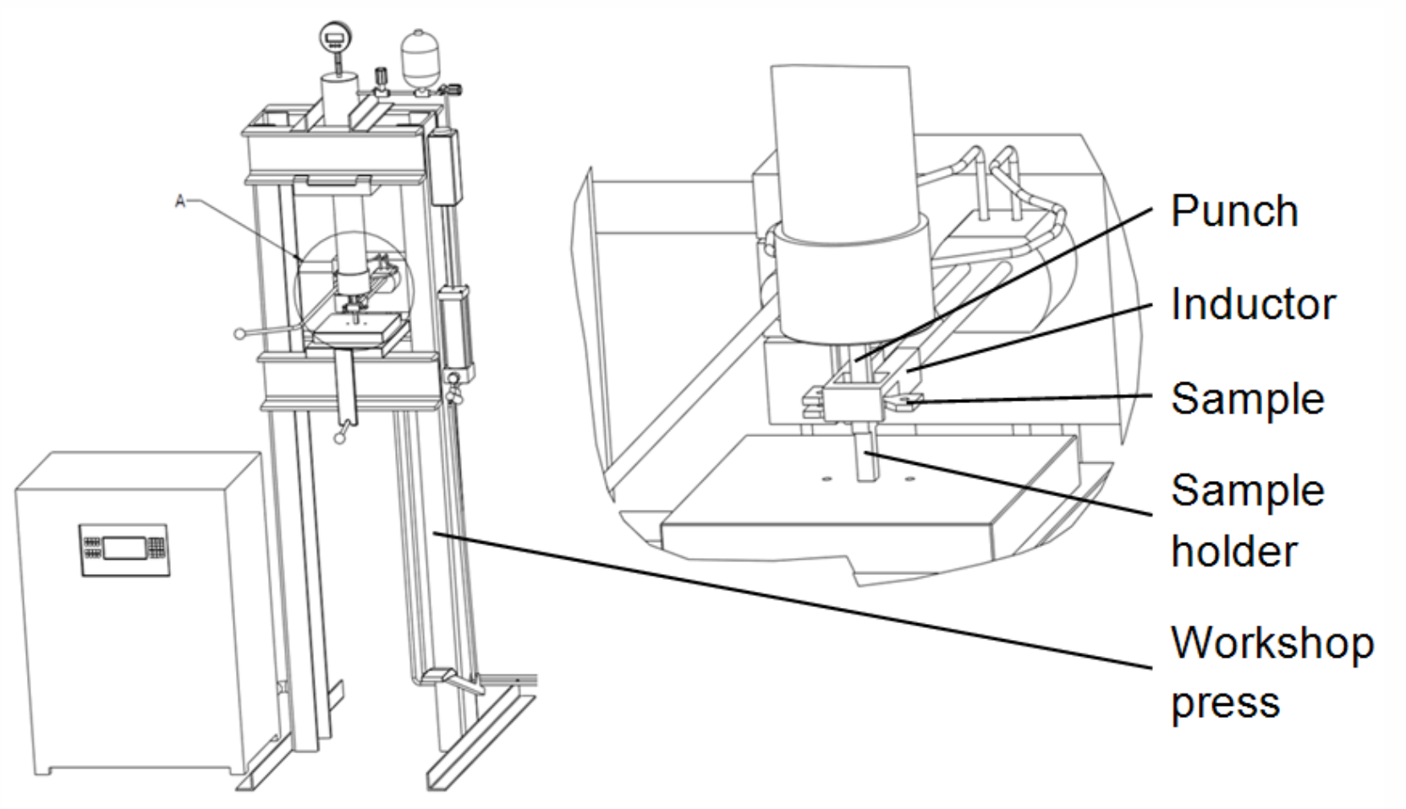
REM image after heat treatment



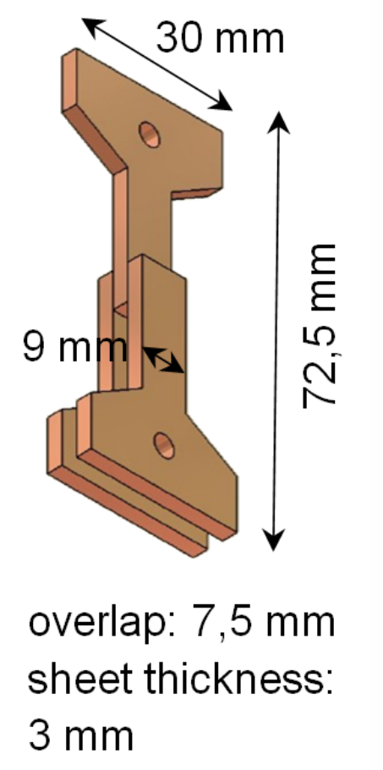
*XRPD-traces after heat treatment of **2** at 160°C*

Joining

Joining system and sample geometry

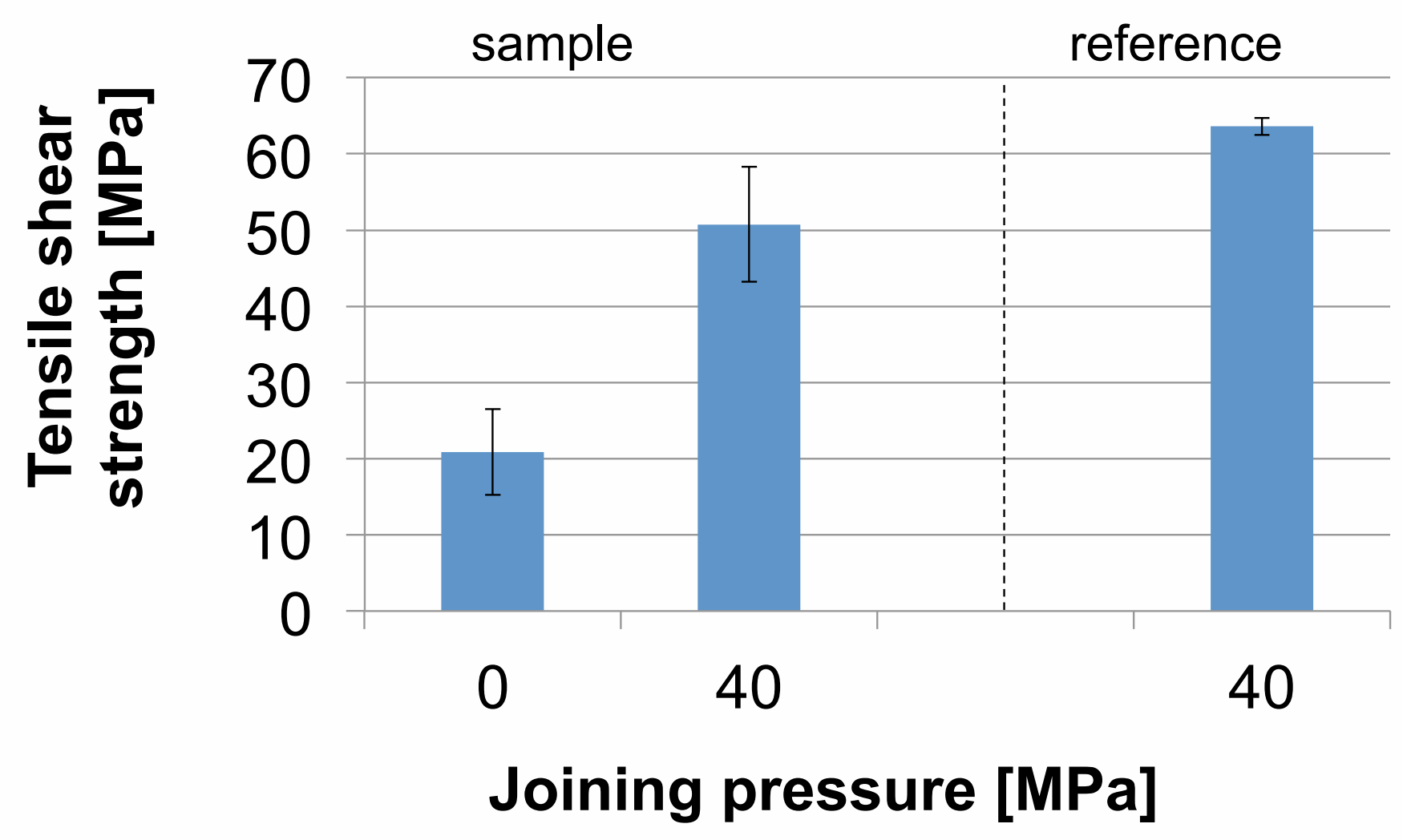


- Application of pressure during joining
- Heating by means of induction
- Joining in air



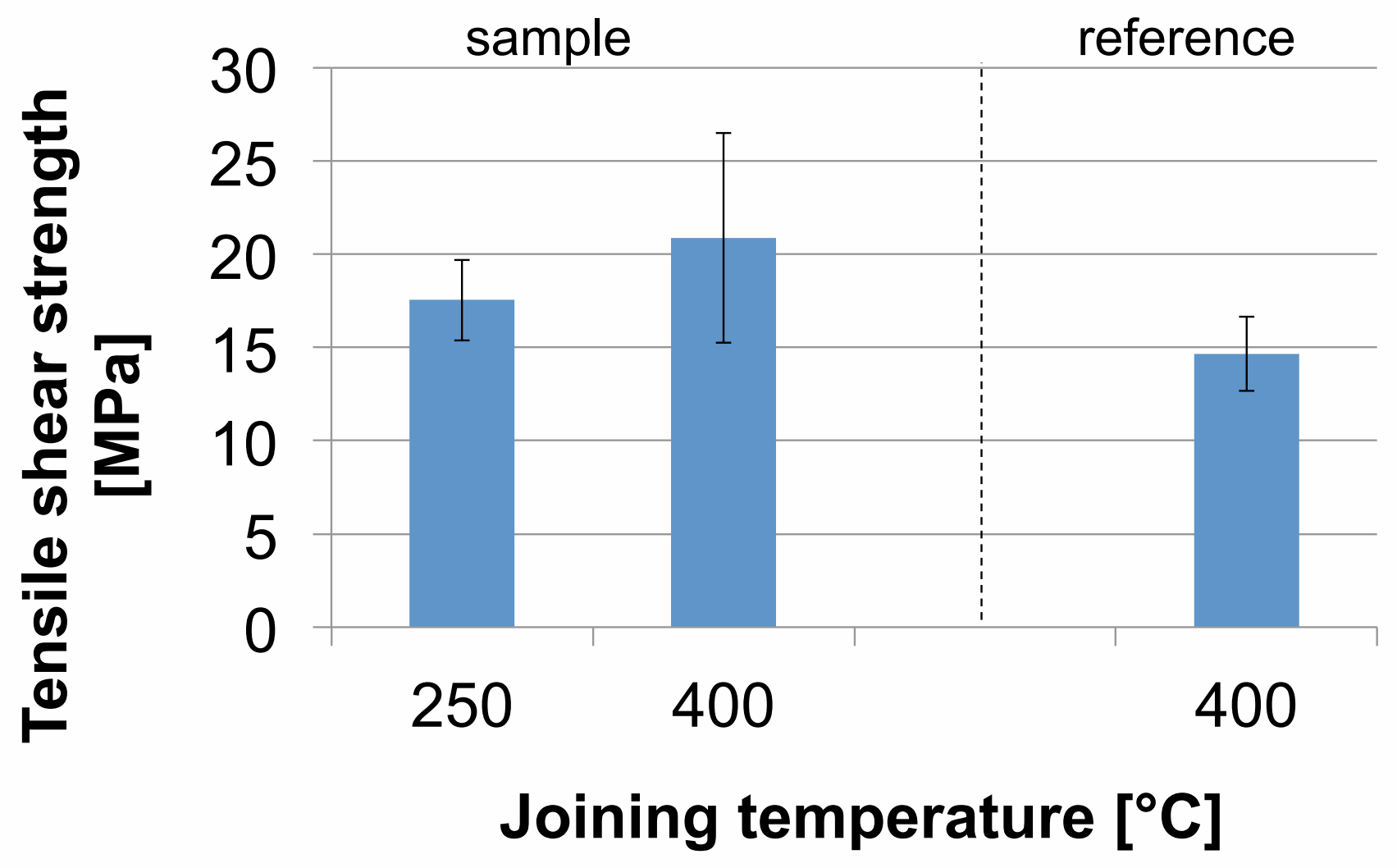
Base material: Cu-ETP

Mechanical properties



- Joining temperature: 400 °C, holding time: 10 min
- Joining pressure has an essential influence on strength behavior
- Strengths of a commercially available Ag nanopaste Harima Chemicals, Inc. are slightly higher

- Joining pressure: 0 MPa, holding time: 10 min
- Joining temperature also influences the strength behavior
- Much higher strengths in comparison to the conventional nanopaste can be achieved without pressure



Conclusion

Conclusion

- The silver precursor [(AgO$_2$CCH$_2$)$_3$N] **2** was prepared by the reaction of the nitrilotriacetic acid trisodium salt with silver nitrate for joining between 250 °C to 400 °C
- The precursor thermally decomposes to give Ag nanoparticles without addition of further reducing agents and stabilizing components
- High tensile shear strengths of joints with copper, comparable with commercial silver-based systems → especially high potential for pressureless joining of the precursor

References

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