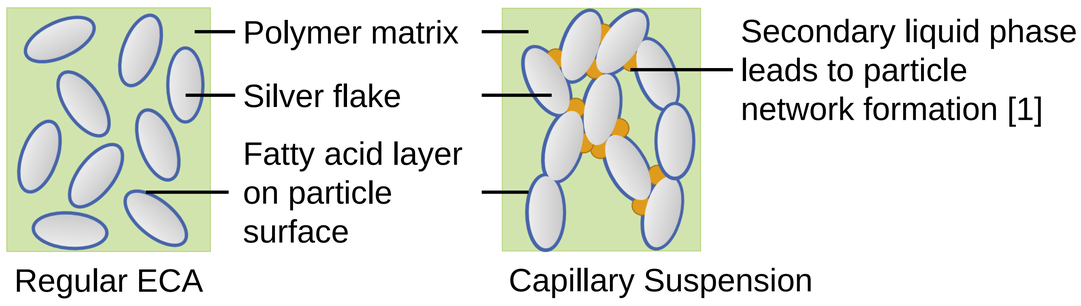
Potential of Low-Filled Electrically Conductive Adhesives for Shingled Solar Cell Interconnection

Applying the Capillary Suspension Concept on Electrically Conductive Adhesives

Marianne Kronsbein and Norbert Willenbacher

Motivation

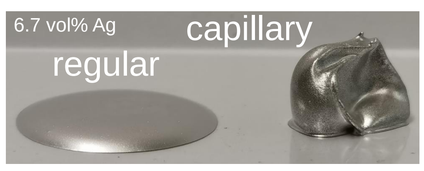
- Saving silver is vital for photovoltaics industry
- Low-filled Electrically Conductive Adhesives (ECAs) posses low conductivity and tend to sedimentation
- Capillary Suspension Concept stabilizes uncured ECA
- Higher conductivity through particle network formation



Material

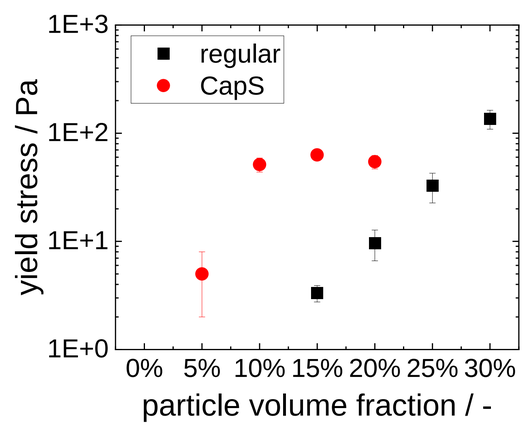
PROTAVIC® ACE 10720

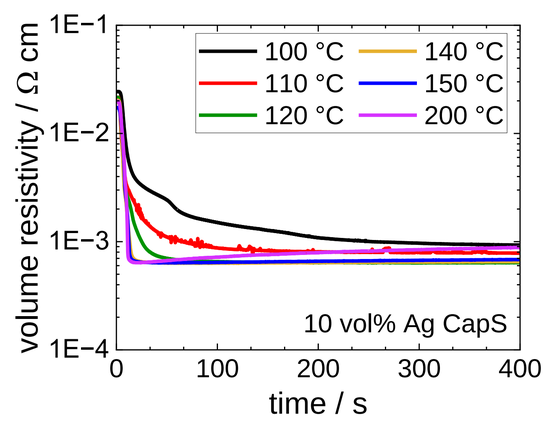
- Snap Cure epoxy resin
- Silver flakes
- Secondary Phase



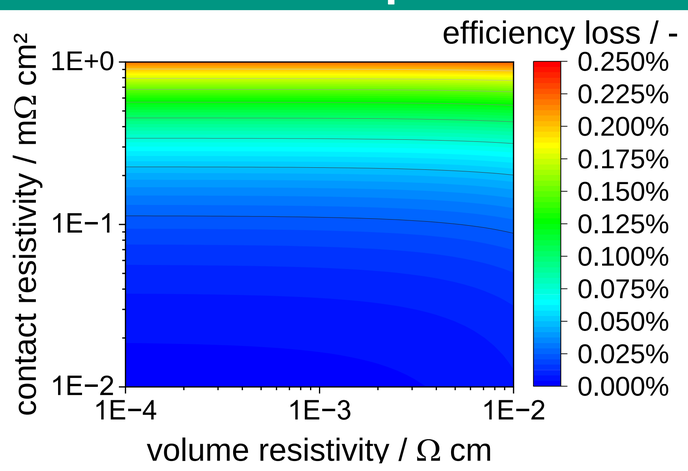
Paste Stabilization and Curing

- Yield stress indicates stabilization and network formation
- Percolation threshold is decreased in Capillary Suspensions (CapS)
- Low-T curing within 30 s
- Over-curing at T > 150 °C





Electrical Properties

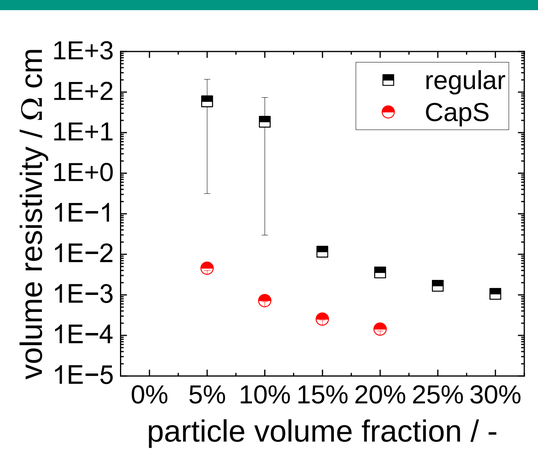


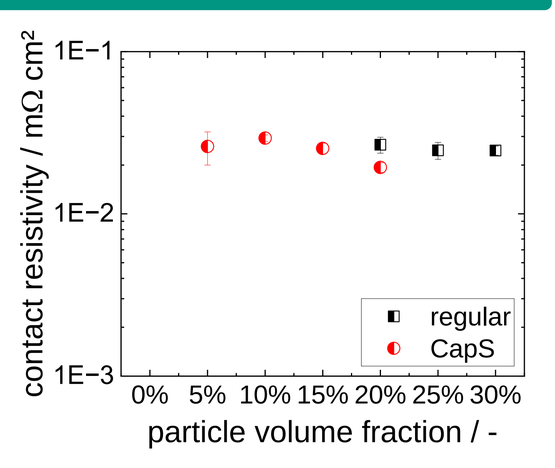
Required resistivity:

- < 1E-2 Ω cm
- < 1E-1 mΩ cm²

Achieved with:

- > 15 vol% Ag regular
- ≥ 5 vol% Ag as Capillary Suspension





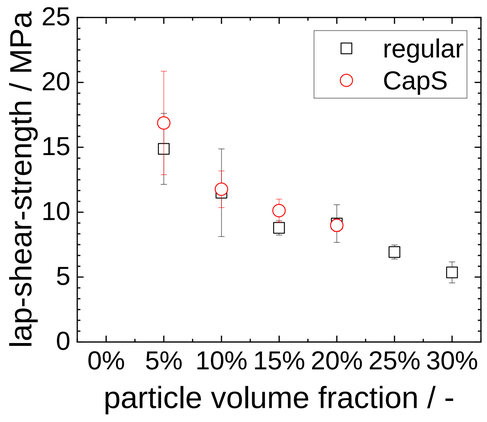
Mechanical Properties

Required lap-shear strength:

- > 10 MPa

Results:

- < 15 vol% filler required
- Cohesive failure above 5%
- Every particle weakens the polymer matrix



Conclusion and Outlook

- Regular suspension ECAs require at least 15-20 vol% silver for sufficient sedimentation stability & conductivity
- Applying the Capillary Suspension concept enables ECAs with silver filler content as low as 5 vol%
- This not only results in significant silver savings but also in a higher lap-shear strength compared to regular Electrically Conductive Adhesives
- Tests on module level at Fraunhofer ISE

Institute of Mechanical Process Engineering and Mechanics – Applied Mechanics
Gotthard-Franz-Straße 3, 76131 Karlsruhe, Germany
Marianne.Kronsbein@kit.edu, +49 721 608 42805

[1] E. Koos and N. Willenbacher, „Capillary Forces in Suspension Rheology“, Science, 331, 897-900, (2011)

Supported by:
Federal Ministry for Economic Affairs and Climate Action
on the basis of a decision by the German Bundestag
PROTAVIC INTERNATIONAL
MEMBER OF PROTEX INTERNATIONAL