

Fundamental Microscopic Studies on the Etching Behavior of Silver Pastes on Poly-Si/SiO_x Passivating Contacts

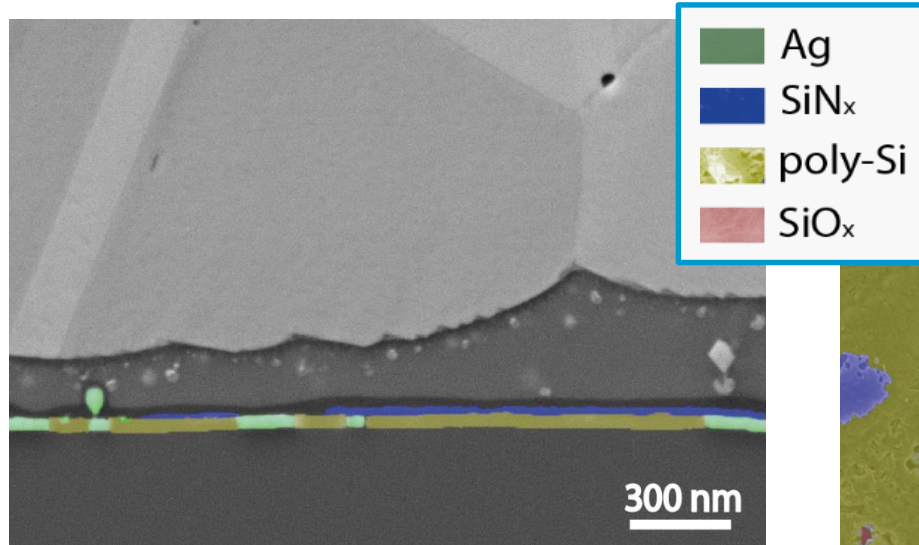


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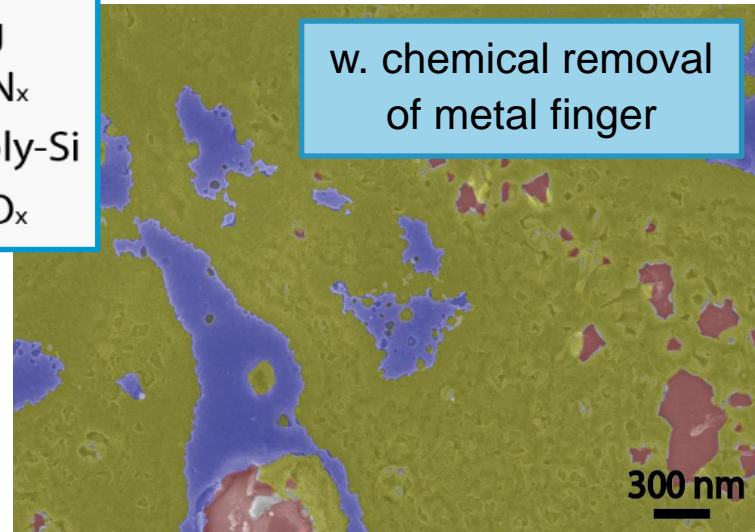
¹ University of Konstanz, ² Fenzi AGT
MiW2023, Neuchâtel – May 8th, 2023

Etching of Ag Paste in Poly-Si/SiO_x Contacts

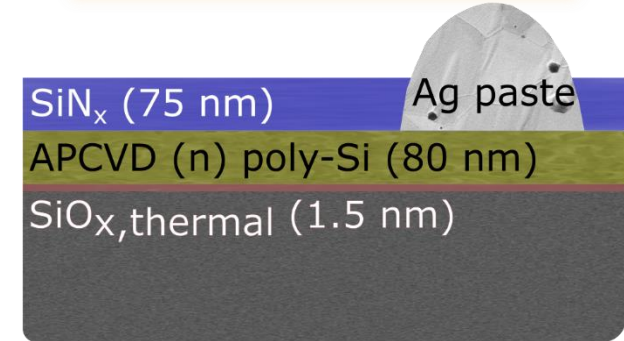
Cross section



Top view



~1 s
T_{meas} 814°C
Air, BF



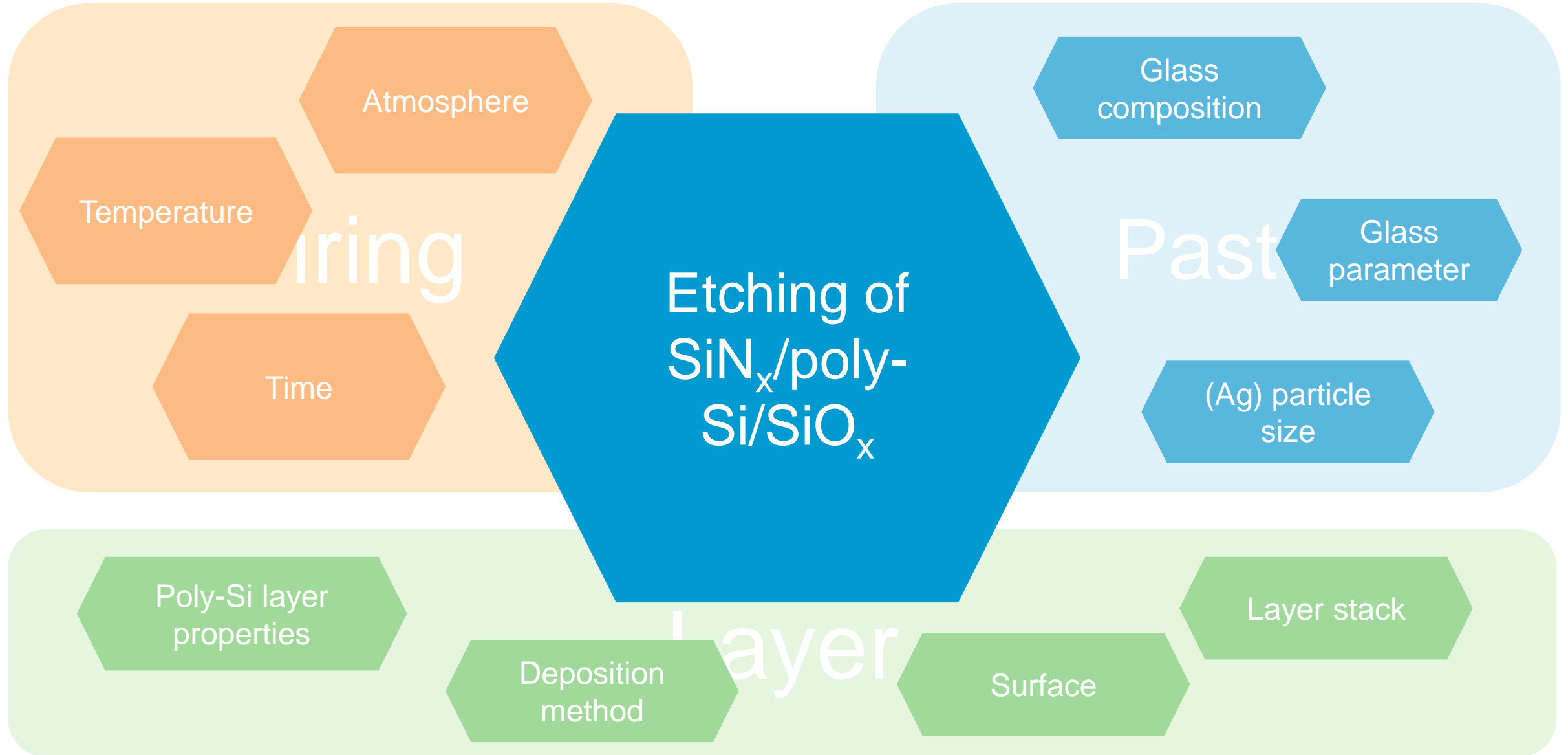
- Etching results in Ag crystallites in poly-Si layer
- No penetration of c-Si substrate by Ag crystallites (planar samples)
- Ag crystallites remove nearly total poly-Si layer

Discussed in Glatthaar et al. Phys. Status Solidi A **219**, 2200501 (2022).

How does the etching
mechanism work for
passivating contacts?

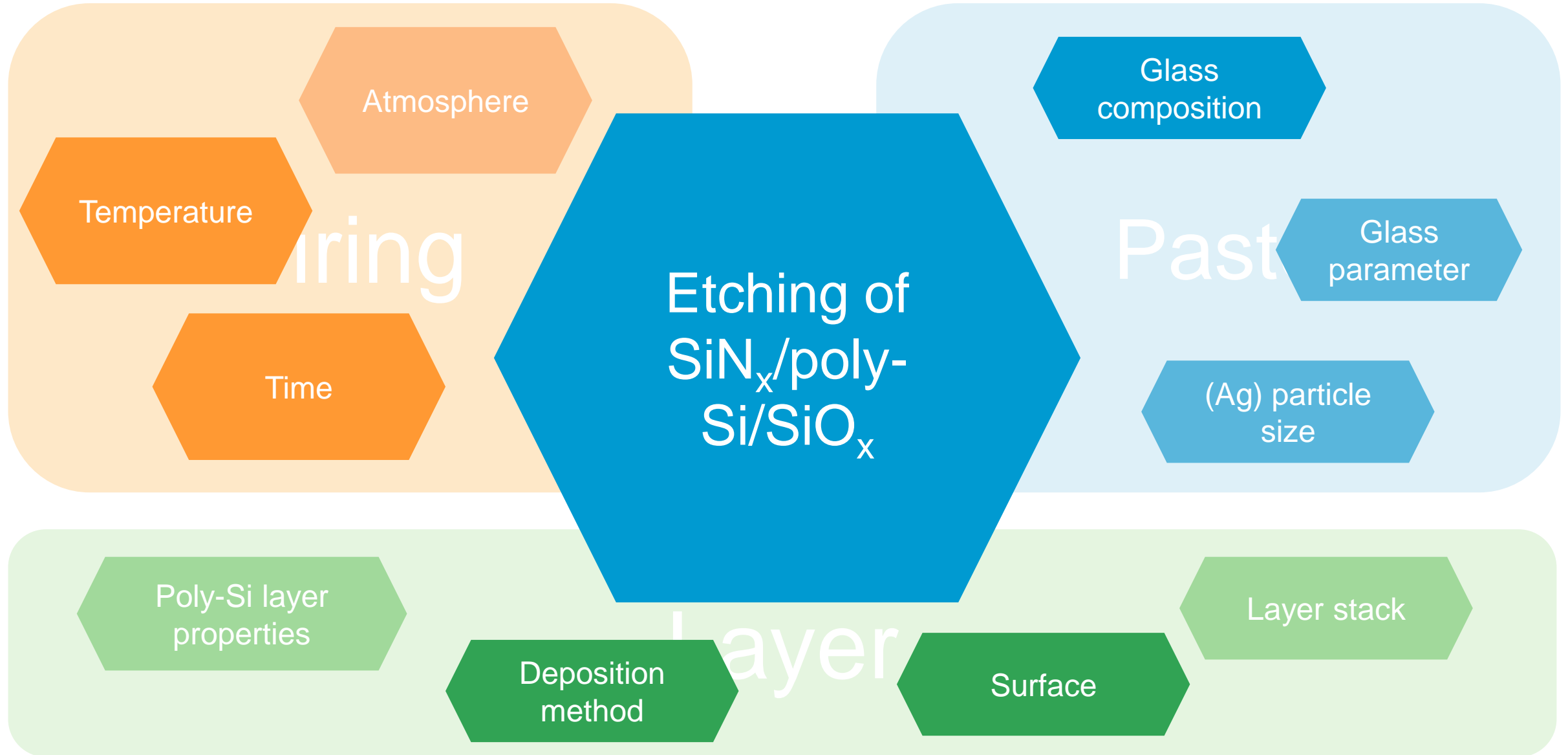
Impact on Ag Paste Etching Mechanism

No complete overview



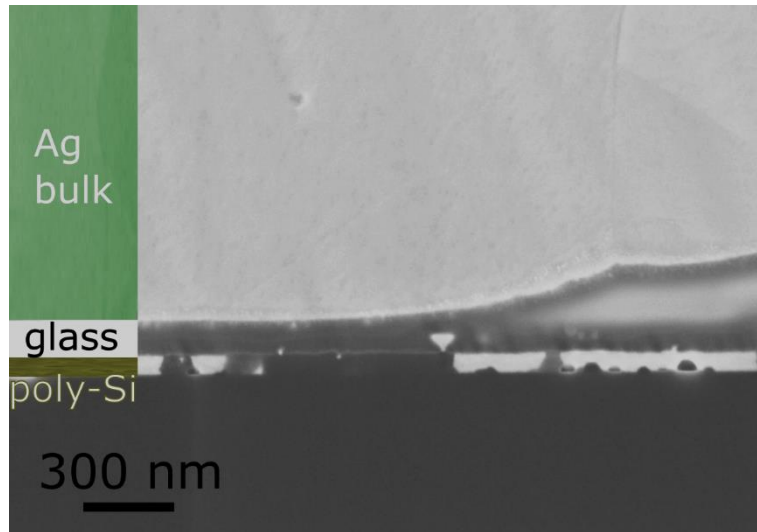
Impact on Ag Paste Etching Mechanism

No complete overview

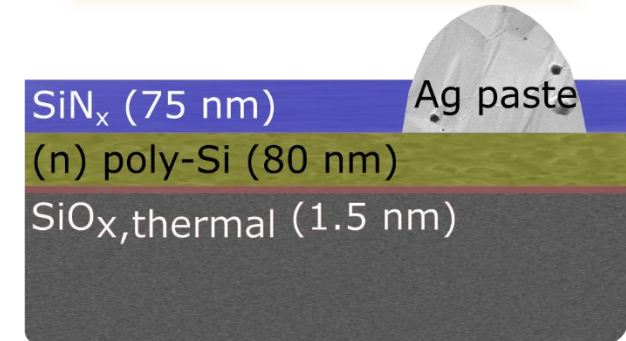
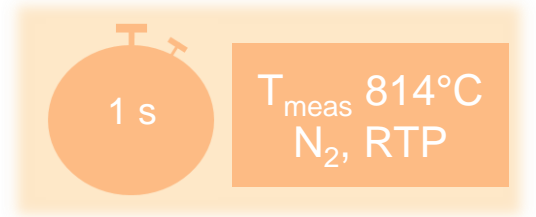
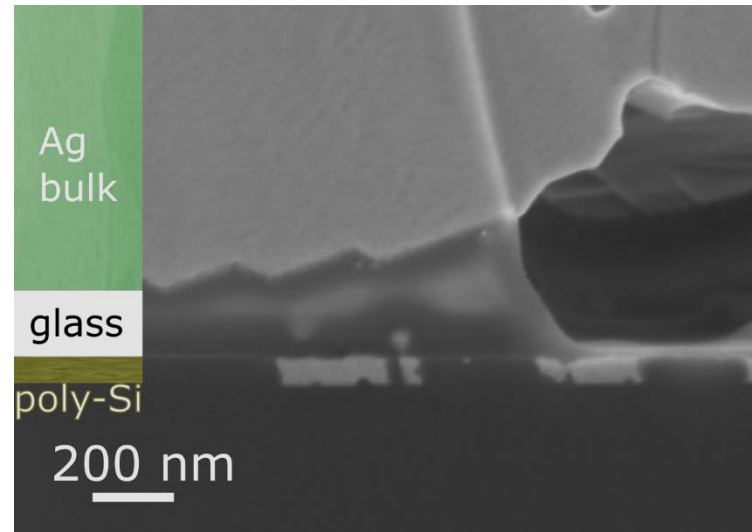


Poly-Si Layer from Different Deposition Methods

APCVD



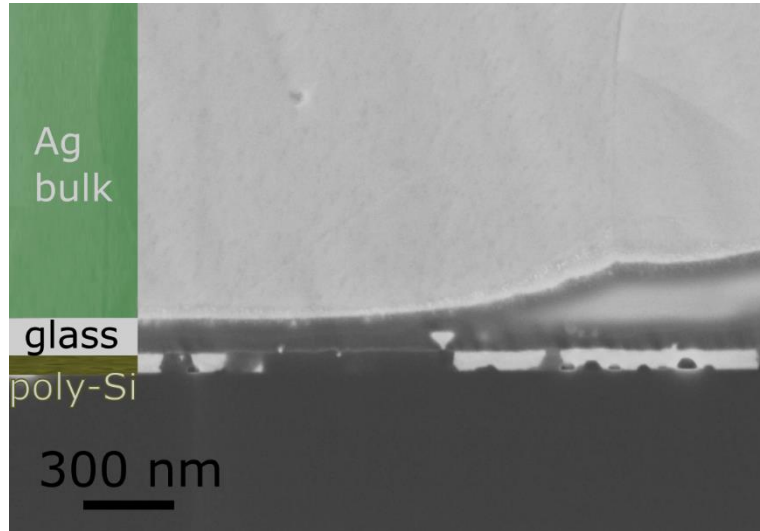
PECVD



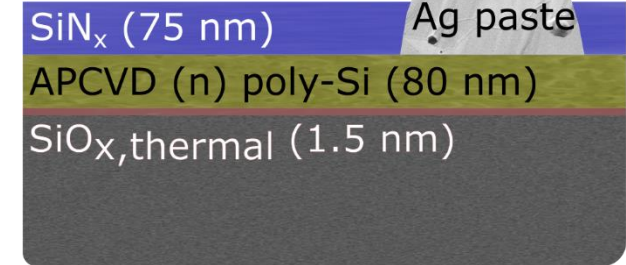
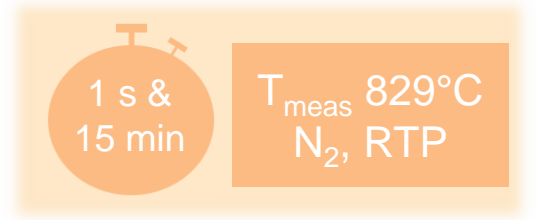
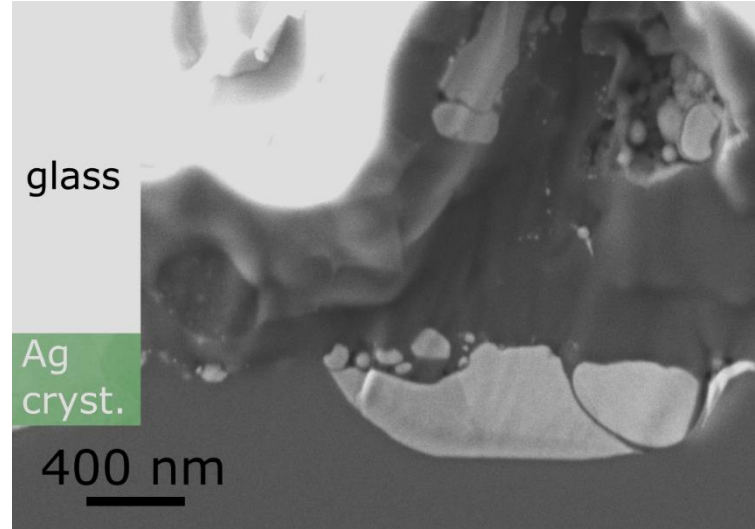
- Ag crystallite formation comparable between APCVD and PECVD
- No statistically significant differences in glass layer thickness and Ag crystallite density
- ρ_C with $<1 \text{ m}\Omega\text{cm}^2$ slightly lower for PECVD samples (data not shown here)

Process Time Variation

1 s



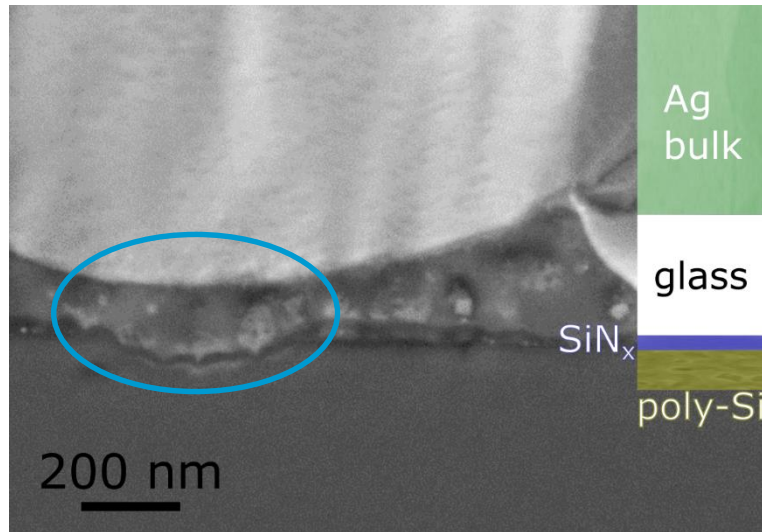
15 min



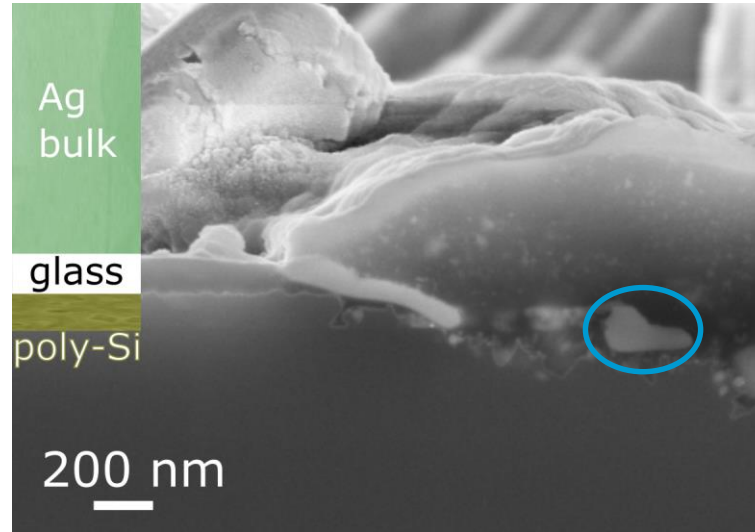
- Poly-Si layer completely dissolved after 15 min
- Massive etching into c-Si substrate
- Formation of up to 500 nm Ag crystallites and thick glass layer

Temperature and Process Time Variation

1 min



15 min



1 min & 15 min

T_{meas} 606°C
N₂, RTP

SiN_x (75 nm) Ag paste

APCVD (n) poly-Si (80 nm)

SiO_{x,thermal} (1.5 nm)

- Slight and non-selective etching into poly-Si layer
- No Ag crystallite formation in poly-Si layer after 1 min
- Strong etching into c-Si substrate after 15 min
- Some Ag crystallites/phases visible after 15 min (detected by EDX)

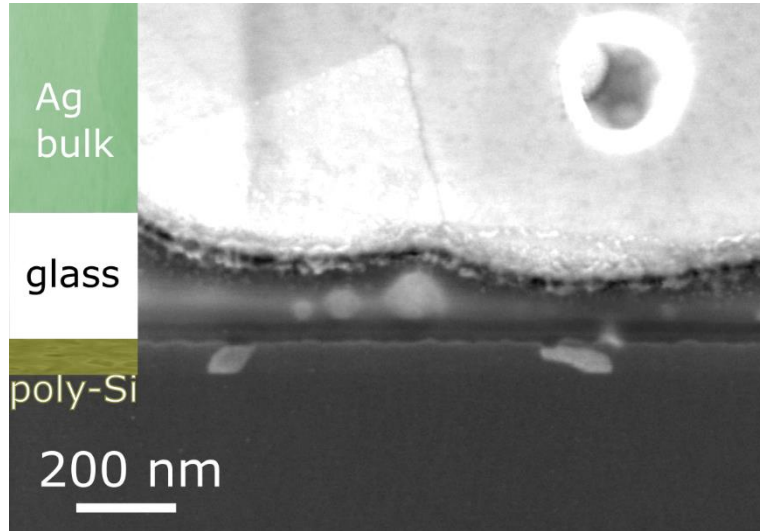
Impact of Glass Frit Composition

Paste variations:

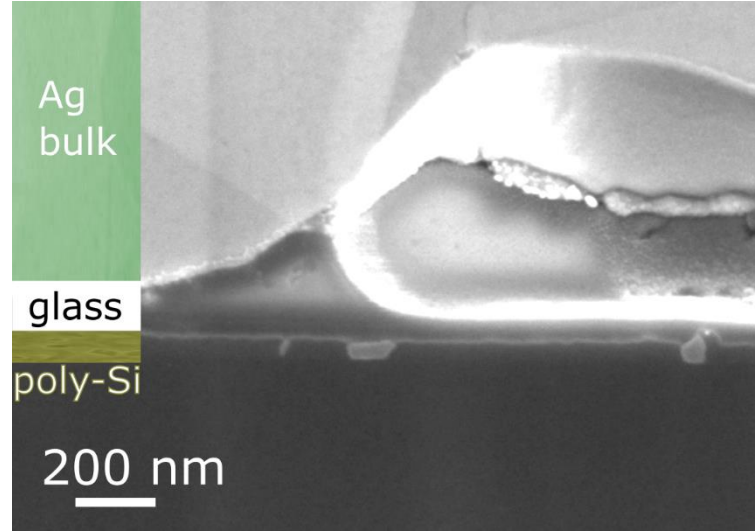
- Industrial paste formulation with
 - Pb based glass frit
 - Te based glass frit
- Experimental paste without glass frit

Impact of Main Component of Glass Frit

Te based



Pb based



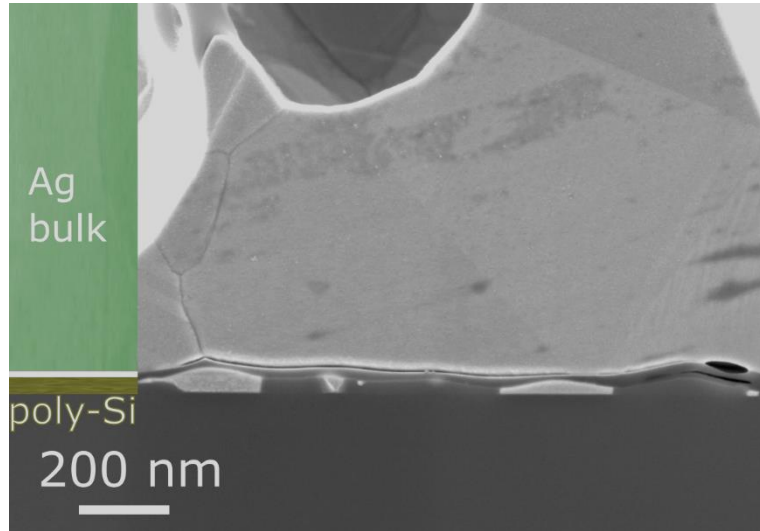
1 s
 $T_{\text{meas}} 808^{\circ}\text{C}$
Air, BF

SiN_x (75 nm) Ag paste
APCVD (n) poly-Si (80 nm)
SiO_{x,thermal} (1.5 nm)

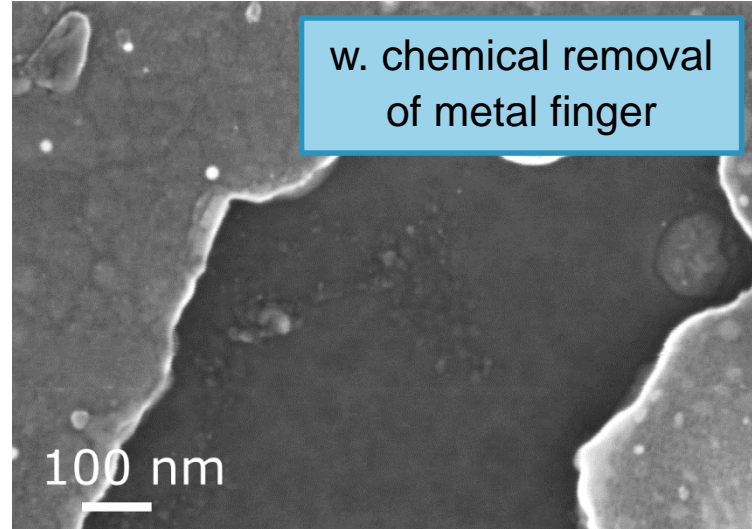
- Ag crystallite formation in poly-Si layer
- No statistically significant differences in glass layer thickness and Ag crystallite density

Ag Paste without Glass Frit

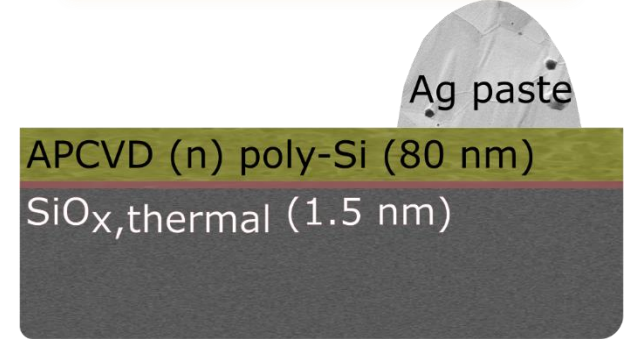
Cross section



Top view



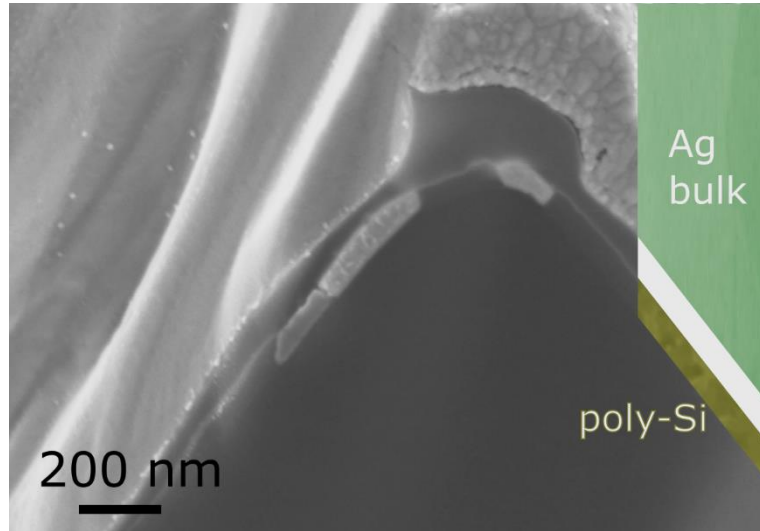
15 min
 $T_{\text{actual}} 829^{\circ}\text{C}$
Ar, RTP



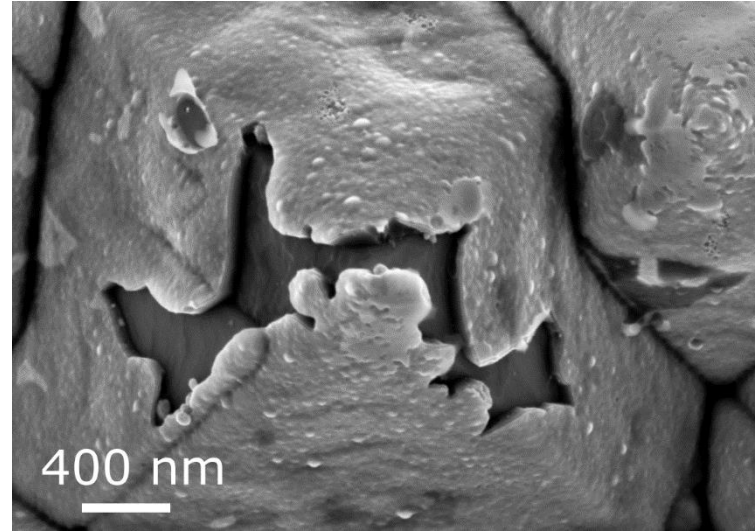
- Ag crystallite formation in poly-Si layer
- No etching into c-Si substrate visible
- Unclear why poly-Si layer is etched inhomogeneously
- Poly-Si identified by phosphorous peak in EDX

Ag Paste without Glass Frit

Cross section



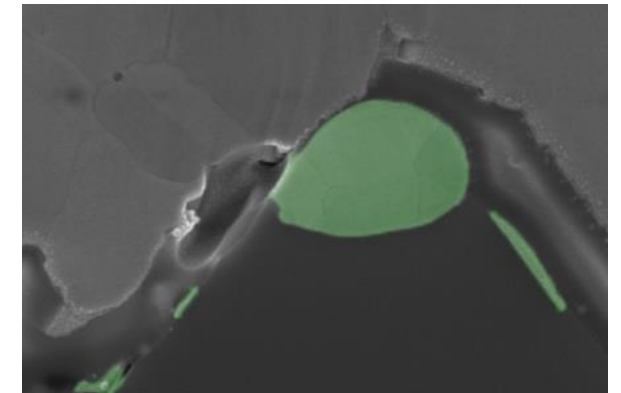
Top view



15 min
 $T_{\text{actual}} 829^{\circ}\text{C}$
Ar, RTP

Ag paste
APCVD (n) poly-Si (80 nm)
SiO_{x,thermal} (1.5 nm)
textured substrate

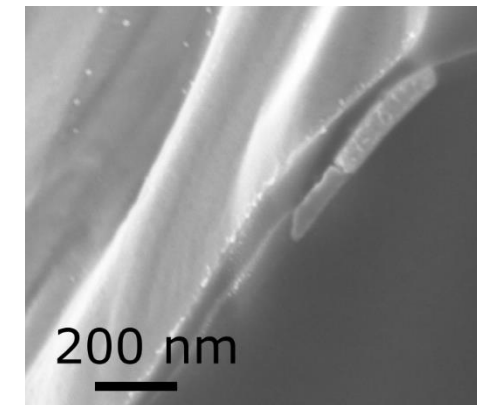
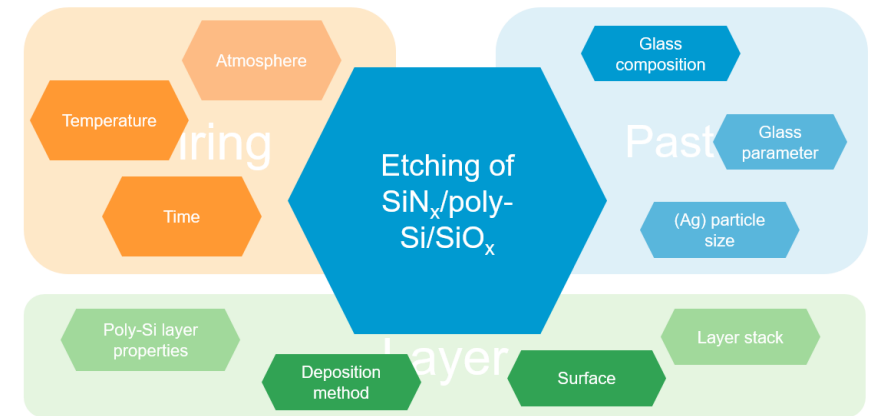
- Ag crystallite formation in poly-Si layer
- No etching into c-Si substrate visible
- Contrast to samples with glass frit

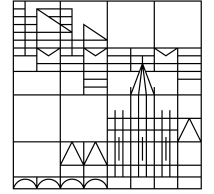


Glatthaar et al. Phys. Status Solidi A **219**, 2200501 (2022).

Summary

- Multiple parameters influence crystallite formation
- APCVD or PECVD and Pb or Te based glass frit differ not significantly in contact formation
- Process temperature and time strongly influence etching behavior
- Etching of poly-Si layer by Ag^+ without glass frit possible





Thank you for your attention!
Questions!

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