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

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Etching of Ag Paste in Poly-Si/SiO\textsubscript{x} Contacts

- 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

How does the etching mechanism work for passivating contacts?
Impact on Ag Paste Etching Mechanism

Etching of SiNₓ/poly-Si/SiOₓ

Poly-Si layer properties
Deposition method
Surface
Layer stack

Poly-Si layer properties
Glass composition
Glass parameter
(Ag) particle size

Temperature
Atmosphere
Time

No complete overview
Impact on Ag Paste Etching Mechanism

Etching of SiN\(_x\)/poly-Si/SiO\(_x\)

Temperature

Atmosphere

Time

Poly-Si layer properties

Deposition method

Surface

Layer stack

Glass composition

Glass parameter

(Ag) particle size

Layer stack

Firing
Poly-Si Layer from Different Depositions Methods

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

1 s
- 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

15 min
Temperature and Process Time Variation

1 min

- Slight and non-selective etching into poly-Si layer
- No Ag crystallite formation in poly-Si layer after 1 min

15 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
  o Pb based glass frit
  o Te based glass frit

• Experimental paste without glass frit
Impact of Main Component of Glass Frit

- Ag crystallite formation in poly-Si layer
- No statistically significant differences in glass layer thickness and Ag crystallite density
Ag Paste without Glass Frit

- 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

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

Top view

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


Microscopic studies on the etching behavior of silver pastes on passivating contacts
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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