Universität Konstanz

Metallization Techniques – Contact Formation with Al-free Ag Pastes on p^+ Layers

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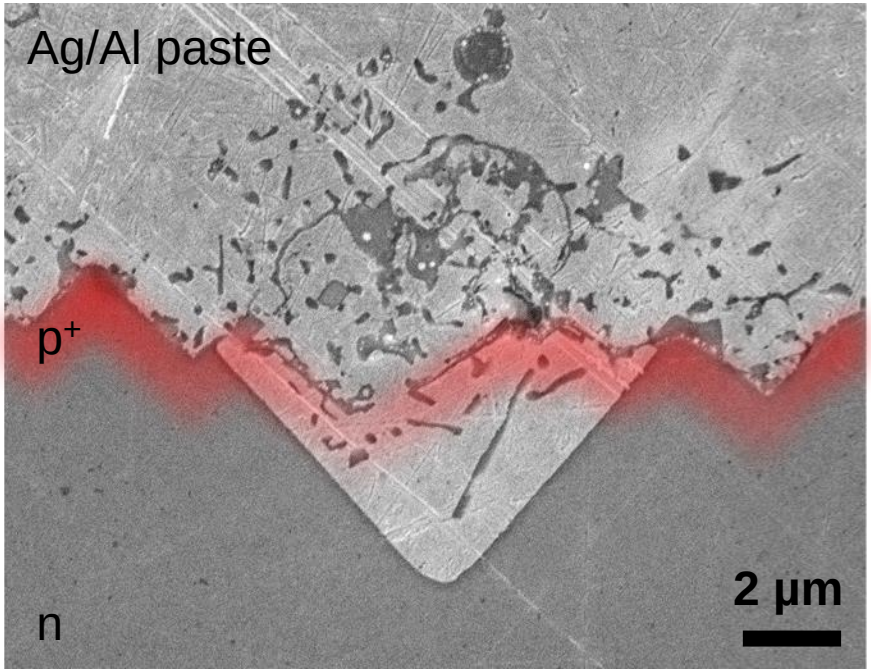
6th Workshop on Metallization & Interconnection for Crystalline Silicon Solar Cells

Motivation

State-of-the-art from publications

Limitations of Ag/Al pastes on p^+

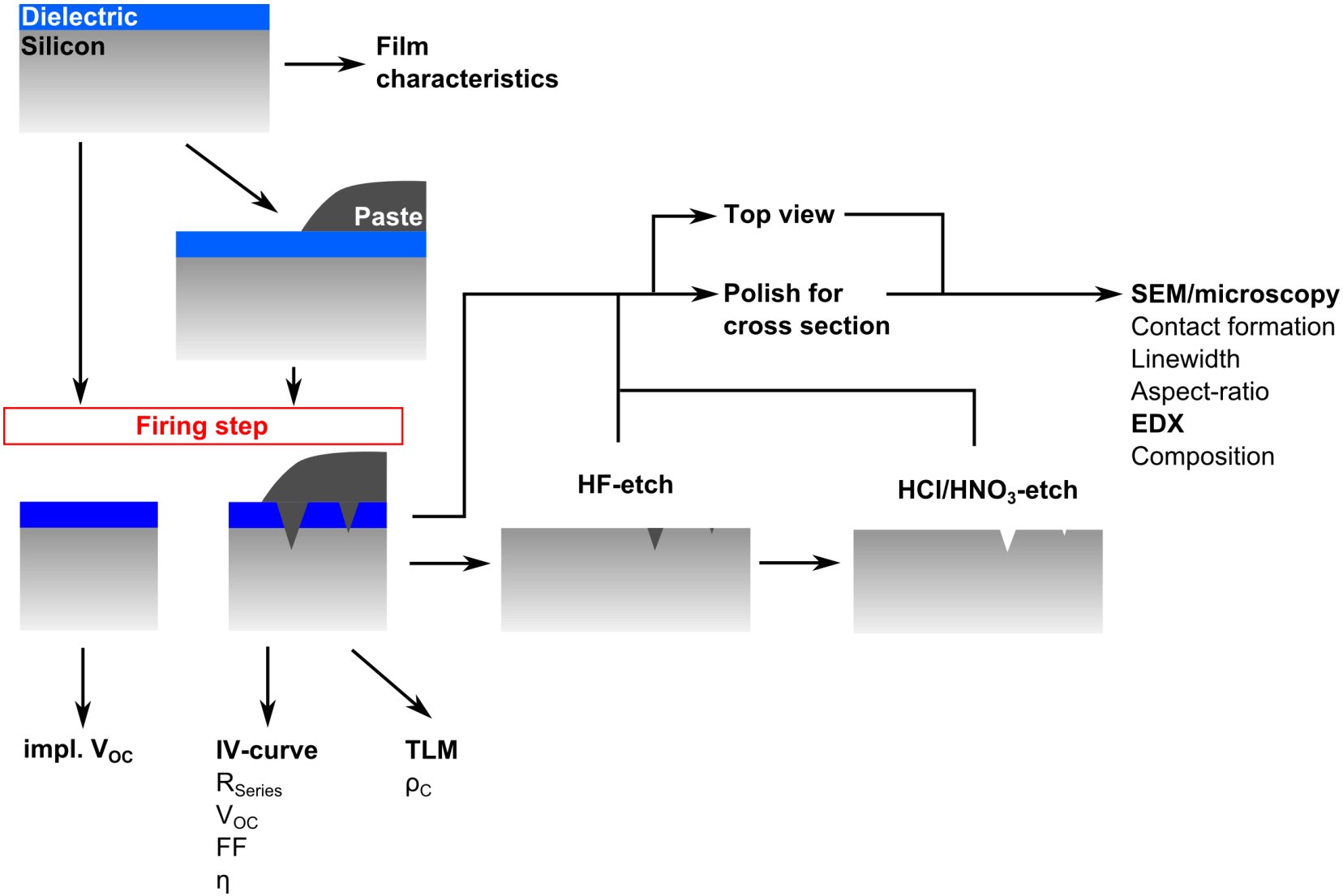
- V_{OC} & FF losses vs. Higher ρ_C
  - Ag/Al spikes
    - Recombination on interface
    - Indiffusion of contaminants
    - Electrical shunting
  - Reduced/missing surface passivation



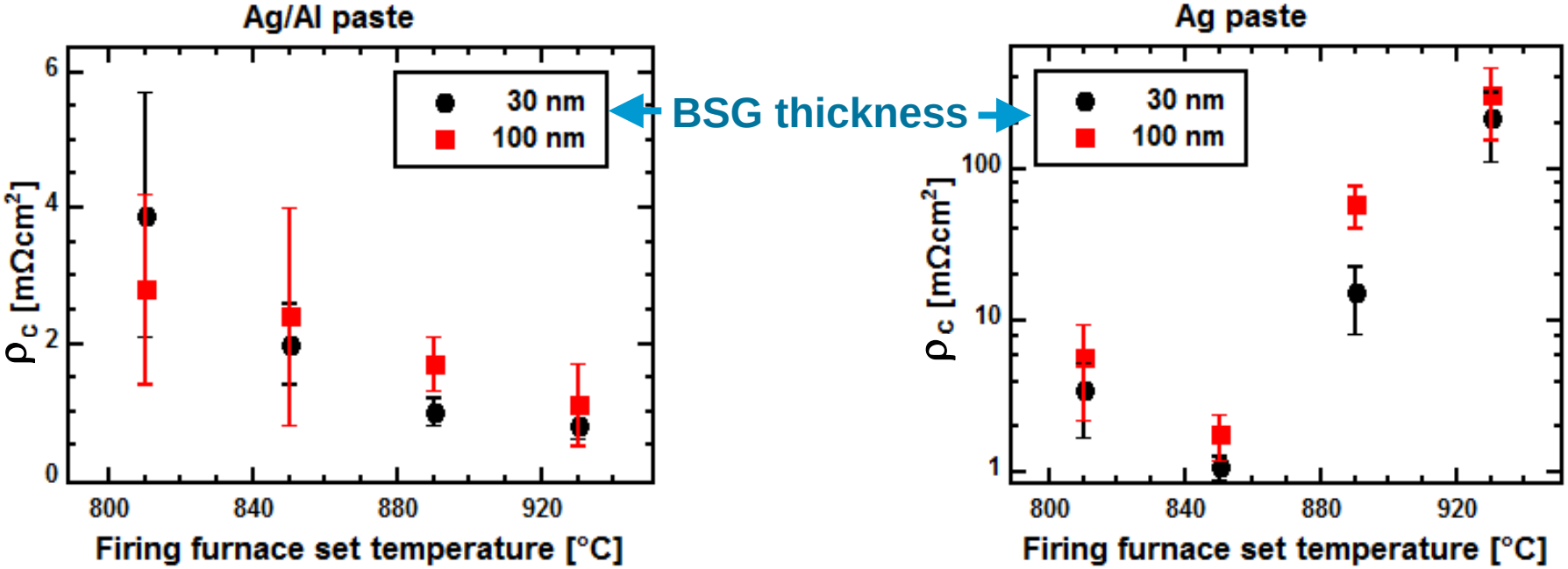
Advantages of pure Ag pastes known from n^+

- Shallow contact crystals
- Glass layer with nano-crystals possible
- Higher crystal density
- Smaller crystals

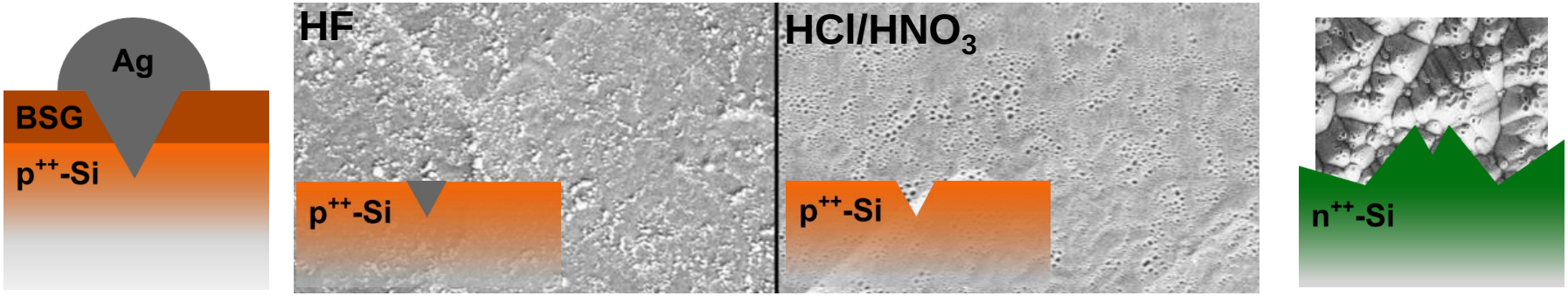
Investigating Screen-printing Pastes



Ag Pastes on p+ Emitters from multi-purpose BSG



J. Engelhardt et al., Proceedings of the 31st EU PVSEC, Hamburg, Germany (2015), 351-354



J. Engelhardt et al., Appl. Phys. Lett. 107, 042102 (2015) 1-4

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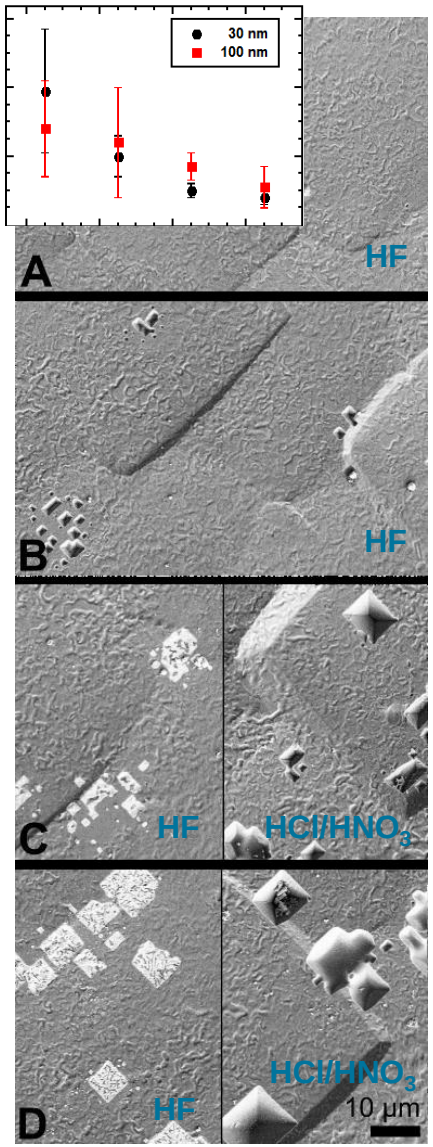


Ag/Al

Growing depth and size of Ag/Al spikes

810°C

850°C

890°C

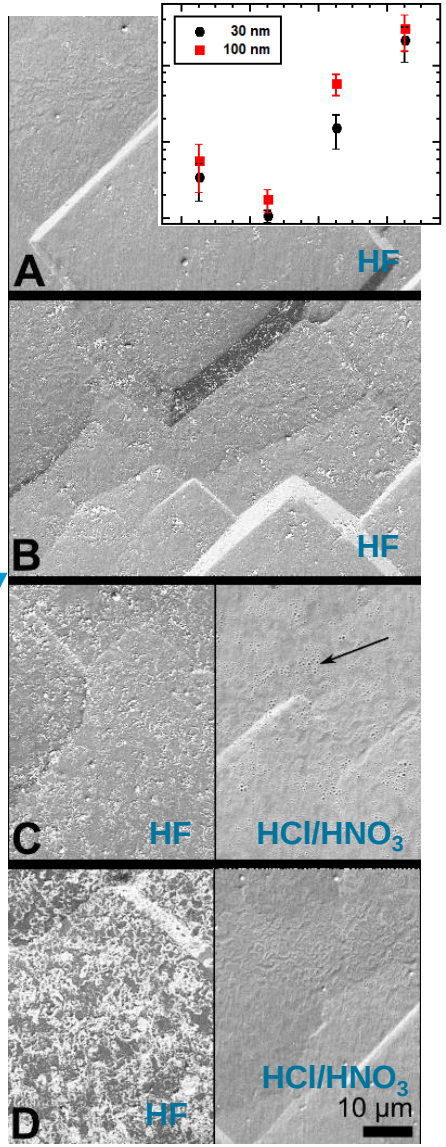
930°C

Ag

Growing density of Ag cryst. pits

Growing density of Ag cryst.

Receding pits



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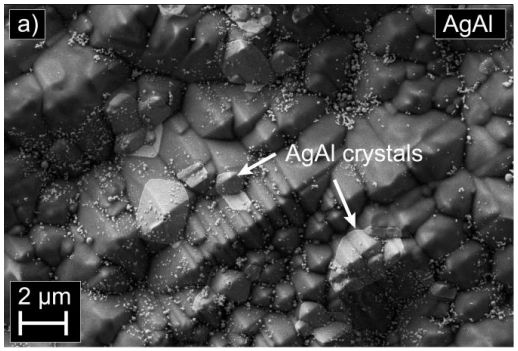
Ag/Al and pure Ag Pastes on SiN_x:H

Ag/Al

Ag

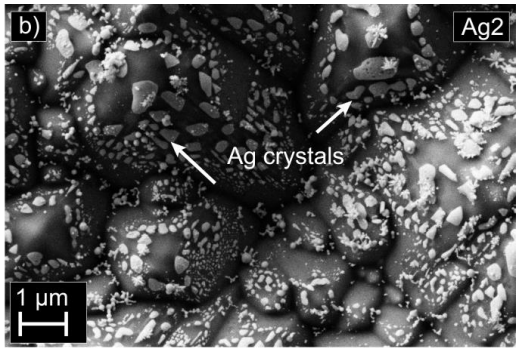


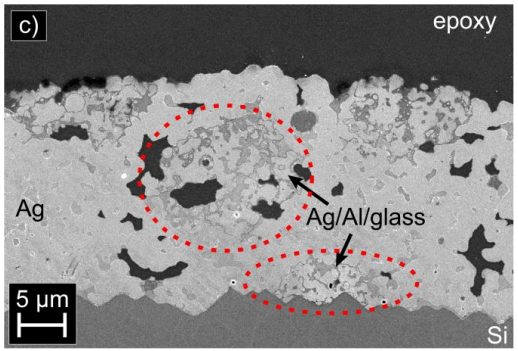
Local large Ag/Al cryst. distribution

> 2 µm

Homog. small Ag cryst. distribution

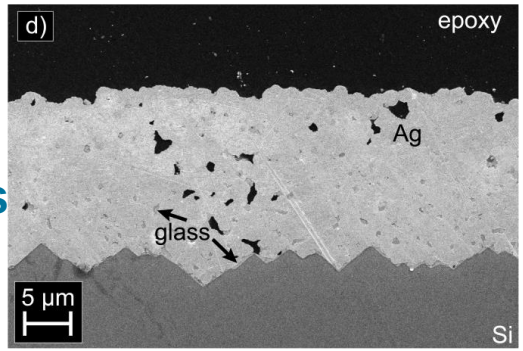
≈ 0.1-1µm

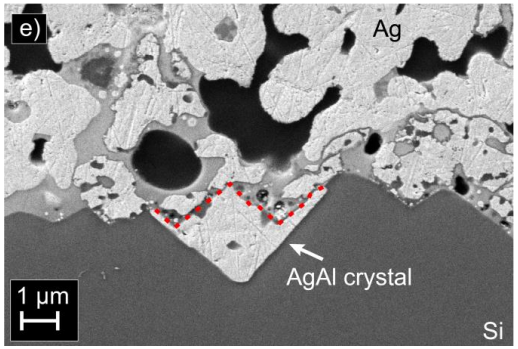




Ag/Al areas in Ag phase inhomog. distributed

Pure Ag phase with glass particles



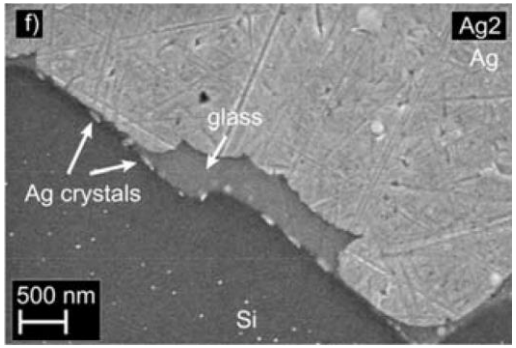


Deep (>1 µm) Al spikes into SCR

V_{OC} & FF loss

Shallow and small Ag cryst.

no loss

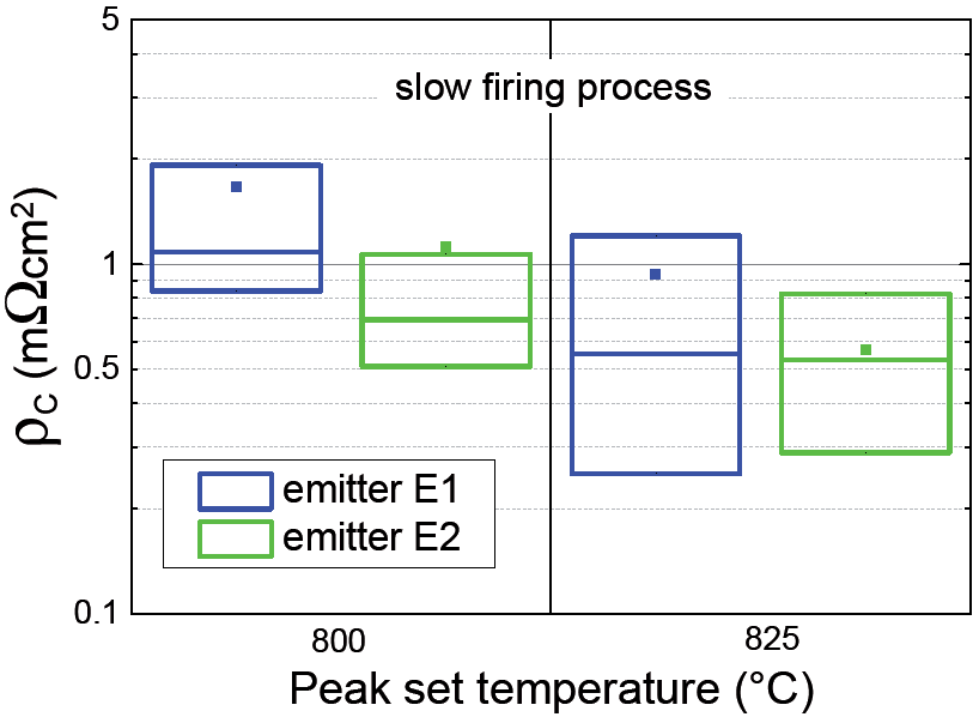


S. Fritz et al., Phys. Stat. Sol. RRL, 1-5 (2016) DOI 10.1002/pssr.201510443

Ag Paste ‚old Generation' / Emitter Influence?

Old generation paste with Pb

- Published as ‚not contacting'
  → First time published
- Very low and narrow
  firing parameter window
- Sparse contact density
- Thick glass layer formation
  for higher temperatures



Influence?

Mechanism?

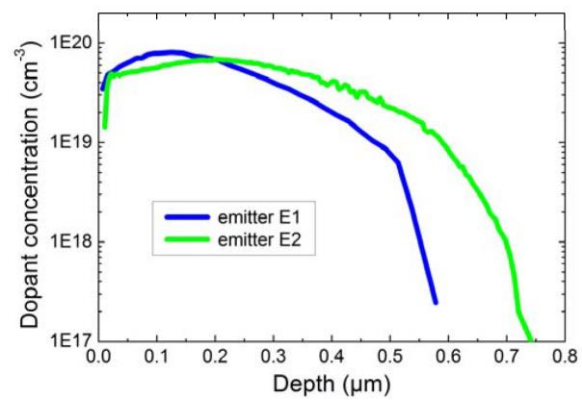
Change?

Surface doping concentration

and/or

sheet resistance variation

without influence

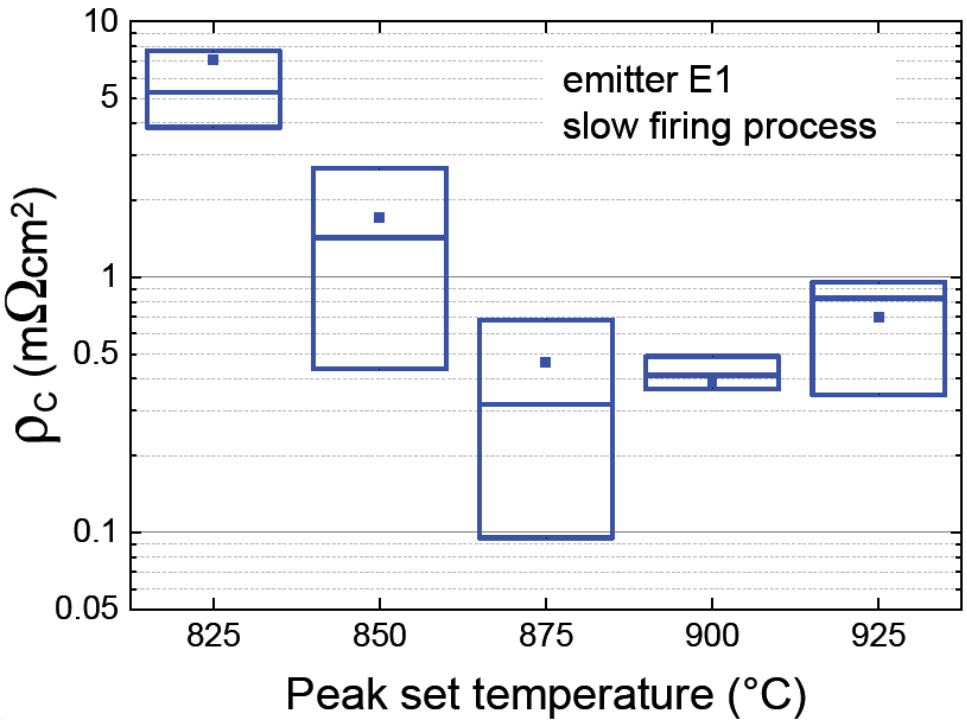


S. Fritz et al., En. Proc. (2016) from SiPV 2016 Proceedings, in press

Ag Paste ‚old Generation' with add. Te

Modified paste containing Te

- High-T and broad firing parameter window
- High contact density
- Shift to high-T due to Te? Glass layer formation changed?
- Similar behavior as new Ag on n^+



Influence?

Mechanism?

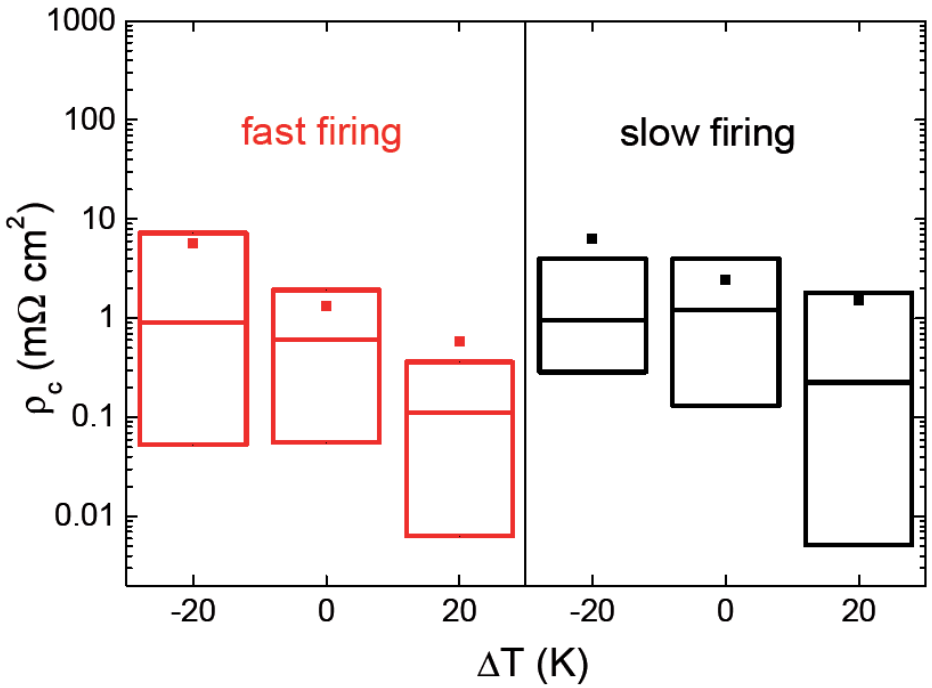
S. Fritz et al., En. Proc. (2016) from SiPV 2016 Proceedings, in press

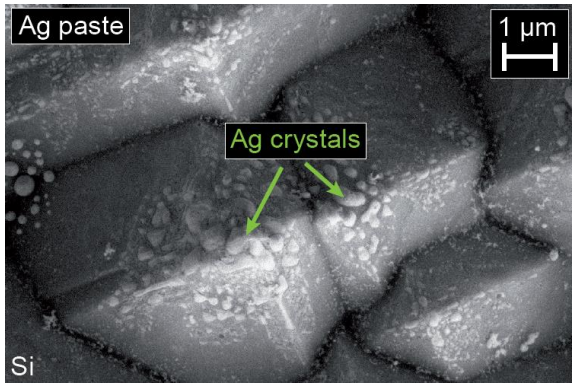
Ag Paste ‚new Generation‘

New generation paste

- Broad firing parameter window
- High contact density

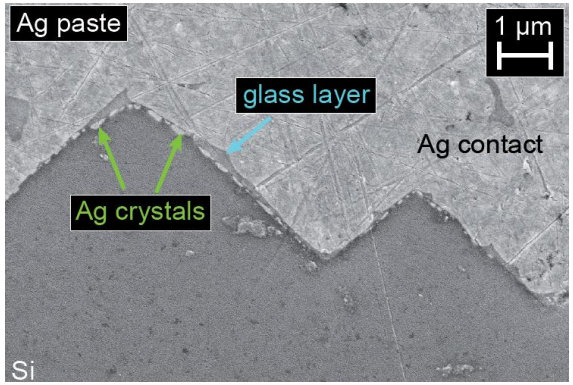
- Similar behavior as new Ag on n^+
- 200 nm deep Ag crystals
  with thin glass layer
  on edge and tip of pyramids





Top view

Cross section



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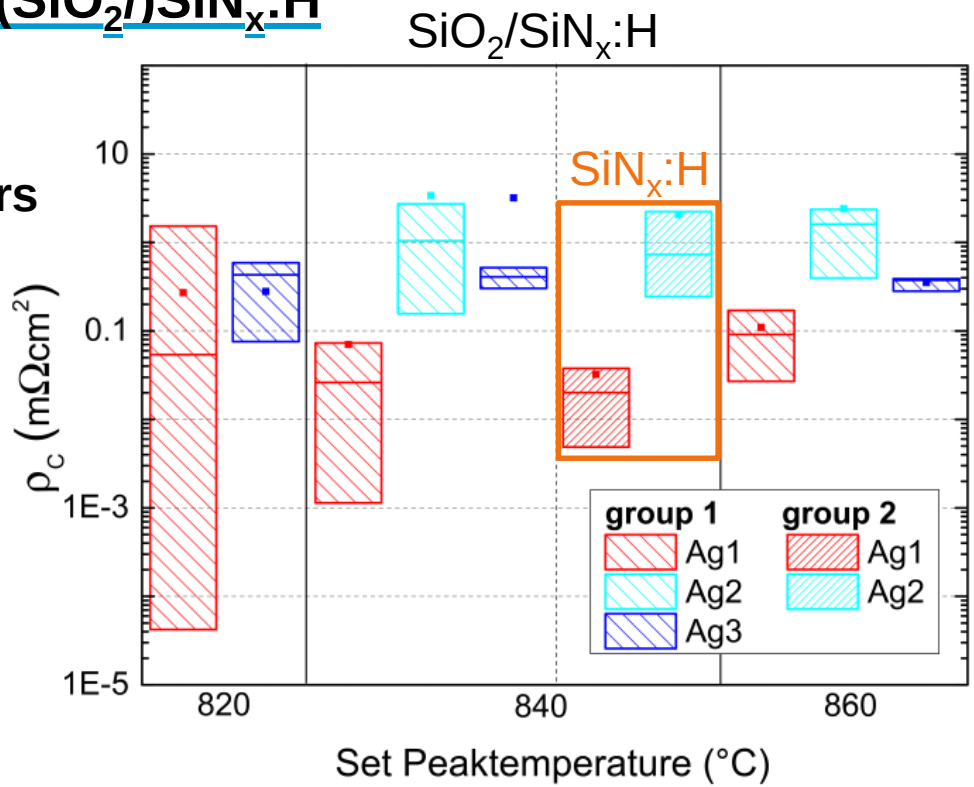
Commercial pure Ag Pastes on (SiO_2/)SiN_x:H

Pastes from different manufacturers

- In general:
  contact formation possible
- Broad firing parameter range
- Slight differences due to paste composition
- Independent of emitter profile

Advantageous for specific applications

- IBC
- Bi-facial
- Broad firing window
- Shallow emitters
- ...



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Thank you

for your attention.

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