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

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Motivation

State-of-the-art from publications

Limitations of Ag/Al pastes on p⁺
- $V_{OC}$ & FF losses vs. Higher $\rho_C$
  - 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


Ag Pastes on p⁺ Emitters from multi-purpose BSG

Growing density of Ag crystallites

Growing density of Ag crystallite pits

Growing depth and size of Ag/Al spikes

Receding pits

Ag/Al

810°C

850°C

890°C

930°C

HF

HCl/HNO₃

Ag/Al and pure Ag Pastes on SiN₅:H

Ag/Al

Local large Ag/Al cryst. distribution > 2 µm
Ag/Al areas in Ag phase inhomog. distributed
Deep (>1 µm) Al spikes into SCR

Homog. small Ag cryst. distribution ≈ 0.1-1µm
Pure Ag phase with glass particles
Shallow and small Ag cryst.

V_OC & FF loss no loss

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

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?

**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

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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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