# Screen-printed complex Ag inks for Si HJT metallization

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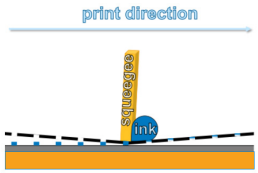
## Introduction

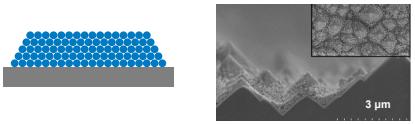
- *Screen printing is currently the dominant technology for Si PV metallization.*
- *Heterojunction solar cells (HJT) require low-temperature metal pastes with a higher amount of Ag.*
- *Complex Ag inks may be an alternative to the current nanoparticle-based pastes.*
- *This work presents the first demonstration of screen-printed complex Ag inks on Si HJT solar cells.*

### Screen Printing




*Schematic representation of screen-printing*

### Low Temperature Nanoparticle Pastes

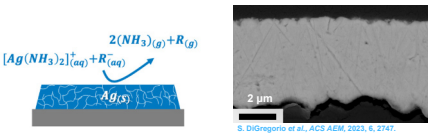



J. Schube *et al.*, *PSS RRL*, 2019, 13, 1900186.

*Schematic representation of nanoparticle ink (left) and SEM image of resulting inkjet printed trace (right)*

- *Silver form: nanometer scale silver flakes*
- *Peak temperature: 200ºC*
- *Benefit: well-controlled rheology → fine line resolution*
- *Drawback: low metal density → lower conductivity*

### Complex Ag Inks



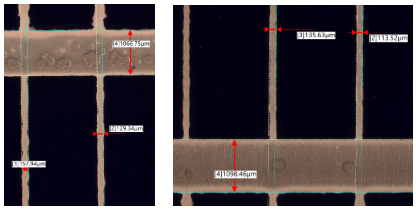

S. DiGregorio *et al.*, *ACS AEM*, 2023, 6, 2747.

*Schematic representation of complex Ag ink (left) and SEM image of resulting printed trace (right)*

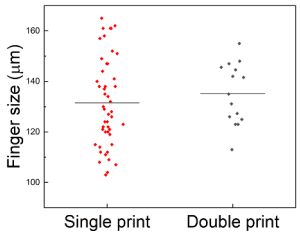
- *Silver form: metal-ion organic complex*
- *Peak Temperature: 200ºC*
- *Benefit: high density metal → high conductivity*
- *Drawback: low viscosity ink → resolution challenges*

## Printing quality

- *A screen was designed with finger openings of 80 µm.*
- *The size of the fingers was measured, and the spreading of metal inks was quantified.*
- *A double print is expected to produce better continuity in the fingers without increasing their size.*



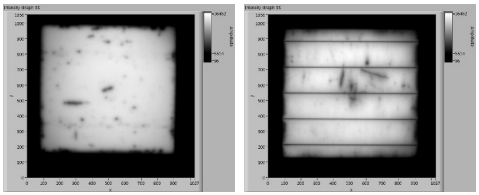
*Optical images of screen-printed fingers and their size using an 80 µm designed finger opening screen with single print (left) and double print (right).*




*Finger size for wafers screen-printed with an 80 µm screen.*

## Photoluminescence imaging

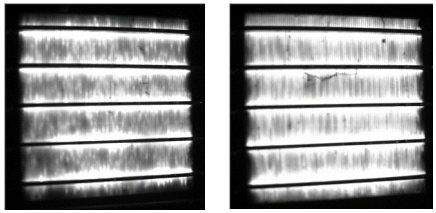
- *PL images before and after metallization with complex Ag ink show similar intensity, indicating that the inks make soft contact with the Si.*



*PL images of a G1 HJT cell before (left) and after (right) complex Ag ink screen-printing and curing at 185ºC for 30 minutes.*

## Electroluminescence imaging

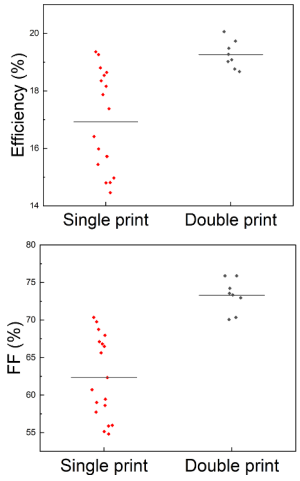
- *A double print shows brighter EL intensity than a single print, indicating improved conductivity of the front-side metal grid with double printing.*



*EL images of Si HJT devices with single-print (left) and double-print (right) front side Ag grid.*

## Device performance

- *Full-area G1 (158.75 x 158.75 mm²) Si HJT cell precursors were used ("blue cells" before metallization).*
- *Double printing results in better-performing devices with a maximum cell efficiency of ~20.3%.*




*Efficiency (top) and Fill Factor (bottom) of the screen-printed Si HJT solar cells using the 80 µm screen.*

## Conclusions

- *Successful demonstration of screen printing complex Ag inks on HJT solar cells.*
- *Devices with efficiency > 20% can be achieved while reducing Ag consumption by > 80%.*
- *More work is needed to develop industry-compatible solar cells with efficiency > 24%.*

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