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COMET COPPER METALLIZATION FOR SUSTAINABLE N-TYPE PV TECHNOLOGIES

INDUSTRIALLY VIABLE COPPER METALLIZATION FOR HETEROJUNCTION SOLAR CELLS

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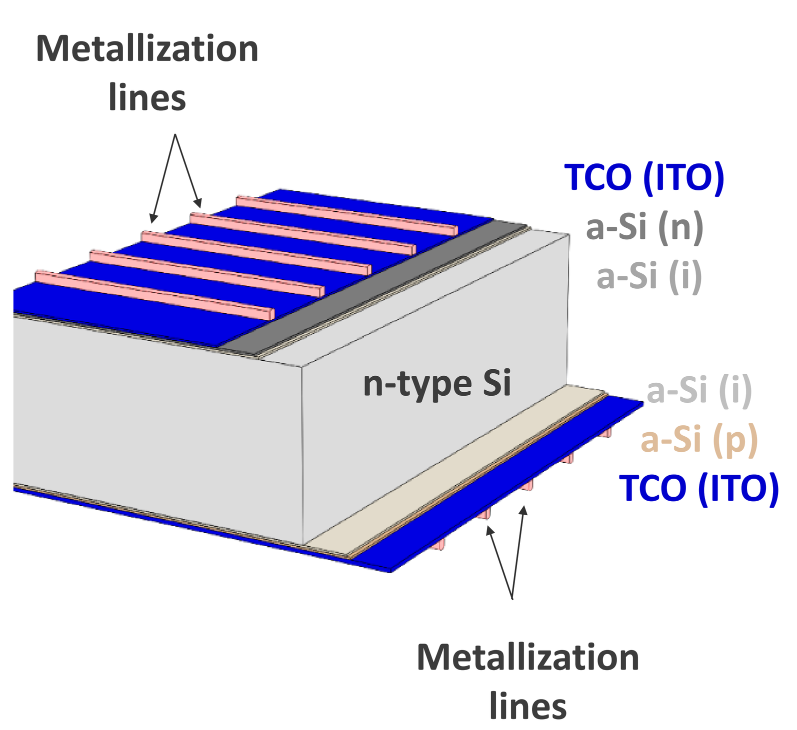
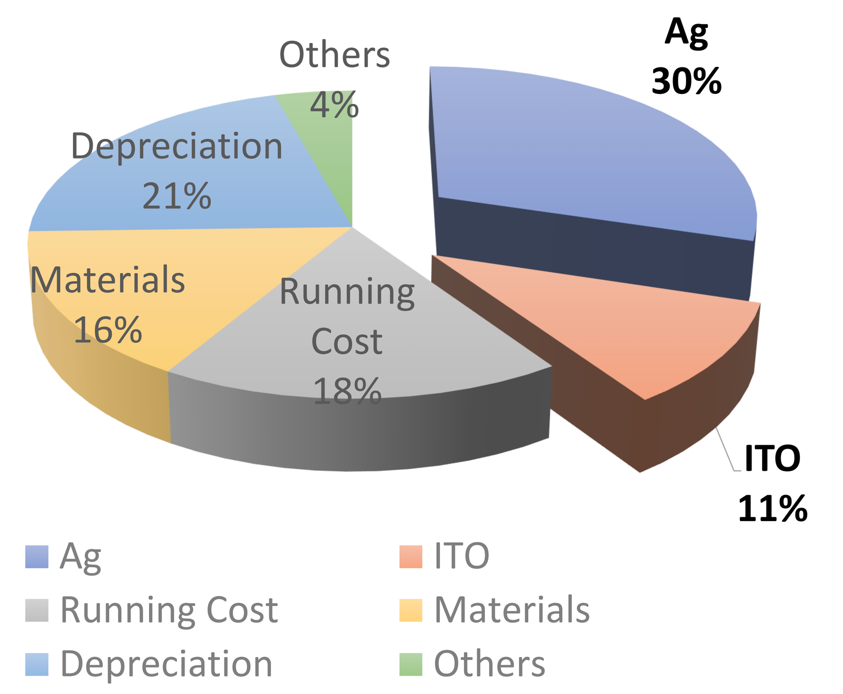
HETEROJUNCTION SOLAR CELLS



Heterojunction cells are symmetrical and intrinsically bifacial, with layers of amorphous Si and transparent conductive oxide (TCO), usually indium-tin-oxide, (ITO) on both sides.
Besides high efficiency and a simple processing sequence, with all processes at low temperature, the structure offers an important advantage for copper processing: TCOs are excellent barriers against copper diffusion.[1] This makes heterojunction cells resistant against copper ingress into silicon and the perfect structures for copper metallization.

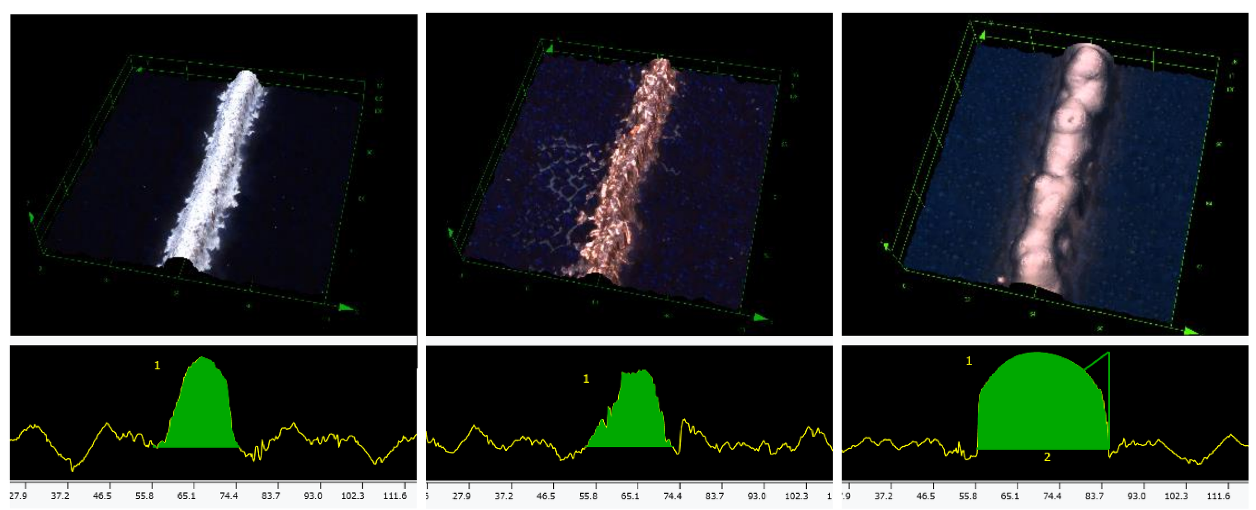
COST STRUCTURE CELL PROCESS



Calculation based on recent mass production data.

The conventional metallization for heterojunction cells involves screen printing of a silver particle paste. Despite recent advancements such as the adoption of pastes with reduced silver content and printing of busbar-free layouts to reduce paste laydown, silver still contributes significantly to the overall cell production costs. Moreover, silver and indium are scarce elements, and their limited availability impose constraints on cell production volumes. [2]

NARROW COPPER LINES [3]

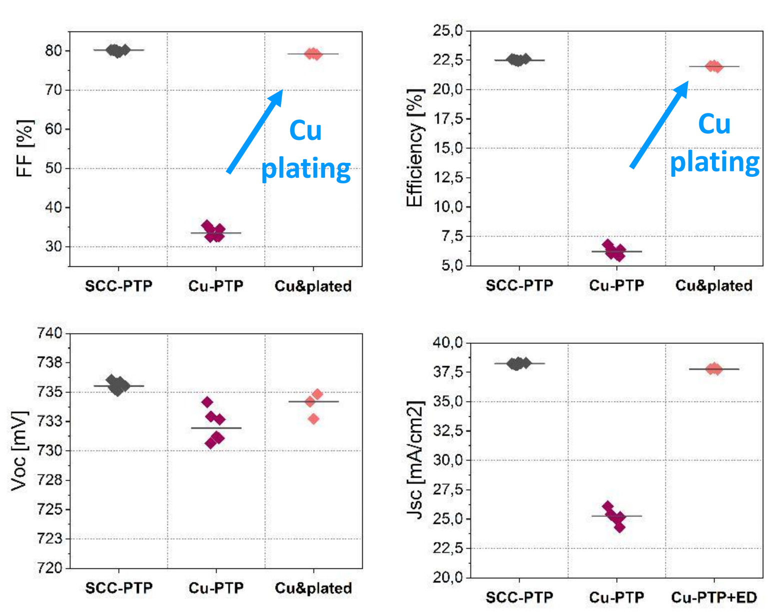


Silver-coated copper paste	Pure copper paste	Pure copper paste + electrodeposited copper
Line width 18.9 µm	Line width 21.5 µm	Line width 25.0 µm
Line height 10.3 µm	Line height 9.3 µm	Line height 17.6 µm
CS area 116 µm²	CS area 102 µm²	CS area 335 µm²

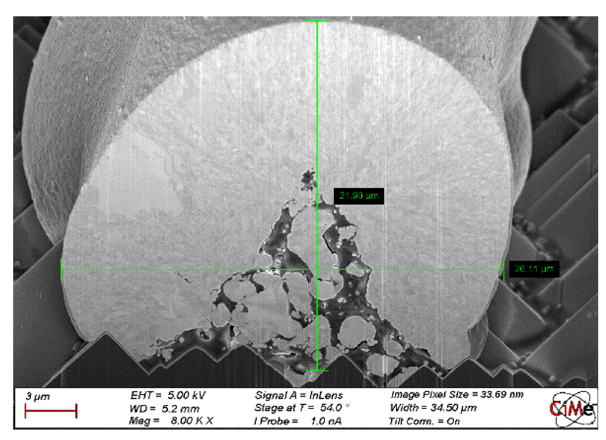
Pad to pad dist. 26 mm	SCC paste	Cu paste	Cu paste + electrodepos. Cu
Ω	1.5	5.1	0.18

Narrow copper lines have been achieved with pattern-transfer printing (PTP).
The resistivity of copper paste alone is very high.
The efficiency of cells having lines of only printed copper is at 6% ! With additionally electrodeposited copper 22.3% are achieved.

Cell results on M2 industrial precursors of medium quality.

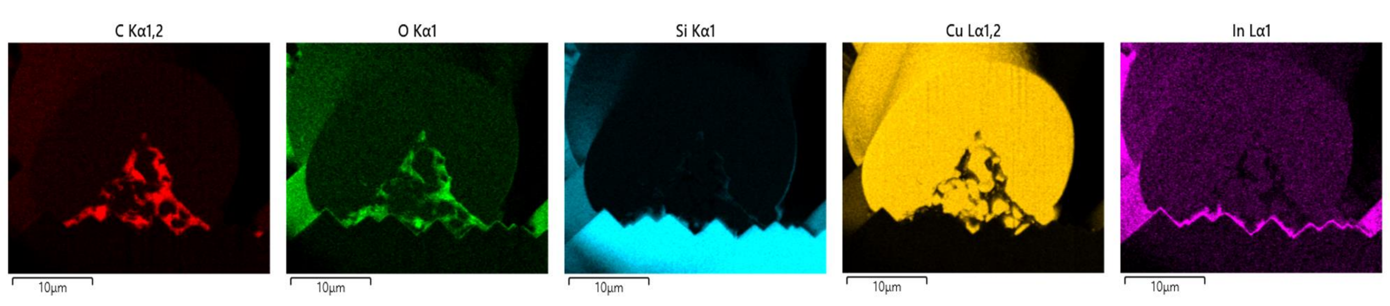


Ion beam cross section of a line printed with pure copper paste (with organic components), dielectric layer and with electrodeposited copper.

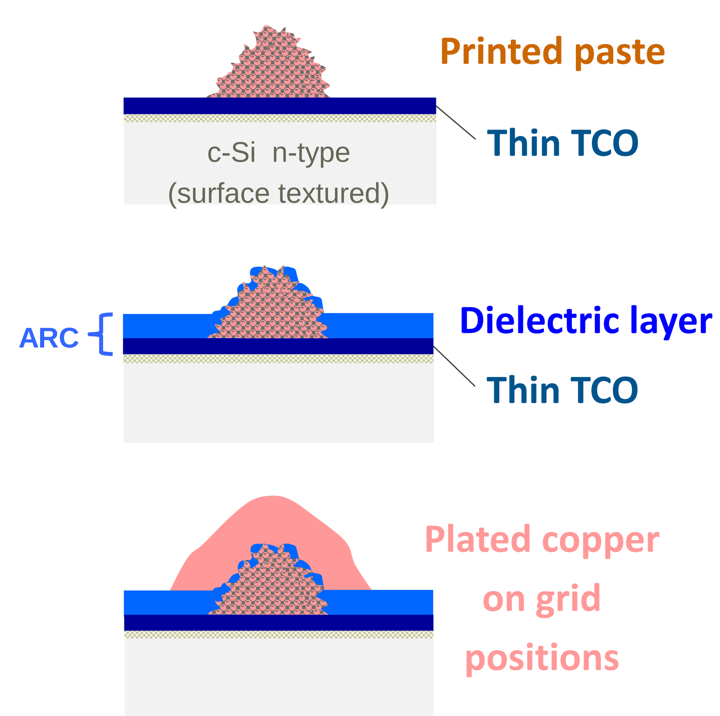


Height 21.9 µm
Width 26.1 µm

EDX analysis



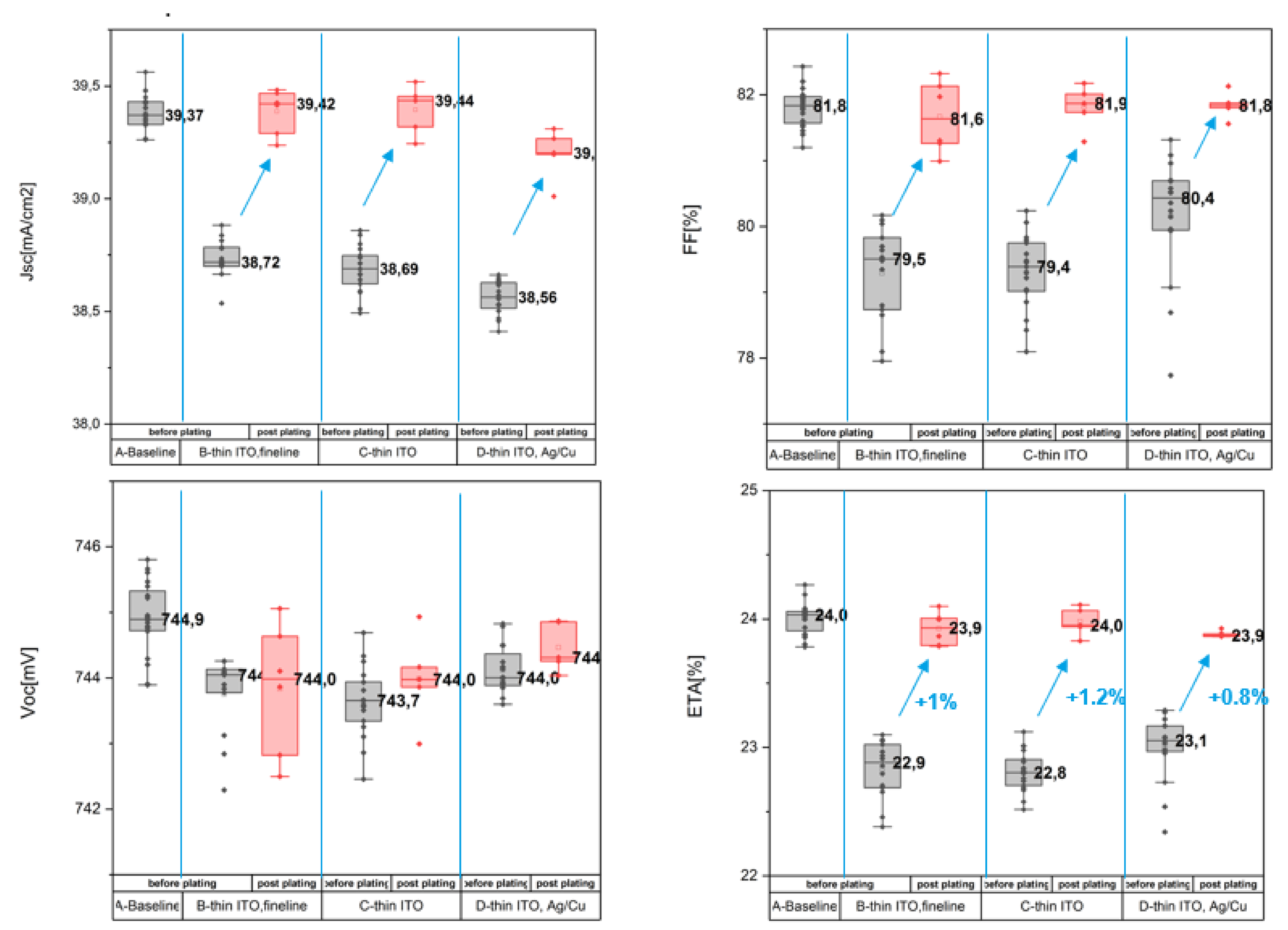
CSEM COPPER METALLIZATION PROCESS



Only 3-steps:

1. Seed-grid printing on (thin) TCO and curing (200°C)
2. Dielectric layer deposition over the entire wafer surface
3. Copper electrodeposition

IV results from process sampling for a large solar cell manufacturer, on M10 cell precursors with reduced ITO thickness. Through the deposition of the dielectric layer and copper plating the efficiency is significantly improved, by 1% on average.



Aknowledgement:

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References

[1] C. Liu et al., "ITO as diffusion barrier between Si and Cu», Journal of the Electrochemical Society, 2005

[2] P. Verlinden, "Future challenges for photovoltaic manufacturing at the terawatt level", J. Renewable Sustainable Energy, 2020

[3] A. Lachowicz et al., "Aging tests of mini-modules with copper-plated heterojunction solar cells and pattern-transfer-printing of copper paste", EPJ-PV, 2024