Laser Direct Writing Techniques for Metallization of Solar Cells

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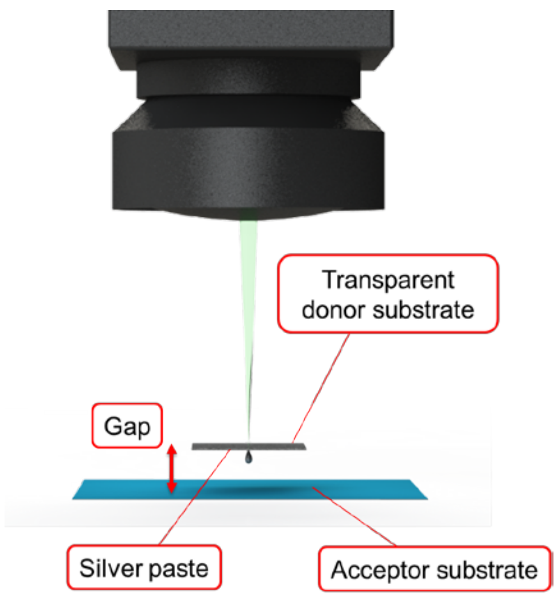
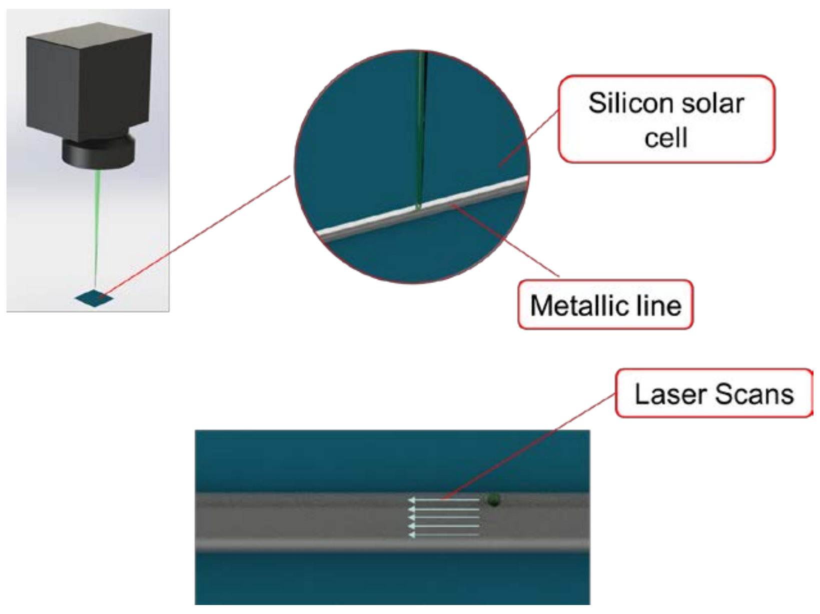
Abstract

Front metallization is an expensive, fundamental step in the fabrication of solar cells. It comprises different processes including the printing of fingers and busbars and several thermal treatments in order to cure and sinter the printed material. These two steps have been replaced by laser direct writing techniques, what allows printing fully personalized metallization designs, with high throughput velocities and a lower thermal budget for the solar cell structure.

Laser-Induced Forward Transfer (LIFT) & Laser Thermal Treatment



LIFT

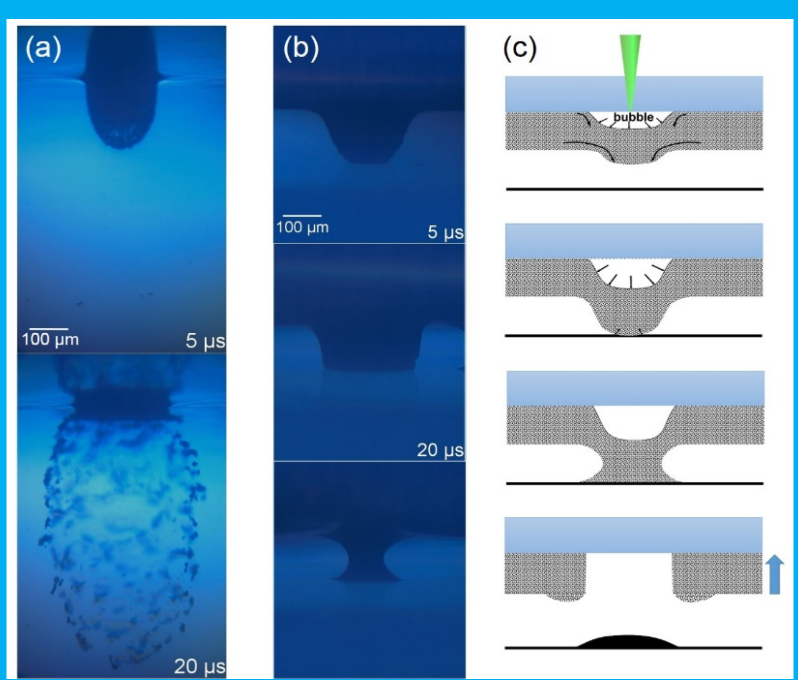


Laser local heating

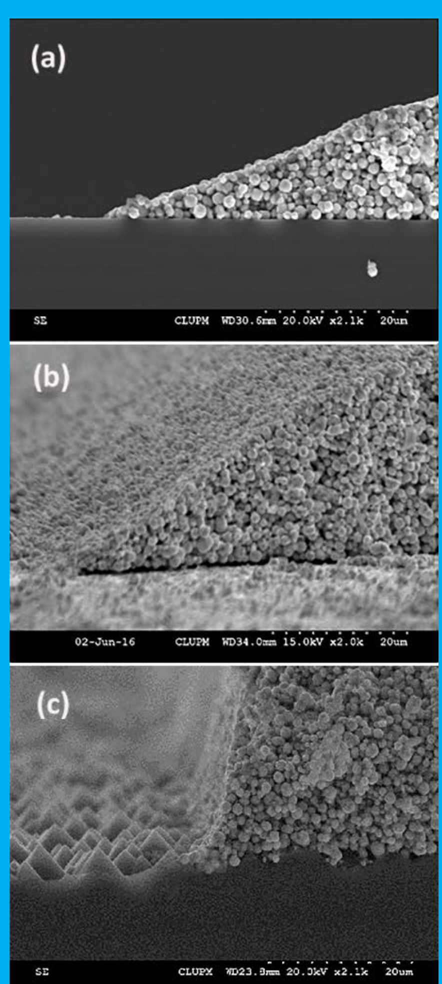
	Metallization	Curing & sintering
Technique	LIFT	CW laser local heating
Laser source	Spectra Physics Explorer ▪ Pulsed laser (15 ns) ▪ 532 nm ▪ Pulse Energy up to 40 µJ	Spectra Physics Millenia ▪ Continuous Wave ▪ 532 nm ▪ Power up to 20W
Optical path	▪ Optical Scanner (ScanLab HurryScan) ▪ F-Theta Lens, focal 250 mm ▪ Focused beam diameter ~20 µm	

LIFT printing of fingers and busbars

- Commercial, high viscosity, non-Newtonian, micron-sized particles, silver paste (DuPont Solamet PV17F).
- Concrete-dot transfer regime: the protruding paste reaches the acceptor substrate, allowing the formation of a continuous pillar between donor and acceptor.
- Highly textured surfaces provide high adhesion forces and prevent the paste from spreading along the surface.



D. Munoz-Martin et al. Applied Surface Science 366, 389–396 (2016)

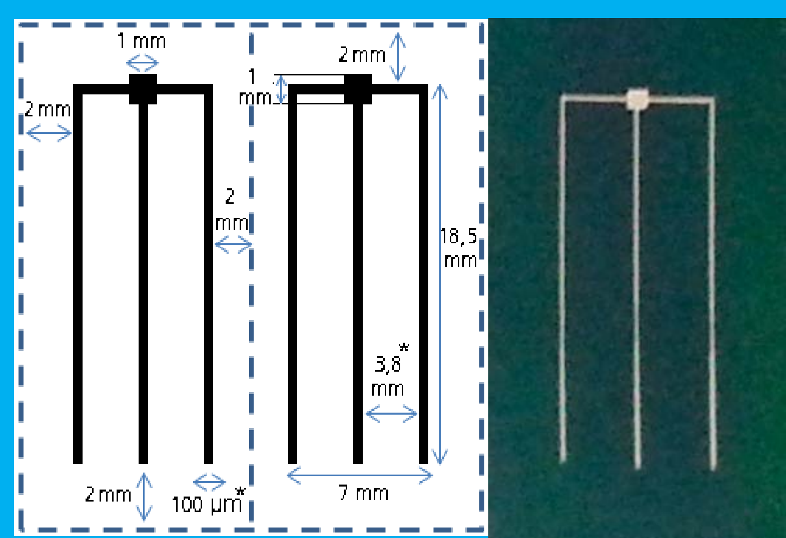


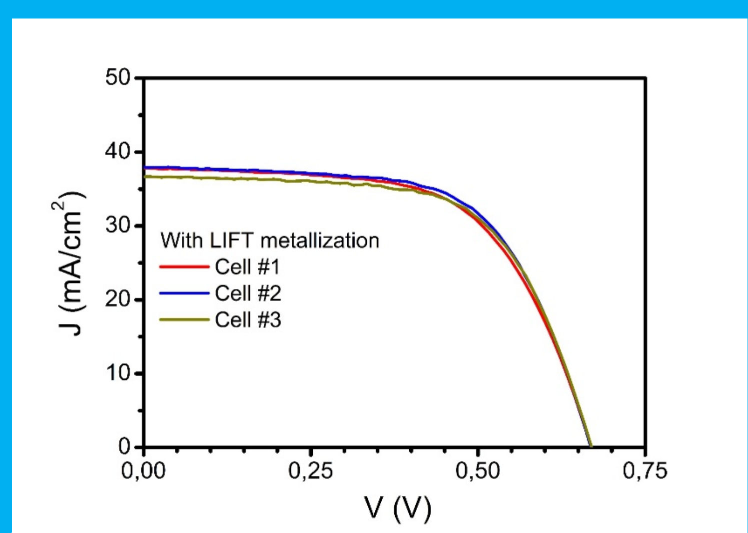
Y. Chen et al. Results in Physics 6, 998-999 (2016)

Curing the printed material

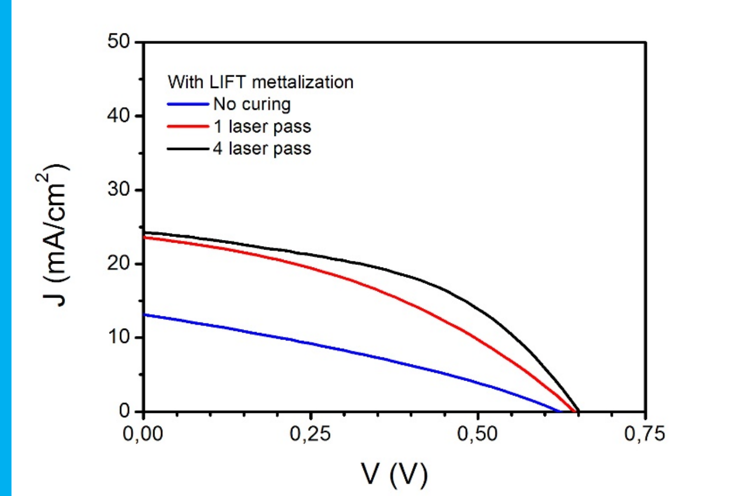
- Lines (widths down to 80 µm and heights up to 40 µm) have been printed onto solar cell materials: c-Si wafers and CIGS flexible solar cells.
- Metallization finishes with a series of heating steps

CIGS solar cell





Standard furnace treatment



Laser Curing:

Low power (~0.5 W) & low speed (~mm/s).

Several passes were needed.

Conclusions

- The physics of LIFT of high viscosity fluids has been studied. High aspect ratio lines (~0.5) can be printed.
- All-laser based metallization process has been applied: LIFT printing and laser thermal treatment for curing and sintering.
- Flexible CIGS solar cells have been metallized showing appropriate functionality

Acknowledgements

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