



Some of the basic problems found in current state of the art technologies within the flex/3D electronics industry can be overcome by using laser techniques for material transferring as well as defining the metallic contacts onto flexible optoelectronics devices, especially in planar geometry. UPM is working on the design and development of reliable schemes for direct writing of electronics and photovoltaics in planar geometry by means of Laser Induced Forward Transfer (LIFT) and post-deposit laser firing and curing techniques.

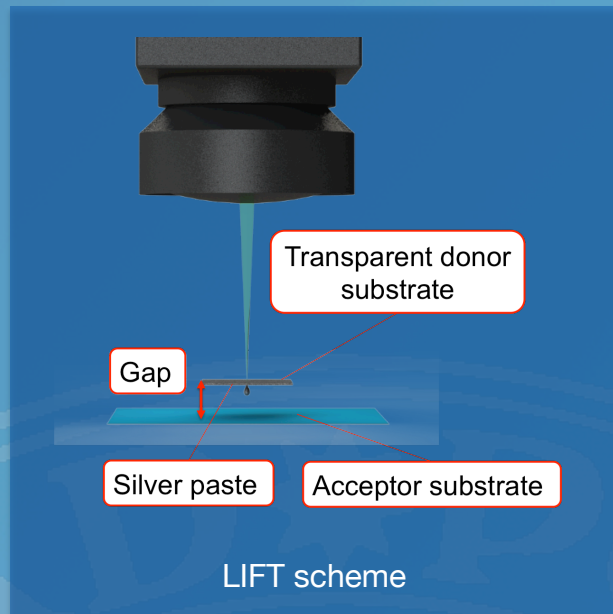
Laser Induced Forward Transfer

The LIFT process is a local technique to transfer different materials (especially metallic solid materials or material dissolved in an assisting matrix) of different sizes onto a number of different substrates. LIFT uses laser pulses to push thin disks of a ribbon material from a transparent substrate and deposit them onto an acceptor substrate.

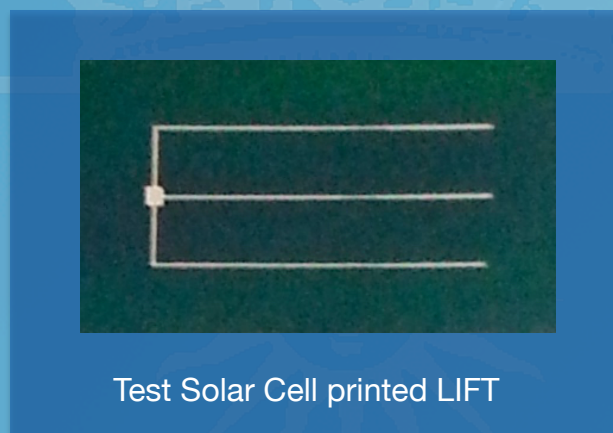
The laser beam is focused into the donor substrate or ribbon interface. During the pulse duration, the laser energy is deposited into the interface within the laser spot size, evaporating a little amount of the material and generating the expansion of the remaining material, accelerating the non-evaporated part of the metal film towards the acceptor substrate.

The LIFT made with ns pulses is a well-known technology to generate structured metallization onto substrates. But it has not yet been applied to define the fingers of front contact in a photovoltaic device in one

single step.



In the ns range the transfer of very precise geometries is difficult to control, but the use of ultrafast lasers may overcome this difficulty. Relative translation of the source and substrate, or the scanning of laser beam, allows the generation of complex pattern formation in three dimensions in a conformal way.



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New Laser Systems for LIFT

In the frame of the APPOLO project, it has been designed and built a test bench for installing different ps-laser sources provided by laser manufacturers such as EKSPLA and OneFive GmbH.

The results obtained with these new generation industrial lasers are being

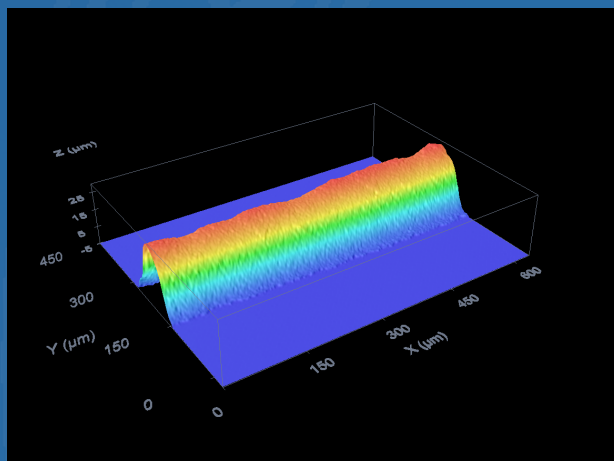
compared with those obtained using standard ns-lasers.

High power and repetition rate picosecond laser from Ekspla combined with high speed polygon scanner with SuperSync™ technology from Next Scan Technologies has been tested and proved to be a perfect combination for LIFT applications.

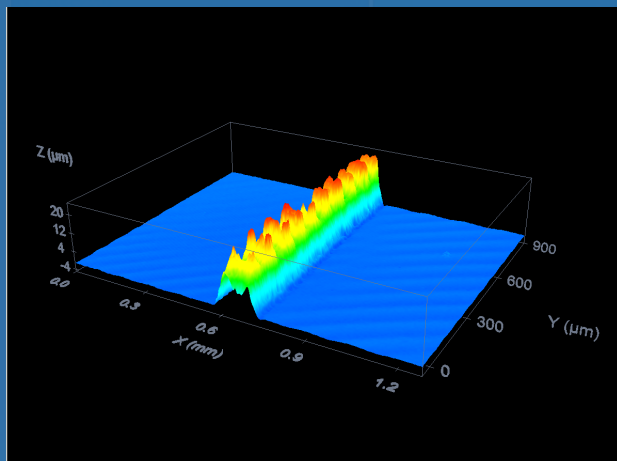


Appolo Test Bench

LIFT printed line



EKSPLA laser and fix optics



EKSPLA laser and Next Scan



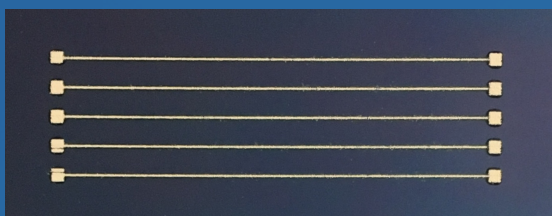
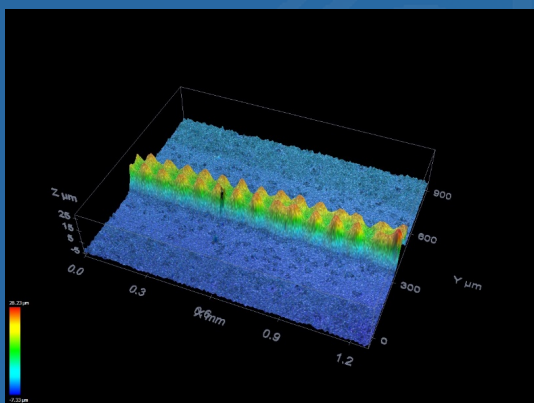
Solar cell metallization with LIFT

UPM currently has a working installation for LIFT. It is based on a ns-pulse diode pumped solid-state green laser. Using this station it is possible to transfer a large amount of material per laser pulse (hundreds of pL) and to deposited continuous metallic lines with aspect ratios higher than 0.4.

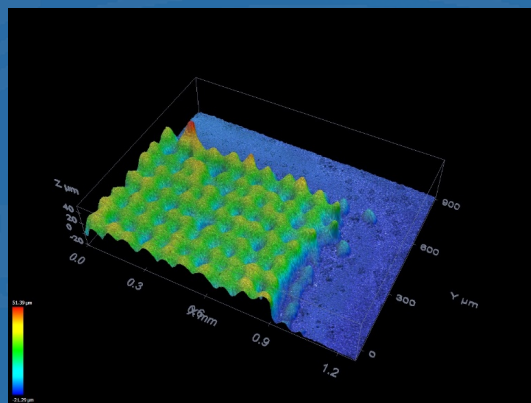
They are larger than those obtained with screen-printing techniques using the same pastes.

As a proof of concept, an important milestone for the technology, is the full metallization of a solar cell on flex substrate with a free form grid with fingers and busses deposited by LIFT technology.

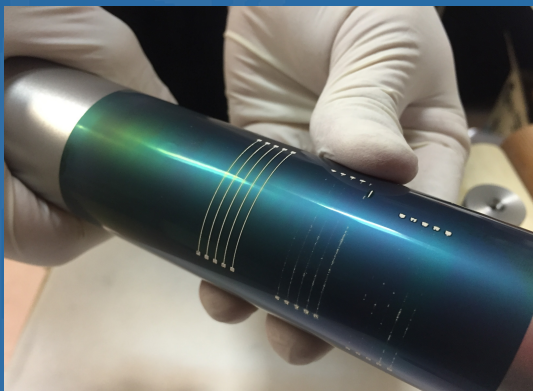
LIFT printed finger



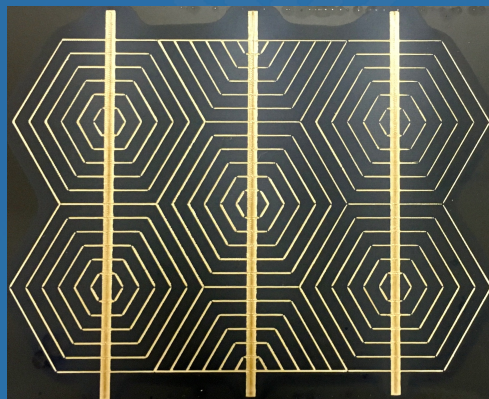
LIFT printed busbar



Good mechanical properties



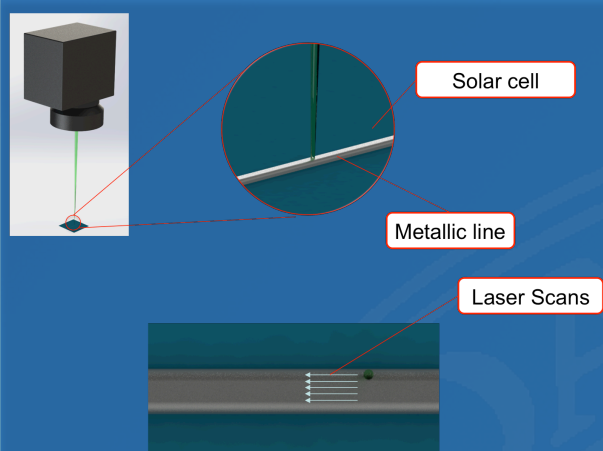
Free form grid





Curing/Sintering of the deposited material

The conductive material deposited by LIFT needs to be thermally treated in order to evaporate the solvent, cure the paste and sinter and melt the metallic particles. This process can be done by laser heating of the deposited material using continuous wave laser sources.



Laser curing/sintering scheme

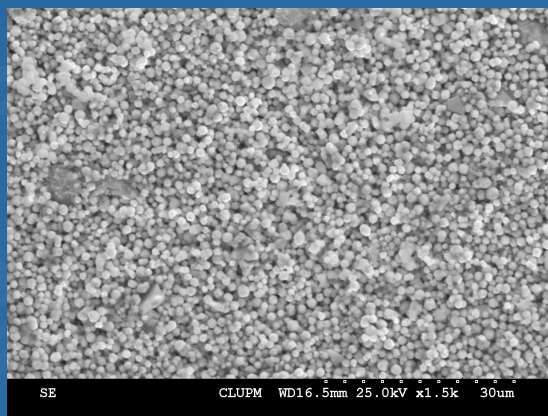
This laser process has the advantage of being a low-temperature process. Meaning that only the deposited material is heated up avoiding any furnace steps that could affect the performance of the electronic device negatively.

Curing can be achieved at different laser powers and scanning speeds, but there is a small parametric window for obtaining the best results.

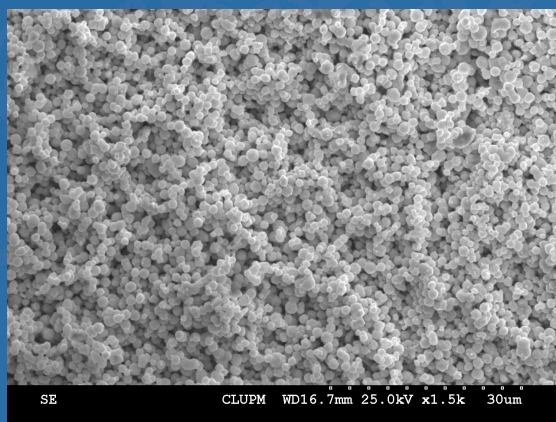
Process can be achieved at high speed giving the possibility to be used in future industrial applications.

Bulk resistivity is reduced two orders of magnitude and it is achieved by only heating the line without damaging the substrate.

SEM images of Ag-paste lines



As-deposited



After laser curing/sintering

Acknowledgments

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