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LASER PROCESSING OPTIMIZATION FOR 2DMATERIALS-PEROVSKITE SOLAR MODULES

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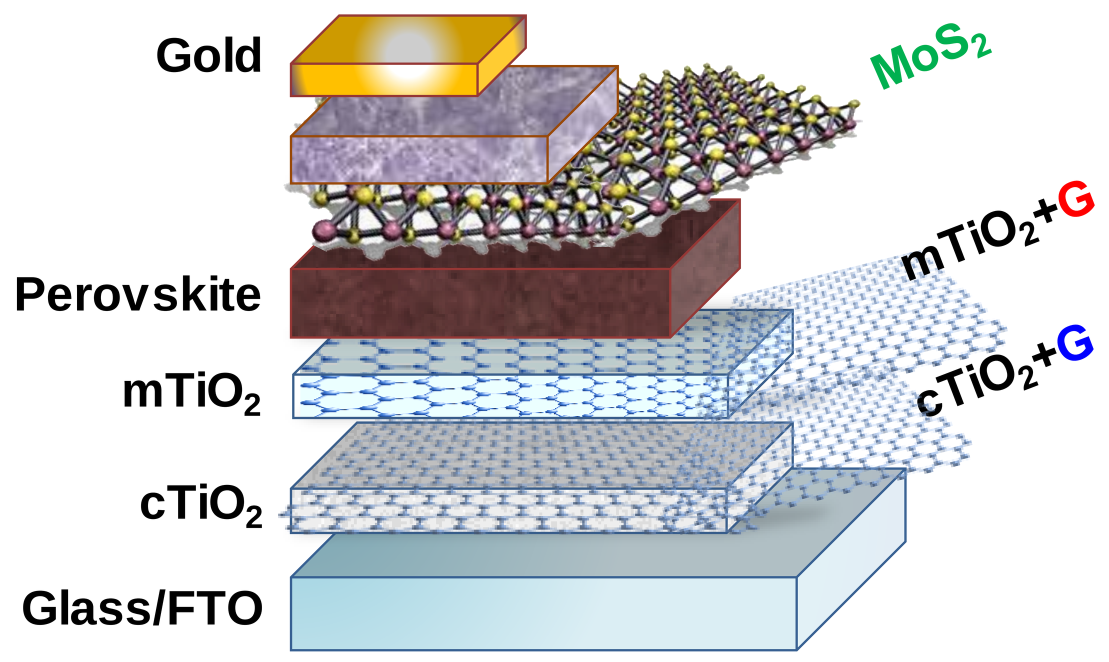
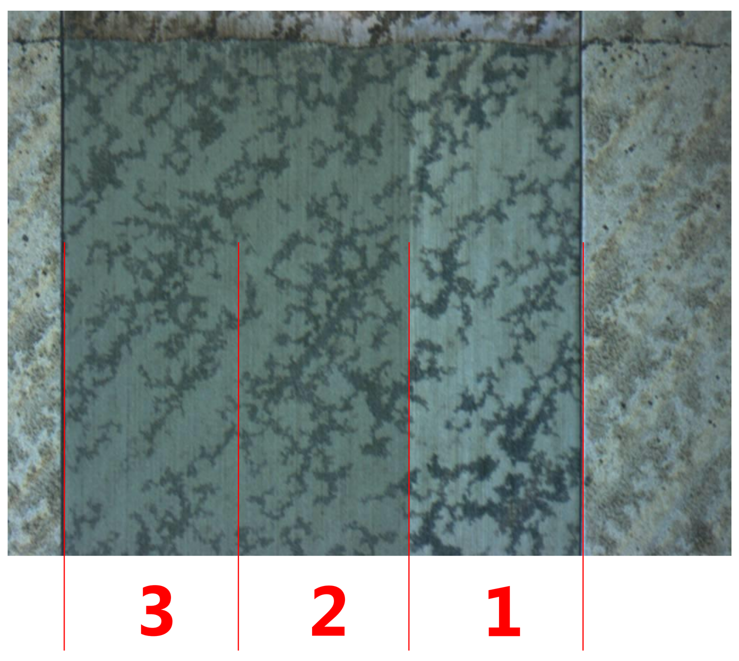
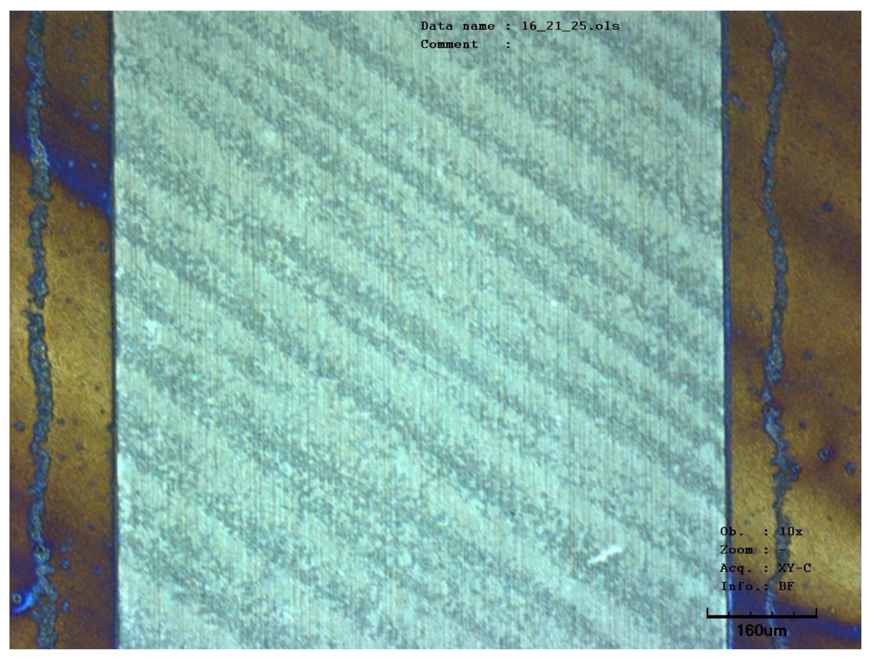
ABSTRACT Industrial applications for two-dimensional (2D) material-perovskite solar devices require optimized fabrication steps devoted to scale-up efficient lab-scale devices to large area modules. In this work, with the aim to get an efficient series interconnection between module constituting sub-cells, we employed a 10 ps laser (λ=355 nm) for all the ablation processes (namely P1, P2, P3), by carrying out a fully optimized device layout [1,2]. If, on one hand, the quality of P2 process has a strong impact on the module serial resistance, on the other hand a not fully optimized P3 process can lead to low parallel resistance value. In the present work, we show how the module performance can be improved by the optimizing P2 and P3 processes. The parameters used for each laser ablation step were set to obtain an efficient and fast process by retaining high process repeatability. As a matter of fact, laser fluence and process speed need to be optimized taking into account the presence of 2D materials and their depositions techniques, preventing the incomplete removal of the layers or the laser-induced active area degradation.

RESULTS

P2

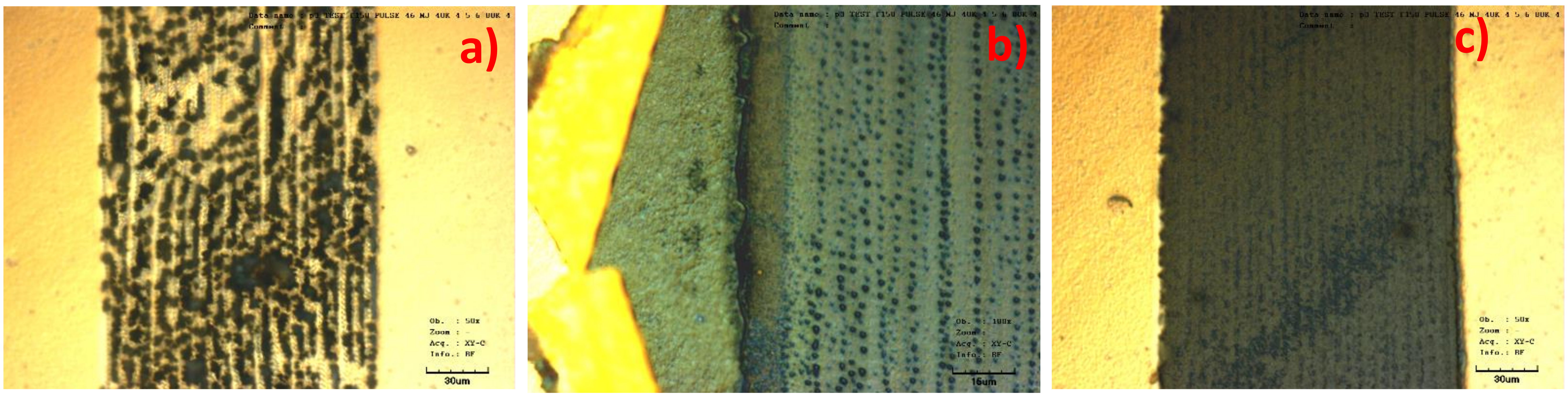




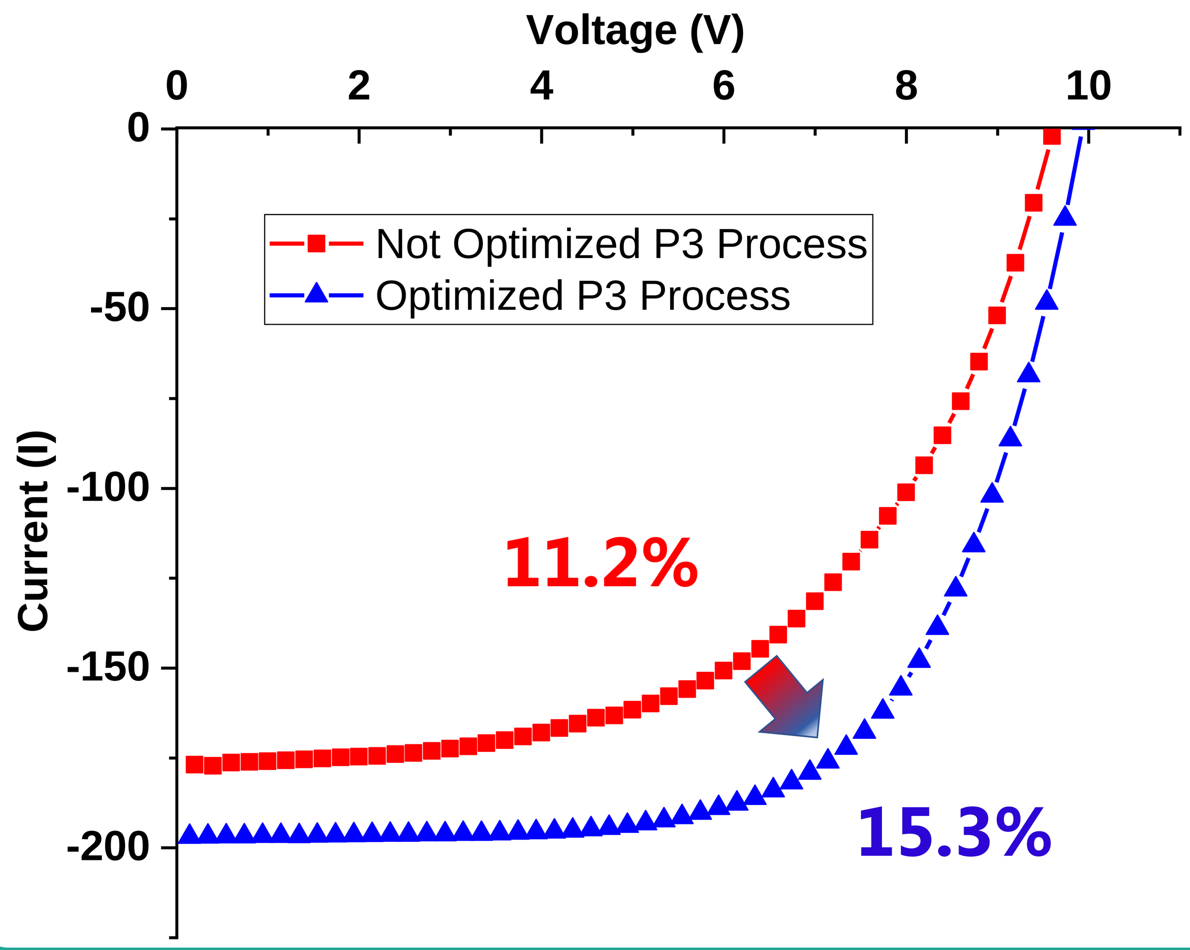


For the optimized P2 process, we set a fluence value lower than the required one for an optimal removal of all the layer stack, by repeating the process more than one time. In this **way we achieved a robust and repeatable manufacturing process, independently from layer thickness**, and by preventing damages in the underneath FTO layer due to intrinsic fluctuations of the laser power. As clearly visible in the microscope image, **two ablation steps guarantee a good material removal**. The obtained P2 area showed in the image on the right was obtained for all the produced modules with good repeatability.

P3



The insertion of 2D materials-based interlayers or dopants within the device structure can modify the gold adhesion strength to the underneath layer. **An incomplete gold removal (Fig.a) generates electrical bridges between module constituting sub-cells**, by eventually reducing the Fill Factor (FF). On the other hand, an excessive stress of the layer during the laser process could induce layer delamination (Fig.b), by eventually reducing the active area. **During P3 process the risk to damage FTO is lower than P2 process**, so a larger tolerance about laser fluence is allowed and **it's possible to achieve a good result by only one step (Fig.c).**



The Graph shows how P3 process impacts on module performance. The **red I-V curve** is acquired on a module with **not optimized P3** process. The incomplete gold removal reduces the module maximum voltage and FF. By performing a second **optimized P3** process on the same module, the efficiency was boosted up to **15,3%** (blue curve)

Using the procedures described in this work **we realized more than 400 modules during the last year**, changing dimensions, layout and layer composition. We obtained a good uniformity and repeatability **on substrate of dimension up to 14X14 cm².**

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[2] Alessandro Lorenzo Palma, Fabio Matteocci, Antonio Agresti, Sara Pescetelli, Emanuele Calabrò, Luigi Vesce,Silke Christiansen, Michael Schmidt, and Aldo Di Carlo,IEEE Journal of Photovoltaics, 6 (2017) 1674-1680

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