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ROLA-FLEX

Laser printing and laser sintering for the digital fabrication of micro-conductive patterns in OTFTs and ITO-free organic photovoltaics

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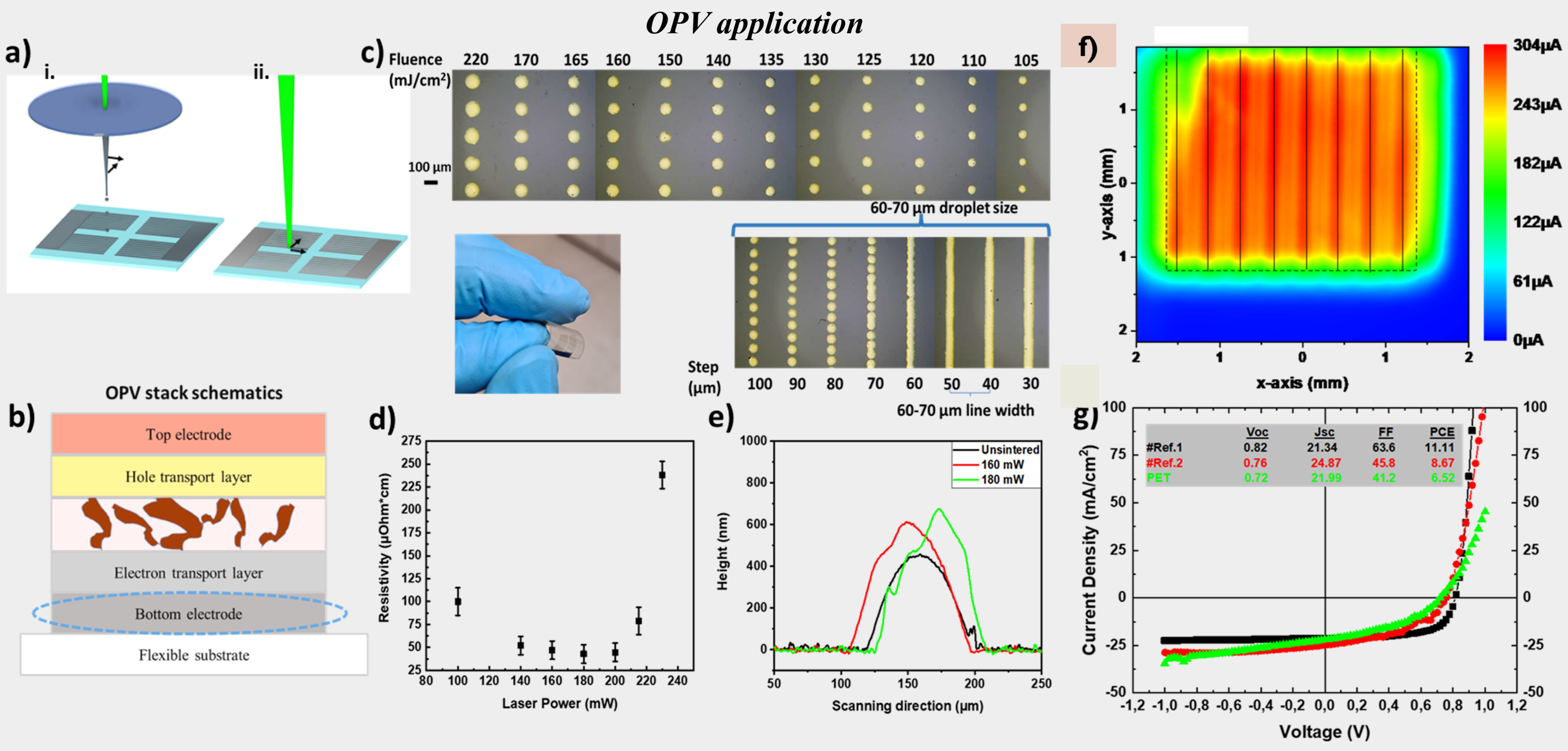
RoLA-FLEX's consortium has demonstrated the conformal laser printing and sintering of silver nanoparticle inks for the digital and additive manufacturing of organic Organic Thin Film Transistors (OTFT) involved in the next generation of organic displays [1] and ITO-free Organic Photovoltaics (OPV) [2]. Employing the so-called "Laser Induced Forward Transfer" technique, Ag nanoparticle inks were printed to form linear patterns with line width down to 80 μm and line height of 500 nm on flexible chips consisting of multiple functional layers. These linear microelectrodes were then laser sintered to obtain metallic conductivity and served as top gate electrodes for OTFT structures developed for a next-generation organic liquid crystal display (OLCD). Organic semiconductor performance tests indicated that the laser fabricated devices achieved performances comparable to the standard manufacturing process (photolithography), but were implemented in a significantly smaller number of processing steps and without the involvement of any masks. Thorough characterization comprising SEM and profilometry shed light to the heat affected zone of the substrates, as well as the morphology and structure of the laser sintered patterns. The electrical behaviour of the laser printed and sintered patterns was assessed through electrical measurements of the printed lines using a 4-point probe IV station and the electrical characterisation of the OTFTs. Moreover, employing these laser-based digital fabrication techniques, conductive grids displaying high optical transmittance (77% compared to 81% for ITO) and low resistivity (27μOhm*cm compared to 30 μOhm*cm for ITO) were fabricated on glass substrates. These grids were employed as bottom electrodes on inverted structure ITO-free OPV solar cells which exhibited high power conversion efficiency (PCE) of 11%. The photovoltaic cell's optical transmittance was evaluated with a spectrophotometer, whereas the electrical behavior of the conductive lines was assessed by means of electrical measurements in a 4-point probe IV station. These demonstrations validate LIFT and laser sintering as digital micro-fabrication techniques for the development of the next generation of flexible and organic printed electronics.

References:
[1] Andritsos, et. al. (2023). Conformal laser printing and laser sintering of Ag nanoparticle inks: a digital approach for the additive manufacturing of micro-conductive patterns on patterned flexible substrates. Virtual and Physical Prototyping, 18(1), e2138462
[2] Pozov, S. M., et al. (2022). Indium Tin Oxide-Free Inverted Organic Photovoltaics Using Laser-Induced Forward Transfer Silver Nanoparticle Embedded Metal Grids. ACS AppliedElectronic Materials.

OPV application



a) Laser processing for conductive patterns on flexible substrates ai) LIFT aii) laser sintering

b) LIFT and sintering of Ag NPs for the replacement of ITO as bottom electrode of OPV / ITO rigid, not compatible with flexible substrates

c) Laser fluence scanning for droplet formation. Consecutive droplets result to 70 um width line formation. Thus, a number of PET/AG grids samples were prepared.

d) Resistivity values down to 25 μOhm*cm and profilometry investigation. Acceptable morphological and electrical characteristics for OPV application

e) Photocurrent mapping measurements indicated generated photocurrent up to 304 μA.

f) JV characteristics and comparison with reference devices .

g) PET device fill factor of 41.2% and PCE of 6.52%.

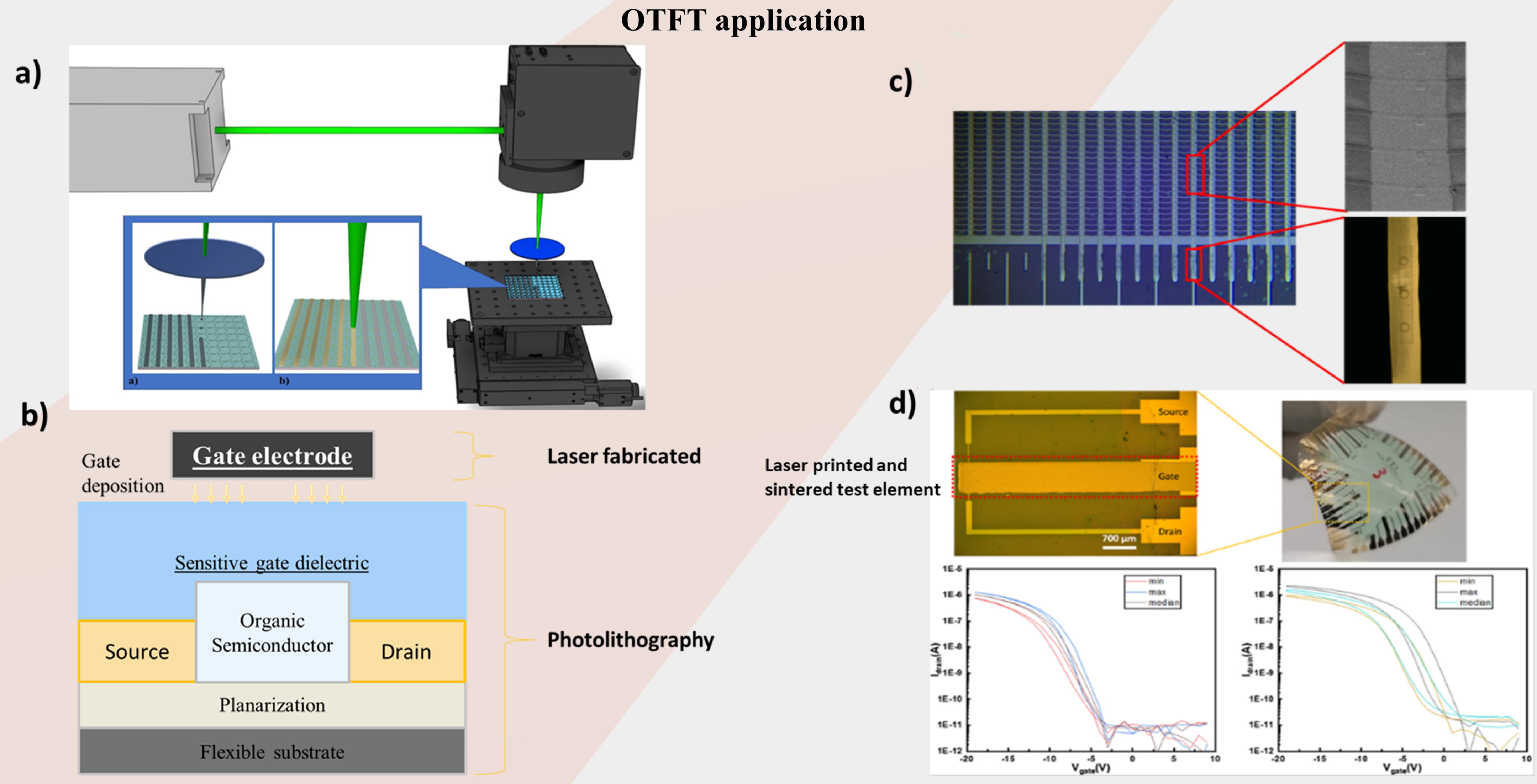
OTFT application

a) Laser processing for conformal fabrication of conductive patterns on non linear pre patterned multilayered devices incorporating sensitive materials

b) LIFT and sintering of Ag NPs for gate electrode fabrication on flexible OTFT, with rest of layers having fabricated with photolithography.

c) Conformal printing and sintering of Ag NPs. SEM confirming conformity

d) Test elements fabrication for OSC characterization on flexible OTFT substrates. Transfer curve measurements comparison for LIFT printed with sputtering fabricated gates. Mobility drop by < 10%



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