Inkjet printing for customized Perovskite Solar Cells

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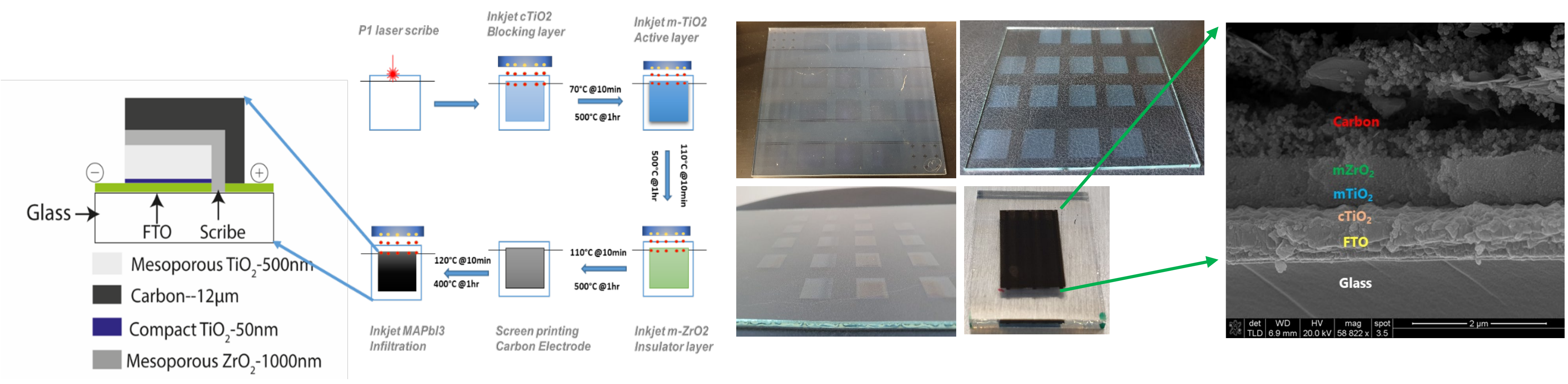
Introduction

Inkjet printing is a digital, versatile, contactless deposition technology which is used for customizable printing. It has the capability to produce small batches of different shapes and sizes as well as having high throughput production. Perovskite solar cells are the fastest developing solar cell technology till time. In a short time span, power conversion efficiencies exceeding 25% in small area lab cells were reported by different research groups.

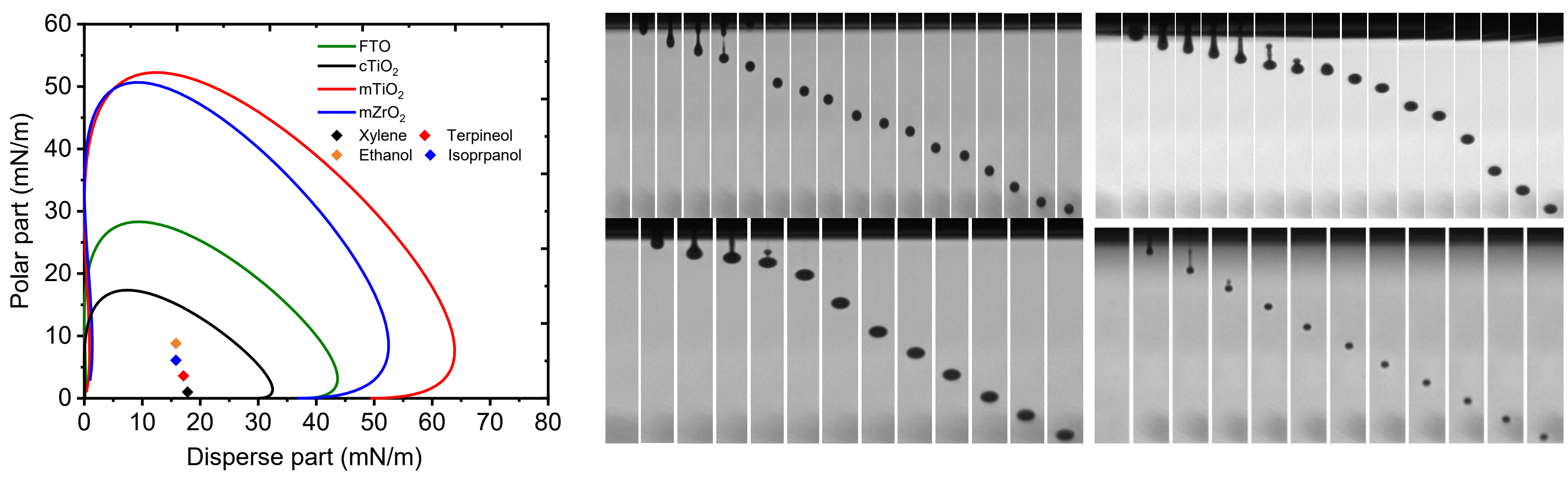
In this work, we report development of inks and processes to inkjet print four out of five layers the of mesoporous perovskite solar cell architecture.

Inkjet printing MPSC



Device architecture of the MPSC with desired layer thicknesses in cross section view (a). Process flow demonstrating inkjet printing of four layers cTiO2, mTiO2, mZrO2 and infiltration of MAPBI3 perovskite precursor. Inkjet printed $cTiO_2$, $mTiO_2$, $mZrO_2$ and carbon (b) SEM cross-section of four layer inkjet printed and carbon screen printed device (c).

The solar cell module is built atop a single fluorine-doped tin oxide coated glass, where distinct areas are drawn by an insulation line in the conductive layer. On one area, dense and mesoporous titania layers form the electron selective anode. These layers are subsequently inkjet printed by an insulating layer of mesoporous zirconia, followed by screen printing graphite/carbon-black layer which constitutes the hole-selective cathode. The cells are completed by the inkjet printing of methylammonium lead iodide perovskite from the annealing of a precursor solution sipped into the porous structure.



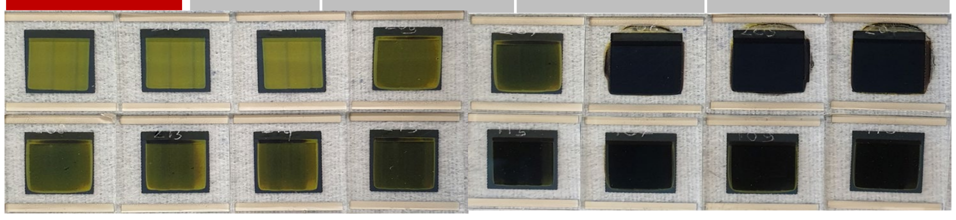
Surface energy of each solvent used to develop inks lies inside the wetting envelope of FTO and respective layers thus predicting good wetting behavior aligning with the experimental observations (a). Jetting of $cTiO_2$, $mTiO_2$, $mZrO_2$ and $MAPbI_3$ inks, the jetted drops are imaged at an interval of 20µm.

Device performance

Inkjet printed layers	V_{oc} (V)	J_{sc} (mA/cm^2)	FF (%)	PCE (%) (max)
$cTiO_2$	0.87	22	57.7	11.1
$cTiO_2$ and $mTiO_2$	0.86	17.8	65.6	10.2
$mZrO_2$	0.9	19.1	71.8	12.35
$MAPbI_3$	0.96	20.77	67	13.47
$cTiO_2$, $mTiO_2$, $mZrO_2$ and $MAPbI_3$	0.9	17.2	59	9.1
Carbon	0.78	0.1	25.5	0.02 (0.1 At V=0.5V)
ITO	0.87	0.9	27.6	0.2

Influence of infiltration of $MAPbI_3$

	Number of prints	Ink Volume (µL)	Substrate temp.(°C)	PCE (%) Mean
Inkjet infiltration of $MAPbI_3$	1x	1,5	25	1.4
	2x	3	25	12.3
	3x	4.5	25	12.5
	1x	6	25	8
	1x	6	50	7.6



Effect of ageing for 3 months on different volume filling on MAPbI3. Yellow top left bottom: low filling ; Spreading top right: over filling; Bottom right: optimal filling.

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