Gravure printing for organic electronics

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Sheet-to-sheet gravure printing is a fast and simple technique to achieve thin layers of organic material. It can be used to print different organic layers sequentially to produce thin film transistors, solar cells or light emitting devices. Solvent, concentration, viscosity and molecular weight are important parameters. Further problematic issues relate to the resolution of printable lines, the accuracy at the edges, the roughness of the layer and the alignment of the plates. For an all-printed top-gate transistor consisting of semiconductor, two layers of insulator and conductive ink as gate, an on/off ratio of $10^{4.6}$ and mobility of 0.047 cm^2/Vs can be achieved. This is comparable to spin-coated devices with the same materials and same layer structure. The investigation of the printing process has further been extended to binary blend materials for use in organic solar cells and first active layers have been printed. An efficiency of 0.1% can be achieved.

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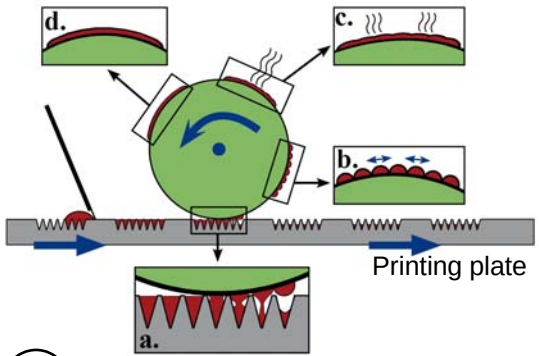
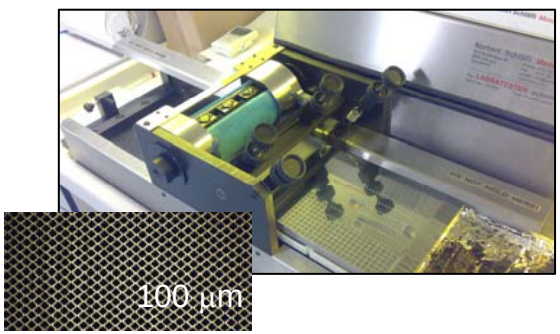
Gravure technique

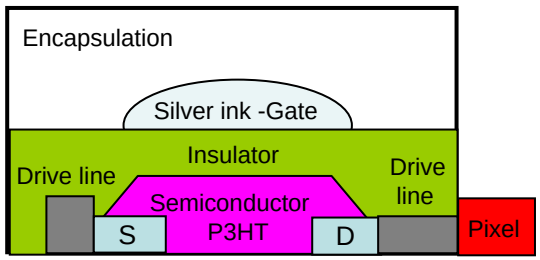


1 General scheme of gravure printing



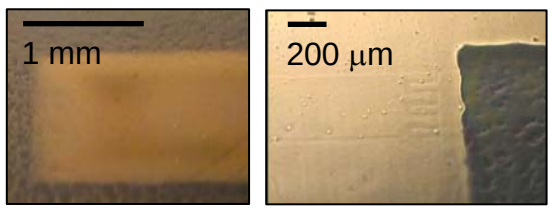
2 Small laboratory version of an gravure printer (Norbert Schläfli-Maschinen), not optimized for organic electronics, and (inset) the plate to transfer the ink.

Transistors: design



3 Bottom contact – top gate structure with source/drain (S/D) 30 μm channel length on PES/ITO as substrate

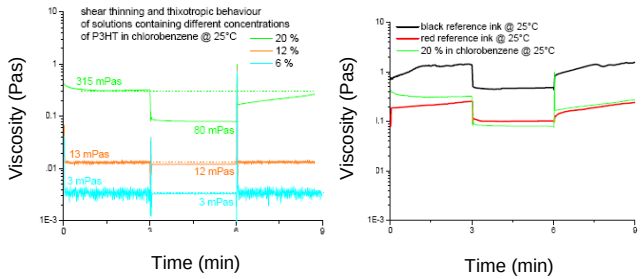
Prints



4 **Left:** P3HT printed on PES/ITO
Right: an all-gravure printed transistor, seen from the gate, with the prepatterned source/drain underneath all layers.

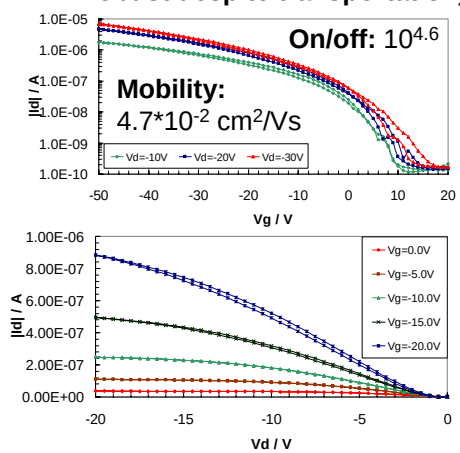
Results

Shear behaviour and viscosity (IMEC)



5 Best printing was achieved outside the parameter window for standard inks (right), below 6% P3HT in CB (Newton-fluid (left))

Transistor characteristics and output (4 layers printed at Asulab, measured at IC: robust despite transportation)



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Solar cells: design

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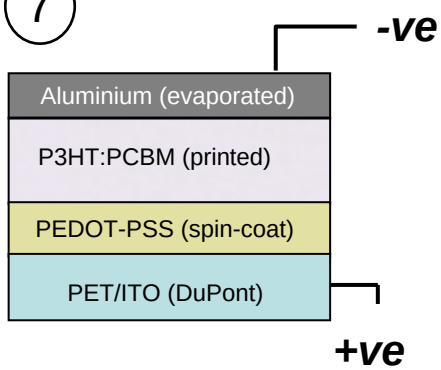

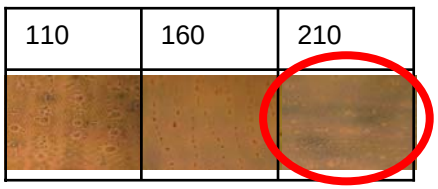

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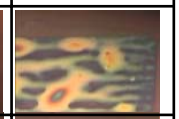
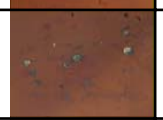
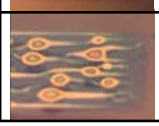
2x1 cm^2 area print for 4% P3HT:PCBM 1:1 in THN as function of the gravure grid density in lines/cm

Prints

Solvent	2%	3%	4%
CB			
ODCB			
THN			
Mesity-lene			8

1x2 mm^2 area for P3HT:PCBM 1:1 as a function of solvent and concentration (wt-%): best behaviour for 3-4% P3HT:PCBM in 1,2,3,4 Tetrahydronapthalene (THN)

Outlook

Improve layer uniformity to reduce leakage, optimize layer thickness and processing

Results

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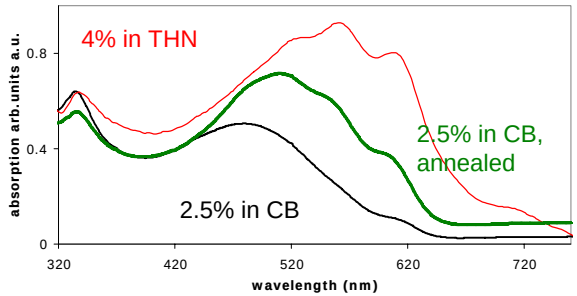
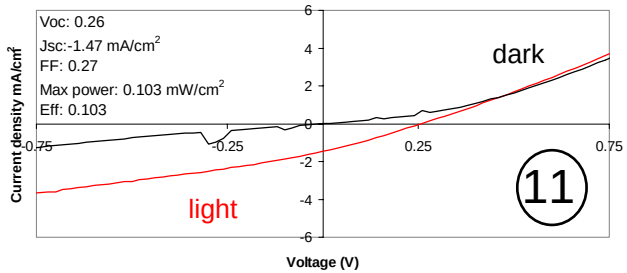
UV-Vis of P3HT:PCBM 1:1



J/V curve for solar cell under AM 1.5 illumination with printed P3HT:PCBM in THN



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Acknowledgements

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