Enhanced reproducibility of inkjet printed organic thin film transistors based on solution processable polymer-small molecule blends.

Marie-Beatrice Madec^{1*}, Patrick J. Smith², Andromachi Malandraki¹, Nan Wang², Jan G. Korvink^{2,3} and Stephen G. Yeates^{1*}

1. Organic Materials Innovation Centre, School of Chemistry, University of Manchester, Oxford Road, Manchester, UK, M13 9PL

* <u>stephen.yeates@manchester.ac.uk</u>

* marie-beatrice.madec@manchester.ac.uk

2. Department of Microsystems Engineering, University of Freiburg, Georges-Köhler-Allee 102, Freiburg im Breisgau, Germany, D-79110

3. Freiburg Institute of Advanced Studies, University of Freiburg, Albertstraße 19, Freiburg im Breisgau, Germany, D-79104

Supporting Information Available: Details of experimental procedures, Device transfer characteristics, Thin film X-ray diffraction, Grazing incidence SAXS.

Experimental Details

Device Fabrication.

Discrete bottom-gate, top-contact organic field effect transistor (OFET) devices were fabricated on phenyl ethyl trichlorosilane (PhTS) treated heavily n-doped silicon wafers comprising a 3000 Å thermally grown gate oxide layer. Substrates were cleaned by sonication in de-ionised water for 15 minutes, then methanol for 15 minutes and finally acetone for 15 minutes, prior to immersion in a solution of 10mM PhTS in toluene for 20 min maintained at 60 °C. Substrates were then dried on a hot plate for 2 hours at 120 °C in ambient conditions. Semiconductor solutions were inkjet printed, in Freiburg, in a glove box (oxygen and moisture levels, <1ppm) onto the substrate using a PixDro LP50 printer equipped with a multi-nozzle piezoelectric print head cartridge (PixDro PL128/S) having a nominal volume of 19 pL used in single nozzle mode. The printing voltage was 50 - 60V and the dot-spacing used was equivalent to 700 dpi in X and 508 dpi in Y. Film quality for all measured devices was good with no evidence of pin holes or dewetting from the substrate. Gold source and drain channel electrodes with a 60 µm channel length and 2 mm channel width were thermally evaporated, at 10⁻⁶ mBar at a rate of 0.5 nm/s until a layer thickness of 50 nm was obtained, vielding 9 transistors per substrate. All inkjet printed devices were successfully measured. For comparison of electronic properties, similar devices were made by conventional drop casting. These showed between 50 and 60% success rate because of dewetting issue whilst drying.

Device Characterization.

DC characteristics of the devices were obtained using an E5270B 8 Slot precision measurement frame from Agilent Technology coupled to a 3 Agilent E5287A atto level High Resolution Module. Contacts were made using Karl Süss PH100 manual microprobes. Output characteristics were obtained at a constant gate voltage $V_{\rm G}$ = -80 V and transfer characteristics at a constant drain voltage $V_{\rm SD}$ = -80 V. From the slope of the square root of the drain intensity characteristic, we were able to calculate the saturated hole mobility (μ_{FET}). Measurements were performed in air, in the dark under normal atmosphere pressure.

Thin Film X-Ray Powder diffraction.

Powder diffraction of the thin film devices were recorded using a Philips X'pert system with a Cu source (λ =1.54Å) using a rotating sample holder at 4rpm. Signal was filtered using two successive 1/8" and 1/4" slits, increasing the ratio signal over noise. Samples were scanned between 2 and 35° (20) with a scanning step of 0.1°.

Grazing Incidence Small angle X-Ray Scattering.

GISAXS in grazing incidence was carried out using a HECUS 3. Sample height were ajusted and grazing incidence maintained at 0.5°

Anisole 1 layer



Figure S1: Transfer and output characteristics (at a fixed drain voltage of -80V) for 1:1 TIPS-pentacene:polystyrene blends in anisole as a function of number inkjet layers and compared with drop casted film.



Figure S2: Transfer and output characteristics (at a fixed drain voltage of -80V) for 1:1 TIPS-pentacene:polystyrene blends in 9:1 anisole : acetophenone as a function of the number inkjet printed layers and compared with drop casted film.



Supplementary Material (ESI) for Journal of Materials Chemistry This journal is (c) The Royal Society of Chemistry 2010

Figure S3: OOP Xray diffraction of TIPS-pentacene: amorphous polystyrene in (a) anisole for one (red), two (blue) and three (green) layers thin film produced by inkjet printing and in (b) anisole: acetophenone (90:10) for one (red), two (blue) and three (green) layers thin film produced by inkjet printing.



Figure S4: GISAXS 3D imaging of 2 layer inkjet printed from (a) pure anisole and (b) anisole: acetophenone (90:10 ratio).