Gravure printing of polymer thin film transistors on flexible substrates

A. J. Campbell*, M. Voigt, A. Guite, D.-Y. Chung, F. Meng[1], J. Steinke[1], S. Springer[2], C. Barron[2], J. Grupp[2] and D.D.C. Bradley

Department of Physics, The Blackett Laboratory, Imperial College London, South Kensington campus, London, SW7 2AZ, UK
[1]Department of Chemistry, Imperial College London, South Kensington campus, London, SW7 2AZ, UK
[2]The Swatch Group R&D Ltd, Division Asulab, Rue des Sors 3, CH-2074 MARIN, Switzerland

**email: alasdair.campbell;@imperial.ac.uk*

As they are cheap, lightweight, flexible and fully solution processable at room temperature and pressure, polymer thin film transistors (TFTs) could revolutionize mass consumer electronics. To fully realize their potential a fabrication method needs to be found which allows mass production in a roll-to-roll process. Gravure contact printing is such a method. Here we demonstrate the gravure printing of state-of-the-art, top-gate polymer TFTs on flexible substrates within the European Commission funded FPVI CONTACT project.

Devices are bottom-contact, top-gate TFTs designed for use in a flexible liquid crystal display. The structure consists of: plastic substrates with pre-patterned indium-tin-oxide source and drain; poly(3-hexylthiophene) (P3HT) as the active material; two layers of polymer insulator; metal ink gate. We demonstrate the range of different P3HT structures of varying thickness, surface roughness and coverage which can be gravure printed depending on the viscosity, wetting and shear behaviour of the polymer ink formulation. We have been able to print highly planar, thin and uniform P3HT squares. We show how different insulators can be gravure printed whilst others dewet depending on the solvents and materials involved. Silver inks can also be printed to form high conductivity wires, and 50μm wide strips have been demonstrated showing it is possible to print source and drain at this resolution. Our current devices consist of 4 gravure printed layers (P3HT, 2 insulator layers, Ag ink gate). We were able to achieve an ON-OFF ratio of $>10^4$ and a saturation mobility of 0.08 cm^2/Vs, which are state-of-the art for top-gate P3HT TFTs partially processed in ambient. We thereby demonstrate the viability of gravure contact printing for the mass production of flexible organic electronics.