Electroprinting and Electrospinning of Transparent, Flexible, Conducting Polymers

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This is a PhD project in collaboration with ARJOWIGGINS, Beaconsfield, UK. In the first year of the project PEDOT:PSS solutions were tested and modified with additives to lower the resistivity and surface tension. Processing trials included spin coating and drop casting. AFM was carried out to study the self-assembly of PEDOT:PSS chains in aligned nanostructures as the resistivity was reduced and the effects of the additives on the domain size.

An ink jet printer was constructed including a constant printing head and a computer controlled platform for a 2D moving substrate. Specifications include position accuracy < 2 μm (at 1/8th step), position repeatability < 10 μm, print rate from 0 to 100 mm s^{-1} and print acceleration 0 – 100 m s^{-2}. Variables that can be controlled include: Drop shape/ velocity, drop position and overlap, substrate temperature, ejection rate, print rate and drop angle. Computer simulations of flow through a 60 □m nozzle concluded that drop break up occurred at a Weber number $We < We_{critical}$ where $We_{critical} = 15$.

Further simulations of the ink jet printing under constant flow-rate boundary conditions yielded results illustrating the drop formation and drop motion but there is still some disagreement between experimental and computational results, due to the fact that the flow-rate is not constant in the experiment but varies as a result of the pressure wave imposed by the piezoelectric type of print head. Further work is expected to correct this. Computer simulations of electrospinning were carried out successfully for two types of polyurethane solutions, and the corresponding CNT-polyurethane solutions. The simulations were in agreement with the experimental results in the predictions of electrospinning, spraying and bead formation that occurred selectively in these experimental case-studies.

Further work is expected to focus on the ink jet printing of PEDOT:PSS patterns and electrospinning of carbon nanotube nanocomposite membranes or films on substrates and testing of the resistivity and transparency of the products. First trials of drop deposition on different types of paper have already been carried out and the work will continue on the paper substrates supplied by ARJOWIGGINS.