Layer by Layer Fabrication of Sub-Micron Light Trapping Structures for Dye-Sensitized Solar Cells

Andrew Knott[1], Oleg Makarovskiy[1], James O'Shea[1], Christopher Tuck[2] and Yupeng Wu[2]

[1]*School of Physics and Astronomy, The University of Nottingham, NG7 2RD, UK*
[2]*Faculty of Engineering, The University of Nottingham, NG7 2RD, UK*

Converting solar energy directly into electricity as a clean and renewable energy resource is immensely important to solve the energy crisis and environmental pollution problems induced by the consumption of fossil fuels. Dye-sensitized solar cells (DSSCs) have attracted a great deal of attention following their development in 1991 by Grätzel and O'Regan [1]. They provide a technically and economically credible alternative that could challenge the dominance of conventional p-n junction photovoltaic devices in the solar energy market.

DSSCs use dye molecules adsorbed at the surface of nanocrystalline oxide semiconductors such as TiO_2 to collect sunlight. These nanocrystalline thin films require a large surface area, to adsorb many dye molecules, and mesoporous channels so the electrolyte can permeate the film and regenerate the dye molecules. This favourable morphology is traditionally achieved by the random assembly of a network of nanoparticles by the sintering process [2].

3D printing and other additive manufacturing techniques allow the fabrication of geometrically complex end-use products and components in a variety of materials by using technologies that deposit material layer-by-layer. The additive manufacturing of optoelectronic devices is still in its infancy but has the potential to completely revolutionise the industry.

Two-photon polymerisation is a technique used to fabricate polymer 3D structures with resolutions down to 400 nm [3]. We use this technique to fabricate polymer templates of designed light trapping structures for DSSCs. These templates will then be infiltrated with TiO_2 nanoparticles and subsequently removed to produce the desired TiO_2 structures. Our designed films will have a considerable advantage over the conventional (random assembly) films as it will allow the implementation of light scattering designs which should be able to significantly increase the overall efficiency of the cell.

In this pioneering interdisciplinary project we apply submicron 3D designs to DSSCs improving their efficiency and exploring the application of this additive manufacturing technique to electronic and optoelectronic devices.

[1] B. O'Regan and M. Grätzel, *Nature*, 353, 737, (1991).
[2] M. Grätzel, *J. Photochem. Photobio. C. Photochem. Rev.*, 4, 145, (2003).
[3] R. Farrer, C. LaFratta, L. Li, J. Priano, B. Naughton and J. Fourkas, *J. Am. Chem. Soc.*, 128, 1796, (2006).