Graphene and carbon nanotube based PV electrodes

Supervisor: Prof. Robin Nicholas, robin.nicholas@physics.ox.ac.uk, 01865-272250
Co-Supervisor: Dr. Moritz Riede, moritz.riede@physics.ox.ac.uk, 01865-272377
Department of Physics, University of Oxford, OX1 3PU

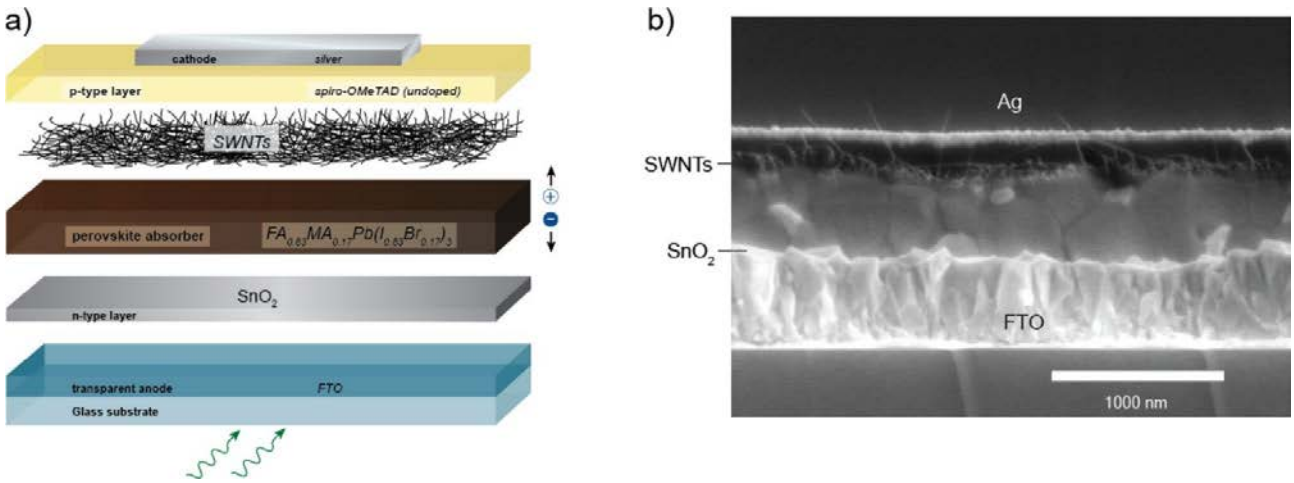
Both graphene and carbon nanotubes have very high electrical conductivities and mechanical strength, which makes them ideally suited for use as electrodes for flexible solar cells, replacing costly and brittle ITO and FTO. Over the past three years, CDT-sponsored Giulio Mazzotta has been successfully working on these kinds of electrodes, investigating how to use graphene monolayer electrodes, graphene flakes and carbon nanotubes as both electron and hole collecting layers in PV cells. We have demonstrated the versatility of this approach by making PV cells using perovskite, organic semiconductor and colloidal quantum dot absorbing layers. For example, we showed that it is possible to reach more than 18% efficiency with carbon nanotube top electrodes in perovskite solar cells. Furthermore, we have found that nonconducting polymers wrap carbon nanotubes and can – contrary to common belief – produce very high quality electronic films (patent application pending). The exact mechanism for this is still under investigation, but opens the door to a whole range of science and applications as it allows e.g. the fabrication of a conductive substrate and/or barrier film.

We propose an experimental project which will build on these results and continue with the development of nanotube/polymer/graphene/titania/tin oxide combinations to produce the next generation of nanohybrid particles. It will aim at exploring the possibilities of using non-conjugated polymers to wrap carbon nanotubes for making conductive films and how to integrated graphene and carbon nanotube based electrodes into PV cells both as external contacting layers and as internal electrodes capable of implementing tandem cell designs for various PV technologies. In addition to spin-coating, we will explore the capabilities of a custom made spray-coater in the department which can deposit nanoparticles including carbon nanotubes, aiming to make this process compatible with roll-to-roll fabrication.

The three main objectives of this project are:

- Understand the wrapping of carbon nanotubes with non-conjugated polymers and explore its science and commercial potential.
- Make solar cells with nanotube/polymer/graphene/titania/tin oxide combinations to produce the next generation of nanohybrid particles for PV electrodes.
- Demonstrate spray coating of these electrodes compatible with roll-to-roll fabrication.

Typical device structure:



This project will be undertaken as part of the Sustainable Photovoltaics CDT