Chemical Vapour Deposition Synthesis of Novel Nanostructured Materials

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DECLARATION

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APPENDIX: PUBLICATIONS ARISING FROM THIS THESIS

Part of the work presented in this thesis has been published to refereed journals. The following is lists of publications that have arisen as a result of work presented in this thesis.

(1) **A. Supangat**, G. Bryant, W. J Belcher and P. C. Dastoor, "Synthesis of Indium Oxide Nanowires Encapsulated in Amorphous Carbon Nanostructures on Indium Tin Oxide Substrate", *Materials Research Innovations*.
(DOI: 10.1179/1433075X11Y.0000000034)

(2) **A. Supangat**, X. Zhou, W. J. Belcher and P. C. Dastoor, "Chemical vapour deposition of poly(p-phenylenevinylene) nanofilms for use in organic photovoltaics", *Materials Research Innovations*, Vol 15, 2011. pp. 18-20

(3) **A. Supangat**, G. Bryant, W. J. Belcher and P. C. Dastoor, "Templated Growth of Poly (p-phenylenevinylene) Nanostructures by Chemical Vapour Deposition", *Materials Research Innovations*.
(DOI: 10.1179/1433075X11Y.0000000024)

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ABSTRACT

The growth of carbon and poly-*p*-phenylene vinylene (PPV) nanostructures via chemical vapour deposition (CVD) has been studied. Working temperatures of 400, 450 and 500°C and 270°C have been applied for the growth of carbon and PPV, respectively. In this work, indium tin oxide (ITO) modified by the CVD growth of carbon nanostructures has been used as an electrode in the fabrication of organic photovoltaic (OPV) devices. Therefore, the effect of thermal treatment on ITO conductivity, physical properties and chemical composition is studied.

The growth of carbon nanostructures on ITO is studied under a variety of CVD conditions, in particular, the effect of varying growth time, temperature and system pressure have been investigated. Pressures between 100 and 400 Torr were used during the growth of the carbon nanostructures. Two layers, comprising a dense amorphous interface layer and the nanostructured layer have been observed at all pressures in this range. However, an abrupt change at the interface and nanostructured layer was seen at 400 Torr. The thickness of the interface layer, which is composed of amorphous carbon, is directly proportional to the system pressure. H_2 plasma treatment has been applied to reduce the amorphous carbon layer thickness. Multiwalled carbon nanotubes (MWCNTs) have been successfully synthesised at pressures between 100 and 300 Torr. The diffusion of indium from the substrate into the nanostructured layer is observed to occur at 450°C and 400 Torr which initiates the growth of indium oxide nanowires encapsulated by a carbon layer.

Presented here for the first time is an OPV whose active layer has been fabricated via the CVD technique. A PPV nanofilm is synthesised by CVD onto ITO without the use of solvent or solution. Two different monomers, α,α'-dichloro-p-xylene and α,α'-dibromo-p-xylene, are used and the properties of the chloro-derived PPV and bromo-derived PPV is compared for the future fabrication. The chloro-derived PPV has an advantage over bromo-derived PPV in terms of the energy band gap and conjugation length. As a consequence, an OPV is wholly fabricated by the starting monomer of α,α'-dichloro-p-xylene.

To realise PPV nanostructures that could potentially be integrated into OPV devices, CVD based polymerisation of PPV in a porous alumina template has been investigated.

Five different angles of the template with respect to the gas flow were tested. A series of interesting PPV nanostructures such as fibre-like and nanotubes have been effectively synthesised via this method.