Project Leader: Assoc. Prof. Dr. Lim Hong Ngee

Fundamental investigation on utilization of graphene-based anti-reflective coating to improve the efficiency of dye-sensitized solar cell

Dye sensitized solar cells (DSSCs) garner a massive interest amongst researchers because of their simplicity in fabrication, and most essentially, their tunable conversion efficiency. Their wide range of efficiency from two percent to 15 percent enable applications in various electronic devices, from highly aesthetic decorative watches to powerful indoor photovoltaic module for window application in buildings. However, a significant limitation of DSSCs is caused by reflective photoanodes, giving rise to low transmittance of light, consequently reducing the theoretical efficiency of the devices by more than 30 percent. The aim of this project is to modify the photoanode glass by introducing a graphene-based anti-reflective coating (ARC). The ARC consists of graphene sheets that are decorated with mesoporous silica nanoparticles (MSNs) synthesized by an *in situ* chemical method. The nanocomposite will be inkjet printed on the non-conductive side of an indium tin oxide glass. To ease the process of inkjet printing, the graphene oxide precursor of the nanocomposite will be functionalized with amine-based molecules, targeting the carboxylic edges of the graphene oxide sheets to form amide. The basal plane of the graphene oxide will be free from organic molecules to allow maximum reaction to form MSNs. A DSSC coated with an ARC material will improve the penetration of solar light compared to that of a non-ARC DSSC, hence increasing the efficiency of the device. An electrochemical workstation will be employed to measure the photocurrent signals of the fabricated DSSCs through the J-V curves. DSSCs possessing outstanding conversion efficiency provide a higher electrical output, thus harnessing the solar energy more effectively. This research proposal can be categorized into two important parts; the first is to synthesize a graphene-based ARC ink for inkjet printing, and the second is to produce DSSCs with excellent conversion efficiency.

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Grapheneous conductive ink for inkjet printing of nanodevice applications

Graphene is one of the strongest, lightest and most conductive fibre known to man, with a performance-per-weight greater than any other material. The exceptional electron and thermal transport, mechanical properties and chemical stability of graphene make it a potentially disruptive technology for electronics and energy applications. As transparent conductors and energy storage additives, graphene is prized for its excellent electronic, thermal, and mechanical properties, and it will strongly compete for supremacy in these sectors in the coming years. The preparation of stable ink is still a challenge in inkjet printing of circuits on a substrate. Functionalization of graphene may hold promise in adding value to this wonder material. Functionalizing graphene with an additive may reduce processing step during manufacturing. In addition, functionalized graphene has high stability in solvent, enabling a facile approach in formulation. Consequently, this new class of novel inks may emerge as a superior alternative to metallic conductive inks. Graphene may allow for the replacement of existing electrically conductive materials that are in short supply, expensive and limited in their use with flexible substrates.

Project Leader: Assoc. Prof. Dr. Lim Hong Ngee

Fundamental electrochemical studies of charge/discharge storage mechanism of bifunctional photo-supercapacitor

The feasibility of integrating dye sensitized solar cell (DSSC) and supercapacitor to materialize a photo-supercapacitor is slowly but surely drawing considerable attention among researchers recently. It is envisioned to be widely applicable in most optoelectronic devices. By looking into DSSC individually, this environmental benign device utilizes solely the cheapest, most abundant, and importantly renewable resource solar energy to kick start the storage and energy conversion system by converting solar energy to electrical energy. Meanwhile, supercapacitor is credited to be a cost efficient device with its high power and energy conversion efficiency. In this research, a DSSC will be fabricated as a transducer for conversion of solar energy to electrical energy. The electrical energy will subsequently be used to charged a fabricated supercapacitor. The DSSC comprises a working electrode and a counter electrode. The supercapacitor is made flexible to fit in the most challenging geometries. The availability of chemicals used throughout this research enables participation from middle- and low-income countries. This invention is endeavoring to minimize consumption as well as to reduce the huge loss of energy through efficient energy transfer. Additionally, this device reduces the depletion of resources by providing an alternative and efficient system in harvesting and transfering of solar energy that is found abundantly in nature, especially in the developing countries.