

Investigation of composite structures based on graphene and graphene oxide

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Abstract

Carbon materials and in particular carbon nanomaterials (graphene, graphene oxide and carbon nanotubes) have received huge attention as replacement materials for a wide range of solar-cells components [1]. Graphene has been employed effectively as a replacement for ITO/FTO transparent conducting substrates and also as an alternative counter electrode material. The conversion of graphite to graphene oxide results in the functionalisation of the graphene oxide sheet with carboxyl, epoxide and alcohol moieties and leads to certain advantages of this material over the pure graphene.

In this paper the properties and possible applications of two types of composite structures based on graphene and graphene oxide (GO) were investigated. For the first type, the GO (and reduced graphene oxide (rGO)) was used as a template for the deposition of platinum and gold nanoparticles. For the second type, the graphene (or graphene oxide) mixture with nematic liquid crystals was used for infiltration into grooved Si structures acting as a one-dimensional photonic crystal. It was found that platinum and gold nanoparticles could be successfully deposited, with a small size distribution and in high concentration (Fig. 1a) onto the surface of GO. Multiple techniques were investigated for the deposition of these materials onto fluorine tin oxide (FTO) glass substrates. The main aim was the formation of a stable and catalytically active electrode on FTO glass substrates. Such an electrode could then be tested electrochemically and in dye synthesized solar-cells and potentially offer new routes towards fabrication of low cost solar energy devices.

A number of different characterization techniques such as XRD, SEM, TEM, electrical testing, FTIR and micro-Raman spectroscopies were employed to study the properties of the fabricated composites. Raman spectroscopy, in particular, is a powerful tool for identifying the number of layers, the structural quality, the degrees of doping and disorder in graphene and GO structures as well as for unique investigation of alignment of liquid crystals inside the Si micro-channels [2]. Changes observed in the Raman spectra of GO are due to the disruption of the delocalised π - π network that extends across the graphene oxide layer. Raman area-mapping was also employed for characterization of different graphene and GO-based samples deposited on a Si/SiO₂ substrate. Figure 1b shows the comparison between Raman spectra of GO, rGO and rGO with deposited Pt and Au nanoparticles (PtrGO and AurGO) in the region of G and D bands. The red shift of G-band is observed upon oxidation of graphite as well as for AurGO and PtrGO. The observed increase in the G and D bands intensity ratio (I_D/I_G) has been linked to the creation of new graphitic domains, which are smaller in size than that present in GO but more numerous in number. The possible applications of the obtained structures are discussed.

References

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Figures

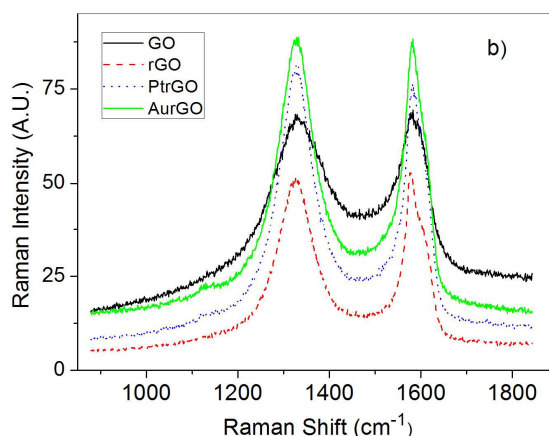
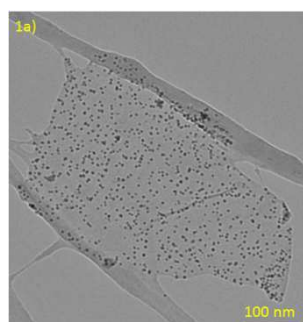


Figure 1. a) TEM image of rGO with Pt nanoparticles (PtrGO), b) Raman spectra of D and G bands for GO, rGO, PtrGO and AurGO structures.