

Supplementary Information

Excellent optoelectrical properties of graphene oxide thin films deposited on a flexible substrate by Langmuir–Blodgett assembly

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Experimental

Graphene oxide (GO) was synthesized based on the modified chemical method, according to our previous work^{1,2}. Essentially, 5 g of natural graphite flakes (Asbury Graphite Mills) and 150 mL of sulfuric acid (H₂SO₄, General Chemical) were mixed in a round bottomed flask at 200 rpm. 50 mL of fuming nitric acid was added to the mixture and stirred for 24 h at room temperature. The mixture was then washed using deionized (DI) water, followed by centrifugation and drying at 60 °C for 24 h to obtain a graphite intercalation compound (GIC). The dry GIC powder was expanded at 1050 °C for 15 s to produce expanded graphite (EG). 1 g of EG and 200 mL of sulfuric acid were mixed and 10 g of KMnO₄ was added to the mixture while stirring. Deionized (DI) water and H₂O₂ were mixed with the solution while in an ice bath, resulting in the color change of the suspension to light brown. The GO particles were washed and centrifuged with HCl solution followed by washing with DI water until the pH of the solution became about 5 to 6. The GO particles were diluted using DI water (~1 mg mL⁻¹) and dispersed by gentle shaking.

Characterization

Raman spectroscopy of deposited GO layers

The Raman spectroscopy has been widely used for determining the number of graphene layers by measuring the intensity ratios of major peaks^{3,4}. The D/G intensity ratio is commonly used to characterize the disorder in graphitic structure, which is found to increase with increasing the number of GO layers, indicating more defects when more GO layers are deposited. Besides the strong G and D bands, there are two other Raman bands, namely 2D and D+G at 2600–3000 cm⁻¹, which are often ignored due to their weak intensities compared to the D and G bands. The 2D band is Raman

active for crystalline graphitic materials and is sensitive to the π band in the graphitic electronic structure, while the combination mode of D+G is induced by disorder. It is worth mentioning that the 2D/(D+G) intensity ratio consistently decreased with increasing the number of GO layers, exhibiting a higher sensitivity than the D/G intensity ratio. These results can be explained by the interaction between the adjacent GO layers causing the changes in electronic structure and electron-phonon interaction³.

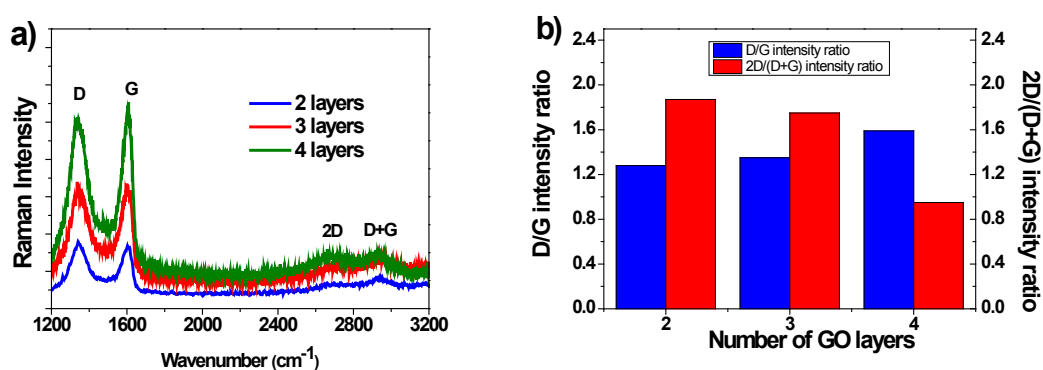
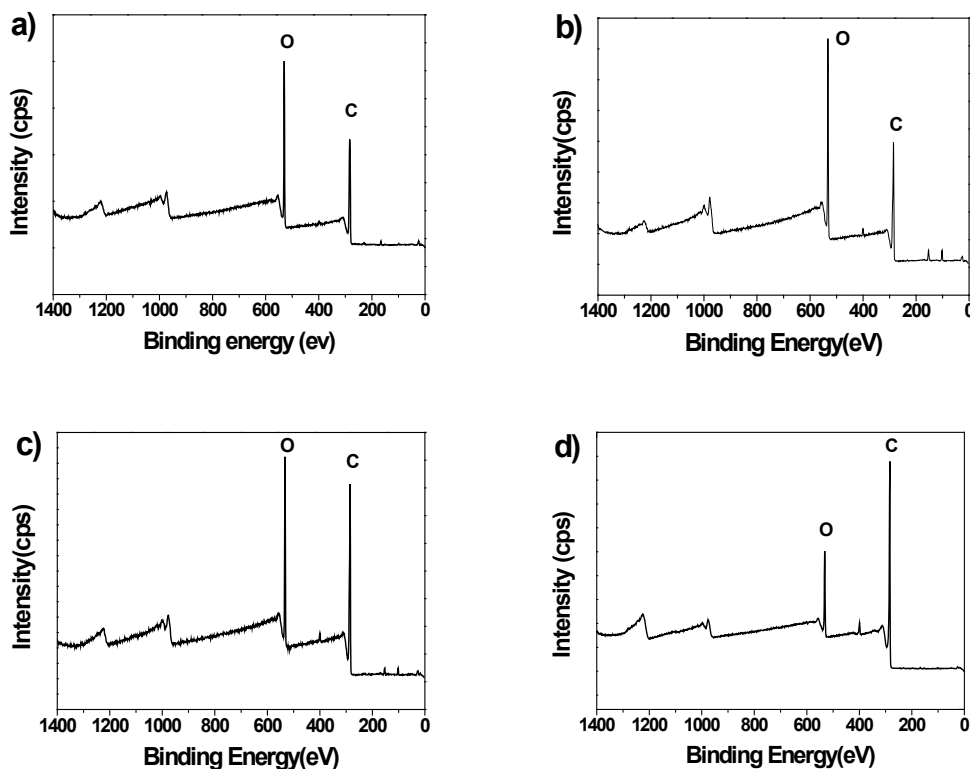


Fig. S1 (a) Raman spectra for GO thin films with different numbers of GO layers (b) corresponding D/G and 2D/(D+G) intensity ratios.



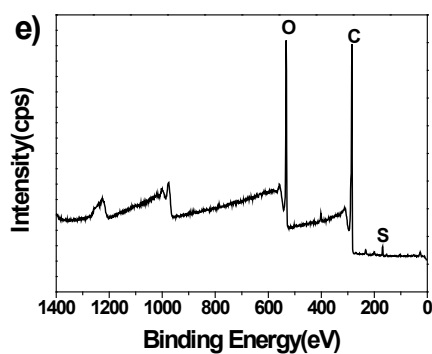


Fig. S2. XPS general spectra of (a) bulk GO, (b) neat PET, (c) 4 GO layers on PET, (d) after reduction and (e) after chemical doping.

References

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