Biosensing and imaging with graphene based platforms

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Ultra-sensitive detection and diagnosis are of vital relevance for biomedical applications. We are thus developing two kinds of sensors based on graphene for the detection, quantification and imaging of molecules and biomarkers.

The first one is based on the covalent functionalization of graphene by adding carboxyl acid groups which allow successive binding with different biologically active molecules for antigen sensing applications. Up today, graphene oxide derived materials are used for these applications, however, the presence of high fractions of other functional groups, low conductivity and reproducibility problems are important limiting issues. We present a new approach for specific surface functionalization of graphene: during the CVD growth, highly conductive COOH functionalized monolayer or few-layer graphene is generated. The homogeneity and functionalization degree are evaluated combining micro-Raman and XPS spectroscopies. The COOH content is around 5 %, which corresponds to an average inter-spacing < 1nm, adequate to accommodate antibodies. Moreover, the relative concentrations of the other functional groups are lower than for graphene oxide derived materials. The obtained electronic transport characteristics (sheet resistance ~7 kΩ and mobility ~800 cm^2/Vs) are very adequate for sensing using the change in conductivity induced by antigen anchoring. The bio-molecules detection is carried out through the immobilization of antibodies (IgG1– with a green fluorophore) by the carbodiimide method, which allows the formation of a strong amide bond. The anchoring is demonstrated to be effective by comparing bare and functionalized graphene fluorescence images.

The second kind focuses on enhancing the analyte Raman signal. Raman spectroscopy is a non destructive easy to use specific technique but with low sensitivity. Here we present how interference enhanced Raman scattering (IERS)[1] in adequately designed ordered porous alumina structures provide interesting amplification factors We have designed and fabricated, according to the calculations, Al_2O_3 membranes from Al where the Al_2O_3 layer at the pore base has been reduced down to < 5nm. Transferred graphene on top of these membranes is used here to reveal the amplification power of the tested platform and as the appropriate substrate for the deposition of organic molecules. The overall IERS amplification is > 400 and, optimized membranes for IERS combined with metallic nanoparticles can lead to IERS + SERS combined effects with excellent amplification values.

Figures

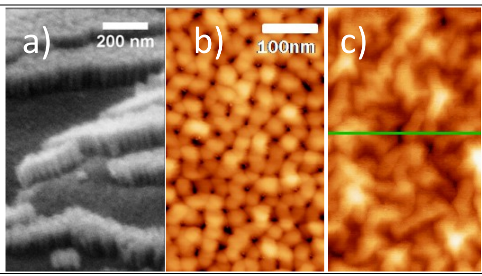

Fig. 1: Alumina porous membrane: SEM (a) and AFM (b) images; c) AFM image with graphene

1 L. Alvarez-Fraga, E. Climent-Pascual, M. Aguilar-Pujol, R. Ramirez, F. Jiménez-Villacorta, C. Prieto, A. de Andrés ACS Appl. Mat. & Interfaces 9, 4119 (2017)