The Effect of Functionalization and Incorporation of Gold Nanoparticles on the Interfacial Capacitance of Graphene Devices

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Abstract

Interfacial capacitance of graphene can be tuned through their functionalization and incorporation of gold nanoparticles.

Introduction

Graphene has received widespread attention due to its unique electronic properties[1]. However, only few reports has focused on understand the interfacial capacitance (Ci) developed on the graphene electrolyte interface and in the possibility to tuning and improve this property through the functionalization of graphene surface.

In this work, we address the effect of noncovalent functionalization and incorporation of gold nanoparticles on graphene surface in their interfacial capacitance. These results provide important information regarding how to employ the tuning interfacial capacitance as a sensing mechanism in graphene devices.

Results and Discussion

The interfacial capacitance of graphene was determined by electrochemical impedance spectroscopy measurements, based on procedure showed by Ji *et al* [2]. An electrochemical cell comprising of three electrodes was used. As working electrode, a monolayer graphene grown by chemical vapor deposition process (CVD) was transferred on 300 nm SiO_2/Si substrate and electrically connect by a copper tape, was employed. A Pt spiral wire as the counter electrode and an Ag/AgCl (filled with 3 mol L^{-1} gel electrolyte with potential of 222 mV versus normal hydrogen electrode (NHE)) as reference electrode (RE). The impedance spectra were obtained in 1 mmol L^{-1} PBS solution (in 1.5 mmol L^{-1} NaCl) by applying a sinusoidal wave with an amplitude of 10 mV at a fixed frequency of 100 Hz and a scanning potential range of -600 to 400 mV vs Ag/AgCl.

Figure 1 (a-b) shown a capacitive map dC/dz, obtained by an AFM in the electric force module, of graphene before and after the incorporation of gold nanoparticles (AuNPs), where it is possible to relate with the capacitance improvement after the incorporation of AuNPs. The C-V curve (Figure 1 (d)) clearly shown the V shape, with a mean minimum value of 1.42 μF cm^{-2} located at 40 mV (vs. NHE). The Ci increases linearly on both sides, related with the holes and electrons regime. After the immobilization of the Au NPs, the minimum value of Ci was shifted to high potentials and increased, for a mean of 1.62 μF cm^{-2}. This increment in the graphene capacitance with the incorporation of the Au NPs may be related with the increase of the surface area, as well of the surface charge.

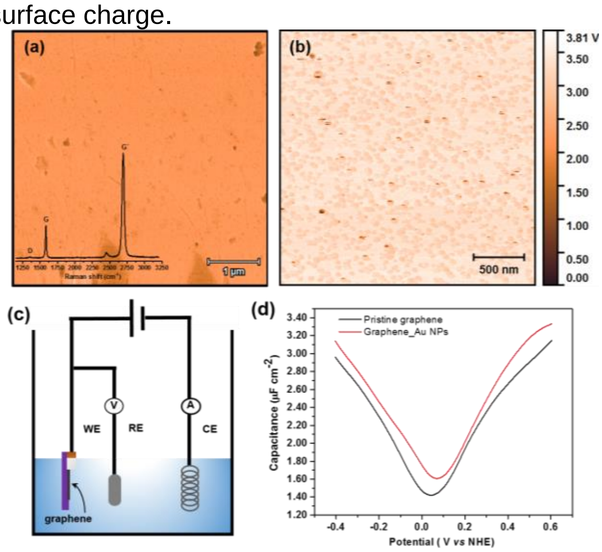

Figura 1. dC/dz map of (a) pristine CVD graphene (in inset the raman signature of pristine monolayer graphene) and (b) after the immobilization of the Au NPs. (c) Schematic of the three electrode electrochemical cell used for the graphene Ci measurements. (d) C-V curve for the graphene before and after the 2D-self-assembly of the AuNPs at 100 Hz of frequency and in 1 mmol L^{-1} PBS solution (in 1.5 mmol L^{-1} NaCl).

Conclusions

The Ci can be tuning and improved by incorporation of AuNPs and these results are important for a basic understanding and application in the development of capacitance sensors based on graphene.

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