Chemical and Biomolecule Sensing using Graphene Field Effect Transistors

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Graphene's two dimensional nature, highly sensitive unique electrical properties and low intrinsic noise characteristics make it a prime candidate for the creation of a new generation of molecular electronic sensors. Here we present a combined experimental and theoretical study of the electronic detection of different physisorbed biomolecules on graphene. Graphene field-effect transistors (GFETs) are used as a molecular sensors by measuring conductance changes as a function of gate voltage upon controlled adsorption of target molecules [1-3]. It is demonstrated that GFETs have a potential to measure distinct, coverage dependent, conductance signatures upon adsorption of small organic molecules in vacuum [1,2]. This method allowed electronic discrimination of individual DNA nucleobases on GFETs [1], providing a first step towards label-free graphene based electronic DNA sequencing. We compare electronic detection of different molecules on GFETs in vacuum, air and liquids and present various strategies for highly sensitive label-free electrical detection. To get a deeper insight into the origin of the sensing mechanism and molecular recognition in GFET measurements we also performed ab initio electronic structure calculations using density functional theory (DFT) [4,5]. The molecular recognition mechanism is found to be closely linked with specific noncovalent molecular interactions with graphene. We identify that the local electric fields induced by electric dipole moments and direct charge transfer play the dominant role in the modification of the electronic structure of graphene during the molecular detection. These effects open up a range of new opportunities for biomolecular recognition and enhancement of molecular sensitivity of graphene-based electronic sensors.

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