

Functionalization of Graphene by Plasma Treatments for Tailoring Electrical Properties

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Abstract

Graphene holds several peculiar properties such as high carrier mobility, optical transparency, flexibility and high chemical resistance which have stimulated a vast amount of research in several technological fields. However, the diffusion of graphene technologies is still limited by the difficulties (i) in opening a gap in the graphene band-structure, (ii) in modulating its work function, and (iii) in the processing of graphene itself being a relatively inert material. Chemical functionalization has been reported to be effective in addressing these issues. Literature on graphene presents a variety of experimental work exploring its decoration by several functional groups ranging from simple hydrogen, for tailoring graphene structural and electrical properties [1], to complex organic molecules, for increasing the graphene reactivity toward specific chemical species [2]. However, the control of the graphene functionalization processes as well as the reduction of induced defects and related structural damage are still challenging.

In this contribution, we present chemical and plasma-chemical routes for the tailoring of electrical properties in large area chemical vapor deposition (CVD) graphene [3] by functionalization with several chemical groups including oxygen, nitrogen [4] and sulfur groups as well as hydrogen and fluorine atoms. Our functionalization processes have been developed and optimized with the twofold aim: the fine tuning of graphene electrical properties and the strong minimization of induced structural damage. To this purpose, we perform "mild modulated plasma processes" for the covalent binding of functional groups without introducing structural defects related to ion radiative damaging. We also exploit intrinsic defects in CVD graphene which acting as preferential reactive sites allows the reduction of the operating temperature. This, in combination with the real time monitoring of graphene optical properties by spectroscopic ellipsometry, allows for an unprecedented control over the degree of functionalization.

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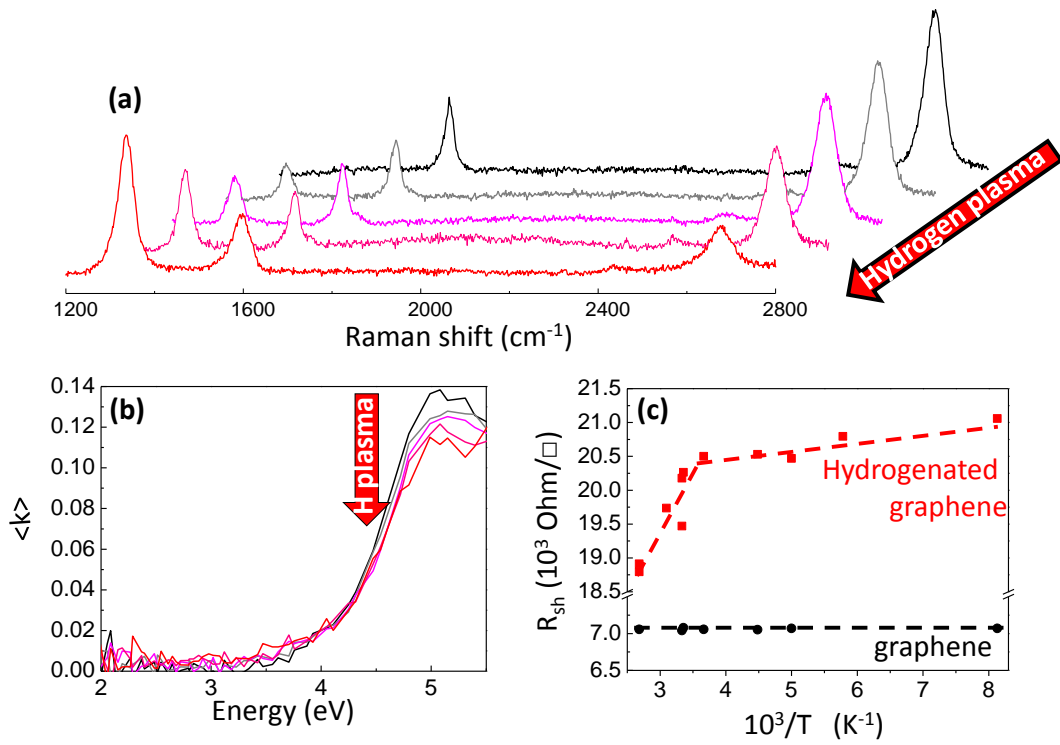


Figure. Time evolution of (a) the Raman spectra and (b) ellipsometric spectra of the pseudoextinction coefficient of CVD graphene on glass substrate during hydrogen plasma treatment. (c) Temperature dependence of the sheet resistance for pristine and hydrogenated graphene.