

Differences in the changes of the optical and morphological properties depending on the number of graphene layers under UV oxidation

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Graphene, like other carbon nanomaterials, is considered as a promising component for organic and non-organic electronics. Because of molecular-scale nature, its properties highly depend on the number of layers. Graphene's morphology can be greatly changed under the influence of heat, plasma or ultraviolet oxidation, and in the presence of various chemicals. Thus, there is a noticeable change in the electronic properties of carbon materials, which makes these methods promising for use in electronic applications that require surface functionalization or modification to the energy levels in the graphene. In this work we investigated the difference in chemical reactions with environment for graphene with various number of layers. Graphene has been transferred by the modified method of mechanical exfoliation on the Si substrate with thermal oxide thickness of 300 nm. For UV treatment we used a 240 W high pressure mercury lamp. UV photooxidation lasted for 3 hours in a wet atmosphere. We measured Raman spectra (Fig. 1), made AFM (Fig. 2) and SEM images for pristine and oxidized sheets. Treating graphene in a wet atmosphere under high pressure mercury UV lamp may involve several mechanisms: graphene oxidation, etching and doping. We found the process of UV oxidation during prolonged treatment is different. It depends on the graphene number of layers associated with increased activity of monolayer graphene energy and high resistivity to oxidation of multilayer graphene associated with a high energy barrier for the formation of sp^3 hybridized carbon atoms induced by UV photons. The p -doping of graphene takes place in all cases. The chemical doping results from the charge transfer by absorbed or bound to the oxygen species on the graphene's surface. The process of UV oxidation in a wet atmosphere allows a controlled method for carrying out the functionalization and doping of graphene, and its removal. Also we addressed the interest to photocatalytic oxidation with making use of titanium oxide nanoparticles. We demonstrated now effect in difference for photocatalytic oxidation under UV lamp because of very low energy transferred to nanoparticles. We suggest the rapid photocatalytic oxidation by pulsed laser irradiation. Calculation shows that it possible to provide sufficient energy to nanoparticles during single laser pulse to initialize the local graphene oxidation. It can be widely used in the formation of active electrode elements based on graphene containing different number of layers.

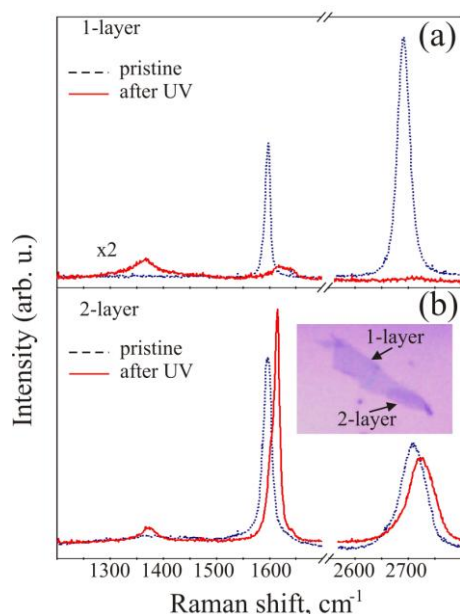


Fig. 1. Raman spectra for pristine (dotted) and oxidized (solid) graphene (a – 1-layer, b – 2-layer) for 3 h under UV photooxidation in a wet atmosphere.

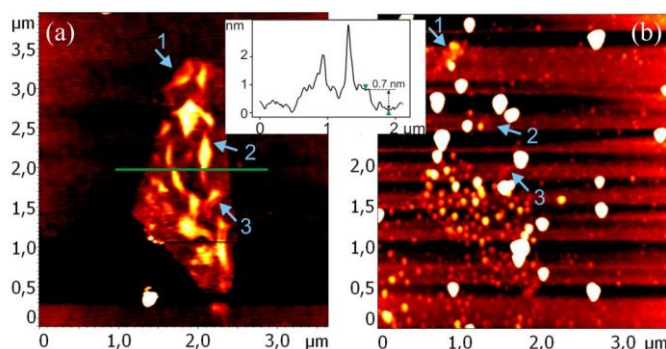


Fig. 2. AFM images of single-layered graphene flake: a - pristine graphene on 300nm thermal SiO_2 , b – graphene sheet after oxidation in wet air for 3 h under UV irradiation. Arrows marks the non-oxidized parts of the graphene with lateral size less than 300 nm.