ESR Spectroscopy of graphene with NaCl particles absorbed

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It is commonly expected that graphene will find wide application in many devices. Discovery of graphene has opened in particular possibilities of building ultrasensitive, label-free, miniaturized electrostatic or electrochemical sensors. Recently it is considered to use graphene as an active fluid flow sensor. In studies with a view of implementation of such graphene sensor, besides measuring the influence of flow rate on graphene electric properties, it is very important to study the impact of different fluids on graphene layer.

In this work we focus on metallographic microscopy, Atomic Force Microscopy (AFM) and Electron Spin Resonance (ESR) techniques which can be used to study presence of solid deposition on graphene and change of graphene electric properties, after exposure to NaCl solution.

Graphene was grown by chemical vapor deposition of carbon layers on SiC substrate from hydrocarbon precursors, subsequently immersed in the 0,1 M NaCl solution for 3 days, and then carefully rinsed in distilled water. Reference graphene sample that was not exposed to NaCl solution was also studied. Standard metallographic microscope and atomic force microscope were applied to observe graphene surface. For detailed characterization of the deposition, Bruker ELEXSYS E580 CW ESR spectrometer operating at X-band (9.4 GHz) equipped with goniometer and helium cryostat allowing cooling down to 2 K were used.

Optical microscope with Nomarsky contrast revealed contaminants on graphene surface. In AFM, decorated edges of macrosteps, filled hollows on macrostep terraces and microprecipitates on graphene surface were observed.

The ESR of graphene was measured as a function of microwave power, angle of magnetic field incidence and temperature. The spectrum had a tangled character. Sharp resonance line originating from SiC substrate was present for magnetic field about 3350 Gs (g factor about 2,002). Additionally, several lines originating from NaCl microcrystals were clearly visible for magnetic field perpendicular to the graphene layer (Fig. 1). The spectrum revealed very complicated and non-monotonic temperature dependence. In angular measurements shift of the observed lines to higher magnetic field was seen. Amplitude of NaCl spectrum decreased very rapidly, and after rotation by about 10° the spectrum vanished which indicated the attachment of the microcrystals to the graphene surface. After additional immersing in distilled water for several days, the NaCl spectrum finally vanished, which showed reversibility of the NaCl deposition process. The nature of the ESR lines, as well as possible mechanism of the processes which occurred in the sample will be discussed.

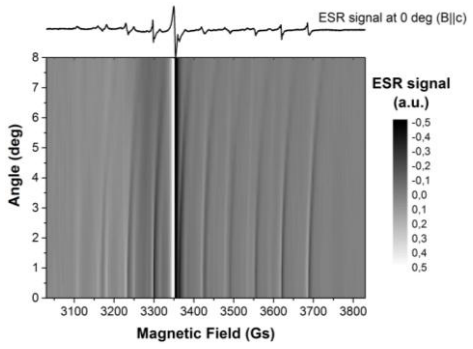

Fig. 1. Angle dependence of ESR spectrum of graphene with NaCl particles and cross-section for magnetic field perpendicular to the graphene surface.

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