Kinetics of graphene hydrogenation: XPS study

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Recently graphene has been discussed as a material with higheSt potential for post-silicon electronics [1]. The main requirement for graphene to have applications in electronics is existence of a phase transition from semimetal to semiconductor or insulator. The most promising route for the realization of this transformation is through chemical functionalization, such as hydrogenation.

The totally hydrogenated graphene is well known as the "graphane". Electronically, graphene is the zero-gap semiconductor and graphane is an insulator with an energy gap of 3.5 eV [2] which makes it an attractive material for optoelectronics in the UV range. For graphane theory predicts electron localization[3], a peculiar midgap state [4], strong excitation effects[5] and high-Tc superconductivity in hole-doped graphane [6].

In this work kinetic properties of the graphene hydrogenation were studied by means of X-Ray photoelectron spectroscopy (XPS) approach with high energy resolution, achieved by using the synchrotron radiation source. Graphene was prepared using chemical vapor deposition technique (CVD) on the Ni(111) thin film. Gold intercalation approach was used to obtaine quasi-freestanding graphene and to reduce Ni influence on the hydrogen adsorption process.

Stability of the intermediate states of the hydrogenation process was observed, which allowed using "step by step" technique for investigation of kinetic process. By performing long hydrogenation cycle it was shown with XPS that only 25% of carbon atoms can be bonded with hydrogen. The results of quantitative XPS data analysis were treated in the frameworks of the Langmuir adsorption theory to obtained kinetics constants. Low adsorption probability - only 3.5% and high reflection (85.5%) and stimulated hydrogen desorption (11%) probabilities were demonstrated.

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