Graphene sheets analyses by the different microscopic methods

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Graphene is a monolayer of carbon atoms that are densely arranged in a honeycomb crystal lattice. It´s name comes from graphite, which consists of a many graphene sheets stacked together. Perfect graphenes consist of hexagonal cells; pentanogal and heptagonal cells are caused by defects. The term graphene is known since 1987[1]. In 2004 was made the first isolation of graphene monolayer from graphite [2]. Discovery of graphene opened a new field of interest. Usage of this material is very important in several fields of science and technology because of its good properties.

Graphene is the strongest substance known to man. Its spring constant is 1–5 N/m and its Young's modulus was 0.5 TPa, which differs from bulk graphite. These high values make graphene very strong and rigid. These intrinsic properties could lead to the possibility of utilizing graphene for NEMS applications such as pressure sensors and resonators [3]. The near-room temperature thermal conductivity of graphene is between $(4.84\pm0.44)\times10^3$ to $(5.30\pm0.48)\times10^3$ $Wm^{-1}K^{-1}$[4]. One layer of graphene (thickness of this layer is 1 atom) absorb approximately 2.3% of white light intensity [5,6]. Graphene also displays an anomalous quantum Hall effect and is an ideal material for spintronics due to small spin-orbit interaction and near absence of nuclear magnetic moments in carbon [7].

This work reports on AFM, TEM and SEM study of graphenes. Graphenes studied in this work were prepared by chemical exfoliation. For this research Transmission Electron Microscope JEOL 2010 - type high contrast (TEM), Scanning Electron Microscope Hitachi SU 6600 (SEM) and Atomic Force Microscope Explorer NTEGRA Aura (AFM) were used.

The samples for TEM were prepared by the dispersion of nanopowder graphene in ethanol by ultrasonic waves. Obtained solution was dropped on copper grid with holey carbon film. Finally the samples were dried at room temperature. Preparation of the sample for SEM and AFM were the same. Liquid dispersions of graphene were placed on support with carbon adhesive tape (in the case of SEM) and on a mica sheet (in the case of AFM). Then these samples were dried at 50ºC.

In the case of AFM, semicontact mode was used. Fig. 1 presents 3D AFM image (a) and step measurements on grapheme sheets (b). Secondary electron mode with accelerating voltage of 15 kV was used. This method gives information mainly about surface morphology of the sample. Clearly is seen that the graphene sheet is “transparent” for primary and secondary electrons. The image of the graphene sheets is shown on the Fig. 2a. TEM was used due to ability to display internal structure of graphene (Fig. 2b). Accelerating voltage of 160 kV was used. The image of electron diffraction (Fig. 3) demonstrates crystalline structures of graphene.

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1. S. Mouras, et al., Revue de Chimie Minerale **24**(1987) p572.
2. K.S. Novoselov et al., Science **306**(2004) p666.
3. I.W.Frank et al., J. Vac. Sci. Technol. B **25**(2007) p2558–2561.
4. A.A. Balandin et al., Nano Letters ASAP (2008).
5. A. B. Kuzmenko et al., Phys. Rev. Lett. **100**(2008) p117401.
6. R. R. Nair et al., Science **320**(2008) p1308.
7. A. K. Geim et al., Nature Mater. **6**(2007) p183–191.
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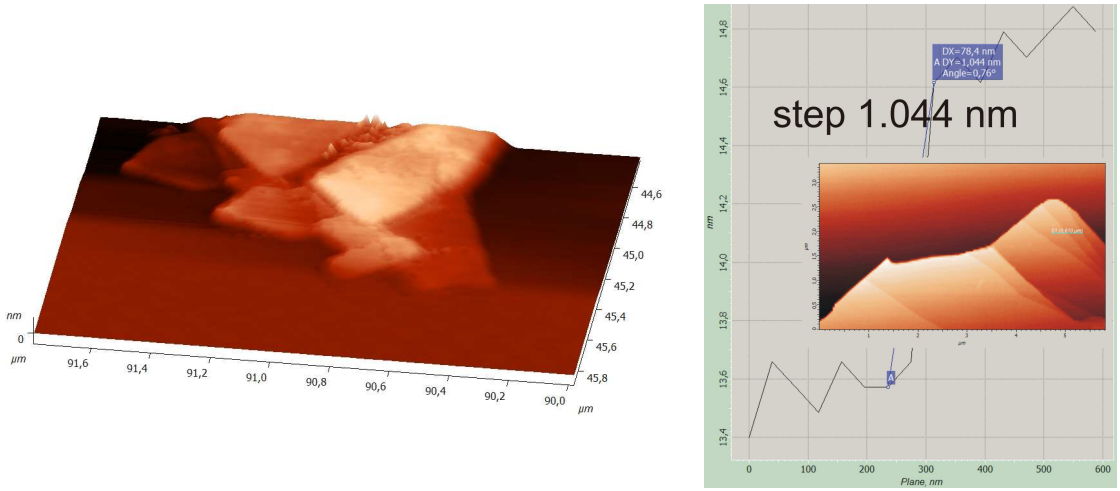
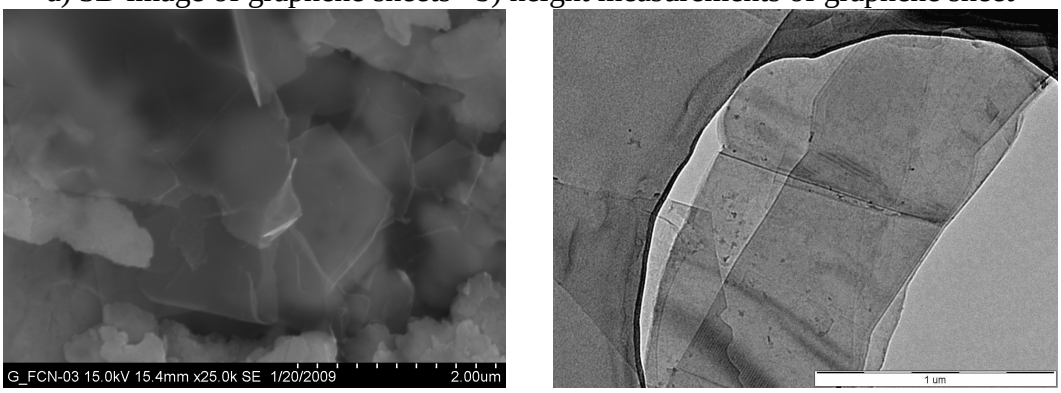


a) b)

Figure 1. AFM images of graphene
a) 3D image of graphene sheets b) height measurements of graphene sheet



a) b)

Figure 2. Graphene sheets imaged by a) SEM, b) TEM

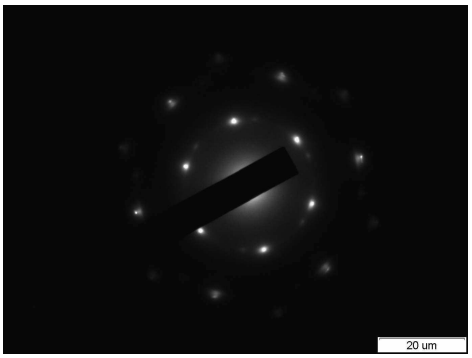


Figure 3. Electron diffraction of the sample

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