Raman scattering and electrical resistance of highly disordered graphene

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Raman scattering (RS) spectra and current-voltage characteristics at room temperature were measured in six series of small samples fabricated by means of electron-beam lithography on the surface of a large size (5x5 mm) industrial monolayer graphene film. Samples were irradiated by different doses of carbon ions. It was observed that at the utmost degree of disorder, the Raman spectra lines disappear which is accompanied by the exponential increase of resistance and change in the current-voltage characteristics. These effects are explained by suggestion that highly disordered graphene film ceases to be a continuous and splits into separate fragments. The relationship between structure (intensity of RS lines) and sample resistance is defined. It is shown that the maximal resistance of the continuous film is 20 kOhm, approximately equal to the reciprocal value of the "minimal graphene conductivity". Preliminary results of these measurements are reported in [1]. Irradiation with heavy Xe ions and annealing of radiation damage were used to show that the structure and properties of the irradiated graphene films depend only on the density of irradiation-induced defects.
Measurements of the temperature dependence of conductivity down to 2 K in zero magnetic field and in magnetic fields parallel and perpendicular to the graphene film showed the gradual metal-insulator transition: with increase of disorder, metallic conductivity of pristine films is replaced by the regime of quantum corrections to the conductivity characteristic for dirty metals and by the variable-range-hopping conductivity of localized carriers in strongly irradiated films. The main parameters of hopping conductivity are determined as a function of concentration of the irradiation-induced defects: the localization radius and the density-of-state in the vicinity of the Fermi level.

[1] I. Shlimak *et al*., arXiv:1410.3425v1, submitted to Phys. Rev. B.