Structure and electron transport in monolayer graphene gradually disordered by ion irradiation

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Raman scattering (RS) and film resistance R were measured in six series of samples fabricated by electron-beam lithography on the common surface of a large size (5×5 mm) monolayer graphene films. Samples were irradiated by different doses Φ of C^+ ions up to 10^{15} cm^{-2}. It was observed that in highly irradiated samples, the RS lines disappear (Fig. 1, left) which was accompanied by the exponential increase of R and strongly nonlinear current-voltage characteristics [1]. These facts are interpreted as the evidence that highly irradiated graphene film ceases to be a continuous and splits into small-size fragments. Comparison of irradiation with light C^+ and heavy Xe^+ ions showed that degree of disorder is determined by the density of irradiation-induced defects $N_D = k\Phi$, where k depends on the energy and mass of ions.

Measurements of the temperature dependence $R(T)$ and magnetoresistance reveal the gradual transition of conductivity with increase of N_D: from metallic conductivity in initial samples through the weak localization (antilocalization) regime (WL) at small degree of disorder to the variable-range-hopping conductivity (VRH) of strongly localized carriers in more irradiated samples (Fig. 1, right). Fitting the theoretical curves with experimental data showed a good agreement and made it possible to determine such parameters as the dephasing length in the WL regime and the width of the Coulomb gap and radius of localization for the case of strong localization [2].

It is suggested that the strengthening of localization with increasing N_D could be explained by assuming that the structural defects in graphene are of amphoteric nature, *i.e.* they can be either donors or acceptors and compensate each other.

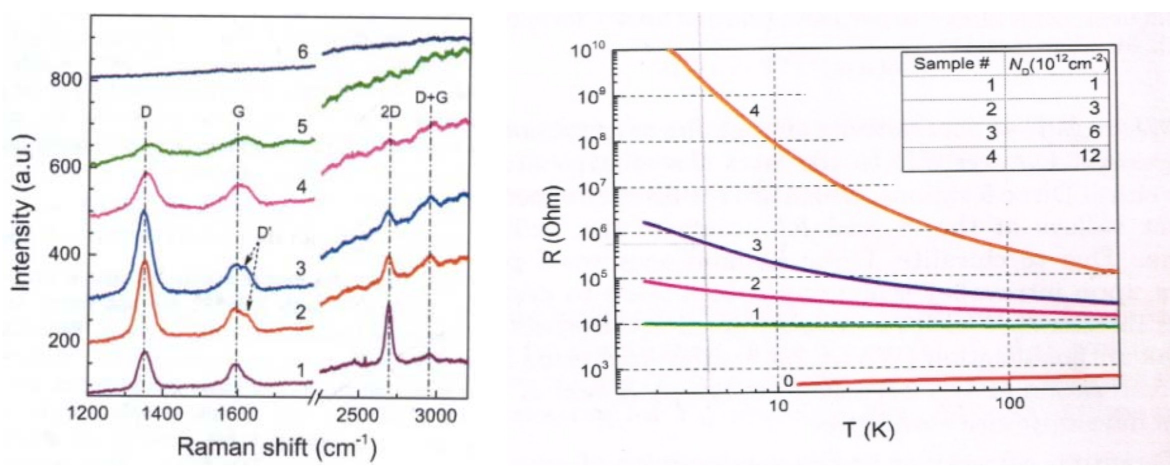

Fig. 1. Raman scattering *vs.* C^+ ion irradiation (left); temperature dependence of irradiated films *vs.* defect density N_D (right).

1. I. Shlimak *et al.*, *Phys. Rev. B* **91**, 045414 (2015).
2. E. Zion *et al.*, arXiv: 1501.04581v1 (2015), submitted to *Phys. Rev. Lett.* (2015).