Properties of He^+ ion implanted graphene grown on SiC(0001)

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A Chemical Vapor Deposition (CVD) graphene monolayer grown on 6H-SiC(0001) substrate was used for implantation experiments. The graphene sample was irradiated by He^+ ions at fluencies ranging between $1x10^{12}cm^{-2}$ and $1x10^{16}cm^{-2}$. The room temperature Raman spectra and electrical transport parameters have been measured as a function of increasing implantation dose. The defects concentration introduced by implantation have been determined from intensity ratio of the Raman D and G peaks, as it was shown previously [1]. It was found that number of defects caused by one He^+ ion was 0.0012. Charge carrier concentration, mobility and sheet resistance have been determined from electrical measurements by van der Pauw method, whereas carrier concentration was also estimated from Raman G versus 2D energy relation derived from micro-Raman maps. It was found that mobility decreases almost by two orders of magnitude as the defect concentration increases from $1x10^{11}cm^{-2}$ to $5x10^{12}cm^{-2}$. The inverse of mobility versus defect concentration is a linear function, which is an indication that the main scattering mechanism is connected to defects generated by implantation (Fig1). For low defect concentration the mobility is not affected by implantation. The ratio of intensities of Raman modes D/D' provides information about nature of defects [2]. This ratio was constant and close to 6 – 7 in the regions where D' has been observed. This indicates that the dominant graphene defects generated by implantation are vacancies. The carrier (holes) concentration is not so strongly affected by implantation and decreases only by factor 2 for the highest He^+ dose. Decrease of carrier concentration is most likely caused by damage of the SiC substrate by implanted He^+ ions. Our results show that implantation is a useful tool for a controllable generation of defects in graphene. We analyze their nature and impact on electronic transport.

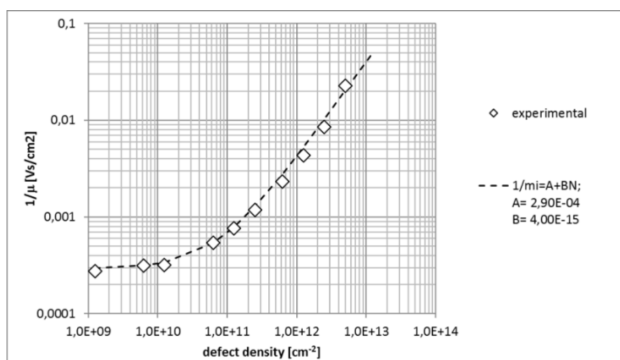

Figure1. Inverse of the mobility vs. defect concentration.

[1]. M.M. Lucchese et al., Carbon 48, (2010) 1592

[2]. A. Eckmann et al., Phys. Rev. B 88, (2013) 035426