Ambipolar remote graphene doping by low-energy electron beam irradiation

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Graphene has unique transport properties that can be tuned by changing the type and concentration of charge carriers. Original approach of controlled graphene doping is based on applying an external electric field provided by the voltage between the graphene and a gate electrode followed by the deposition of atoms or molecules featuring as donors or acceptors. Recent establishment of remote doping is based on charge trapping in a gate dielectric [1] and provides a way of graphene n-doping and high level p-doping without need of additional deposition of molecules. Protocol for achieving a full scale doping range remains an open issue.

We employ low-energy electron beam irradiation to induce both n- and p-doping in a graphene layer [2]. Graphene fabricated by chemical vapour deposition is transferred to a SiO_2/Si substrate into a device in the field effect-transistor configuration. Device is then covered with Al_2O_3 layer to passivate the graphene and thus prevent possible interference of adsorption/desorption from the surface with electron beam induced changes of interest. The electron beam irradiation is carried out under ultra-high vacuum conditions. We have identified a threshold in gate voltage dividing doping behaviour in electron beam induced doping. Electron beam irradiation above the threshold results in n-doping whereas below the threshold voltage p-doping is obtained. Depending on the threshold voltage set by beam parameters and applied gate voltage during irradiation we obtain either n- or p-doped graphene. By setting an appropriate irradiation protocol, any desired doping level can be achieved.

References

[1] P. Procházka et al., Sci. Rep., 7 (2017) 563.
[2] V. Stará et al., Nanoscale, 10(37), (2018) 17520–17524

Figures

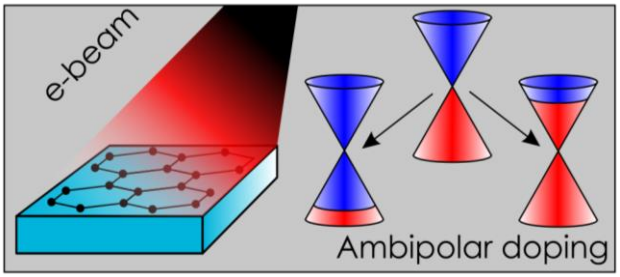

Figure 1: Electron beam irradiation induces ambipolar remote doping of graphene depending on the beam parameters and voltage applied to the graphene.