Diamond-like carbon and nanodiamond layers as a platform for supporting graphene

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Inevitably the substrate that attaches to a material such as graphene will influence the electronic properties of the carbon monolayer. The majority of reports concerning the electronic properties of chemical vapour deposited (CVD) graphene that has been transferred to an insulating substrate for electronic characterization concern the use of SiO_2-Si, due to the widespread availability of this material system. A more ideal platform for the graphene could be another carbon form such as diamond and favourable reports has appeared [1], and our own group have investigated the influence of terminating chemical groups on the diamond substrate on the graphene layers electrical properties [2]. However, the limited area of single crystal diamond materials is an obvious limitation for the deployment of this material as a graphene substrate. A potential alternative, diamond-like carbon (DLC) can be deposited at room temperature on a wide range of materials over large areas. A report on the use of DLC as a graphene support has appeared [3], but no investigation into the effect of surface terminations of the DLC on the resultant graphene properties has been reported. We initiated such a study; initial results from this work are extremely encouraging, in terms of Hall effect measurements, AFM, SEM, XPS and Raman Spectroscopy which are reported here. In addition, the use of detonation nanodiamond (ND) layers attached by conventional seeding methods to a range of substrates, again over large areas, has been studied for this application.

CVD produced monolayer graphene was transferred onto DLC and ND coated substrates that had been previously subjected to differing chemical and plasma treatments to lend them differing surface terminating groups. For example, monolayer attachments of H and O were investigated, in all cases leading to a p-type graphene layers. Stark differences in the electrical character of the resultant graphene-DLC or ND-heterostructure were observed. For example, it was found that higher carrier mobility values cannot be simply associated with lower carrier densities (as they are in conventional semiconductor systems). Rather, each chemisorbed species give rise to a unique character. In the case of H terminations, the maximum p-type mobility arose (more than 500 cm^2/Vs), allied to the lowest carrier concentration, but the carrier concentration rose noticeably for O terminations, *with only a modest decrease in mobility*. In additional to chemical changes (XPS), surface roughness changes (AFM) associated with differing termination treatments also led to different mobility values. These results will be discussed in terms of the possible surface-transfer effects that may be occurring within the DLC-terminating group graphene heterostructures, and the potential use of this approach for engineering tunable electrical properties.

References

[[1] Jie Yu and co-workers, Nano Lett. 2012, DOI: 10.1021/nl204545q
[2] Fang Zhao *et al* Presented at the International Conference on Diamond and Related materials, Granada, Spain, September 2012
[3] Yanqing Wu *et al*, Nature 472, 74–78 (2011)