Diamond 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 indeed favourable reports of the use of Diamond-like carbon (DLC) [1] and diamond itself [2] have recently appeared. We initiated a study on the use of both single crystal and thin film nanocrystalline diamond, with a view to investigating the influence of the surface terminating groups on the diamond surfaces on the subsequent electronic properties of the deposited graphene layer. The initial results from this work, in terms of Hall effect measurements and Impedance Spectroscopy are reported here.

CVD produced graphene (Cu-foil) was transferred onto single crystal diamond (100) substrates that had been previously subjected to differing chemical and plasma treatments to lend them differing surface terminating groups. Diamond with monolayer attachments of H, O, F and N were investigated, in all cases leading to a p-type system once graphene had been deposited. Stark differences in the electrical character of the resultant graphene-diamond heterostructure were onbserved. For example, in table 1, it can be seen 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 mobility arose, allied to the lowest carrier concentration, but the carrier concentration rose noticeably for O terminations, with modest decrease in mobility. In contrast, a similar carrier concentration was observed when N-terminations were charactersied, but a sharp decline in mobility was associated with this heterostructure. In the case of F-terminations, the mobility decreased even further, but the carrier concentration became extremely high. These results will be discussed in terms of the possible surface-transfer effects that may be occurring within the diamond-terminating group-graphene heterostructures, and the potential use of this approach for engineering tunable electrical properties.

References

[1] High-frequency, scaled graphene transistors on diamond-like carbon**.** Yanqing Wu, Yu-ming Lin, Ageeth A. Bol, Keith A. Jenkins, Fengnian Xia, Damon B. Farmer, Yu Zhu & Phaedon Avouris *Nature* 472, 74–78 (2011)

[2] “Graphene-on-Diamond Devices with Increased Current-Carrying Capacity: Carbon sp^2-on-sp^3 Technology, Jie Yu, Guanxiong Liu, Anirudha V. Sumant, Vivek Goyal, and Alexander A. Balandin*Nano Lett.*,*Pub: February 13, 2012 (Letter), DOI: 10.1021/nl204545q*

TABLE 1.

Sample	Temperature (Kelvin)	Sheet resistivity (Ohm/sq)	Carrier concentration (cm^{-3})	Mobility (cm^2/Vs)
Graphene on H-SCD	298	4392	6.44E+12	220.86
Grpahene on O-SCD	298	1345	2.79E+13	195.54
Grpahene on N-SCD	298	12000	2.37E+13	18.63
Grpahene on F-SCD	298	11716	5.12E+14	1.04