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A facile synthesis of transfer-free graphene by Ni-C co-deposition

Sehoon An[1,3], Geun-Hyuk Lee[1,3], Seong Woo Jang[1,3], Sehoon Hwang[1], Jung Hyeon Yoon[2], Sang-Ho Lim[3], Seunghee Han[1]

[1]Photo-electronic Hybrids Research center, Korea Institute of Science and Technology, Seoul 02792, South Korea
[2]Advanced analysis center, Korea Institute of Science and Technology, Seoul 02792, South Korea
[3]Department of Materials Science and Engineering, Korea University, Seoul 02841, South Korea

Graphene, as a single layer of sp^2-bonded carbon atoms packed into a 2D honeycomb crystal lattice, has attracted much attention due to its outstanding properties. In order to synthesize high quality graphene, transition metals, such as nickel and copper, have been widely employed as catalysts, which needs transfer to desired substrates for various applications. However, the transfer steps are not only complicated but also inevitably induce defects, impurities, wrinkles, and cracks of graphene. Furthermore, the direct synthesis of graphene on dielectric surfaces has still been a premature field for practical applications. Therefore, cost effective and concise methods for transfer-free graphene are essentially required for commercialization.

Here, we report a facile transfer-free graphene synthesis method through nickel and carbon co-deposited layer. In order to fabricate 100 nm thick NiC layer on the top of SiO_2/Si substrates, DC reactive magnetron sputtering was performed at a gas pressure of 2 mTorr with various Ar : CH_4 gas flow ratio and the 200 W DC input power was applied to a Ni target at room temperature. Then, the sample was annealed under 200 sccm Ar flow and pressure of 1 Torr at 1000°C for 4 min employing a rapid thermal annealing (RTA) equipment. During the RTA process, the carbon atoms diffused through the NiC layer and deposited on both sides of the NiC layer to form graphene upon cooling. The remained NiC layer was removed by using a 0.5 M $FeCl_3$ aqueous solution, and graphene was then directly obtained on SiO_2/Si without any transfer process. In order to confirm the quality of resulted graphene layer, Raman spectroscopy was implemented. Raman mapping revealed that the resulted graphene was at high quality with low degree of sp^3-type structural defects. Additionally, sheet resistance and transmittance of the produced graphene were analyzed by a four-point probe method and UV-vis spectroscopy, respectively. This facile non-transfer process would consequently facilitate the future graphene research and industrial applications.

Keywords: Graphene, Co-deposition, NiC