Graphene Epitaxy by Chemical Vapor Deposition on SiC

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Graphene deposited on a SiC has great potential for electronics applications, however, a major factor hindering the development of technology for the large-scale production of graphene-based nano-electronic devices is the lack of access to high-quality uniform graphene layers grown on large SiC substrates.

In this paper, we report the CVD of epitaxial graphene (CVD-EG) on SiC substrates using propane gas as the carbon precursor. Graphene layers were grown using a commercially available horizontal CVD hot-wall reactor (Aixtron VP508), which is inductively heated with an rf generator. The epitaxial CVD of graphene relies critically on the creation of dynamic flow conditions in the reactor that simultaneously stop Si sublimation and enable the mass transport of propane to the SiC substrate. While protecting against Si sublimation, C deposition was enabled with one monolayer resolution by taking advantage of the high efficiency of kinetic processes at high *T* and low *P*. Additionally, the formation of FLG is possible on the Si-face SiC(0001) which, in comparison to max 2-3 ML of S-EG, creates greater research opportunities. The proposed method permits the growth rate of graphene on the C-face of SiC(000-1) to be considerably lowered enabling the growth of 1ML, which is extremely difficult in the case of S-EG. Our approach also enables precise growth rate control by adjusting the mass transport of the carbon precursor in a similar way to the method used in MOCVD/CVD, as well as the passivation of the SiC substrate by any substances prior to graphene growth. Moreover, one can tune the reactor conditions to grow both CVD-EG and S-EG in the same system.

To provide information at the atomic scale, samples were characterized by scanning tunneling microscopy (STM), micro-Raman spectroscopy and transmission electron microscopy (TEM). The thickness of the graphene films were estimated by ellipsometry, the position of the σ and π electronic energy bands were evaluated by angle-resolved photo-emission spectroscopy (ARPES). The transport parameters of the graphene samples were measured with the van der Pauw method at room temperature. The electron density in 1-2 ML graphene films was typically 8-10x10^{12} cm^{-2}, with a macroscopically averaged electron mobility inferred from Hall voltage in the range 3000-3200 cm^2/Vs, demonstrating the high electronic quality of the CVD-EG layers on the wafer scale. The micro Raman maps have been created with 3mm light spot using 530 points measured on 2,3 x 2,3 mm^2 area in the center of the sample. Histograms reveal that CVD growth of graphene produces much less strained layers in comparison with S-EG. CVD epitaxial graphene has been also studied by LEED and LEEM methods. The approach proposed here offers numerous potential benefits including the application of well-developed commercial epi-systems for SiC epitaxy, a precise growth rate control by adjusting the mass transport of the carbon precursor in a similar way to the method used in MOCVD/CVD, doping of graphene, as well as the passivation of the SiC substrate by any substances prior to graphene growth.