Selective Area Growth of Epitaxial Graphene Layers on 4H-SiC by Electron-Beam-Irradiation

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Abstract:

Graphene, a flat layer of sp^2-bonded carbon atoms arranged in a two dimensional (2D) hexagonal honeycomb lattice, has garnered tremendous interest due to its novel properties including high electron mobility with low electronic scattering that make it a very promising candidate for next generation nanoscale electronics and photonics devices. Several outstanding advancements in graphene fabrication technology have been explored including research grade mechanical exfoliation of graphite, chemical vapor deposition, thermal decomposition of SiC and chemical methods. Among them, epitaxial graphene (EG) on SiC surfaces is very promising approach for large area fabrication as it is compatible with existing Si device technology. However, a facile and novel approach for the growth of graphene on SiC substrates remains challenging for producing large area graphene with desired layers.

In this work, we demonstrate the selective growth of EG layers on 4H-SiC (0001) substrate by low energy e-beam irradiation. Sublimation of Si occurs by energetic electron irradiations on SiC surface via breaking of Si-C bonds in the localized region which allows the selective growth of graphene. The surface features of the EG were examined using atomic force microscopy and Field emission scanning electron microscopy. The optical quality, stacking dimension, thickness, strain and uniformity of the graphene layers were investigated by Raman scattering [Fig.1a]. XPS spectroscopy has also been performed to visualize the complementary structural and bonding nature of the graphene [Fig.1b]. The maximum reproducible Hall mobility of monolayer graphene on Si face is ~6450 $cm^2V^{-1}s^{-1}$. Current-voltage measurements reveal that EG on 4H-SiC forms a Schottky junction with high current. Our study reveals that the barrier height at the Schottky junction is low (~ 0.45 – 0.6 eV) due to the Fermi-level pinning above the Dirac point [Fig.2]. The features and thickness of graphene are highly sensitive to the e-beam energy and duration of irradiation. Results of our present study suggest that e-beam irradiation

technique is a viable route to define wafer scalable selective and large area graphene structures directly on 4H-SiC substrates for electronic applications.

References:

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Figures

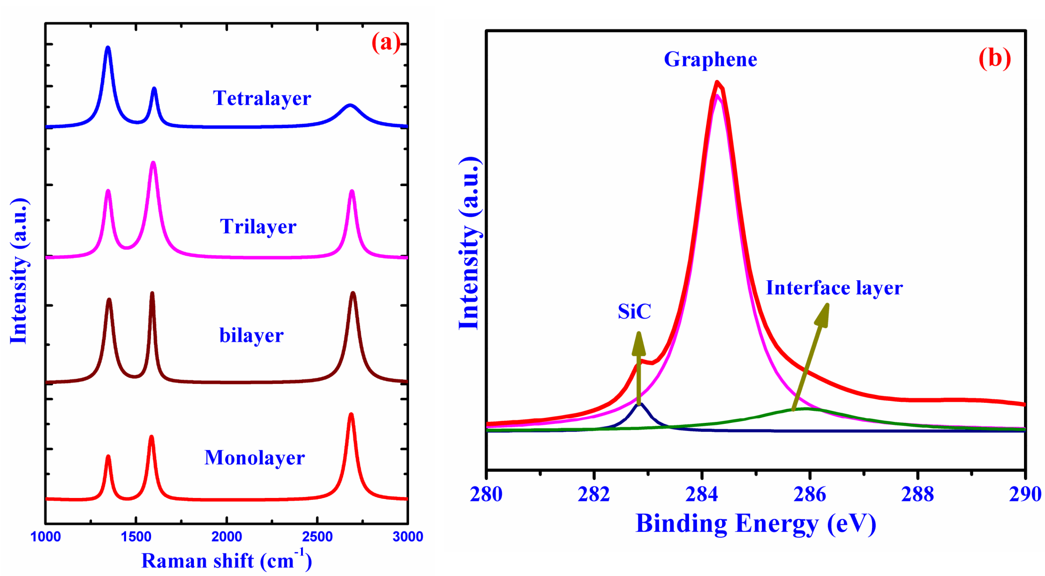

Figure 1: (a) Raman spectra of the EG layers on SiC substrates (SiC contributions are subtracted) and (b) Deconvoluted XPS spectrum of EG on SiC substrate.

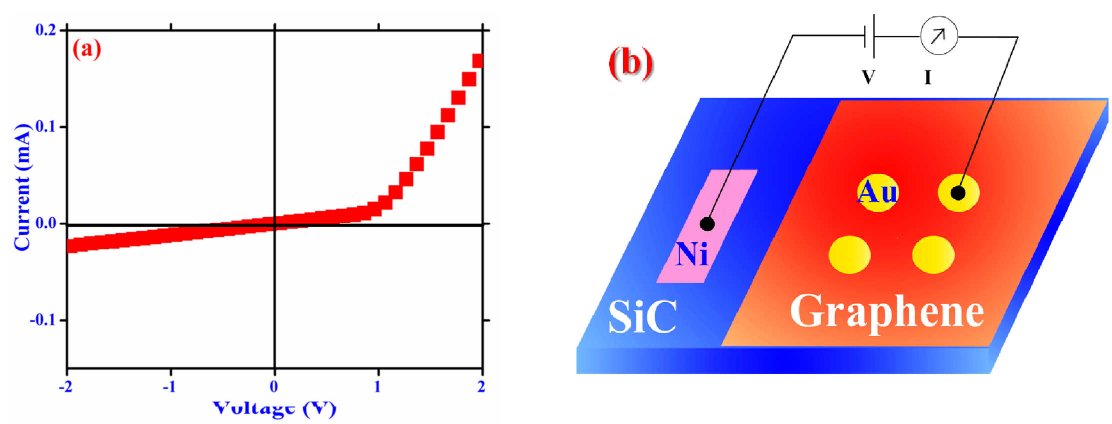

Figure 2: (a) I-V characteristics of the EG and SiC heterojunction and (b) Schematic diagram of our Heterojunction device.