Van der waals heteroepitaxy of high quality InAs nanowires on graphite for high-performance flexible devices

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The talk will focus on the Van der waals (VDW) heteroepitaxy of high quality InAs nanowires on graphite for high-performance flexible optoelectronic devices. Semiconductor nanowires (NWs) have emerged as potentially important building blocks for future photonic and electronic devices due to their fascinating properties including; superior light absorption, enhanced photo-carrier separation and dislocation-free growth on foreign and flexible substrates .There is renewed interest in the monolithic integration of III-V semiconductor NWs on graphite to enable cost-effective, flexible devices and circuits. Exploiting the novel physical properties of graphite and semiconducting nanowires would provide a unique platform for the development of new and sophisticated devices including nanostructured solar cells with superior transparency and flexibility as well as improved stability[1] and relatively cheap cost. Graphene-based solar cells have recently been demonstrated[2].Despite these enormous potential benefits the fabrication of functional graphene-hybrid heterostructures by combining graphene with semiconductor nanowires epitaxially is very challenging owing to the inability to covalently bind these inorganic nanowires to the chemically stable carbon atoms in the absence of dangling bonds.

Here we report the VDW heteroepitaxy of high quality free-standing InAs NWs oriented along the (111) axial direction on highly ordered pyrolytic graphite (HOPG). The samples were grown on HOPG substrate by solid source plasma assisted molecular beam epitaxy under As rich conditions for 20 minutes at a growth temperature of 440-470^{o}C. The surface morphology and crystalline quality of the resulting samples were studied by scanning electron microscope (SEM) and X-ray diffraction (XRD) respectively. The results will be presented showing SEM image of InAs NWs which are vertically aligned (Figure 1) and hexagonal in cross-section (shown in the inset of Figure 1) with mean diameter, height and number density of 80nm, 1.1µm and of 4.4 x 10^8 cm^{-2} respectively. Our study further shows the InAs NWs crystals are zinc blende, vertically aligned, normal to the HOPG substrate as indicated by the high intensity of the (111) plane reflection (depicted in Figure 2). Further analysis of the intensities of the observed (220) and (420) peaks reveals that they originate from the faceted islands grown alongside the nanowires. The inset shows the high magnification image of the InAs (111) diffraction peak confirming the epitaxial growth of high quality zinc blende InAs NWs on graphite. Finally, the results will demonstrate that the heteroepitaxial growth is attributed to the unconventional, noncovalent, nonwetting VDW epitaxy promoted by the nearly coherent in-plane lattice matching of InAs NWs and HOPG as schematically illustrated in Figure 3.

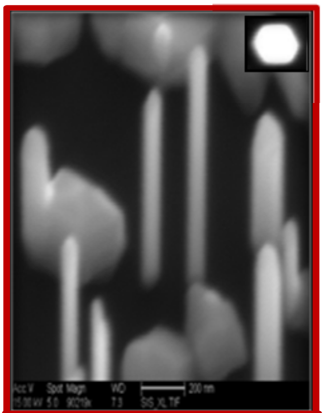

Fig. 1: SEM images of InAs NWS on HOPG. Insets shows the hexagonal cross-section of a nanowire

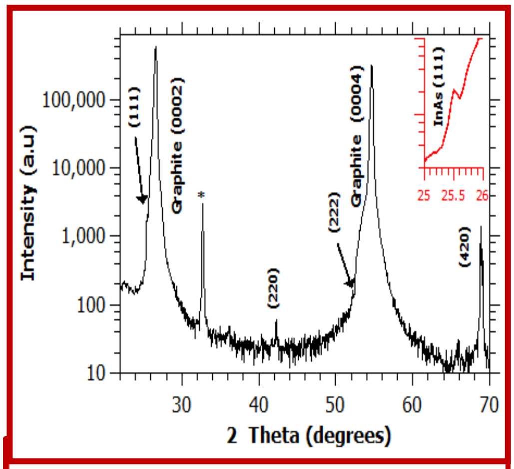

Fig. 2 XRD of InAs NWs on HOPG. Inset shows the magnified InAs (111) diffraction peak.

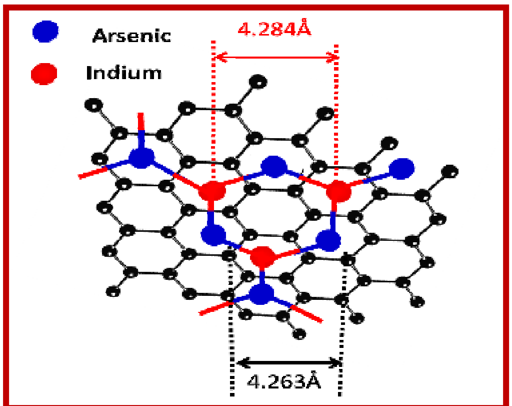

Fig.3: Schematic showing nearly lattice-matched InAs/ highly oriented pyrolitic graphene (HOPG) in-plane lattice constants resulting in heteroepitaxy of InAs($\bar{1}\bar{1}\bar{1}$)[$\bar{1}$10]|| HOPG(0001)[1$\bar{2}$10]

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