On-site CVD Formation of Multi-layered Graphene on Silicon Nanowires

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Graphene for device applications is often produced on flat catalytic substrates, then exfoliated and transferred to the device. This procedure is time consuming and is difficult to apply to complex device configurations. Furthermore, graphene's properties and uses could be expanded if grown in non-flat configurations. As a solution, our research outlines a process to form multi-layer graphene with complex shapes on-site by using a deposited Ni catalyst on a thin passivation layer SiO_2 on silicon architectures such as silicon nanowires (SiNWs). Graphene is grown using a CVD process from the carbon precursor CH_4, and the Ni catalyst is later removed by wet etching. The graphene films remain on the surface after etching and conform to the shape of the SiNW substrate.

Using a Scanning Electron Microscope, conductive carbon layers can be seen to cover the entire SiNW surface over a 1 cm^2 sample area. The layers are loose but do not wash away during etching due to anchoring by the unique nanowire structure. Raman spectrography shows that the observed layers have a graphene signature with strong carbon G and 2D peaks. The Raman peak ratio and Transmission Electron Microscope observations indicate a multi-layer structure. This new configuration of graphene with regular bending structures is expected to have altered properties. The nanowire architecture may be favorable for future device configurations due to the increased surface area of the graphene in combination with the light-trapping optical properties of the SiNWs.

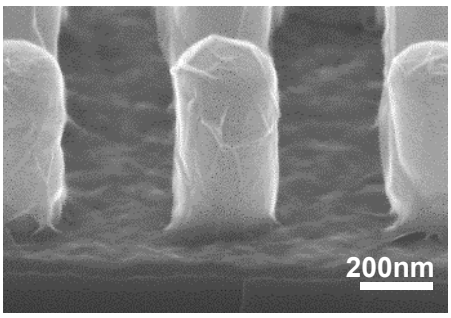

Fig. 1: SEM image of graphene sheets on SiO_2 surface of SiNW sample.

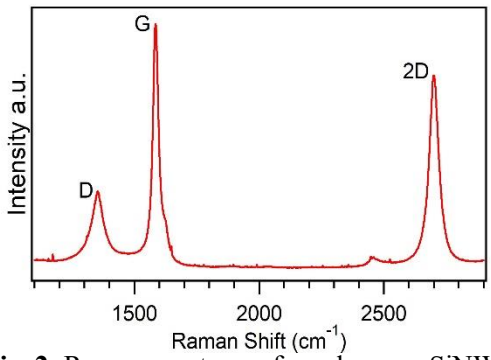

Fig. 2: Raman spectrum of graphene on SiNWs showing carbon D, G, and 2D peaks.

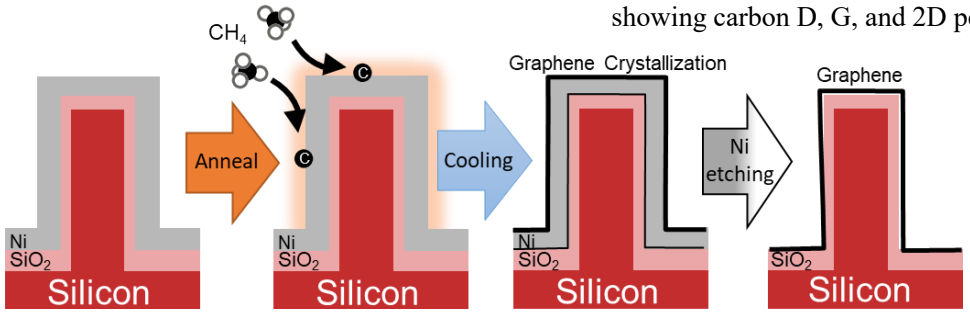

Fig. 3: Schematic of experimental graphene growth process. CH_4 is decomposed on Ni during annealing to form graphene sheets that remain on the SiO_2 surface of Si nanowires after Ni etching.