Formation of Graphitic Carbon Layers on SiO_2 Surfaces of Silicon Nanowires

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Applications of graphene related materials has generally had difficulty fitting to the constraints of its growth methods. Graphene layers for device applications is often produced on flat catalyst substrates, then exfoliated and transferred to the device. This procedure is time consuming and has difficulty being applied to complex device configurations. One solution is to form graphitic structures with complex configurations on-site. The proposed method for this is to use nickel as the catalyst that has an interface with a passivation layer such as SiO_2 as part of complex silicon architectures. Carbon structures are formed from carbon precursors at the nickel interfaces and the nickel is later removed by etching.[1,2] This will leave a graphitic film that remains on the surface with the shape of the silicon architecture.

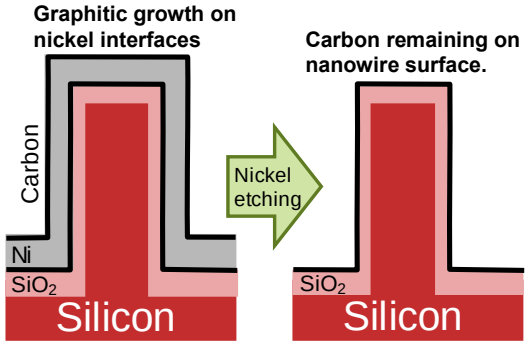

Fig. 1: Concept diagram of graphitic growth process on a nanowire architecture. Carbon precursors break down and organize on nickel interfaces and remain on the architecture surface after nickel removal.

Various growth conditions have been applied to nickel layers deposited on approximately 30nm thick SiO_2 films on silicon nanowires to find the conditions to produce graphitic carbon layers on the nanostructure surface. Research has focused on heating a methane or amorphous carbon precursor to 900°C on the nickel catalyst surface before using Marble's reagent to etch the nickel away while maintaining the carbon material. Raman micro-spectroscopy supported by SEM and TEM observations have been used for the initial characterization of the resulting structures.

Graphitic carbon layers have been produced on the nanostructure surfaces with complex shapes and coverage depending on the growth conditions. Nickel migration over time favors forming nanoparticles on the nanowire tops and exposing the nanowire walls, which can form discontinuous carbon sheets on the tops and bottoms of the nanowires. The experiment has shown that the growth procedures are capable of being applied to complex surfaces favorable for future device configurations over areas limited by the nickel coverage. The carbon layers are able to conform to the surface to produce non-flat sheet configurations with properties that will be studied in future research. Incorporation of other passivation layers and electronic device integration are among the future goals.

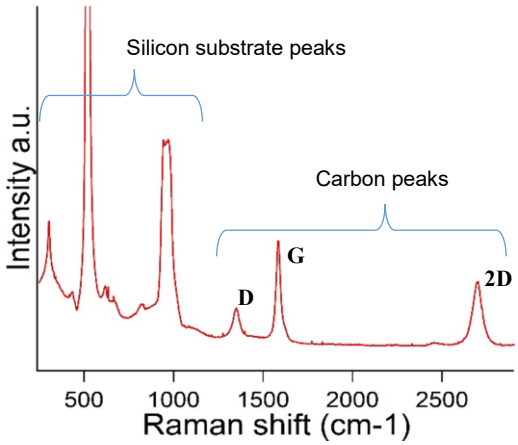

Fig. 2: Raman spectroscopy plot showing the presence and structuring of carbon directly on a 35nm SiO_2 thin film on silicon nanowires.

Reference:

[1] Zhiwei Peng, et al. "Direct Growth of Bilayer Graphene on SiO_2 Substrates by Carbon Diffusion through Nickel" ACS Nano vol. 5, no. 10 8241–8247 (2011).

[2] Daniel Q. McNerny, et al. "Direct fabrication of graphene on SiO_2 enabled by thin film stress engineering" Scientific Reports 4: 5049 (2014).