Carbon Nanotubes and Graphene for Fuel Cell Applications

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We report a large-scale growth methodology for graphene nanowalls (GNW) on Si substrate by MPCVD and demonstrated its advantages in methanol oxidation and pH sensor. When applied as an electrochemical electrode, the GNW exhibits nearly reversible redox characteristics, whereas as employed in the solution gated field effect transistor, the GNW shows a near-Nernstian behavior (50mV/pH) and a linear conductance-pH relation over a broad range of pH values (2-12). In addition, the strained GNW supported Pt catalysts demonstrates a remarkably high methanol oxidation mass activity (425 A/g), low onset potential (0.23 eV) and a forward to reverse anodic peak current ratio as large as 2.2, indicating a more effective oxidation of methanol and better tolerance to CO poisoning. This superb performance is attributable not only to the smallness of the Pt particles, good dispersion of the electro-catalysts, but also enhanced catalyst-support interaction induced by surface strain of graphene.[1] Further effort on the improvement for the strain control of few-layer GNW and detailed insight into the electronic properties for metal-support interaction could lead to better understanding on the strain induced catalytic enhancement. It is believed that the strained GNW with large surface area, controllable graphene layer number, and enhanced edges may hold great promise for use in catalysis, electrochemistry, biosensors, and energy conversion and storage devices. While more detailed investigation is under way, preliminary results shed light to enhanced catalytic activity using GNW as support.

Meanwhile, growth of large-area graphene has been demonstrated using CVD technique. Single layer graphene with up to 10 cm in size and transferable to a designated substrate and a typical mobility of 1500 cm^2/V.sec can be achieved. Raman, Hall and field effect (FET) measurements have been applied to study the correlation of the defect and mobility.[2] Intentional doping of the graphene with boron and nitrogen has been carried out to explore the possibility of gap opening. Meanwhile, high density GNWs offering large surface area and good electrical conduction for electrochemical applications have been realized using MPCVD.

1. *"Few-layer strained graphene sheathed SiC nanowalls for heterogeneous catalysis and sensing application,"* M.S. Hu, C.C. Kuo, C.T. Wu, C.W. Chen, P. K. Ang, K.P. Loh, K.H. Chen and L.C. Chen, *Carbon* (communicated, 2011).
2. *"Correlating defect density with carrier mobility in large-scaled graphene films: Raman spectral signatures for estimation of defect density,"* J.Y. Hwang, C.C. Kuo, L. C. Chen, K. H. Chen, *Nanotechnology* **21**, 465705 (2010).

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