CVD Synthesis of Graphene/Carbon nanofiber hybrids and "Square" Graphene Domains

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We report a one-step, low-pressure, chemical vapor deposition (CVD) process to obtain three-dimensional (3D) carbon architecture consisting of vertically aligned carbon nanofiber arrays on multi-layered graphene films. The morphology and structure of the hybrid materials grown on transmission electron microscopy copper grids have been determined by electron microscopy and Raman spectroscopy.

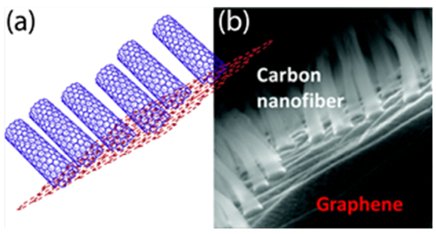

Figure 1. (a) Schematic and (b) SEM image of carbon nanofiber growth on graphene.

The resulting architecture is shown schematically in Figure 1a where carbon nanofibers are seen to grow directly from an underlying graphene sheet. Figure 1b is a scanning electron microscope (SEM) image of the resulting material. The importance of such hybrid mesostructures stems from the fact that there has been tremendous interest in using carbon nanostructures such as 1D nanotubes/nanofibers and 2D graphene to improve the performance of both dye sensitized solar cells and next generation batteries.

We have also recently developed a facile vapor phase technique for large scale growth of "square", single crystal, graphene monolayers. The approach entails the chemical vapor deposition of graphene onto Cu foils at low pressures with temperatures on the order of 1000 °C. What results are highly crystalline, single domain graphene squares as shown in Figure 2. Typical dimensions are on the order of 9 µm x 9 µm with a minimum observed domain size of 500 nm x 500 nm.

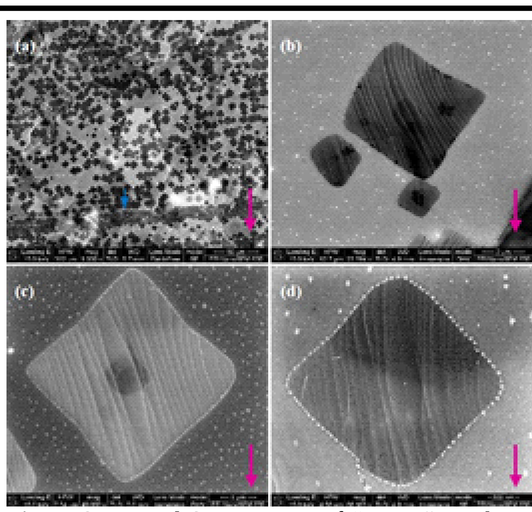

Figure 2. Typical SEM images of "square" graphene domains. (a,b) Low magnification. (c,d) High magnification.

A notable outcome of the study is the observation of coalescing graphene sheets. This is of particular interest to the DSSC/battery work here since graphene squares appear to coalesce seamlessly into a defect free structure. Raman measurements taken on multiple coalescing domains (not shown) reveal spectra near identical to those of pristine single monolayer graphene. The remarkable conclusion then is that very large area, defect free, graphene monolayers can be produced.

References:

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2. Square" monolayer graphene domains on Cu foils produced by low pressure chemical vapor deposition, Dai, G. P.; Wu, M. H.; Taylor, D. K.; Vinodgopal K. Materials Research Letters, **2013**, DOI:10.1080/21663831.2013.772078