Chemically and Structurally Manipulating Graphene for Electronic Applications

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The presentation with have two parts: (a) Wrinkle formation of graphene *via* bacteria and (b) graphene functionalization for electronic applications. (A) Curvature induced dipole moment and orbital rehybridization in graphene wrinkles modify its electrical properties and induces transport-anisotropy. Current wrinkling processes are based on contraction of the entire substrate, and do not produce confined or directed wrinkles. Here we show that selective desiccation of bacterium under impermeable and flexible graphene *via* a flap-valve operation produces axially-aligned graphene-wrinkles of wavelength 32.4 – 34.3 nm, consistent with modified Föppl-von Kármán mechanics (confinement ~0.7 X 4 mm^2). Further, electrophoretically-oriented bacterial device with confined wrinkles aligned with van der Pauw electrodes were fabricated and exhibited anisotropic transport barrier (DE = 1.69 meV). Theoretical models were developed to describe the wrinkle formation mechanism. The results obtained here show bio-cellular desiccation *via* flap- valve to produce confined, well-oriented and electrically anisotropic graphene wrinkles, which can be applied for electronics, bioelectromechanics and strain-patterning. (B) To widen the spectrum of its applications, it is important to functionalize graphene, while preserving its superior properties, and retaining its planar lattice (for high mobility) and its carbons' sp^2 hybridized state (for high carrier density). Such a functionalization mechanism, when conducted in compliance to the needs of semiconductor manufacturing processes will enable graphene's incorporation into diverse applications. Here, we develop a unique eta-6 organometallic approach to functionalize graphene in a vapor-phase process, which retains the structural and electrical properties, while offering chemical sites for interaction and interfacing with other chemical or biochemical systems. In contrast to other functionalization processes, the eta6-functionalized graphene maintained its high charge carrier mobility (1000 $cm^2V^{-1}s^{-1}$ at 300 K). We will discuss the mechanism of charge transfer in eta-6 functionalization of chromium carbonyl on graphene. The chemical groups were utilized for subsequent chemistry via an in-situ formation of silver nanoparticles at functionalization sites. We show that this graphene-eta-6- Ag structure enables an ~11-fold plasmonic enhancement in the efficiency of graphene/n-Si solar cells (1.24%) to exemplify the potential of this functionalization. This process will unveil graphene's previously unknown potential to hierarchically interface with physical and biological components to produce novel systems and applications. Results will also facilitate gate- fabrication for FETs *via* atomic-layer-deposition (currently a major challenge).

Vikas Berry is a Chemical Engineering Professor and Department Head at University of Illinois at Chicago. Dr. Berry has made pioneering contributions in the fields of graphene quantum materials and Bionanotechnologies; and has received several honors, including the NSF-CAREER Award, Sigma Xi Outstanding Junior Scientist Award, Big 12 Fellowship, Prof. Rudolph Marcus Award, and William H. Honstead Professorship. Dr. Berry received his bachelor's degree from the Indian Institute of Technology-Delhi, India, in 1999, master's degree from the University of Kansas in 2003, and a doctorate degree from Virginia Polytechnic Institute and State University in 2006.

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