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Hybridized Graphene Materials

JEREMY ROBINSON, Naval Research Lab

Graphene's high-quality structure and properties continue to motivate intensive research to mold it into the electronic material of the future. Analogous to other electronic materials, however, defects are a tool to engineer graphene's properties and tune its response to various stimuli. In this talk I discuss our efforts to engineer and manipulate defects in hybrid graphene materials for applications ranging from sensing to nanomechanical structures. First, I will present our results using chemically modified graphene to not only improve chemical sensing, but also achieve new functionality for electronic systems. In particular, we hybridize graphene via the addition of fluorine atoms [1] and show the subsequent formation of nanoribbons and tunnel barriers exploiting property changes from the fluorine adsorbates. Second, I will present results on the electronic hybridization of stacked graphene layers, where the moiré pattern formed by the relative twist between layers is responsible for new properties of the bilayer system [2]. Defects specific to this system include rotational disorder, strain, and chemical doping [3]. These defects modify, but do not destroy the strong interlayer coupling. Finally, I will present results on the influence of chemistry and defects on the properties of graphene nanomechanical systems. By measuring the response of high-quality nanomehcanical resonators, we can extract relevant mechanical properties including tension, yield strength, resilience, and modulus as a function of defect introduction [4]. This work is carried out in collaboration with M. Zalalutdinov, P.E. Sheehan, W.-K. Lee, T. Reinecke, S.W. Schmucker, J.C. Culbertson, and A.L. Friedman at Naval Research Laboratory, and T. Ohta, T.E. Beechem and B. Diaconescu at Sandia National Laboratories. [1] Nano Letters 10, 3001 (2010); [2] ACS Nano 7, 637 (2013); [3] ACS Nano 8, 1655 (2014) [4] Nano Letters 12, 4212 (2012)