Preparation and Application of Chemically Functionalized Graphene

Mark C. Hersam
Department of Materials Science and Engineering
Northwestern University
2220 Campus Drive, Evanston, IL 60208-3108
http://www.hersam-group.northwestern.edu/

Graphene has emerged as one of the leading materials in condensed matter physics due to its superlative electrical and mechanical properties. With an eye towards expanding its functionality and applications, this talk will highlight our latest efforts to tailor the surface chemistry of graphene via chemical functionalization [1]. At the molecular scale, we employ ultra-high vacuum (UHV) scanning tunneling microscopy (STM) and conductive atomic force microscopy (cAFM) to characterize chemically modified epitaxial graphene on SiC(0001) [2,3]. For example, a suite of perylene-based molecules form highly ordered self-assembled monolayers (SAMs) on graphene via gas-phase deposition in UHV [4,5]. Due to their noncovalent bonding, these SAMs preserve the superlative electronic properties of the underlying graphene while providing uniform and tailorable chemical functionality [6]. In this manner, disparate materials (e.g., high-*k* gate dielectrics) can be seamlessly integrated with graphene, thus enabling the fabrication of capacitors, transistors, and related electronic/excitonic devices [7]. Alternatively, via aryl diazaonium chemistry, functional polymers can be covalently grafted to graphene [8], while exposure to atomic oxygen in UHV enables chemically homogeneous and thermally reversible epoxy functionalization of graphene [9]. In addition to presenting opportunities for graphene-based chemical and biological sensing, covalent grafting allows local tuning of the electronic properties of the underlying graphene. Beyond UHV STM characterization, this talk will also delineate our most recent efforts to exploit chemically functionalized graphene in technologically significant applications. Specific examples include the utilization of graphene oxide as an interfacial layer in organic photovoltaic devices [10], solution-processed graphene for transparent conductors [11-13] and flexible GHz transistors [14], pluronic-dispersed graphene for *in vivo* biomedical applications [15,16], and graphene-titania nanocomposites as photocatalysts for the production of solar fuels from carbon dioxide [17].

References

[1] Q. H. Wang and M. C. Hersam, *MRS Bulletin*, **36**, 532 (2011).
[2] J. A. Kellar, et al., *Applied Physics Letters*, **96**, 143103 (2010).
[3] J. M. P. Alaboson, et al., *Advanced Materials*, **23**, 2181 (2011).
[4] Q. H. Wang and M. C. Hersam, *Nature Chemistry*, **1**, 206 (2009).
[5] Q. H. Wang and M. C. Hersam, *Nano Letters*, **11**, 589 (2011).
[6] J. D. Emery, et al., *Surface Science*, **605**, 1685 (2011).
[7] J. M. P. Alaboson, et al., *ACS Nano*, **5**, 5223 (2011).
[8] Md. Z. Hossain, et al., *Journal of the American Chemical Society*, **132**, 15399 (2010).
[9] Md. Z. Hossain, et al., *Nature Chemistry*, in press, DOI: 10.1038/nchem.1269 (2012).
[10] I. P. Murray, et al., *Journal of Physical Chemistry Letters*, **2**, 3006 (2011).
[11] A. A. Green and M. C. Hersam, *Journal of Physical Chemistry Letters*, **1**, 544 (2010).
[12] A. A. Green and M. C. Hersam, *Nano Letters*, **9**, 4031 (2009).
[13] Y. T. Liang and M. C. Hersam, *Journal of the American Chemical Society*, **132**, 17661 (2010).
[14] C. Sire, et al., *Nano Letters*, in press, DOI: 10.1021/nl203316r (2012).
[15] M. C. Duch, et al., *Nano Letters*, **11**, 5201 (2011).
[16] J.-W. T. Seo, et al., *Journal of Physical Chemistry Letters*, **2**, 1004 (2011).
[17] Y. T. Liang, et al., *Nano Letters*, **11**, 2865 (2011).