Laboratoire PPSM – UMR CNRS 8531

Photochimie et Photophysique Supramoléculaires et Macromoléculaires

Séminaire du PPSM

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Salle de conférence du Pavillon des Jardins

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Invité par : Fabien Miomandre

«Functionalized Graphene in the Development of Adaptive Materials»

I will present work on the development of adaptive materials. To do so, we focus on pixelated matter with pixels that show functionality either autonomously or when addressed electronically through conducting graphene-filled polymeric leads. To develop electronically conducting and stress/strain sensing polymeric composites,[1] we use functionalized graphene single sheets (FGSs) and piezoelectric fillers not only to impart electronic conduction but also to enhance the mechanical properties of the composites. In the case of metallic or ceramics structures, the coatings of such polymeric composites are used to accomplish the same functionality on the surface as protective coatings. Variations in local current densities generated by stress variations in turn yield mass deposition on the high stress regions to negate the weakening effect generated by the stress.

Functionalized single graphene sheets used in our studies are produced in bulk quantities through the thermal expansion of graphite oxide (GO).[2] Exfoliation to form FGS occurs when the decomposition rate of the epoxy and hydroxyl sites of graphite oxide exceeds the diffusion rate of the evolved gases, yielding pressures that exceed the van der Waals forces binding the graphene sheets.[3,4] To exfoliate, we first increase the c-axis spacing by oxidation to 0.7 nm and eliminate the 0.34 nm graphite interlayer spacing.[3] Comparing the Arrhenius reaction rate to the calculated diffusion coefficient based on Knudsen diffusion suggests a critical temperature of 550 °C for exfoliation.[3] The exfoliated FGSs are wrinkled due to the presence of chemical functional groups and lattice defects[5,6] and thus do not reassemble back to GO. Analysis by AFM shows that over 80% of the exfoliated material consists of single sheets, with average thickness of 1.75 nm. Diameters of the single sheets range between 0.1 to 2.5 µm with an average aspect ratio of ~ 1,000.

One proof-of-concept case study will demonstrate crack healing under cyclic (i.e., fatigue test) loading. The energy source for such a system is either an internal galvanic pair or chargeable battery that may eventually be miniaturized.[7] As cracks form on a protective insulating coating of a metal, local current density fluctuations trigger transport of matter through electrolyte towards the cracks. The basic mechanisms of matter transport are partially understood.

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References

[1] T. Ramanathan, A.A. Abdala, S. Stankovich, D.A. Dikin, M. Herrera-Alonso, R.D. Piner, D.H. Adamson, H.C. Schniepp, X. Chen, R.S. Ruoff, S.T. Nguyen, I.A. Aksay, R.K. Prud'homme, L.C. Brinson , "Functionalized Graphene Sheets for Polymer Nanocomposites, " *Nature Nanotechnology* 3 327-331 (2008).

[2] H.C. Schniepp, J.-L. Li, M.J. McAllister, H. Sai, M. Herrera-Alonso, D.H. Adamson, R.K. Prud'homme, R. Car, D.A. Saville, I.A. Aksay, "Functionalized Single Graphene Sheets Derived from Splitting Graphite Oxide," *J. Phys. Chem. B* 110 8535-39 (2006).

[3] J.-L. Li, K.N. Kudin, M.J. McAllister, R.K. Prud'homme, I.A. Aksay, R. Car, "Oxygen Driven Unzipping of Graphitic Materials," *Phys. Rev. Lett*. 96 176101 1-4 (2006).

[4] M.J. McAllister, J.-L. Li, D.H. Adamson, H.C. Schniepp, A.A. Abdala, M. Herrera-Alonso, D.L. Milius, R. Car, R.K. Prud'homme, I.A. Aksay, "Single Sheet Functionalized Graphene by Oxidation and Thermal Expansion of Graphite," *Chem. Mater*. 19 4396 (2007).

[5] K. N. Kudin, B. Ozbas, H.C. Schniepp, R.K. Prud'homme, I.A. Aksay, R. Car, "Raman Spectra of Graphite Oxide and Graphene Sheets," *Nano Letters* 8 36-41 (2008).

[6] H.C. Schniepp, K.N. Kudin, J.-L. Li, R.K. Prud'homme, R. Car, I.A. Aksay, "Bending Properties of Single Functionalized Graphene Sheets," *ACS Nano* 2 2577-2584 (2008).

[7] D.H. Wang, R. Kou, D.W. Choi, Z.G. Yang, Z.M. Nie, J. Li, L.V. Saraf, D.H. Hu, J.G. Zhang, G.L. Graff, J. Liu, M.A. Pope, I.A. Aksay, "Ternary Self-Assembly of Ordered Metal Oxide-Graphene Nanocomposites for Electrochemical Energy Storage," *ACS Nano* 4 1587-95 (2010).

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