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Materials Science and Engineering

THE 2013 DOW LECTURE

Karen I. Winey

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Tuesday, February 26, 2013
Tech L211, 4:00pm

"Electrical Properties in Polymer Nanocomposites"

Nanoparticles, particularly carbon nanotubes and metal nanowires, provide new routes for engineering the electrical properties of polymers. This lecture will focus on two aspects of this expanding field, namely electrical conductivity and resistive switching. With regard to electrical conductivity, Winey's group has demonstrated the importance of nanotube orientation both via simulation and by melt processing the nanocomposite to align carbon nanotubes and using X-ray scattering to quantify the extent of orientation. To better compare simulations and experimental results, Winey's group has made silver nanowires of well-defined aspect ratios ($L/D < 50$) and the experimental thresholds for electrical percolation compare favorably with both their simulations and analytical models as a function of aspect ratio. Most recently, Winey's group has extended the simulations to polydisperse systems and thin films. The study of electrical percolation in polymer nanocomposites presumes that two states dominate such that below and above the critical concentration the electrical conductivity is dominated by the insulating matrix and by the conductive fillers, respectively. In contrast, Winey and her group have found resistive switching in nanocomposites of silver nanowires and polystyrene, wherein these bulk materials can reversibly transform from high to low resistance as a function of applied voltage. Cyclic voltammetry measurements at 10K are consistent with the hypothesis that applied voltage can form conductive silver filaments between neighboring nanowires. Dynamic electrical properties in bulk polymer nanocomposites may enable new applications for polymer nanocomposites as functional materials.

Biography: Karen I. Winey is Professor of Materials Science and Engineering at the University of Pennsylvania with a secondary appointment in Chemical and Biomolecular Engineering. Winey is also Penn's Director for the Nanotechnology Institute and the Energy Commercialization Institute, which are funded through the Ben Franklin Technology Partnership to promote advanced technologies in the region. Beyond Penn, she serves as an Associate Editor for *Macromolecules*, the premier journal for polymer science. Winey's current interests include both polymer nanocomposites and ion-containing polymers. In nanocomposites, she designs and fabricates polymer nanocomposites containing carbon nanotubes and metal nanowires with the aim of understanding how to improve their mechanical, thermal, and especially electrical conductivity and resistive switching properties. Polymer dynamics in the presence of nanoparticles is also of interest. In ion-containing polymers, including block copolymers and polymers with ionic liquids, Winey combines imaging and scattering methods to provide unprecedented insights into their morphologies. Current efforts focus on correlating nanoscale structures with ion transport properties. In both areas, Winey couples experimental studies with simulation and theory, either within her group or with collaborators.

Winey received here B.S. from Cornell University in materials science and engineering and her Ph.D. in polymer science and engineering from the University of Massachusetts, Amherst. Following a postdoctoral position at AT&T Bell Laboratories, she joined the faculty of the University of Pennsylvania in 1992. Elected positions include chair of the Polymer Physics Gordon Research Conference (2010) and Chair of the Division of Polymer Physics within the American Physical Society (2013). Winey's honors include Fellow of the American Physical Society (2003), a Special Creativity Award from the National Science Foundation (2009-2011), and the 2012 George H. Heilmeier Faculty Award for Excellence in Research.

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