Wednesday, July 10, 2002
3:00 pm
APS Auditorium, Building 402, Argonne National Laboratory
APS Colloquium home

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Direct Assembly of Polymers From the Nanoscopic to Microscopic

Directing the spatial assembly of polymers in thin films mandates controlling the interfacial energies of the components with the underlying substrate or requires the use of external fields to overcome the interfacial interactions. Electric fields have proven to be a very effective means of achieving this end in thin films. Low voltages across a thin film produces high field strengths. Under a field applied normal to the film surface both lamellar and cylindrical microdomains can easily be oriented normal to the surface producing ordered arrays of nanostructures with lateral densities in excess of $10^{11}/cm^2$. Subsequently, standard lithographic processes can be used to produce arrays of nanopores that can be used either as a scaffold in which to grow nanoscopic structures or as a template for transferring the pattern into the substrate. With thin homopolymer films between two electrodes with an air gap, the gradient in the density across the polymer-air interface produces a gradient in the field strength. This translates into an electrostatic pressure which, acting against a Laplace pressure, generates ordered, periodic structure on the micron length scale. In the case of a bilayer, the surface energy is replaced with a much lower interfacial energy and decreases the size scale by at least a factor of five.

Thomas P. Russell received his PhD in 1979 in Polymer Science and Engineering from the University of Massachusetts Amherst. In the following two years he was a Research Fellow at the University of Mainz, Germany. In 1981 he became a Research Staff Member at the IBM Research Laboratories in San Jose, CA In 1986 he joined the faculty of the Polymer Science and Engineering Department at the University of Massachusetts. He is currently the Director of the Materials Research Science and Engineering Center on Polymers, the Director of the Keck Nanostructures Laboratory, and an Associate Editor of Macromolecules. He has been the past-Chair of the Division of Polymer Physics of the American Physical Society, Chairman of the Solid State Science Committee of the National research Council, the Basic Energy Science Advisory Committee of the Department of Energy, and the Spallation Neutron Source at Oak Ridge, TN, and a member of the Program Advisory Committees for the Reactor Radiation Division at the National Institute of Standards and Technology, the Neutron Scattering Center at the Los Alamos National Laboratory, and the National Synchrotron Light Source at the Brookhaven National Laboratory. He currently is a member of the Advisory Committee of the

Intense Pulsed Neutron Source at the Argonne National Laboratory, the Scientific Advsory Committee of the Hyperstructured Organic Materials Research Center at Seoul National University, Korea, the Scientific Advisor of Polynao, a seven nation European Common Market consortium investigating nanoscopic materials and a member of the Advisory Board of the Journal of Polymer Science, Polymer Physics. His research focuses on the surface and interfacial properties of polymers, phase transitions in polymers, directed self-assembly processes, and the use of polymers as scaffolds and templates for the generation of nanoscopic structures. He is a fellow of the American Physical Society and, in 1984, received the A.K.Doolittle Award of the American Chemical Society.