Nanoscale Science and Engineering Center for Directed Assembly of Nanostructures

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The NSF *Nanoscale Science and Engineering Center for Directed Assembly of Nanostructures* (www.nano.rpi.edu) was founded in September 2001 at Rensselaer Polytechnic Institute, the University of Illinois at Urbana-Champaign, and Los Alamos National Laboratory. Our NSEC addresses the fundamental scientific issues underlying the design and synthesis of nanostructured materials, assemblies, and devices with dramatically improved capabilities for many industrial and biomedical applications. Directed assembly is the fundamental gateway to the eventual success of nanotechnology. Therefore, our NSEC strives to discover and develop the means to assemble nanoscale building blocks with unique properties into functional structures under well-controlled, intentionally directed conditions. We combine theory and computational design with experimentation to focus on discovery of novel pathways to assemble functional multiscale nanostructures with junctions and interfaces among structurally, dimensionally, and compositionally different building blocks. Our NSEC integrates research, education, and technology dissemination to serve as a leading national and international resource for fundamental knowledge and applications in nanoscale science and technology. The NSEC *research program* consists of three coordinated interdisciplinary and inter-institutional thrusts.

Thrust 1: Nanoparticle Gels and Polymer Nanocomposites focuses on the synthesis, phase behavior, structure, and assembly of organic and inorganic nanoparticles with homogeneous or heterogeneous surfaces by means of chemical and / or physical control. Its goal is to guide the organization of nanoscale building blocks to create 3-D hierarchical materials with novel properties. We continue to focus on two primary research areas: nanoparticle gels and polymer nanocomposites, which are closely integrated through shared intellectual threads and a highly collaborative and interdisciplinary research team. During the past five years, we have synthesized organic and inorganic nanoscale building blocks with controlled size, composition, and surface functionality, studied the viscoelasticity, phase behavior, and structure of model nanoparticle-polymer mixtures, created 3-D hierarchical structures by means of direct-write assembly of nanoparticle inks, and synthesized, assembled, characterized, and modeled the behavior of polymer nanocomposites.

Thrust 2: Nanostructured Biomolecule Composite Architectures is focused on the incorporation of biological macromolecules into nanocomposite materials to enable specific applications, including directed assembly based on biorecognition and biocatalysis, which impact tissue engineering, biosensing, self-cleaning and self-repair capabilities, and the design of novel lamellar structures. Its goal is to enable the efficient and selective interaction of biomolecules with synthetic nanoscale building blocks to generate functional assemblies. Achieving fundamental understanding, both experimental and computational, of the molecular events that govern biological function and selectivity in nonbiological nanoscale environments is crucial to developing nanostructured biomolecule composite architectures.

Our research team is well positioned at the interface of biological and material sciences, which enables us to integrate our extensive interdisciplinary expertise in biomolecular engineering; nanomaterial preparation, characterization, and functional assembly; and theory and simulation. During the past five years, we have focused on the preparation, fundamental understanding, and potential applications of biomolecule / nanomaterial hybrid composites with tailorable structures and functions.

Thrust 3: Serving Society through Education and Outreach has as its goal to serve society by: (i) raising public science literacy through informal and formal education, and reaching a diverse audience to broaden the technical reach of our NSEC through programs that are carefully designed to integrate nanotechnology research with education, and (ii) enhancing the responsible, safe, and efficient transfer of nanotechnology developments to industry, the primary route through which society can benefit from the fruits of our research. Hence, our continuing vision encompasses research, education, and outreach through interactions with students of all ages and researchers in universities, national laboratories, and industry. We have reached hundreds of people so far, and are on our way to reaching ever-wider segments of society.

Through our industry outreach program, we have already entered into several pre-commercial trials of technology developed in our NSEC laboratories. We are continuing our strong industry interactions, which not only provide a mechanism for transferring technology to benefit society, but also broaden the education of our undergraduate and graduate students. To better understand how technology is used by industry, we initiated a study of socioeconomic impacts that is already providing an understanding of the role of industry, the role of collaborations, and the role of public perception in the development of nanotechnology.

There have been a number of major accomplishments in our NSEC program during 2001-2006. Some examples include: elucidating the structure and properties, as well as 3-D writing, of nanoparticle gels; interfacially tailoring fillers in polymer nanocomposites; discovering a unified relationship between polymer nanocomposite and thin-film thermomechanical behavior; understanding and exploiting protein-nanoparticle-nanomaterial interactions; biomimetic templating; DNAzyme-catalyzed assembly and sensing; and creating the science literacy vehicle *Molecularium*^{TM}, the book *Nanocomposite Science and Technology*, the *Virtual Microscope*, and two business startups based on NSEC technology. Outstanding progress has already been made in research, education, and outreach and we are now poised to continue this progress and to increase our NSF NSEC's positive impact on both science and society over the coming years.