NANOTECHNOLOGY-BASED MATERIALS AND DEVICES FOR BIOMEDICINE

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ABSTRACT

The ability to characterize, manipulate and organize matter at nanoscale offers tremendous opportunities for the creation and utilization of new materials, devices and systems that will greatly benefit biology and medicine. In this talk, I will overview the nanobiotechnology research that is being conducted at the Institute of NanoScience and Engineering, University of Pittsburgh. My presentation will focus on the materials, devices and instrumentations research intended for gaining a fundamental understanding of nanobiostructures and processes and for diagnostic and therapeutic applications in advanced healthcare. Below is a brief illustration of sample projects in this category.

New tools for measurement and manipulation of individual biomolecules have been developed, and are being utilized to understand at the single nucleosome and single chromatin fiber level the interrelationship between biological processes using DNA as a template and the structure and dynamics of chromatin. We are applying several single-molecule approaches such as AFM, magnetic tweezers, optical tweezers and evanescent-field microscopy (single-pair FRET) to native or reconstituted chromatin fibers of different protein compositions. Single-molecule techniques provide the sensitivity to detect and to elucidate small, yet physiologically relevant, changes in chromatin structure and dynamics.

Bacteriophages are viruses of bacteria, and they perform as molecular nanomachines. Every time a phage infects a bacteria cell, it has the opportunity to swap genes with other phages or otherwise mutate to create new genomes. We are investigating the potential for nanobiotechnological applications, such as the utility of the virus capsid, a protein structure that packages and protects the viral DNA, in the molecular manipulation with complex self-assembled structures and the use of phage tape-measure proteins as molecular railroads to move small protein segments from one location to another.

A hierarchical assembly process has been developed to create crystalline colloidal arrays of nanoscale and mesoscale colloidal particles. Monodispersed particles and composite of particles are synthesized and are combined with hydrogel matrices to form materials with nanoscale periodicities, whose transmission and diffraction properties can be controlled by binding of particular chemical species. These materials are being developed into bio-chemical sensors, such as noninvasive monitoring of glucose levels.

A directed self-assembly process has been developed to form ordered nanopore arrays on macroscale (chip to wafer scale) area of foreign substrates. The nanostructured wafers are being investigated as a host or template for variety of nanodevices useful for biomedicine, such as separation and absorbent media, catalytic surface and supports and high-density sensor/probe arrays. Nano-optic technologies are being investigated to develop chip-scale, multifunctional spectroscopic tools that will allow for highly parallel quantification of multiple analytes in a low-cost and low-sample volume format, important for proteomics technology and point-of-care applications.