The Nano/Bio Interface Center

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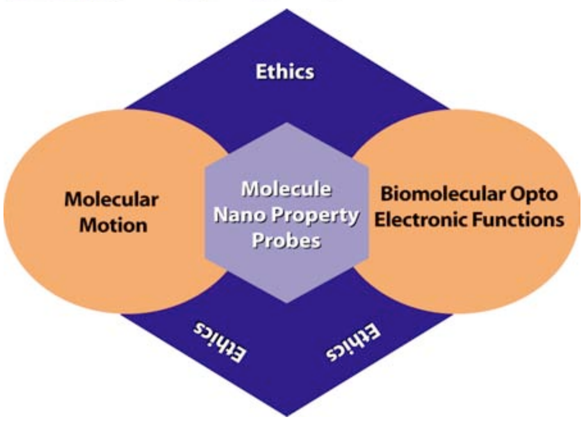
The ***Nano/Bio Interface Center*** at the University of Pennsylvania exploits Penn's strengths in design and control of molecular functionality, quantifying behavior of individual molecules, and interactions at organic/inorganic interfaces to perform research that establishes the foundation for understanding molecular function in the context of interfacing with physical systems. The NBIC unites investigators from three schools (the School of Engineering and Applied Science, the School of Medicine, and the School of Arts and Sciences) to provide, not only new directions for the life sciences but also for engineering, in a two-way flow essential to fully realizing the benefits of the intersection of biology with nanotechnology.

NBIC NANO / BIO INTERFACE CENTER



Two multi disciplinary research teams are focused on aspects of the fundamental issues and two cross cutting initiatives develop ideas integral to all research activities making explicit links between them. The fundamental themes are: optoelectronic function in synthetic biomolecules; and mechanical motion of molecules from physiological systems. Intersecting all three themes is an initiative on development of new probes of molecular/nanostructural behavior. They are specifically forwarding near field optical and fluorescent probes and multiple modulation scanning probes. In addition, an overarching activity concerns the ethical implications of nanotechnology.

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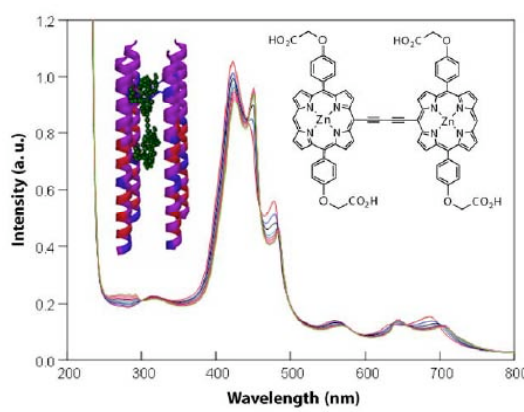
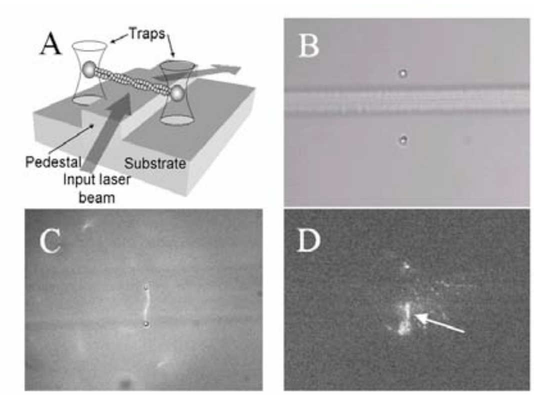
Highlights from 2005/2006



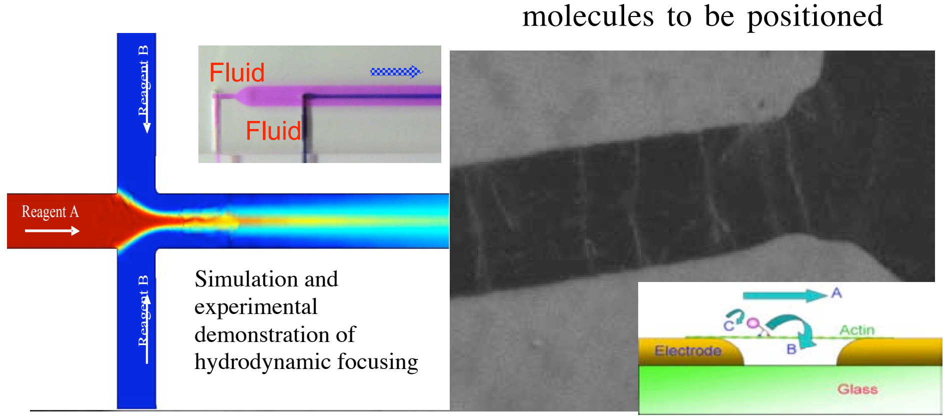
<u>Design of Optically Active Proteins and Properties (J. Saven, K. Blasie, M. Therien, A. T. Johnson, D. Bonnell)</u>

A protein complex that binds specifically to a nonbiological cofactor has been successfully designed and synthesized for the first time. This is made possible by the complete computational design of peptide sequence and structure. Electronic absorption spectrum of the "Zn33Zn" cofactor (inset on right) upon binding to the apo-AP2 peptide. All features above 400nm shift to the red upon peptide binding, a direct result of axial histidyl coordination of only one of the two zinc porphyrins in the cofactor. The left inset shows a model of the cofactor-peptide complex, fully consistent with x-ray scattering and polarized spectroscopic data from the peptide-cofactor complex oriented at the water-air interface.

Single Molecule Investigations in Controlled Environments (H. Bau, H. Hu, Y. Goldman, H. Schuman, J. Schotland)



Two new approaches have been developed to isolate and probe single molecule motor proteins in order to systematically control the test environment. Multi-parameter structural dynamics are being probed simultaneously with optical traps and total internal reflectance (A left). Specialized TIRF microscope objectives have high infrared throughput, making them ideal for combined instrumentation. Optical trap manipulation of cytoskeletal filament, actin, into the evanescent wave of the TIRF microscope (B and C left) demonstrates controllable approach to within 100 nm of the surface**.** Microfluidic devices control positioning of individual actin filaments at pre-determined locations with dielectrophoretic forces and can be combined with FRET, and optical traps. The method allows molecules to be positioned above solid surfaces to explore surface effects (inset right). The devices allow the introduction of various molecules and drugs, controlled alternations of environment, pH, and temperature. Hydrodynamic focusing is used to achieve rapid mixing.



Simulation and experimental demonstration of hydrodynamic focusing

The Nano/Bio Probe Innovation Facility

The Nano/Bio Probe Innovation Facility is located in newly renovated space designed to be a platform for innovating next generation local probes. This unique lab provides immediate access to recently invented techniques by a broader research community; is developing new approaches that combine near field optics with mechanics and opto electronic transport with scanning probes; and is engaging industry to commercialize outcomes.

The Nano/Bio Probe Innovation Facility

The International Nano/Bio Probe Network

The International Nano/Bio Probe Network is nucleated by the NBIC to provide a platform that facilitates advances in the field single molecule and nanostructure probes by: *articulating a global vision of the scientific community, providing a mechanism for junior scientists to rapidly exchange information, enabling routine communications between international collaborators,* *and facilitating international partnering for synergistic research*. Participants are researchers pushing the limits of the scientific advances. Currently 11 participating sites in 5 countries are working to define the network. Though the goal is to facilitate much of this electronically, for example with electronic chat venues, virtual workshops, infrastructure for electronic road mapping activities, etc., a workshop will be held on Jan 16/10 2006 to outline network strategies.

Reaching Out to the Community

In it's first year the NBIC developed and supported several programs designed to inform a wide audience about nanotechnology. A new course on Nanotechnology was offered in the Summer Academy and was the most popular of the program. Twenty-five high school students, including 20 % females, participated in a three-week course that included lectures, workshops, and hands-on lab activities including dielectrophoretic trapping of carbon nanotubes. Eighteen science and math teachers from regional high schools participated in a five-week Penn/Drexel RET program. The demographics of Philadelphia result in a large impact in terms of diversity, 50% female and 44% non causasians participated in 2005. The RET-Nano program introduced basic scientific principles, bioethical implications of nanotechnology, and discussion relating pedagogy and public school curriculum standards.

High school students participate in Nano/Bio labs (above) and NanoDay@Penn (below).

A workshop on nanotechnology and nano/biotechnology was held for print and broadcast journalists on Oct 24, 2005. This activity resulted in at least 6 media reports on nanotechnology including KYW, WHYY, NPR and several newspapers. On October 26th, NanoDay @ Penn offered the local community and high school science classes an opportunity interact with researchers involved in nanoscale research. Over 150 high school students attended as did residents of Philadelphia. Over thirty students displayed their work in a high school science competition. A keynote lecture was given by Horst Stormer of Columbia University emphasized the impact of nanotechnology to society.

References

[1] For further information about this project link to **nanotech.upenn.edu** or email **bonnell@lrsm.upenn.edu**

[2} Ye, S., Discher, B.M., Strzalka, J.W., Xu, T., Wu, S.P., Noy, D., Kuzmenko, I., Gog, T., Therien, M.J., Dutton, P.L. and Blasie, J.K. (2005) Amphiphilic 4-Helix Bundles Designed for Light-Induced Electron Transfer Across Soft Interfaces. *Nano Lett*. 5(9):1658-1667.

[3] Evoy, S. DiLello, N., Deshpande, V., Narayanan, A., Liu, H., Riegelman, M., Martin, R., R., Hailer, B., Bradley, J.-C., Weiss, W., Mayer, T. S., Gogotsi, Y., **Bau, H. H.**, Mallouk, T. E., and Raman, S., 2004, Dielectrophoretic assembly and integration of nanowire devices with functional CMOS operating circuitry, Microelectronic Engineering 75, 31–42.