Yale Institute for Nanoscience and Quantum Engineering

Friday- March 22, 2013

12:00 to 1:00 p.m.

Becton Seminar Room

Light lunch will be served at 11:45 a.m.

Peter Rakich

Department of Applied Physics, Yale University

"Optical Forces and Stimulated Light-Scattering at the Nanoscale"

We explore the impact of sub-wavelength structural control on optical dispersion, optical forces, and optical nonlinearity in nanophotonic systems. Through a general exploration of both Raman and Brillouin interactions, the physics of photon phonon coupling will be explored over a range of length-scales and time-scales. First, THz frequency photon-phonon coupling, through stimulated Raman scattering, will be discussed. We show that the complex dynamics produced by Raman scattering can be harnessed to create wavelength agnostic laser sources spanning mid-IR wavelengths. Additionally, through a fundamental examination of energy and force, we show that optical forces in nanostructured systems radically change the nature of nonlinear interactions. For instance, strong light-boundary interactions yield new forms of Brillouin nonlinearity that produce tailorable coherent phonon emission in nanophotonic systems. Exploiting these strong light-matter interactions, we demonstrate stimulated Brillouin scattering in silicon waveguides for the first time, yielding radically enhanced and tailorable third order nonlinearities.

Xuexin Duan

School of Engineering and Applied Science, Yale University

"Regenerative Nanowire FET Biosensors to Quantify Biomolecular Interactions"

In the last decade, silicon nanowires configured as field effect transistors (Si NW-FETs) have been demonstrated to be capable of detecting a variety of biomolecular interactions below sub-picomolar concentrations. However, most of these sensors can be (practically) used only once, which limited the reproducibility and the performance of the sensors. In this work, we develop regenerative nanowire FET biosensors to quantify biomolecular interactions by using low affinity binding systems and supramolecular sensing interface. First, two representative protein binding systems are reported to demonstrate the versatility of the system. By monitoring the binding kinetics (real-time signal during the protein-receptor association/dissociation cycle), the on/off rate constants and equilibrium binding constant for protein receptor interactions can be determined. To our knowledge, these results are the first time experimental demonstration that Si NW-FETs can be used as high-throughput biosensors to quantify protein interactions. Compared to surface plasmon resonance, the advantage of the approach is sensitivity to small molecular weight proteins. In the second approach, Si NW-FETs were functionalized with β-Cyclodextrin (β-CD), to which receptor moieties can be attached with an orthogonal supramolecular linker. Here we demonstrate full recycling using the strongest biomolecular system known, streptavidin (SAv)-biotin. The bound SAv and the linkers can be selectively removed from the surface through competitive desorption with concentrated β-CD, regenerating the sensor for repeated use. An added advantage of β-CD is the possibility of stereoselective sensors, and we demonstrate here the ability to quantify the enantiomeric composition of chiral targets. The demonstrated regenerative electronic biosensors are very

attractive both from a device performance and economical point of view, since it permits accurate calibration prior to measurements, and repeated use of the same calibrated device.

Host: Mark Reed