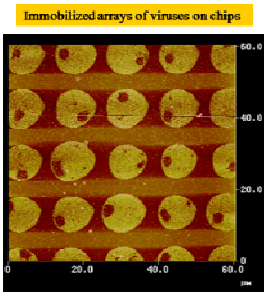
**Altug:** *Laboratory of Integrated Nanophotonics and Biosensing System*




We are working on nano-scale optics and integrated microfluidics to develop ultra-sensitive, real-time, label-free and high-throughput sensing technologies that can detect bio-molecules down to a single virus and proteome analysis from single cell. Nanoscale optical phenomena in resonators are extremely sensitivity to micro-environment. We engineer and use such sensitivity to develop compact, label-free biosensors with dramatically higher detection sensitivities than the current state of the art technologies. By integrating these compact devices in arrays and with microfluidics, we are working on simultaneous detection of multiple agents, which is crucial for proteomics, drug discovery and detection of unknown viruses. Dr. Altug has started collaboration with virologist Dr. John Connor (a fellow Peter Paul Award recipient). She is looking to collaborate with medical researchers who are working on Cancer, Parkinson and Alzheimer diseases and who are interested in using cutting edge technologies for early disease detection.

http://people.bu.edu/altug/index.htm

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**Bigio:** *Biomedical Optics Laboratory*

Develop minimally-invasive diagnostic and therapeutic tools based on optical technologies, including: ***Optical Biopsy***: a tool to measure non-invasively the reflectance spectrum of biological tissues to diagnose diseases such as cancer. ***Optical Pharmacokinetics***: a system that measures drug concentration in tissue in a non-invasive manner. The benefits will be observed in the ability to determine the optimum type and dosage of novel (light activated) chemotherapy drugs, and in the dramatic reduction in the number of animals required for drug studies. ***Sensors*** to monitor the response of tumors to specific treatments. Optical methods for ***noninvasive imaging*** of neural activation and brain function. Optical methods for ***identifying different types of infectious agents***.

http://www.bu.edu/bmo/index.html

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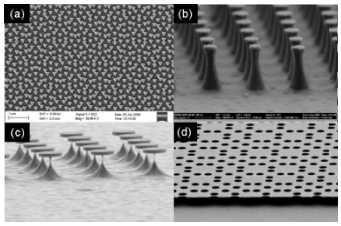
**Dal Negro:** *Nanomaterials and nanostructure optics laboratory: optical label-free biosensing*




To enhance real-time surface enhanced Raman scattering (SERS) detection of single molecules, biochemical agents and bacteria (including pathogenic species such as ***E-coli***, ***Staphylococcus aureus***, etc), we have designed and engineered aperiodic plasmonic arrays of metal nanoparticles. By requring minimal sample preparation, this technology can enable rapid, specific, and completely automated identification of bacteria and provides a unique approach for "whole-organism optical fingerprinting". In addition, we have developed colorimetric scattering bio-sensors based on the control of structural color and multiple light scattering in nano-textured semiconductor surfaces, which can be integrated with microfluidics.

http://www.bu.edu/nano/

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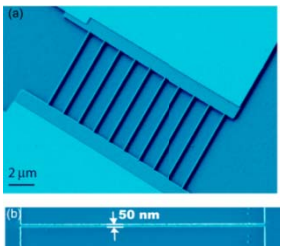
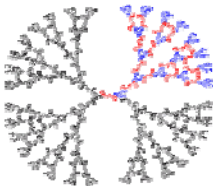
**Erramilli/Mohanty:** *Nanochannel Sensor Arrays for Breast Cancer*




We have developed a novel semiconductor nanochannel sensor capable of detecting specific ions and pH, peptides, proteins and biomarkers. The sensor behaves like a field effect transistor, where the nanochannel conductance is modulated by binding of targeted biomarkers to antibodies functionalized on the surface of the device. Because the signal sensitivity depends on the relative importance of surface effects over bulk conductance contributions, the use of nanoscale sensors is important. The nanochannel sensors have been used to detect selected antibodies and single breast cancer biomarker at clinically relevant concentrations, and can detect CA15.3, a mucin biomarker of metastasis in breast cancer patients. The device combines sensitivity at clinical relevant levels of less than 1 ng/ml, with specificity, and can be integrated into a portable format. Our goal is to build a nanosensor array capable of detecting multiple breast cancer biomarkers to provide patient specific information.

http://nano.bu.edu/

**Grinstaff:** *Macromolecular chemistry and dendrimers*



We pursue highly interdisciplinary research in biomedical engineering and macromolecular chemistry. The major goal in these research projects is to elucidate the underlying fundamental chemistry and engineering principles and to use that insight to direct our creative and scientific efforts. In one of our current research projects, we are designing, synthesizing, and characterizing novel dendrimers, termed "biodendrimers," for tissue engineering and biotechnological applications. We are evaluating these novel biomaterials for the repair of corneal lacerations, for the delivery of anti-cancer drugs, for the delivery of DNA, and as temporary biodegradable scaffolds for cartilage repair. In a second project, we are creating novel polymeric coatings termed "interfacial biomaterials" that control biology on plastic, metal, and ceramic surfaces. In a third project, we are designing electrochemical-based sensors/devices using conducting polymer nanostructures and specific DNA structural motifs.

http://people.bu.edu/mgrin/

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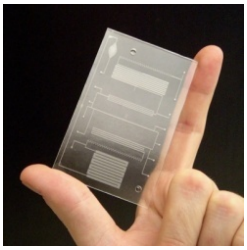
**Klapperich:** *Plastic Microfluidic Chips for Low-cost, Disposable PoC Diagnostics*



We are focused on the design and engineering of manufacturable, disposable microfluidic systems for low-cost point-of-care molecular diagnostics. We are currently working on devices for the detection of infectious diarrhea, influenza and MRSA. We have the capability to extract nucleic acids from mammalian cells, influenza virus, gram-positive and gram-negative bacteria in a miniaturized platform starting from crude samples. We have performed these extractions from human urine, nasopharyngeal washes, stool ultrafiltrate and whole blood.

We are also studying interactions between cells and synthetic microenvironments. Specifically, we are interested in building culture systems in vitro that mechanically mimic the physiological environment. These synthetic microenvironments are intended for use in diagnostics, high throughput drug screening, and to enable previously impossible basic science studies. Currently we have projects aimed at recapitulating the microenvironments of the breast, cochlea and neural tissue.

http://www.klapperichlab.org/

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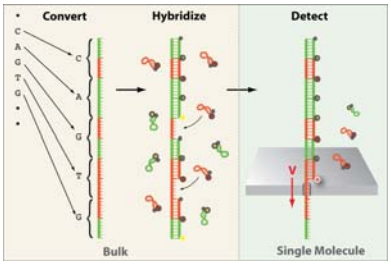
**Meller:** *Ultra Fast DNA Sequencing Using Nanopores and Optical Probes*




We are developing a novel single molecule DNA sequencing technique based on the optical readout of DNA molecule translocations through nanometer scale pores. We first convert the DNA to an expanded, digitized form by systematically substituting every base in the DNA sequence with a specific ordered pair of concatenated oligonucleotides. The converted DNA is hybridized with complementary molecular beacons of two colors. To detect the sequence, nanopores are then used to sequentially unzip the beacons. With each unzipping event a new fluorophore is un-quenched, giving rise to a series of photon flashes in two colors, recorded by a CCD camera. The unzipping process slows down the translocation of the DNA through the pore to a rate compatible with SM optical probing. Extremely high throughput potentially can be achieved since the conversion (performed in bulk), allows parallel processing of millions of different DNA fragments, and the single-molecule nanopore readout can readily employ thousands of nanopores probed simultaneously using a high speed CCD camera.

http://www.bu.edu/meller/index.html

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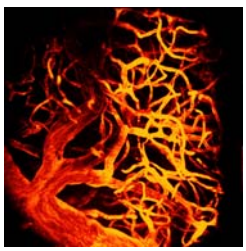
**Mertz:** *Biomicroscopy Lab*



We have developed several imaging techniques for biomicroscopy. Two-photon excited fluorescence (TPEF) microscopy can be used to image thick tissue, and can be combined with other imaging modalities such as optical coherence tomography (OCT) and second-harmonic generation (SHG) microscopy. In collaboration with Bifano (MFG/PHO), a MEMS deformable mirror is being used for background suppression in TPEF imaging. Autoconfocal microscopy is another non-fluorescence imaging technique, based on nonlinear detection, which may be combined with TPEF to monitor calcium dynamics in brain slices of rats. We have also developed

two additional imaging modalities: one obtains phase-gradient contrast using a graded-field configuration, and another called dynamic speckle illumination (DSI) microscopy, which provides confocal-like fluorescence imaging without the use of a scanner.

http://biomicroscopy.bu.edu/

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**Morse:** *Scintillating Nano-cores for Ultra-high Resolution X-ray Imaging*

Diagnosing a number of important medical conditions would be easier and less expensive if X-ray imaging techniques offered improved resolution. Currently, the highest resolution of digital X-ray imaging systems is of the order of 15 μm, resulting in many pathologies being too small to be resolved. Increasing the resolution to 1μm, while keeping the X-ray dose acceptable, will initiate a revolution in medical imaging; the clinical applications are innumerable. For example, in mammography, the resolution of present digital machines is ~50 to 100 μm, with many indeterminate lesions requiring a biopsy (80% of the biopsies reveal a benign condition). With 1 μm technology, it would be possible to better define the morphology of micro-calcifications and significantly reduce the number of biopsies.

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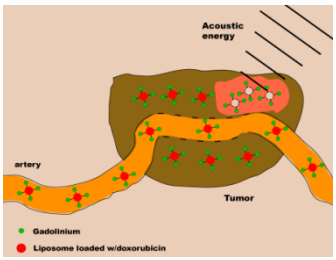
**Porter:** *Paramagnetic ultrasound-triggerable drug carriers for image-guided delivery of chemotherapy*




We have developed novel paramagnetic drug carriers that release their contents in response to ultrasound-induced pressure and temperature changes. These nanosized carriers can extravasate through leaky tumor vasculature and accumulate in the interstitial space. Incorporating gadolinium chelates in the shell allows for monitoring the biodistribution of these carriers with MRI. Clinicians can use MRI to target the carriers collected in the solid tumors with focused ultrasound, and trigger drug release with a high degree of specificity. The combination of MRI and acoustic technology with triggerable drug carriers provides an image-guided platform for localized delivery of chemotherapy, thus maximizing the efficacy of the drug while minimizing systemic toxicities.

http://www.bu.edu/me/people/faculty/pz/porter.html

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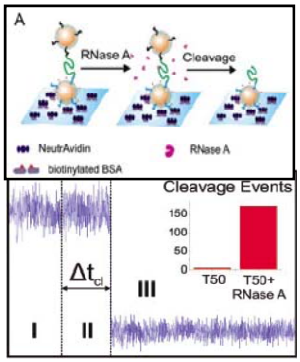
**Reinhard:** *Novel Functional Materials and Single Molecule Biophysics*




We design, implement, and characterizenew tools for imaging and manipulation of "hard" (inorganic) and "soft" (biological) materials. One aim is to produce hybrid materials that combine the interesting electronic/optical properties of inorganic materials with the structural properties of biological materials. We are currently also developing new probes and sensing schemes to characterize the function and dynamics of individual biological molecules and complexes. The ultimate goal of these studies is to generate reliable tools that can grant insight into fundamental biological processes on a single molecule level. We have recently used active nanostructures based on plasmon coupling to monitor the modulation of ribonuclease activity by spermidine and other protein-RNA complexes on the single molecule level.

http://www.bmreinhard.net/

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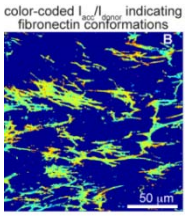
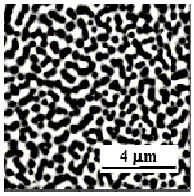
**Smith:** *Mechanotransduction and engineered cell culture platforms for regulating cell behavior in vitro.*




The form and function of cells and tissues is regulated by various properties of their local microenvironment such as rigidity and cell shape. We focus on quantifying the relationship between environmental cues and extra-cellular matrix production, elucidating the mechanisms by which Fibronectin tension and unfolding alters its cell signaling capacity, and engineering culture environments to control the form and function of the ECM. Understanding how these microenvironmental properties regulate cell fate should increase the clinical efficacy of tissue engineering scaffolds that depend upon both biochemical and physical cues. Engineered cell culture platforms might permit long-term maintenance of cell phenotype in vitro, potentially replacing animal experimentation.

**Tsui:** *Atomic Force Microscopy and Nanotribology*




Our interests involve soft condensed matter physics, including dynamics and stability of polymers in nanometer films, as well as the design and fabrication of polymer nano-composite membranes for ion filtration. In my studies, I use atomic force microscopy extensively for dynamic and morphological characterization. As a result, Tsui's research also frequently touches upon nano-mechanics and nanotribology. Recently, we have been focusing on capturing temporally varying events on soft surfaces. Analysis on such data has allowed us to deduce the viscosity (Fig. 1) and dynamic shear modulus of polymer nanometer films, which have not been obtainable with any other mean. We envision that the kind of measurements we do will be able to sense events causing a surface to stiffen or soften.

http://physics.bu.edu/~okctsui/

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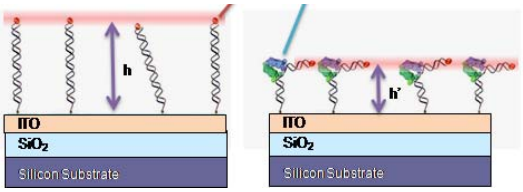
**Ünlü/Goldberg:** *Optical Characterization and Nanophotonics Laboratory*




We are developing technologies to probe biomolecular interactions at the sub-nanometer scale in high-throughput sensing applications. One of our label-free platforms (SRIB) relies on the principles of interferometry and is currently being used to measure macromolecular complex formation such as protein-protein binding, DNA hybridization, and DNA-protein interactions. A second imaging technique, (SSFM) can potentially determine relative changes in molecular orientation with sub-nanometer accuracy. For surface-bound DNA, SSFM has been used to estimate the shape of coiled ssDNA, the average tilt of dsDNA of different lengths, and the amount of hybridization between many different sequences. A third system is capable of in situ synthesis of custom, surface-bound oligomeric DNA strands. Based on UV light-activated chemical synthesis, this system provides the benefits of high-density and large array formatting of thousands of different sequences with simple reagent manipulation and great speed.

http://ultra.bu.edu/

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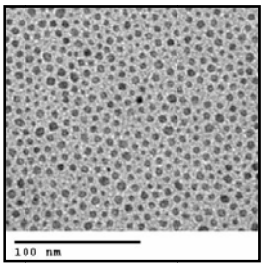
**Wong:** *Biomimetic Materials Engineering Lab*




Dr. Wong's research focuses on the development of biomaterials to probe how structure, material properties and composition of the cell-biomaterial interface affect fundamental cellular processes. Her current research interests include tissue engineering of small diameter blood vessels for bypass and intravascular pharmacology (e.g. stents); development of targeted nano- and micro-particle contrast agents for multi-modal (magnetic resonance, ultrasound, and optical) detection of atherosclerotic and vulnerable plaque; and engineering biomimetic systems to study restenosis and breast cancer.

http://people.bu.edu/wonglab/index.html

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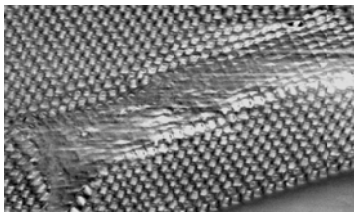
**Zhang:** *Cellular BioMEMS and High-sensitivity MRI*



We are exploring the use of polymeric micro/nanobiosystems to analyze cardiac myocytes and stem cells for cardiovascular research applications. The mechanical force generated by living cells is typically on the order of pN to μN and can be measured by soft material probes such as polydimethylsiloxane (PDMS) and polyacrylamide, due to their mechanical compliance and biocompatibility. We have been using cardiac myocytes and smooth muscle cells as a model to validate our approach; isolated cells have been extensively studied and proven to be invaluable in our understanding of contractile processes in the heart. We have developed a polymer-based system allowing for a simple way to accurately and repeatedly measure the mechanical forces in multiple contracting cells, and yet retain all the capabilities of standard molecular biology manipulation.
We are also developing the micro-engineered structures and devices for high-sensitivity multispectral MRI.

http://people.bu.edu/xinz/