Frontiers of Nanomedicine

Drawing on lessons from materials science and engineering, we’re developing nanoscale devices to provide enhanced observation of critical processes within living cells, enhanced, in vivo imaging of complex biological environments, and ultrasensitive detection of gases and photons. Our research could lead to high-throughput drug development, more accurate disease diagnosis and improved environmental monitoring.

Associate Professor
Xin Zhang (ME, MSE)

Probing Subcellular Forces

To improve our understanding of the behavior of living cells at the subcellular level, we’re pursuing two projects that use nanodevices to study cellular forces in muscle, cardiovascular and stem cells.

To observe small forces within cells, we take both mechanical and electrical measurements. For instance, we are using a biomechanical sensor to observe living cardiovascular cell contraction. We have developed a polymer-based system allowing for a simple way to measure accurately and repeatedly the mechanical forces in multiple contracting cells, and yet retain all the capabilities of standard molecular biology manipulation.

We have also developed an electrical biosensing technique for detecting cellular responses utilizing real-time monitoring of cell adhesion with impedance spectroscopy. We have demonstrated the technique in detecting ongoing cell death processes in cardiac muscle cells, and plan to scale it up to perform high-throughput biosensing for cell biology and pharmacology applications.
Enhancing Imaging and Detection Capabilities

In the imaging and photonics area, we are designing a novel type of nanoparticulate contrast agent that could enable multi-spectral and functional imaging capabilities in MRI applications. Combining the multiplexing capabilities of labeling technologies in optical imaging and the in vivo imaging capability of MRI, our biocompatible magnetic iron oxide nanoparticles could facilitate in vivo imaging of complex biological environments with myriad biomedical applications.

The particle geometry yields distinct spectral properties and allows for diffusion of water through the particle, yielding orders of magnitude signal amplification compared to currently available contrast agents. Our functional MRI contrast agent could also yield more accurate diagnosis and characterization of pathologies ranging from cancer to atherosclerosis.

Finally, we are developing miniature sensors with copper oxide nanowires, which have a brush-like structure that facilitates high-resolution detection of trace amounts of gases and photons. Our preliminary results show that this sensor is highly sensitive to carbon monoxide and other gases. Copper oxide is a very new material for nanowires that’s cheap and easy to manipulate and package into a micro-template targeting gas and photon sensing. Our template could be used for environmental monitoring, medical diagnosis and lab-on-a-chip analytical devices.
Professor Xin Zhang (ME, MSE) observes cellular forces by placing individual cells atop arrays of nanoscale pillars made of soft polymers.