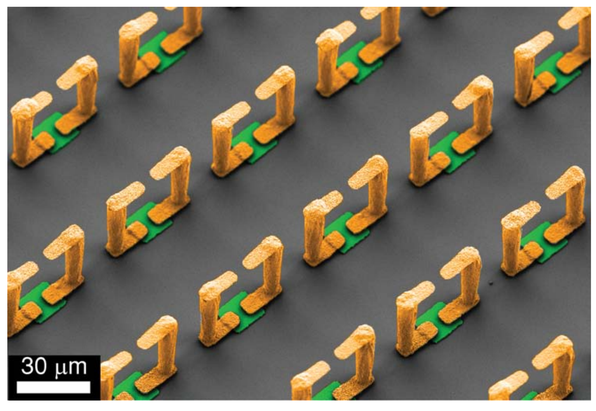
The Laboratory for Microsystems Technology

The Laboratory for Microsystems Technology (LMST), directed by Professor Xin Zhang, is an interdisciplinary laboratory dedicated to research and education programs in the broad area of micro- and nanoelectromechanical systems (MEMS/NEMS) or micro/nanosystems (MNS). Their research includes fundamental and applied aspects of micro/nanosystems. Specifically, they seek to understand and exploit interesting characteristics of micro/nano-scale materials, mechanics, and manufacturing technologies with forward-looking engineering efforts and practical applications ranging from energy to health care to homeland security.



Professor Zhang's research is focused on micro/nanosystems, from their fundamental materials and mechanics aspects through to their application to real world applications. The ultimate success of these technologies hinges both on a rigorous understanding of their underlying principles as well as their development and translation to meet societally relevant challenges. She is therefore deeply interested in this entire spectrum of MNS knowledge and technology development. Furthermore, the intersecting topics of MNS provide a rich milieu for interdisciplinary research, a feature of this work from which she derives much of her passion for its pursuit. She strongly believes that the future of MNS offers unique opportunities in a wide range of applications across a diverse set of scientific disciplines. With a continued focus on the full spectrum of knowledge and technology development, in combination with the ongoing pursuit of cross-disciplinary research at the interface between engineering and science, she seeks to realize the potential of MNS to meet a series of complex global challenges.

Stephan Anderson

"As a Radiologist, my clinical practice includes the sum total of abdominal imaging, with a specific focus on the diagnosis and characterization of chronic and diffuse liver diseases. In close collaboration with Professor Zhang, we are leveraging BioMEMS technologies towards furthering our understanding of the pathophysiologic mechanisms of chronic liver diseases. To this end, we are developing a series of tools which enable the study of the influence of the local cellular microenvironment on cell types which initiate and drive liver disease progression. Specifically, we are tailoring an 'optomechanical' technology combining precisely engineered polymeric cell culture substrates with novel optical readout approaches based on the moiré phenomenon in order to study the influence of physical, mechanical, and chemical features of the microenvironment on cellular force generation, which is of fundamental importance in chronic liver disease. In parallel, we are also measuring the electrical properties of these cells as a function of the local microenvironment; using a technique termed electrical impedance spectroscopy, we are able to measure the influence of the local environment on a range of cellular behaviors and functions in real time. Ultimately, we seek to develop a BioMEMS-enabled toolset in order to allow us to further understand certain aspects of liver disease with an eye towards potentially identifying novel therapeutic approaches to this global healthcare burden."

Huseyin Seren

"In LMST, in collaboration with Professor Richard Averitt (Physics), we apply our micro/nanofabrication experience to create novel, highly functional metamaterial devices and contribute to cutting edge research aimed towards the advancement of terahertz (THz) science and technology. Electromagnetic metamaterials are one of the highest impact research topics of the last decade. They consist of arrays of engineered unit structures that are much smaller than the operation wavelength and act like an artificial atom. These approaches have enabled many exotic materials and applications such as the realization of negative refractive indices and cloaking which are not possible with naturally occurring materials. The THz range, in which wavelengths are on the order of a few hundred microns, lies between the optical and microwave frequencies and has a high potential to be used for imaging, chemical detection, surveillance, and high speed electronic circuits. Using conventional as well as unconventional micro/nanofabrication techniques, we tailor mechanically, electrically, or optically tunable transmissive and reflective THz light modulators, detectors and perfect absorbers on rigid and flexible substrates. Furthermore, we use these approaches to develop and study novel magnetic and nonlinear metamaterials. These devices and studies reveal promising results and, thanks to these advances, we envision that it will be possible see these devices as components of real world applications in the near future."

Xiaoning "Travis" Wang

"My research in LMST focuses primarily on utilizing various engineering techniques to realize size and shape specific micro- and nanoparticles for biomedical imaging/drug delivery applications. The main goal is to improve upon the current limitations of contrast agents in magnetic resonance imaging (MRI) and computed tomography (CT). Specifically, iron oxide micro/nanoparticles with specific geometry and magnetic properties have been fabricated which may bring a multispectral imaging capability to MRI, as well as an enhanced signal to noise ratio and the potential for functional imaging. In order to fabricate size and shape specific nanoparticles for use as CT contrast agents, a scalable nanomanufacturing platform is being developed to achieve cost-effective, high-throughput nanoparticle fabrication. To this end, an anodized aluminum oxide (AAO) template-based pattern transfer, along with a combined photolithography and nanoimprinting technique, is being employed in order to realize the scalable fabrication of hydrogel nanoparticles bearing X-ray attenuating payloads. Another ongoing work in our lab includes the development of biologically-mediated micro/nanomanufacturing strategies using diatoms. Diatoms are incredibly diverse, photosynthetic microalgae contained within a silica exoskeleton which feature a dizzying range of morphologies, from circular to rod-like and myriad imaginable forms in-between. The wide array and intricate morphology of the micro- and nanostructured silica exoskeletons encasing the single-celled diatoms offer a tremendous opportunity for developing biologically-mediated manufacturing strategies."

Xiaoguang Zhao

"In recent years, our lab has established strong collaborations with the oil service industries, including local companies such as Schlumberger-Doll Research and Advanced Energy Consortium (AEC) in the US. One portion of our ongoing work aims to develop a microfluidic platform for wireless and automated interrogation of very small sensors or RFID tags flowing inside microfluidic channels. The project consists of two main parts which include developing a robust wireless communication scheme using miniaturized antennas and developing a microfluidic device that can process a high amount of dust-like sensors for error-free data read-out, programming, and wireless charging. Increasing demand for energy resources requires advanced techniques to increase the efficient recovery of hydrocarbon sources. Besides the improved production efficiency, these advanced techniques will also reduce the environmental hazards inherent in resource extraction. By integrating interrogator antennas inside the microfluidic channels, wireless data read-out from a large number of retrieved sensors may be carried out inside the channels. Moreover, other functions can be added to such a microfluidics platform including reprogramming and recharging of the sensor devices for reuse. Beyond the application to oil and gas extraction, such miniaturized sensors and read-out devices may find other application fields including monitoring of closed-loop fluidic circuits such as hot water-based heat distribution systems, industrial water circulation systems, and hemodialysis equipment."

BOSTON UNIVERSITY