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# In-situ Microscopy in Micro/Nano Science and Engineering


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## ABSTRACT:


A grand challenge in materials science is to design and build a material with desired properties – which might be mechanical, thermal, electrical, magnetic or optical. Nanotechnology provides new paths for achieving this goal, since shrinking the size of a material often unlocks new properties. The burden is to re-measure them and understand the underlying mechanisms at the nanoscale. If we can visualize materials microstructures as we measure their properties, we have a much better chance of understanding the underlying physics. And if we can understand the microstructure-property relationship in detail, it is easier to work out how to actively control it and eventually towards "properties on demand". In-situ microscopy provides simultaneous visualization and measurement and is the perfect tool to study microstructure-property relationship at the nanoscale.

In this talk, I will provide a broad overview about our past and on-going in-situ microscopy research work. In-situ single-domain (like mechanical), multi-domain (like thermo-mechanical) studies and in-situ operations of micro/nano systems will be discussed. I will emphasize how to exploit the size effect to tune microstructures (and hence the properties) of materials. In this work, we adopt an in-situ microscopy approach where the nanoscale specimen is subjected to mechanical stress, temperature and electrical fields inside a transmission electron microscope (TEM). We designed and fabricated a microelectromechanical system with actuators, sensors, heaters and microelectrodes. This solid state 'lab on a chip' allows us to measure mechanical (stress-strain, fracture, and fatigue), thermal and electrical (conductivity) properties. Our work has shown that the mechanical stress, temperature or electrical fields effects on grain size, defect density are not only pronounced at the nanoscale, but also are compounding instead of additive in nature. Or in other words, simultaneously applied stimuli exhibit a synergistic effect to induce unprecedented atomic or defect mobility to enable microstructural changes that are not possible at the bulk scale. This effect may open a new path for time and energy efficient microstructural tuning to actively control the materials properties. I will present case studies of this effect on metallic thin films, carbon nanofibers and two-dimensional materials.


## BIOGRAPHY:

Baoming Wang is a postdoctoral associate in the department of materials science and engineering at MIT. He received his PhD in mechanical engineering from Penn State University, University Park in 2017. His research expertise is on experimental mechanics and physics of nanoscale materials, nanofabrication and in-situ electron microscopy, which he applies on a wide variety of materials and phenomena. Dr. Wang has published over 30 peer-reviewed journal papers and first-authored nearly half of them. He is also an active member of ASME, SES, and MRS.