Materials Science and Engineering Department

Fall Seminar Series

Seeing Becomes Knowing: How Electron Microscopy is Defining our Atomic-Scale View of Structure and Properties in Materials

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11AM-12PM | Hill Seminar Room (LeBow 240)

Over the last two decades, we have witnessed a paradigm change in the way we characterize materials using electron microscopy. This latest revolution in resolution began in the late 1990s with the first successful implementation of an objective lens aberration corrector, which improved the spatial resolution of transmission electron microscopy (TEM) and scanning transmission electron microscopy (STEM) by more than a factor of two to below 50 pm. These developments were followed by faster, more sensitive direct electron (CMOS) detectors, monochromated electron sources for electron spectroscopy, and, most recently, magnetic field-free lenses. As a result of these transformational discoveries, we are now able to study materials with unprecedented resolution, sensitivity, and precision. While spatial and energy resolutions better than 60 pm and 10 meV have been reported, aberration-corrected TEM has also enabled a large variety of in-situ experiments at close to atomic resolution.

In my talk, I will highlight how the TEM instrumentation has evolved over the last two decades, providing state-of-the-art atomic-resolution characterization capabilities for a wide range of materials applications, including novel multivalent ion batteries, thin-film solar cells, novel high-T_c superconductors, and low-dimensional materials. In particular, I will demonstrate how the combination of cryo-STEM and high-resolution electron energy-loss spectroscopy (EELS) has led to the discovery of novel one-dimensional transition metal oxide nanofilaments with intriguing intercalation and optical properties, our recent discovery of novel MXenes, exhibiting surface-group-dependent superconducting behaviors, as well as nickelate-based superconducting bulk and thin-film with unexpected structural features. I will conclude by presenting a vision for the future of electron microscopy, including new instrument designs that will allow for unprecedented imaging and spectroscopy conditions at the sample and will also enable novel operando multimodal methods.

Robert F. Klie is a Professor and Head of the UIC Physics Department. As a scientist, he specializes in Experimental Condensed Matter Physics. He serves as the Director of the *Nanoscale Physics Group*, the Academic Director of the *Electron Microscopy Core Facilities* at the Research Resources Center at UIC, and the co-director of the *UIC Institute for Functional and Regenerative Materials*. Dr. Klie's group uses state-of-the-art transmission electron microscopy to focus on the atomic-resolution characterization of functional and regenerative materials. In recent years, he pioneered novel materials characterization approaches combining solid-state physics with biomaterials and polymer science. Dr. Klie has been awarded numerous grants from the *National Science Foundation* and the *Department of Energy*, including most recently a $4M NSF-MRI grant to purchase a first-of-its-kind scanning transmission electron microscopy that will enable a new level of materials characterization at UIC for next-generation energy-storage/conversion, quantum computing, and superconducting materials. Dr. Klie has published over 240 peer-reviewed papers with more than 12,000 citations with an *h*-index of 54. Overall, Prof. Klie has given more than 100 invited talks at national and international conferences and his scientific achievements have been recognized by prestigious awards, including the *Brookhaven Goldhaber Distinguished Fellowship,* the *NSF CAREER Award,* the *Microscopy Innovation Award* and the *University of Illinois Researcher of the Year* award. He is also a Fellow of the *Microscopy Society of America*.

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