Atomic-Resolution Insights: The Impact of High-Resolution Microscopy on Material Discovery

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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 [1]. 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[2], 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[3], thin-film solar cells[4], novel high-T_c superconductors[5], and two-dimensional materials[6]. In particular, I will demonstrate how the combination of atomic-resolution imaging and spectroscopy has led to the discovery of novel systems for quantum computing, including single-spin systems and novel superconductors 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.

References:

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