Abstract: Nanoscale materials often change structure, morphology, or chemical states, during solution processes, such as, growth, self-assembly, catalysis or other applications. My group develops in-situ liquid phase transmission electron microscopy (TEM) to investigate dynamic materials transformations at the atomic level and to elucidate how atomic scale heterogeneity and fluctuations at solid-liquid interfaces influence the transformation pathways. In this talk, I will highlight some breakthroughs in our ability to capture the atomic level structural and chemical changes of materials in solution processes, which have provided unprecedented opportunities to resolve the underline mechanisms. By tracking single particle growth trajectories our in-situ studies reveal the significance of heterogeneity and defects in the formation of nanoscale materials. Insights garnered from this research have contributed to finding new strategies for controlling nanoscale reactions in synthesis. With the development of novel electrochemical liquid cells, I will present our recent capability in imaging of atomic dynamics at electrified solid-liquid interfaces during electrocatalytic reactions. We track Cu-based catalysts evolution and atomic dynamics of electrified interphases during CO2 reduction reaction (CO2RR). Intermediate structures, mass loss of Cu, and unique transformation pathways of the Cu-based catalysts have been captured. Control experiments have also demonstrated that intermediates can be utilized for enhancing catalytic performance. At the end, I will briefly summarize a set of diverse interesting problems we have been working on by integrating liquid phase TEM, Cryo-EM, and other advanced electron microscopy techniques.