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In-situ and Cryogenic Electron Microscopy for Energy Materials

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Developing new energy materials for batteries, solar cells, catalysts and gas storage requires understanding their structural evolution across multiple length and time scale. Over the past 15 years, the Cui group has been developing a set of electron microscopy tools to realize this purpose including in-situ electrochemical cell, in-situ gas reaction, in-situ mechanical indentation and cryogenic electron microscopy (cryo-EM). In this presentation, he will discuss how these advanced electron microscopy techniques impact energy materials. 1) New generation of battery materials are accompanied by large volume and structure change and instability of interphase. He has developed in-situ electrochemical cells and in-situ mechanical deformation as powerful techniques for establishing the relationship of structural change with electrochemical performance, which provides fundamental guidelines for materials design. Cui has demonstrated the most important case on Si anodes: from fundamental understanding, materials design to realizing commercial success of high energy density batteries. 2) Many energy materials are highly sensitive to environment. Studying their reaction in-situ by environmental electron microscopy could provide insights on reaction mechanisms. Li metal reaction with gases as an important case will be presented. 3) Many energy materials are not stable under electron beam. Advanced cryo-EM recently developed in structure biology could be utilized and further developed for materials science. Cui was the first to demonstrate the cryo-EM towards battery materials and obtained the first atomic resolution images of Li metal and solid electrolyte interphase. With cryo-EM he has answered many important fundamental questions which puzzled the battery field for a long time. He is the first to develop cryo-EM to study a wide range of energy materials including metal-organic frameworks, perovskite and electrocatalysts.