| Berkley: | AHYOUNG KIM | nanoscale luminescent properties of perovskites and other semiconducting materials using cathodoluminescence electron microscopy

| Cambridge: | May Ching LAI | Electron Microscopy of energy materials

# Research Proposal: Investigating Nanoscale Properties of Energy Materials using Electron Microscopy Techniques

## Objective:

The objective of this research proposal is to combine the research interests of May Ching Lai and Ahyoung Kim to investigate the nanoscale properties of energy materials, specifically focusing on cathode materials for lithium-ion batteries and luminescent properties of perovskites and other semiconducting materials. By employing various electron microscopy techniques, this research aims to enhance the understanding of the structural integrity, performance, stability, and reproducibility of these materials, with the ultimate goal of advancing energy storage systems and solar energy technologies.

## Introduction:

The rapid development of cathode materials for lithium-ion batteries has been driven by the demand for high-capacity, long cycle-life, and safe energy storage systems. Li(Ni0.8Mn0.1Co0.1)O2 has emerged as a promising cathode material. However, mechanical integrity issues such as particle cracking have been identified as a significant factor limiting long-term cycle stability. To address this, the combination of various electron microscopy techniques can provide valuable insights into the properties of cathode materials at the nanoscale. Understanding the structural characteristics and performance limitations is crucial for the advancement of electric vehicles.

## Methodology:

Collaborating with battery cell synthesizers and cyclers, May Ching Lai will utilize a focused ion beam-scanning electron microscope (FIB-SEM) to prepare thin lamellae for transmission electron microscope (TEM) studies. FIB-SEM tomography will be performed, and 3-dimensional models will be generated using Dragonfly software. To evaluate the distribution of transition metals, energy dispersive X-ray analysis and electron energy loss spectroscopy will be employed. Additionally, diffraction pattern analysis and high-resolution TEM imaging will provide information on crystal structure, strain, and cracking of the cathode material. The collected TEM data will be analyzed using the Hyperspy Python library for multidimensional data analysis.

Similarly, Ahyoung Kim's research focuses on investigating the nanoscale luminescent properties of perovskites and other semiconducting materials using cathodoluminescence electron microscopy. Perovskites have shown great potential for enhancing light-to-electricity conversion efficiency and reducing the cost of solar energy technologies. However, their low stability and limited understanding of local heterogeneities hinder practical applications. To address these challenges, Ahyoung's research involves examining the dynamic luminescent phenomena of hybrid perovskites in the presence of heat and light using in situ cathodoluminescence electron microscopy imaging. This approach aims to establish correlations between chemical structure, morphology, and light emission properties at the nanoscale, thereby facilitating the development of next-generation perovskites with improved performance, stability, and reproducibility.

## Conclusion:

By combining the research interests of May Ching Lai and Ahyoung Kim, this research proposal aims to utilize electron microscopy techniques to investigate the nanoscale properties of energy materials. The proposed research will enhance the understanding of the structural integrity, performance, stability, and reproducibility of cathode materials for lithium-ion batteries and luminescent properties of perovskites and other semiconducting materials. The findings will contribute to the development of advanced energy storage systems and solar energy technologies, furthering progress towards a sustainable energy system and net-zero goals.