Operando Microscopy Technique Reveal Ion Diffusion in Single Two-Dimensional Nanoparticles

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"MXene materials stand at the forefront of energy storage innovation due to their exceptional electrical conductivity and mechanical properties, making them ideal for next-generation batteries and supercapacitors. Their unique two-dimensional structures offer large surface areas and abundant active sites for ion intercalation, which is crucial for high-capacity energy storage. Recognizing their potential, this pioneering study utilizes state-of-the-art operando microscopy to decode the behavior of ion diffusion within single and few-layer MXene nanostructures down to the level of individual nanoparticles (Fig. 1). The research delivers an in-depth analysis of the dynamics of ion transport and charge transfer, shaped by variables such as ion size, hydrophilicity, and the nature of the solvent used. The deployment of non-invasive operando microscopy for live tracking has shed light on the influence of these variables on ion mobility within MXene frameworks. Notably, the research has identified how ion diffusion contributes to power density at the nanoparticle level, thus enhancing our ability to precisely measure the boundaries of charge transport in MXene films. These breakthroughs are vital for the advancement of energy storage technologies, providing a clearer understanding of ion movement at the nanoscale and its implications for the efficacy of high-performance materials. This investigation lays the groundwork for future enhancements in energy storage devices, suggesting that fine-tuning ion transport could markedly elevate power density and efficiency."

References

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Figures

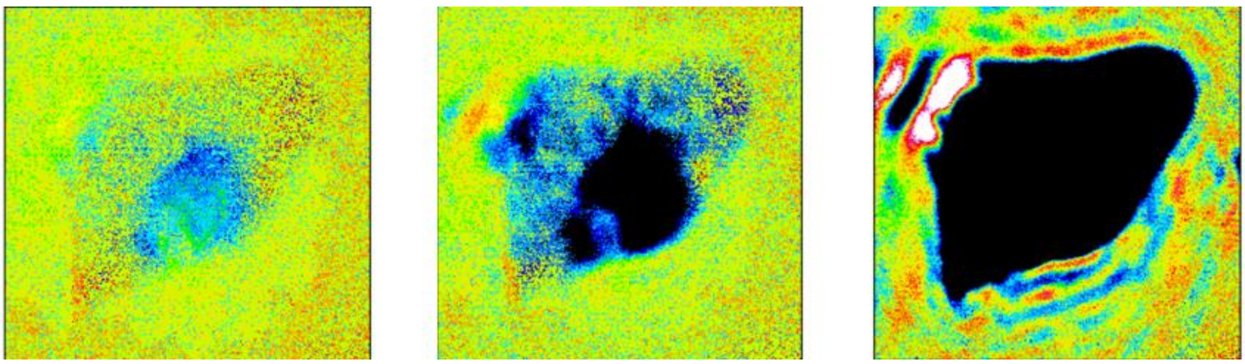

Figure 1. Progressive stages of ion diffusion in a single MXene nanoparticle observed under operando conditions, depicted in a sequence from left to right.