Imaging Dynamic Motion of Atomic Species at Solid Liquid Interfaces

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Atomic structure of surfaces and interfaces is key to the performance of 2D materials and their heterostructures including for exploring new optoelectronic phenomena and quantum behavior. The mobility of atomic species on 2D materials determines their functionality for applications such as electrodes, membranes and catalysts. We report the use of scanning transmission electron microscopy (STEM) techniques for analysing the local atomic structure of 2D materials. We have investigated transition metal dichalcogenide (TMD) heterostructures when combined at small twist angle, to reveal unusual lattice reconstruction and strong piezoelectric textures [1], which can be engineered by the application of applied field in the electron microscope [2]. Complementing imaging with scanning local diffraction analysis (4D STEM) and elemental mapping by energy dispersive x-ray spectroscopy (EDS) allows further investigation of larger scale atomic structure variations in 2D materials, including local variability in intercalated TMD structures and how this evolves during deintercalation as a function of time and annealing temperature [3]. Additionally, I will discuss the use of 2D heterostructure liquid cells [4] for uncovering the dynamics of atomic species on the surfaces of 2D materials [5] where advanced image processing is being applied to allow quantitative understanding of atomic behaviour with statistically significant data sets of >100000 individual STEM measurements.

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[3] S. Shao et al, *Advanced Functional Materials* **33**, 2214390 (2023).
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[5] N. Clark et al, *Nature* **609**, 942 (2022).