Harnessing the structural modulations in van der Waals heterostructures by 4D-STEM nanodiffraction

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The physical properties of two-dimensional materials are highly sensitive to structural distortions such as ripplings or corrugations that produce large strain fields. These effects can be enhanced in van der Waals heterostructures, such as the naturally occurring franckeite, in which the mismatch between its constituent pseudohexagonal and pseudotetragonal two-dimensional layers gives rise to a spontaneous rippling that is responsible for a strong anisotropy of the electrical, vibrational, and optical properties of the material [1]. Moreover, small variations in the multilayered structure and composition of this material can give rise to a strong topological insulator phase [2]. Understanding the complex structure of such materials, specially in its 2D state, is thus of high interest due to their potential applications in new electronic and optoelectronic devices. Here we show how four-dimensional scanning transmission electron microscopy (4D-STEM) nanodiffraction allow us to map the local structural modulations occurring in the van der Waals heterostructure Franckeite and characterize the strong strain fields arising from a 3D structural rippling. We measure a full 2D image of the transmitted electron beam, or a convergent beam electron diffraction pattern (CBED) as the electron beam is raster scanned over a 2D grid of probe positions in real space, as schematized in Fig. 1, and gather new information about the spontaneous rippling and strain modulations in this material. 4D-STEM brings thus a new pathway to study the structural and physical properties of 2D materials and heterostructures.

References

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Figures

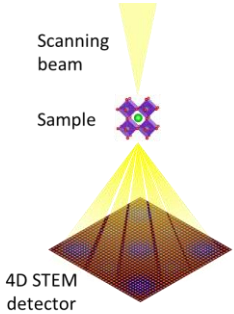

Figure 1: Schematic of a four-dimensional scanning transmission electron microscopy dataset showing the convergent beam electron diffraction patterns acquired as the probe is raster scanned across a 35×35 grid to image a $SrTiO_3$ unit cell in the [001] orientation.

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