Mapping structural information in 2D materials using 4D-STEM

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The 2D materials have attracted a huge scientific interest owing to their reduced dimensionality as well as the predicted properties interesting for the applications in electronics, optics and spintronics [1-3]. However, the synthesized materials often contain inevitable structural anomalies that induce the deviation from the theoretically predicted properties. The knowledge about the structural defects in these materials is thus essential for the understanding of growth mechanisms as well as for the insight into the properties of the synthesized materials.

Up to now, the structural information of the synthesized materials has been most often assessed by means of cm-scale grazing incidence X-ray diffraction giving statistical information about crystal quality or nm-scale aberration-corrected (scanning) transmission electron microscopy giving access to high resolution imaging of atomic defects. Recently, a new imaging technique called 4-dimensional scanning transmission electron microscopy (4D-STEM) has been demonstrated where a 2D diffraction pattern in reciprocal space is captured at each 2D real space electron beam position [4]. The generated 4D datasets contain a huge amount (~GB) of information that can be processed in order to reconstruct micrometer scale real space 2D images of relevant crystal information.

In this work we demonstrate the use of 4D-STEM for the large scale imaging of crystal orientation, polar direction, crystal polymorphs or twist angle for the layered systems synthesized by different growth processes. By carefully selecting the diffraction spots in reciprocal space, specific crystal information can be targeted and retrieved in form of a reconstructed 2D image. Contrary to the x-ray diffraction, the information obtained by 4D-STEM is spatially and quantitatively resolved allowing for the imaging of the distribution of misoriented and/or polar inverted domains, crystal phases and stacked layers. In this way, the spatial distribution of associated crystal defects such as grain boundaries as well as heterojunction interfaces can be imaged and the full structural information on large scale materials is obtained [5].

References

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