Importance of Phase Domains in Complex Materials

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Phase domains are an important, but subtle, kind of disorder has been revealed in a wide variety of crystalline materials. They are revealed by phase sensitive imaging techniques, such as coherent diffraction methods, which see small regions spatially shifted with respect to each other by fractions of a unit cell, while preserving their angular orientations. The domain walls of such structures have translational lattice offsets and zero rotation angle. We refer to these as phase domains because they appear with different phases in the complex electron density maps generated by Bragg Coherent Diffraction Imaging (BCDI) and Bragg Ptychography methods. Phase domains are invisible in ordinary diffraction experiments, except as a broadening of the diffraction peaks, which is not explained by traditional mosaic models. They can be detected in lattice imaging by transmission electron microscopy (TEM) through the Geometric Phase Analysis (GPA) approach. Because of the inherent symmetry of phase domain structures, the inversion of their diffraction patterns to images using phase retrieval methods is particularly challenging. The existence of phase domains appears to be fairly common in complex oxides and is possibly associated with chemical disorder, and it may be enhanced in so-called "high entropy" formulations of materials. The wall structures between such phase domains may be responsible for anomalous physical properties of complex oxides, such as magnetoresistance or ion conduction. In this talk, I will present Bragg Ptychography results on the spin-ordered domains of $La_{2-x}Sr_xNiO_4$ nickelate and BCDI results on solid-state electrolyte materials.