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IT-2-P-2932 Complementary Nature of Microscopy Techniques for Understanding Materials Phenomena

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Advent of nanotechnology over last couple of decades has not only reduced the size of basic building block of materials by several orders of magnitude, complexity of materials architecture and chemistry has also increased enormously. In such a scenario, judicious application of suitable microscopy technique can only provide answer to a particular question. Even though, resolution limits, capabilities and instrumentation of microscopes have improved to a large extent, relatively older techniques even today are found to be equally relevant. In this paper, relative merits of several microscopy techniques will be compared with reference to materials problems encountered in our laboratory.
Understanding anti phase domain boundaries in polar crystals has been a major challenge. Till date, all the interface models for APB are based on (10-10) interfaces. However, anti phase domains apart from this interfaces and complex interaction of these interfaces with other defects are observed very frequently. It is almost impossible to suitably image such boundaries at atomic resolution as crystallography of the interfaces is not known. Diffraction contrast imaging is probably the starting point for understanding APB in polar crystals. In case of phase contrast microscopy the contrast is generated by the interaction of specimen potential with the incident e^- wave which is further modified with the instrument CTF. Whereas, during STEM a very fine e^- probe scans over the atomic columns and during scanning either electron energy-loss spectra or the X-ray signal is used to understand the chemistry. A number of complex oxides have been studied by this method. During incoherent imaging of complex oxides, heavier cations act as strong scattering centers while the relatively lighter oxygen anions scatter weakly. So the image contrast is mostly dominated by the scattering from the cations. The structural imaging of complex intermetallics e.g. V-doped $TiCr_2$ Laves phase is quite different in nature from the complex oxides. The atomic numbers of V, Ti and Cr are pretty close and all of them will scatter almost equally. As a result differential contrast as is generated in a complex oxide will not happen for V-doped $TiCr_2$ phase. Zero loss phase contrast microscopy with image simulation has been proven useful for structural imaging of Ti and Cr atomic columns and also providing V occupancy information.
Though all of these techniques fetch the materials information at the atomistic scale, still each one of them is unique by electro-optical configuration and interaction with the materials. In another words all of these techniques are complementary to each other and only a combination of all of these techniques can provide the complete solution of the materials related issues.

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