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Microstructure and Phase Analyses in TEM

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Abstract

Metallurgy, engineering and material science critically rely on the knowledge of the microstructure – property interconnections in a material. Assessment of the required microstructural state of the material is the starting point of material design and is the backbone of any structural alloy development. Structural materials must fulfill narrow performance criteria and therefore have to possess a well-tuned and stable microstructural state. The study of the microstructure evolution during material production and processing, knowledge of factors affecting the microstructure stability upon changing the external conditions and against wear are very essential parts of the material development. Therefore, the understanding of the underlying principles governing the microstructure evolution is the key to the microstructure control.

Electron microscopy, especially transmission electron microscopy, presents the most powerful tool for the complex microstructure studies. It is the only technique that enables the direct correlation of the structure information obtained by electron diffraction analyses, the whole range of coherent and incoherent imaging modes using parallel (TEM) and conical (STEM) illuminations and the atomic resolution analytical studies employing energy-dispersive X-ray and electron energy loss spectroscopies at the same area of the specimen!

The goal of the lecture is to show how the combination of the TEM & STEM operation modes can be used to tackle a few of most frequent tasks for TEM: phase configurations in the specimen; lattice defects and texture analyses, crystallography and kinetics of the interfacial reactions; etc. The lecture is divided in the three parts: (i) the fundamentals of the conventional TEM (CTEM) which requires deep understanding of the intrinsic connection between the reciprocal (diffraction pattern) and real (image) spaces information complemented by the contrast mechanisms of the low- (LAADF) and high- angle dark field (HAADF) imaging in STEM; (ii) high resolution TEM and STEM imaging used for nano-scale analyses of boundaries, interfaces and planar defects; (iii) elemental content distribution analyses to complete the full scale phase analysis of the material state.

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