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Energy-filtered Transmission Electron Microscopy of Materials

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Elemental mapping with core-loss electrons by energy-filtered transmission electron microscopy (EFTEM) has emerged as a powerful characterization technique in materials science. At the ORNL SHaRE User Facility the emphasis has been on developing and optimizing techniques for quantitative mapping and profiling at ~1nm resolution, especially for applications to segregation at interfaces. Most of the work has been performed with a Gatan imaging filter (GIF) interfaced to a 300 kV LaB_6 Philips CM30T. Optimum experimental conditions require a sound knowledge of electron energy-loss spectrometry (EELS) and digital image processing; extensive experimentation has refined the trade-offs among chromatic-aberration-limited resolution, specimen drift, signal strength, and signal-to-background. Modified procedures for data processing, treating such critical issues as image alignment, edge overlap, and the minimization of diffraction contrast effects and thickness variations, have also been developed. In the spectroscopy mode of the GIF, spatial information can be retained normal to the energy dispersion direction. With a slit in the GIF entrance aperture, spectrum lines (profiles) at ~1nm resolution can be acquired with TEM illumination conditions. The technique is particularly useful for the measurement of energy-loss fine-structure across planar interfaces, yielding information on changes in chemical bonding.

Topics that will be covered include introductory concepts, typical experimental procedures for qualitative and quantitative composition mapping, sensitivity and limitations in elemental mapping, and mapping chemical bonding information from EELS fine structure in one and two dimensions. Illustrative examples will be drawn from research at ORNL, mostly performed in collaboration with SHaRE participants, and will include materials such as stainless steels, superalloys, liquid-phase sintered silicon nitride composites, cobalt-based thin-film magnetic recording media, transition-metal oxides, and diamond-like carbon.

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