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In Situ Materials Characterization across Atomic and Microstructure Lengthscales

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Advanced materials exhibit complex, hierarchical, and multiscale microstructures that control their performance. Today, optimization of these microstructures requires iterative, ex situ studies using multiple independent instruments with different samples. To address many of the grand challenges facing the material research community, it is desirable to correlate material performance under realistic processing and operating conditions with in situ characterization of material structures across atomic and microstructural length scales. To meet this need, we have made progress in recent years in developing a suite of materials-measurement techniques that combines ultra-small angle X-ray scattering, small-angle X-ray scattering, X-ray diffraction, X-ray photon correlation spectroscopy, and X-ray imaging. When making use of high energy x rays from a third generation synchrotron source, this combined suite of techniques not only enables investigation of thick, complex materials under real operating/ processing conditions, but also allows robust structural characterization over 7 decades of structural and microstructural feature sizes, from sub-angstrom to millimeters. Depending on the scattering characteristics of the material, it can cover an unprecedented 11 decades in scattering intensity. This arrangement also allows the combination of measurement techniques be determined solely by the user's needs, allowing an unparalleled flexibility in addressing any set of microstructure, structure and dynamics material-measurement requirements. In this presentation, we will focus on various considerations required to make this combined technique possible, and use data from a series of in situ studies of aluminum alloys as examples to demonstrate the unique capability of this instrument. We will also discuss the potential impact that multi-bend achromat lattice, a concept being embraced by the worldwide synchrotron community, has on this technique.

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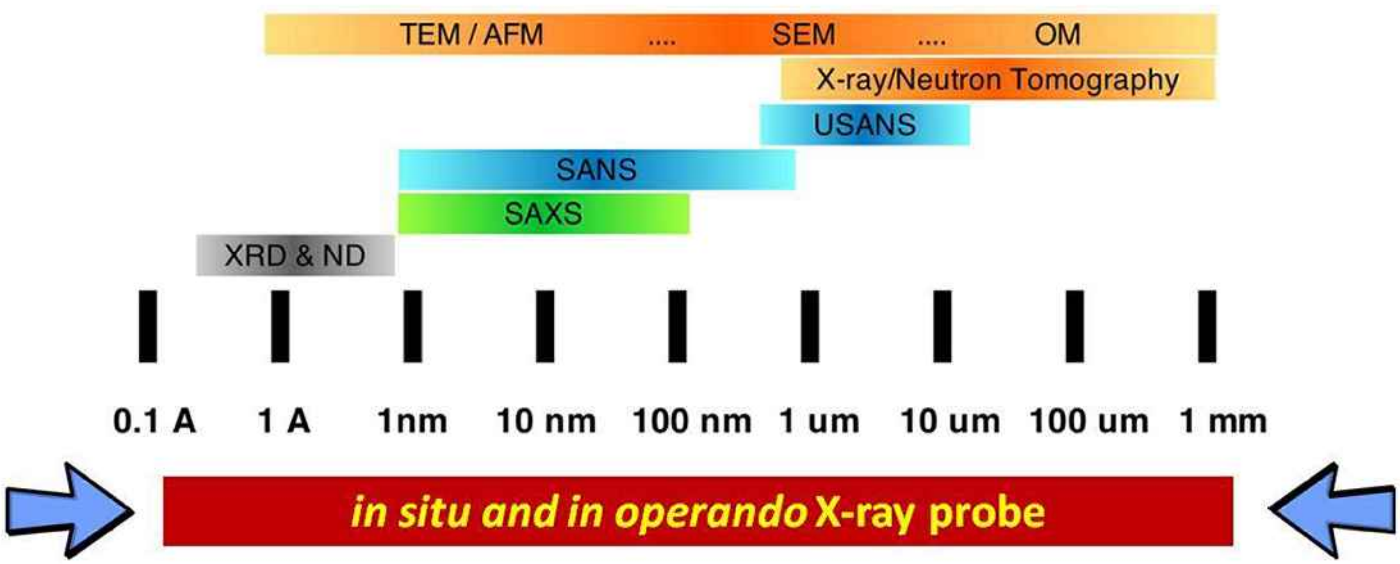

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