A method for determination of 2nd rank strain tensor from nanocrystalline diffraction data and its application to micromechanical deformation

When a material is subjected to an external load, the resultant mechanical deformation is a complex three-dimensional response function best captured by a second rank strain tensor. Further the resultant deformation comprises of several micromechanical modes. Traditionally these modes are classified as reversible (elastic) or irreversible (plastic), but in fact there are several more subclasses of micromechanical deformation and to understand the mechanical response of an advance material (such as superelastic NiTinol) it is often necessary to better understand the partitioning of the global (macromechanical) deformation into its constituent micromechanical modes.

The 3D local mechanical response of a component under external load can be visualized as an ellipsoidal distortion of a spherical surface centered at that point. The local strain in any direction is then measured as deviation from sphericity. Traditional strain measurements, which depend on measuring the deformation of an externally applied 1 or 2D gage, can only sample a limited portion of the strain ellipsoid. In addition, the spatial resolution of these measurements is several mm and it is impossible to distinguish between the different modes of deformation.

A technique of obtaining the deviatoric portion of the 2^{nd} rank strain tensor from white beam laue diffraction is well established when the crystallite size of the material is comparable or larger than the beam size. But because of extreme difficulty in obtaining a nanometer beam size with sufficient flux this technique fails for nanocrystalline materials. In here, we will show a multiwavelength focused beam x-ray powder diffraction technique using an area detector that overcomes all of the shortcomings of traditional strain determination in nanomaterials and yields the full (deviatoric + hydrostatic) 2^{nd} rank strain tensor.

In the second part of this talk we will apply this technique to obtain insight on several interesting issues in micromechanics, including the role of the first order phase transition in superelastic NiTi and remnant crystallographic elastic anisotropy in nanocrystalline metals.