Deformation mechanisms in amorphous and nanocrystalline metals measured by in situ X-ray diffraction

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Amorphous and nanocrystalline alloys exhibit significantly different mechanical behavior than their coarse-grained counterparts due to their disordered atomic structures. While bulk mechanical tests are useful for characterizing the alloy's mechanical properties, these tests provide limited information regarding their plasticity mechanisms and structural aspects of deformation. By combining the high-energy, high-intensity X-rays of 3rd generation synchrotron sources with rapid-acquisition area detectors, the atomic-scale and micromechanical deformation behavior of engineering materials can be measured in situ over a wide-range of strain-rates. We have examined the deformation behavior of both amorphous and nanocrystalline alloys subject to uniaxial loading. For the nanocrystalline alloys, we have investigated the dependence of the deformation mechanisms on both the strain and strain-rate. Results for fcc and hcp metals as well as nanocrystalline-amorphous composites are presented. The role of dislocation-mediated plasticity during deformation is discussed. For the amorphous metal alloys, we find that changes in the average bond length and structural order can be readily measured during homogeneous plastic deformation. The results are correlated with phenomenological models of plastic deformation in metallic glasses.