**Medium-range order of amorphous CuZr-crystalline Cu composites studied by correlated HAADF and nano-beam diffraction**

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Amorphous metals show outstanding strength, and lack ductility. In contrast to crystalline matter, amorphous phases typically deform by localized shear events, often denoted as shear bands. In several metallic systems previous experiments and molecular dynamic (MD) simulations indicate structural changes. However, in binary and metallic amorphous systems experimental evidence of structural changes in shear bands is still missing. MD simulations of CuZr indicate only subtle structural differences between shear bands and surrounding matrix.

In the present work, a multilayered compound of amorphous CuZr and crystalline Cu was processed by sputtering and plastic deformation was induced by cold rolling. Undeformed and deformed states were analyzed using conventional TEM and STEM including HAADF. Additionally, ensembles of nano-beam diffraction pattern (NBDP) and energy dispersive X-ray (EDX) spectra were recorded with a nanometer probe size and comparable small convergence angles. The NBDP were analyzed according to fluctuation electron microscopy (FEM), by plotting the normalized intensity variance as a function of the diffraction angle at a given probe size. By shear offsets, visible in the Cu layers, the position of shear bands in the amorphous CuZr layers can be identified in cross sectional FIB samples. However, no contrast differences between shear band and matrix could be detected in bright-fields, dark-fields and selected area diffraction pattern. However, the FEM data show structural changes in the medium range order of the deformed amorphous phase. Since experimental and simulated HAADF shows no contrast variation between shear band and matrix, it is concluded that the density and chemistry does not change in a shear band. The FEM characteristics that was locally correlated to the HAADF must therefore stem from topological rearrangements of atoms in the medium range order of the CuZr system. The results are also discussed in comparison with MD simulations and corresponding multislice image simulations.