DFXM Mapping of Strain and Mosaicity in TiN and Cu Grains: Resolving Annealing-Induced Intergranular Changes in Ceramics and Metals

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Dark-field X-ray microscopy (DFXM) provides a unique opportunity to resolve simultaneously residual strain and mosaicity gradients across individual grains with unprecedented resolution. In this contribution, the methodology was applied to study properties of embedded ceramic and metallic thin film grains in order to resolve internal gradual microstructure.
In the first experiment, about 20 µm large TiC and TiN particles embedded in a steel matrix were analysed in as-casted and annealed state. The results document gradual crystallographic orientation changes across the particles and the presence of sub-grains, in contrast to electron backscatter diffraction data. These orientation gradients appeared, however, not directly correlated with the observed strain gradients, which were attributed mainly to the different strain states within particles' interiors and envelopes [1].
In the second study, as-deposited and thermally cycled Cu thin films on Si(100) substrates were characterized using DFXM. The aim was to resolve how the cross-sectional gradients of in-plane stresses and mosaicity within individual grains correlate with the thermal history of the chips designed for the experiment. Interestingly, the results revealed a stepwise sub-grain and grain boundary formation within the cycled grains. The thermal fatigue results in the fragmentation of the soft Cu grains and in formation of grain boundaries, voids and pile-ups. DFXM was able to quantify strain and mosaicity changes, which accompany these processes.

References

[1] K. Hlushko, J. Keckes, G. Ressel, J. Pörnbacher, W. Ecker, M. Kutsal, P.K. Cook, C. Detlefs, C. Yildirim, Dark-field X-ray microscopy reveals mosaicity and strain gradients across sub-surface TiC and TiN particles in steel matrix composites, Scr. Mater. 187 (2020) 402–406.