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[1] Van Swygenhoven, H.& Van Petegem, S. Materials Characterization 78 (2013) 47. [2] Grilli, N et al. under review [3] Mekala, S. et al. Philos. Mag. 91 (2011) 908. [4] Sun, Z. et al. Acta Materialia 91 (2015) 91.

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## IN-SITU MECHANICAL TESTING AT THE SYNCHROTRON

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A major challenge in metallurgy is to understand the relation between the microstructure of a metal and its behaviour under an applied load or temperature. This requires a detailed characterization of the evolution of the microstructure at different length scales through the determination of the crystal structure, defect density, grain size distribution, texture etc.

During last decade in-situ mechanical testing under synchrotron radiation has become a widespread tool to investigate the evolution of the microstructure of single and polycrystals during deformation [1]. Many such in-situ deformation tests are performed during continuous or interrupted uniaxial tensile and/or compression tests. Several microstructural properties such as the development of intergranular elastic strains and texture evolution can be directly compared with results from, for instance, molecular dynamics simulations or crystal plasticity modeling. While such tests have proven to be very useful, for further refinement of existing models it is crucial to obtain information from other, more complex deformation tests.

In this work we highlight three such tests recently performed at the Swiss Light Source: (1) in-situ cyclic fatigue of Cu single crystals under shear conditions, (2) stress reduction tests on nanocrystalline Ni and (3) ultrafine-grained AlMg subjected to strain path changes.

(1) It is well known that under cyclic fatigue of metals dislocation patterning occurs. The nature of the resulting dislocation structure depends on several parameters, including stacking fault energy, dislocation mobility and loading conditions. To obtain a better understanding of how these structures form a new continuum dislocation-based constitutive model in the crystal plasticity finite element framework is currently under development [2]. In order to validate this new model in-situ Laue experiments during cyclic shear loading of Cu single crystals have been performed. Laue diffraction is very sensitive to crystal orientation and therefore allows tracking with high resolution the evolution of the crystallographic misorientation between the various dislocation-poor regions that appear under cyclic deformation.

(2) Transient testing is a well recognized technique to capture rate limiting deformation mechanisms. Among the many methods strain rate jump and stress relaxation tests are the most popular ones. Stress reduction tests are maybe less well known, they have however shown to be a suitable technique to determine the full transient response of a material subject to a changing loading condition [3]. In this work we report on stress reduction tests performed on electrodeposited nanocrystalline Ni. Depending on the magnitude of the stress reduction we observe different regimes, revealing the presence of various deformation mechanisms. The results are interpreted in terms of a competition between plasticity based on dislocation nucleation/glide and recovery mechanisms at grain boundaries [4].

(3) Engineering materials often experience complex strain paths during synthesis or under service conditions. For instance, many metals exhibit a lower yield stress (Bauschinger effect) when the sign of the load is reversed after plastic deformation. Some materials, however, exhibit a larger yield stress after the loading direction is changed. These and other phenomena play an important role in manufacturing but are not well captured by current state-of-the-art crystal plasticity models. It is therefore crucial to understand the underlying mechanisms. In this work we present a new biaxial deformation rig that was developed for in-situ testing at the synchrotron. It allows performing complex strain path changes while x-ray diffraction patterns are acquired. We report on the first feasibility tests that were recently performed on a cold-rolled AlMg alloy.

### References

- [1] Van Swygenhoven, H. & Van Petegem, S. *Materials Characterization* **78** (2013) 47.
- [2] Grilli, N et al. under review
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