SWISS LIGHT SOURCE SLS

SLS Symposium on

Neutrons and X-rays for Mechanics of Materials

Tuesday, November 14, 2017

10:00 to 12:15, WBGB/019

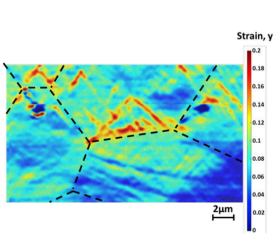
10:00 Suppressed martensitic transformation under biaxial loading in low stacking fault energy TRIP steels.
Efthymios Polatidis, Wei-Neng Hsu, M. Smid, T. Panzner, P. Pant, H. Van Swygenhoven

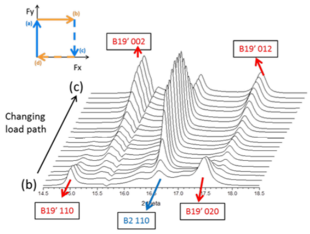
10:30 Phase Transformations in NiTi Alloys under Multiaxial Stress
Wei-Neng Hsu, E. Polatidis, M. Smid, S. Van Petegem, H. Van Swygenhoven

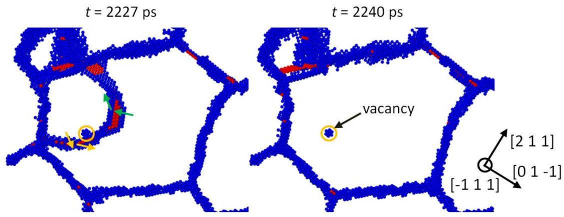
11:00 Coffee

11:15 In Situ Multiaxial Mechanical Testing of cold-rolled Mg AZ31B at Multiple Length Scales
Karl-Alan Sofinowski, J. Capek, T. Panzner, S. Van Petegem, H. Van Swygenhoven

11:45 Dislocation interactions at reduced strain rates in atomistic simulations of nanocrystalline Aluminium
Maxime Dupraz, Z. Sun, C. Brandl, H. Van Swygenhoven.







Suppressed martensitic transformation under biaxial loading in low stacking fault energy TRIP steels.

E. Polatidis, Wei-Neng Hsu, M. Smid, T. Panzner, P. Pant, H. Van Swygenhoven

In metastable austenitic stainless steels martensite forms upon deformation, the so-called transformation induced plasticity or TRIP effect, and this transformation is responsible for a good combination of strength and ductility that these materials exhibit. The amount of martensite formed during straining has important implications on the formability during cold forming processes. During forming, parts of the component are subjected to uniaxial strain paths or more complex loading states. How the loading state influences the transformation characteristics has been addressed in a few studies but remains inconclusive.

The effect of uniaxial/biaxial loading on the martensitic transformation of a low stacking fault TRIP steel was studied by in-situ neutron diffraction on cruciform-shaped/dogbone samples. Uniaxial loading favors the martensitic transformation following the sequence γ-austenite→ε-martensite→α'-martensite, where at low strains ε-martensite is the precursor of α′-martensite. During equibiaxial-loading, the evolving texture suppresses the formation of ε-martensite and considerably less α′-martensite is observed at high strains. The results will be discussed with respect to the deformation textures, the loading direction and the mechanism of the ε-martensite transformation.

Phase Transformations in NiTi Alloys under Multiaxial Stress

Wei-Neng Hsu [a, b], Efthymios Polatidis [a], Miroslav Smid [a], Steven Van Petegem [a], Helena Van Swygenhoven [a, b]

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The superelastic behavior, in NiTi alloys, originates from the reversible stress-induced austenite-to-martensite phase transformation. The majority of previous studies, on superelastic NiTi alloys, were conducted in either uniaxial tension/compression or torsion, however, during manufacturing processes and operational conditions these materials can undergo complex biaxial states or strain path changes. It is thus important to study the transformation behavior of these materials under multiaxial loading or complex stain-path changes.

In the present study, cruciform specimens were developed and deformed in-situ, employing a miniaturized biaxial tensile machine while investigated with High Resolution Digital Image Correlation in scanning electron microscope (HR-DIC) and synchrotron X-ray diffraction on the MS beamline at the Swiss Light Source. The present study focuses on the phase transformation under a "square load path" (as shown in Figure 2) in superelastic NiTi. HR-DIC captured the localization of martensitic transformation. The martensite variant selection and the evolutions of different phases at different loading conditions during the square load path will be discussed.

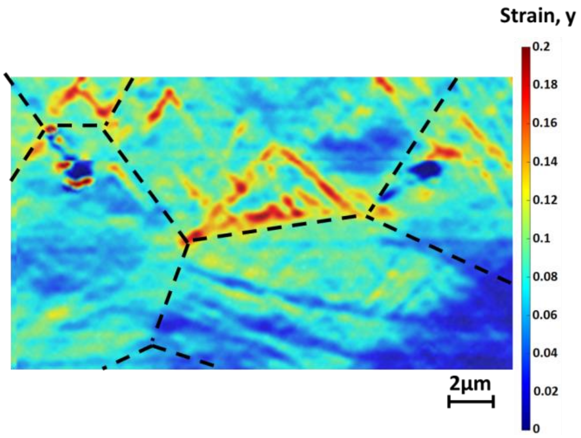


Figure 1: HR-DIC reveals the localized, high-strain traces which corresponding to where martensitic transformation occurred within the grains

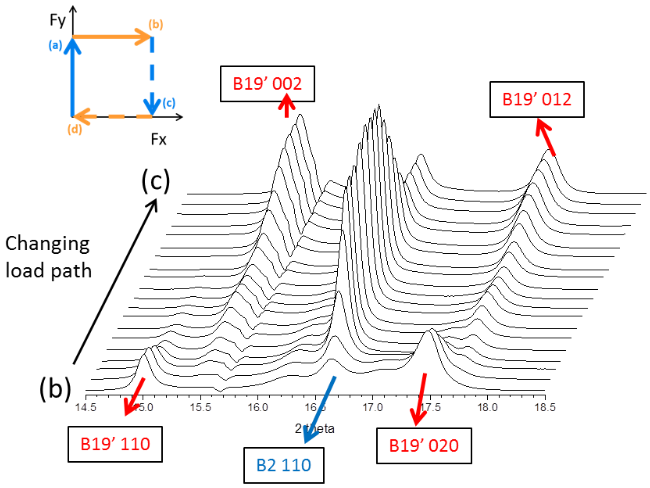
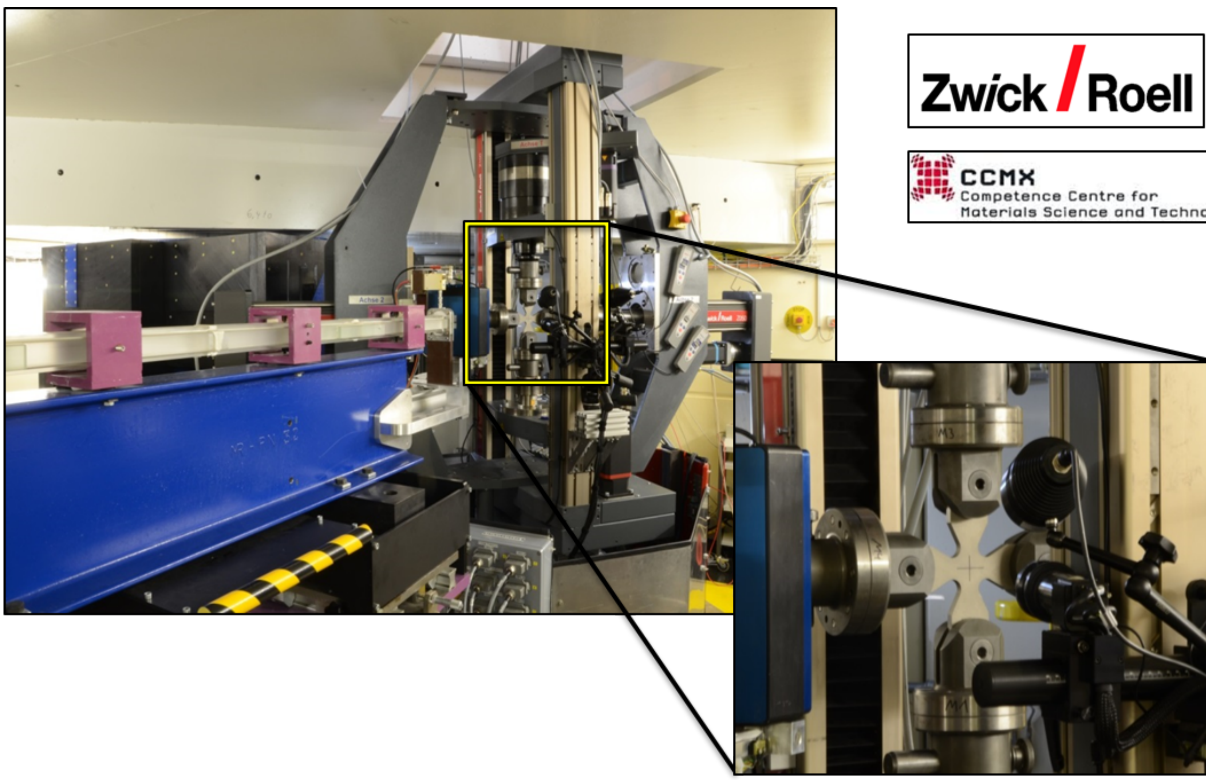


Figure 2: The change of martensitic variants took place during the change of load path. B2 denotes autenite phase, and B19' is the martensitic phase in NiTi.

In Situ Multiaxial Mechanical Testing of cold-rolled Mg AZ31B at Multiple Length Scales

Karl Sofinowski, Jan Capek, Tobias Panzner, Steven Van Petegem, Helena Van Swygenhoven

Modern cold-forming processes subject metals to complex deformation paths that are known to be inaccurately predicted using mechanical data from uniaxial deformation tests. Thus, it is important to study metals under the complex stress states and strain path changes that they undergo in real industrial processes. Under the ERC Advanced Grant MULTIAX, the effect of this non-proportional plastic deformation is studied using in situ diffraction techniques. Each material is examined across multiple length scales, from component-size (POLDI beamline, SINQ), to capture macroscopic material properties, to the micro-scale (MS and MicroXAS beamlines, SLS), to examine the inter-and intragranular deformation mechanisms that contribute to the macroscopic response. In this presentation, the capabilities of the in situ multiaxial deformation rigs will be discussed with respect to strain-path change experiments performed on cold-rolled Mg AZ31B. The results of combined in situ neutron diffraction and acoustic emission experiments (POLDI) will be presented, and future Laue microdiffraction studies of twinning mechanisms will be discussed.



Zwick / Roell

CCMX Competence Centre for Materials Science and Technology

Dislocation interactions at reduced strain rates in atomistic simulations of nanocrystalline Aluminium

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Molecular dynamics has been wildly used to explore the deformation mechanisms in nanocrystalline metals. Because of the high strain rate effect, the method does not allow to reveal the rate limiting deformation mechanism responsible for the constant flow stress typically observed in simulations and in experiments. The constant flow stress reached during uniaxial deformation reflects a quasi-stationary balance between dislocation slip and grain boundary (GB) accommodation mechanisms. Experimentally, stress reduction tests have been carried out to suppress dislocation slip and bring recovery mechanisms into the foreground [1]. When combined with in situ X-ray diffraction it was shown that at intermediate stress drops, dislocation slip can be re-activated after a period dominated by GB accommodation mechanisms. To get a deeper insight in the interplay between dislocation slip and GB accommodation, similar transient tests have been carried out using molecular dynamics performed on a nanocrystalline Al sample with an average grain size of 10 nm. After deforming the sample with 10^8 /s, stress drops with ratios between 0.9 and 0.3 are carried out and the sample is allowed to creep up to 2.3ns at much lower strain rates (~ 10^6 /s). During this creep period, important changes in the grain boundary structure occur via mechanisms such as GB dislocation climb and GB migration. After structural changes dislocation nucleation and slip are re-activated. Besides confirming the interpretation of the experimental *in situ* tests, the creep simulations performed at 2 or 3 orders of magnitude lower strain rates than usual reveal deformation mechanisms that have not been observed previously. First of all, it is evidenced that the misfit dislocations available at the GB assist the propagation of a lattice dislocation on a plane with low resolved shear stress. Furthermore, it is shown that the interaction of two dislocations gliding on parallel slip planes can result in the emission of a vacancy in the grain interior. Finally, the importance of the Schmid factor in the activation of slip in nanocrystalline structures is discussed.

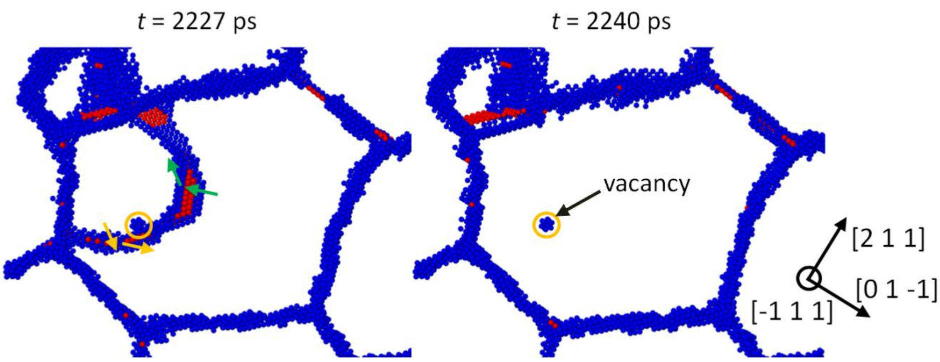

Figure 1 Emission of a vacancy during the propagation of the dislocation dipole. The colored arrows indicate the Burgers vectors of the dislocations travelling in the grain.

REFERENCES

[1] Z. Sun, S. Van Petegem, A. Cervellino, K. Durst, W. Blume, H. Van Swygenhoven, Volume 91(2015)91