SLS Symposium on

Neutrons and X-rays for Mechanics of Materials

Tuesday, November 14, 2017

10:00 to 12:15, WBGB/019

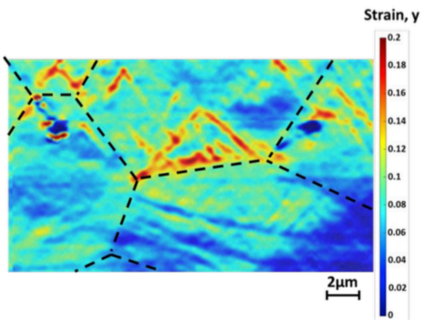
10:00 Nanocrystalline metals: transient testing during in situ X-ray diffraction and molecular dynamics
Zhen Sun

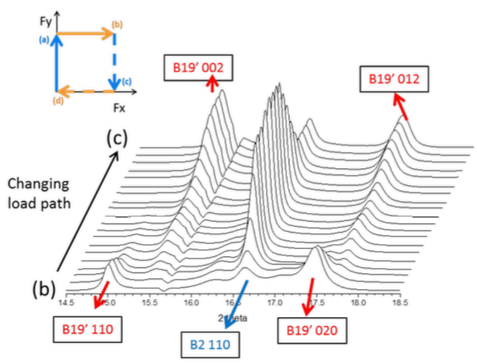
10:30 Phase Transformations in NiTi Alloys under Multiaxial Stress
Wei-Neng Hsu, Efthymios Polatidis, Miroslav Smid, Steven Van Petegem, Helena Van Swygenhoven

11:00 Coffee

11:15 In Situ Multiaxial Mechanical Testing of cold-rolled Mg AZ31B at Multiple Length Scales
Karl-Alan Sofinowski, Jan Capek, Tobias Panzner, Steven Van Petegem, Helena Van Swygenhoven

11:45 To be announced
Manas Vijay Upadhyay





Nanocrystalline metals: transient testing during in situ X-ray diffraction and molecular dynamics

Zhen Sun

Nanocrystalline (NC) metals have attracted widespread interest in materials science due to their high strength compared to coarse-grained counterparts. The stress-strain behaviour exhibits an extraordinary work-hardening followed by an early observation of constant flow stress. Information on possible deformation mechanisms have been gathered by extensive research combining in situ deformation experiments, electron microscopy observations and computational modelling. Generally, these mechanisms are categorized into two types: dislocation slip and grain boundary (GB) accommodation processes. However, the interplay between these mechanisms resulting in the constant deformation resistance is not fully understood.

Transient testing has proven to be a suitable tool to gather information on the rate limiting deformation mechanisms that are activated during the deformation path. Stress reduction experiments allow bringing the underlying mechanisms into foreground during subsequent transient creep. Those mechanisms may play a minor role in the determination of the flow stress but might still be essential in the overall mechanical behavior. Here transient testing is combined with in situ X-ray diffraction at the Swiss Light Source. Since dislocation slip and GB accommodation have an opposite footprint on the peak broadening, the presence of these two types of mechanisms can be distinguished.

Three electrodeposited NC materials with different grain sizes are investigated: two NC Ni batches and one NC Ni50Fe50 batch. The results reveal that the constant flow stress reached during uniaxial deformation of electrodeposited NC metals reflects a quasi-stationary balance between dislocation-based mechanisms and GB-mediated accommodation. By comparing transient responses among different NC materials, the relative contributions of dislocation slip and GB accommodation mechanisms are discussed in terms of grain size and alloying. MD simulations confirm that dislocation slip is reduced after a moderate stress drop, however dislocations can continue to operate after adaption of the GB structures by a variety of GB accommodation mechanisms explaining the non-monotonic behaviour of the peak broadening during transient creep.

The differences between Ni and Ni50Fe50 suggest a promising route to develop a novel material for LIGA microcomponents used in watch industry.

[1] Z. Sun, S. Van Petegem, A. Cervellino, K. Durst, W. Blum, H. Van Swygenhoven, Dynamic recovery in nanocrystalline Ni, Acta Mater. 91 (2015) 91–100.
[2] Z. Sun, S. Van Petegem, A. Cervellino, W. Blum, H. Van Swygenhoven, Grain size and alloying effects on dynamic recovery in nanocrystalline metals, Acta Mater (Accepted)
[3] Z. Sun, M. Dupraz, C. Brandl, H. Van Swygenhoven, Stress reduction tests in molecular dynamics simulations, Acta Mater. (In preparation)

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.

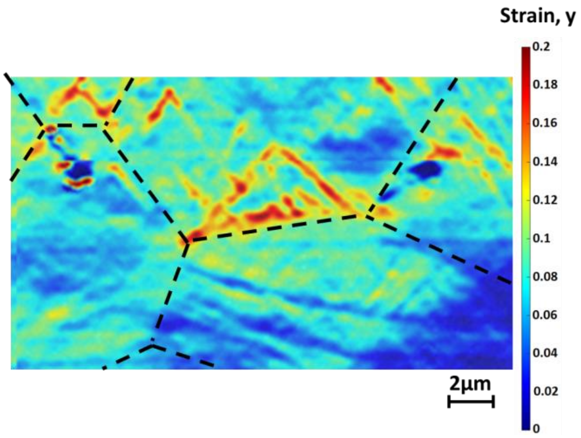

Figure 1: HR-DIC reveals the localized, high-strain traces which corresponding to where martensitic transformation occurred within the grains

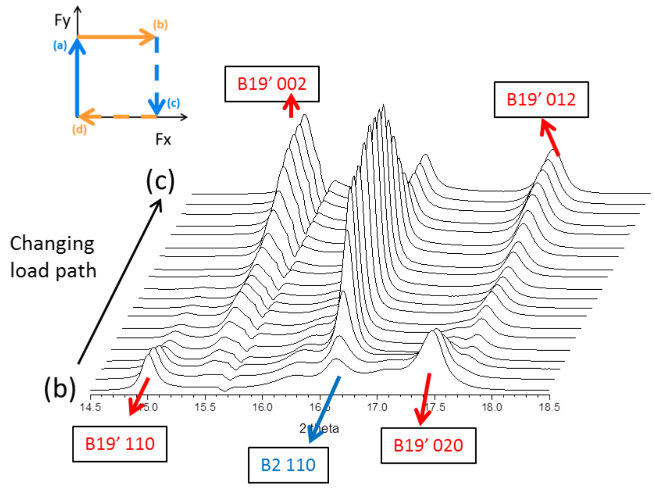

Figure 2: The change of martensitic variants took place during the change of load path. B2 denotes autenite phase, and B19' is the martensitic phase in NiTi.

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.