THE BAUSCHINGER EFFECT IN NANOFILAMENTARY CU/NB WIRES EVIDENCED BY IN-SITU TENSILE TESTS UNDER SYNCHROTRON RADIATION

L. Thilly*, P.O. Renault, V. Vidal
PHYMAT, University of Poitiers, 86962 Futuroscope, France
S. Van Petegem, H. Van Swygenhoven
Paul Scherrer Institute, CH-5232 Villigen-PSI, Switzerland.
F. Lecouturier
Laboratoire National des Champs Magnétiques Pulsés, UPS-INSA-CNRS, 31400 Toulouse, France

Nanocomposite wires are processed by severe plastic deformation (Accumulative Drawing and Bundling) to obtain a multiscale Cu matrix embedding Nb nanotubes. They exhibit high strength that results from size effects in the Cu nanochannels and in the Nb nanotubes (Scripta Mat 57 (2007) 245).
The macroscopic stress-strain curve during tensile loading-unloading cycling exhibits an increasing hysteresis, evidencing the presence of internal stresses (Bauschinger effect). By performing such load-unload experiments in-situ under synchrotron radiation at the Swiss Light Source, it is possible to follow continuously the diffraction peak positions and peak widths of the large and the fine Cu channels as well as the Nb nanotubes, revealing the details of the load sharing and deformation mechanisms responsible for the Bauschinger effect.
During tensile loading, the large Cu channels provide most of the plastic strain and dislocation storage can be evidenced. The fine Cu channels and Nb nanotubes however mainly store elastic energy. Upon tensile unloading, this energy is partly released via reverse yielding in compression of the large Cu channels: in other words, the large Cu channels are subjected to a built-in true Bauschinger test (inversion of load direction). The observed large plastic strain gradient, added to the sink character of the Cu-Nb interfaces, induce the continuous build-up of internal stresses during co-deformation.
These results evidence unambiguously the reverse yielding of the soft phase in composite material with strong yield stress mismatch and bring further understanding to the complex residual stress state of nanocomposite materials obtained by severe plastic deformation processes where repeated loading-unloading cycles are applied (APL 90 (2007) 241907).