ICSMA19 Metz, France, June 26 - July 1, 2022
International Conference on Strength of Materials

Curious rise in peak profile asymmetry during unloading in cyclic deformation

A.M. Diederichs[a], U. Lienert[b], W. Pantleon[a]

[a]*Department of Mechanical Engineering, Technical University of Denmark, Produktionstorvet 425, 4000 Kongens Lyngby, Denmark*

[b]*DESY Photon Science, Deutsches Elektronen Synchrotron, Notkestraße 85,*

22607 Hamburg, Germany

[a]*pawo@dtu.dk*

Plastic deformation causes internal stresses within deformation structures. The development of such internal stresses even in single crystals of pure metals were discovered by X-ray diffraction through asymmetric peak broadening [1]. A monotonous relation between asymmetry and internal stresses is commonly taken for granted. During cyclic deformation in tension and compression, the sign of both, asymmetry and internal stresses, reverses repeatedly as confirmed by investigations after unloading [2]. Following cyclic deformation in tension and compression in-situ in aluminium without intermediate unloading by X-ray diffraction using high resolution reciprocal space mapping reveals a more complicated behavior: the absolute amount of asymmetry increases during unloading as well as elastic reloading and decreases first when plastic yielding occurs in the opposite direction. Such an increasing asymmetry, indicating an apparent increase in internal stresses, opposes the general assumption of frozen-in internal stresses during elastic deformation. The counter-intuitive finding sheds new light on the relation between asymmetry and internal stresses; its consequences for the interpretation of asymmetries are discussed.

Keywords: Cyclic deformation, deformation structure, internal stresses, X-ray diffraction, asymmetric profiles.

References:

[1] Ungar T, Mughrabi H, Rönnpagel D, Wilkens M, X-ray line broadening study of the dislocation cell structure in deformed [001]-oriented copper single-crystals, Acta. metall., 32 (1984) 333
[2] Biermann H, Ungar T, Pfannenmüller T, Hoffmann G, Borbely A, Mughrabi H, Local variations of lattice parameter and long-range internal stresses during cyclic deformation of polycrystalline copper, Acta metall. mater. 41 (1993) 2743