Fatigue Tests of Penta-twinned Ag Nanowires under TEM and Their Structure Analysis

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Ag nanowires (NWs) have applications in flexible electronics because of their excellent electrical and optical properties. The polyol process used to fabricate Ag NWs leads to a distinctive penta-twinned structure containing five {111} twin planes sharing a common axis along [110]. Here we study the mechanical performances of these wires through TEM analysis of individual NWs after cyclic deformation. This is achieved by spraying Ag NWs onto 3mm porous polycarbonate disks covered by an electron transparent collodion thin film, selected fibres suspended over pores in the disks can be identified for repeated TEM study after deformation. The disks are repeatedly cycled from 0 – 8% tensile strain and individual NWs are selected and characterized before and after fatigue tests. A bamboo defect structure, defined as repeated narrow regions of contrast difference across the diameter of the penta-twinned Ag wires that repeat along a wire at distances significantly greater than the wire diameter, is observed under TEM observation. An increase in density of bamboo defects in the Ag NW networks is observed after increasing numbers of fatigue cycles. Further characterization using precession assisted scanning nanobeam electron diffraction (NBED) suggests that the bamboo structure is caused by crystal rotation in the penta-twinned NWs around the [110] growth direction. We propose that the torque that generates rotation is induced by the presence of NW/NW joints within the network allowing circumferential loading of individual NWs when the network is in global tension. Fewer bamboo structures are observed after fatigue when examining lower density NW networks, supporting the network joint hypothesis.