

## IN-SITU BENDING TESTS OF PENTA-TWINNED Ag NWs And Their Structure Analyses

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Key Words: In-situ bending process observation, Penta-twinned structure, scanning nano-beam diffraction, decomposition, Coincidence site lattice.

Ag nanowires (NWs) are readily available for applications in flexible electronics because of their excellent electrical and optical performance. Research into the mechanical properties and deformation mechanisms of NWs is important to understand the durability of these devices. The polyol process used to fabricate Ag NWs leads to a penta-twinned structure containing five  $\{111\}$  twin planes sharing a common axis along the  $[110]$  direction. Here we study the microstructures of the twinned NWs after plastic deformation in bending (Fig 1 (a)-(c))<sup>1</sup>. When deformation is highly spatially confined a clear grain boundary is observed under dark field imaging (Fig 1 (d)). To further characterize the deformed penta-twinned wires, scanning precession nano-beam diffraction was used to map their structure and determine the crystal orientations. The diffraction signal and corresponding physical localization for every sub-crystal were isolated from the data using non-negative matrix factorization (NMF)<sup>2</sup>. For example in Fig 1. (e)-(f), the crystal orientation is confirmed to be  $[110]$  albeit with an in-plane rotation of the pattern corresponding to the bend in the wire. The same approach was applied to other sub-crystals. The structure of penta-twinned Ag nanowire and the direction of incident electron beam are illustrated in Fig 1. (h). From the outlined shape of the subcrystals in the bent penta-twinned Ag NWs (Fig 1. (e), (f)), it was observed that the sub-crystals can expand or contract when approaching the bending interface. To explain these behaviors, a coincident site lattice (CSL) was used to model the structure of grain boundaries formed during the bending process<sup>3</sup>. The change in orientation within a sub-crystal across the bending interface could be assigned in many cases to a particular highly coherent planar interface. This study is a clear example of how nano-materials with complex structure can be explored under advanced TEM experiments to provide insight into the deformation mechanisms of nanostructures.

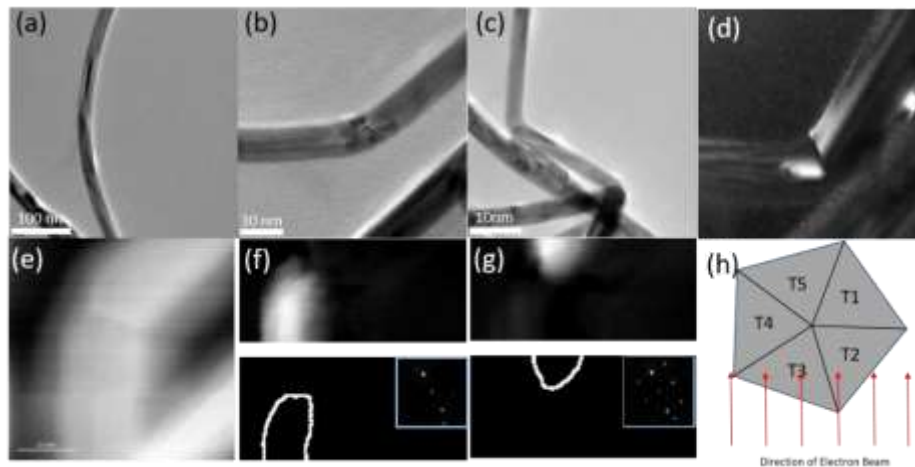


Figure 1 – In-situ bending process and structure characterization through scanning nano-beam diffraction methods and subsequent decomposition. (a)-(c) Bending process of penta-twinned Ag NWs. (d) Dark field image of the bent wire. (e)-(h) Structure analysis of another bent Ag NW. From the diffraction pattern, the zone axes of subcrystals are aligned to  $\langle 110 \rangle$  both in (f) down and (g) up parts of the bent wire. (h) The relative position of the incident electron beam and the penta-twinned structure.

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