PLASTIC DEFORMATION OF SUB-MICRON AL AND BE WIRES: A TEM AND IN SITU TEM STUDY.

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The origin of the improved strength of sub-micron single crystals and whiskers is still debated, but after studies concentrated solely on size effects, it appeared that an as important parameter was the dislocation content of these small crystals.

In this presentation, the importance of the dislocation content and the role played by the external surface on the triggering of plasticity in both Al and Be sub-micron wires investigated by in-situ transmission electron microscopy (TEM) will be highlighted. The wires, obtained by selective etching of Al/Al2Cu and Al/Be eutectic alloys (Fig.1), all exhibit a thin Al oxide outer layer. Al wires present a large variability in dislocation density while Be wires parallel to their c-axis are usually dislocation free or contain very few dislocations.
In Al, we show that multiplication of dislocations through intermittent spiral sources directly causes a power-law increase of the yield stress with decreasing cross-sectional size. The size effect and resulting mechanical response are directly linked to the initial defect density and the distance between the source and the surface. In the absence of dislocations, fibers elastically reach high stresses with limited to no plasticity, reminiscent of whisker behavior.

A similar fragile-like behavior is also observed in dislocation free Be wires. In this case moreover, the plastic deformation is strongly dependent on the orientation of the crystal with respect to the straining axis. When strained along their c axis, wires tend to twin. In twinned area, ductile behavior was observed due to the favorable orientation for prismatic slip. Twin nucleation and propagation is thought to be triggered by surface nucleation. Because of the presence of a remaining Al oxide surrounding the wire, we show that the deformation may require dislocations moving along the fiber axis. Our observations indicate that these dislocations are thought to move in or close to a remaining Al/Al oxide layer at the wire surface. In any case, no "special" mechanism is needed to explain the unusual properties of these wires.

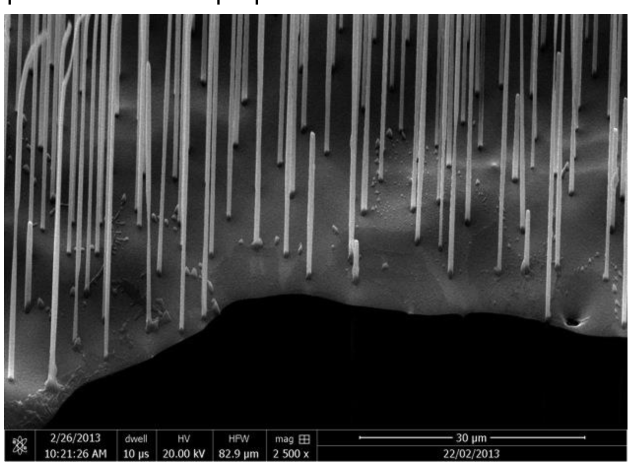

Figure 1 – Be wires obtained after etching away the Al matrix of an Al/Be eutectic alloy (SEM image).

References

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