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Observations on Heavily Deformed Tantalum

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The deformation of metals having the body-centered cubic (BCC) crystal lattice [1] is thought to occur by the glide of dislocations with a Burgers vector of $^{1}/_{2}$<111> [2, 3] or by twinning [4]. The present study is concerned with the deformation of the BCC, period-6 (third-series), transition metal, Tantalum [5, 6]. Although the slip planes have been discussed and modeled since before 1970 (see [3]), there are still many questions concerning the planes on which the screw dislocations glide and how the slip systems differ for different BCC metals. It is with these questions in mind that the authors are examining samples of Ta that have been heavily deformed under well controlled conditions.

The material examined in the present study was obtained as a textured sputter target from the H.C. Starck company. Conventional tensile specimens were prepared from bulk disks and cut to shape using electro discharge machining (EDM) following the procedures used previously for Ta metal obtained from a different source [5]. The TEM analysis was performed on an FEI Tecnai F30 TEM operating at 300kV and on an FEI Titan G2 80-200 equipped with Chemi-STEM Technology operated at 200 kV.

Part of the deformed sample that was used to extract FIB TEM specimens is shown in Figure 1a. The surface of the deformed material was quite uneven and showed effects of the EDM. However at a distance of 1 to 2 μm below the surface, the microstructure of the deformed Ta was clearly visible and consisted of very small grains with few dislocations in some parts (e.g., in Figure 1b), and relatively large grains in other parts containing both dislocations and sub-grain boundaries as illustrated in Figure 2; no contamination from the EDM was detected in these regions. Additional analysis using the chemical analysis capabilities of the Titan TEM was performed to determine the presence and location of any impurities, including oxygen, in the specimens. The structure of the Ta and of selected grain boundaries was determined using calibrated high-resolution imaging and diffraction pattern analysis. The initial results of this analysis, some of which are indeed surprising, will be presented.

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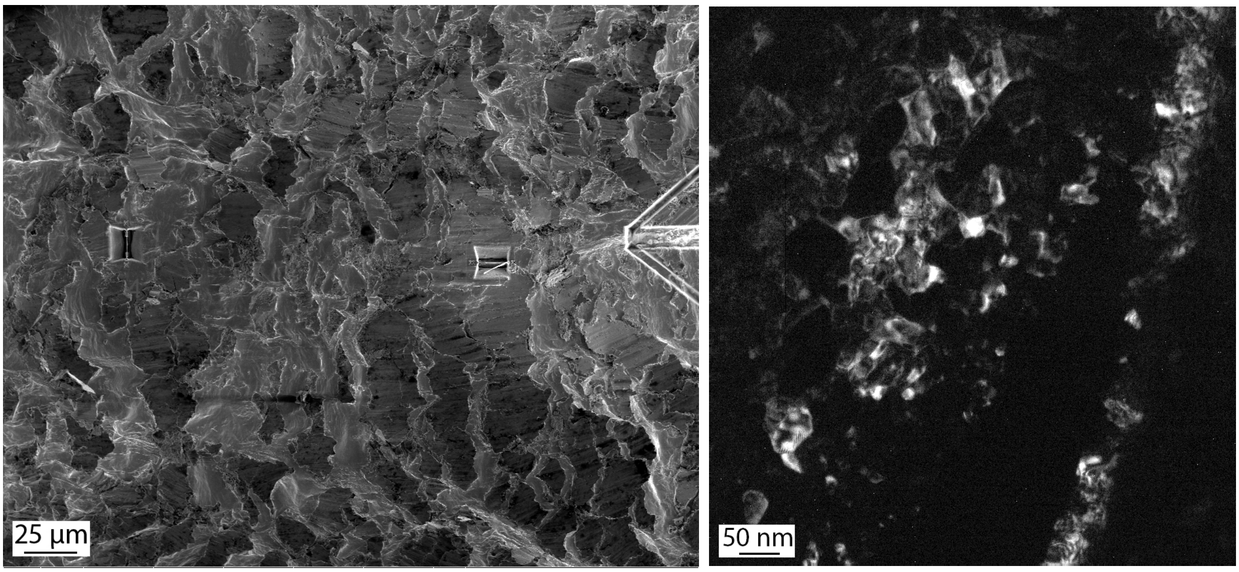

Figure 1. a) SEM image of a fractured Ta tensile sample. The arrow on the right was added to aid locating the two samples that had been cut using a FIB instrument for lift-out. B) A TEM DF image of one sample showing the small grain size in this region.

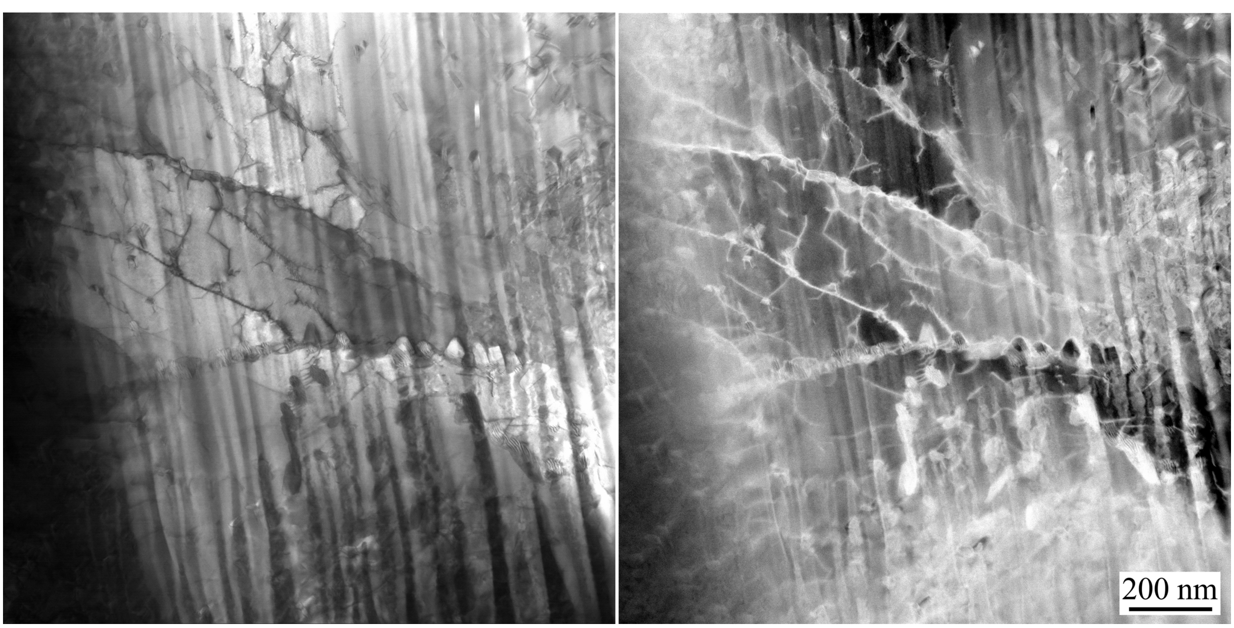

Figure 2. STEM image recoded in the probe-corrected Titan using both the BF and ADF detectors. Dislocations and low-angle grain boundaries are clearly visible as are special small grains on the left side of each image.

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