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In situ TEM Investigation of the Electroplasticity Phenomenon on Dislocation Behavior in Ti-6wt%Al

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Electroplasticity (EP) is a phenomenon where an applied pulsed electrical current during deformation of metals can result in reduced flow stress and increased formability [1]. In this work, *in situ* TEM electromechanical tests of Ti-6Al samples on electrical push-to-pull device (E-PTP) [2] were performed, as shown in Figure 1 (a). Specific loading and observation directions were selected and focused ion beam (FIB) lift-out was then used to attach the sample to the E-PTP device, with the sample geometry shown in Figure 1 (b). The specimens were deformed uniaxially in tension and the load function vs time is shown in Figure 1 (c). **The red bar marks an electrical current pulse with a current density of** 2.77×10^3 A/mm^2 and the blue bar marks a sweep electrical current with the same maximum current density**.** We also developed the frame-by-frame contrast analysis for identification of individual dislocation and defect traces from *in situ* testing [3]. This setup and control of parameters enabled us to correlate direct observations of dislocation dynamics with both mechanical data and applied electrical pulses to provide clarity on the true origin of the electroplasticity phenomenon.

From the study, we chose a Ti-Al alloy that is uniquely suited for observations of electroplasticity. Previous work showed that electrical pulses would interrupt the formation of dislocation organization in bulk deformation [4]. Here, we observed *in situ* that the dislocation behavior could be seen to change during the pulsing period. Crystal orientation of the sample and the loading direction was determined, as shown in Figure 2 (a, b). During pure mechanical tension with no electrical current, only a few slip directions were activated, and dislocation motion occurred mostly through < a > type dislocations,as shown in Figure 2 (c). Upon applying an electrical current, we observed a change in slip directions, with promoted cross-slip event and possible <c+a> dislocation activation, shown in Figure 2 (d). We will discuss these observations and others as they relate to the electroplasticity effect, which can now be studied at the single defect level.

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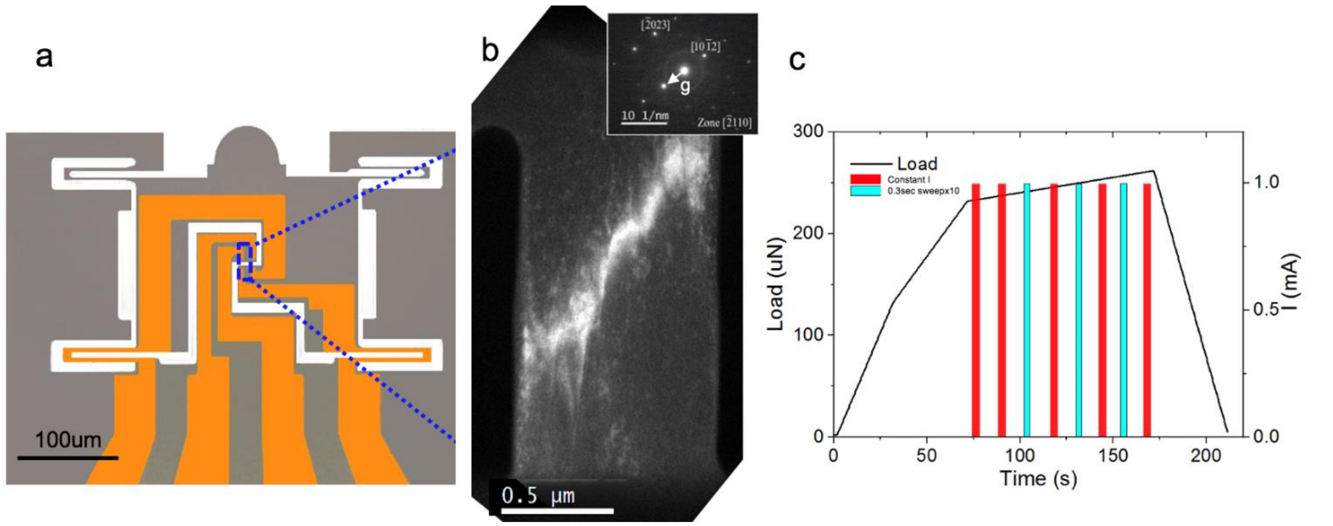

Figure 1. *Figure 1. Experiment setup. (a) The electric push-to-pull (E-PTP) device. (b) Lift-out metal thin Ti-6Al foil and a dark field image of the dog-bone shape sample. (c) Load function vs time with current pulse applied during the tension test.*

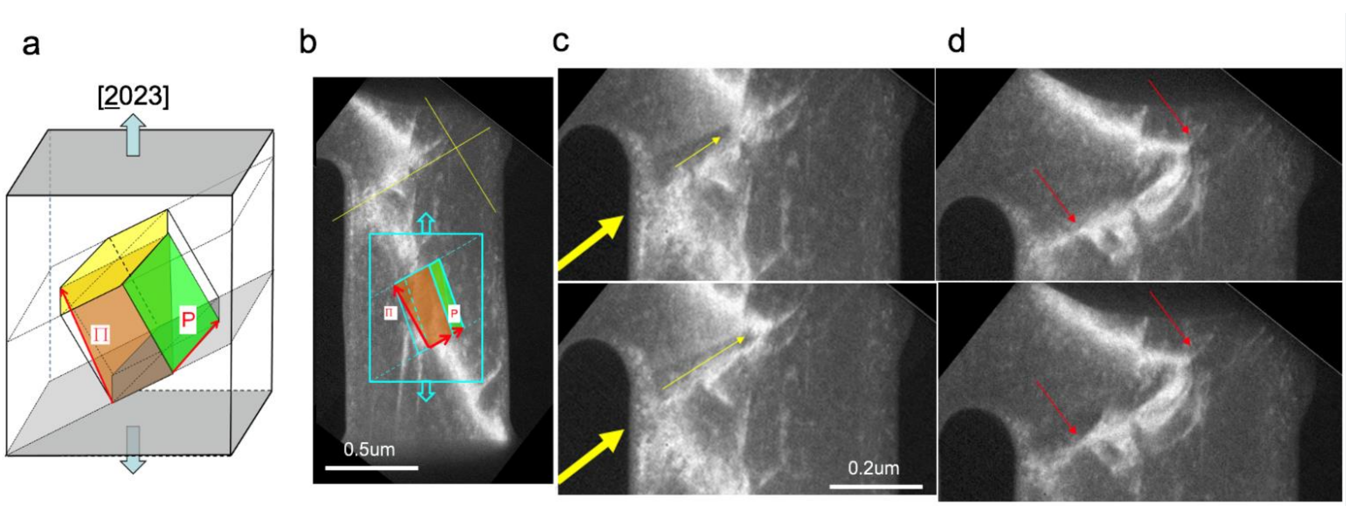

Figure 2. *Figure 2. Crystal orientation and observed dislocation motion. (a) Crystal orientation of the sample and the loading direction was determined. (b) Possible slip directions on the sample in dark field. (c) During pure mechanical tension with no electrical current, dislocation motion occurred are mostly type. (d) Upon applying an electrical current, a change in slip directions were observed, with promoted cross-slip event and possible dislocation activation.*

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