

## Understanding the Slip Planarity and Residual Strain Field in Ti-6Al using Nanobeam Electron Diffraction and First Principles Calculations

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The anomalous solid-solution strengthening and low strain hardening of Ti-Al alloys have long been attributed to the chemical short-range ordering (SRO) of Al atoms [1-2]. The existence of SRO and its impact on deformation behavior has been revealed through various indirect techniques [3-5]. Zhang et al. directly observed the SRO domain structure with Energy-Filtered Transmission Electron Microscopy (EFTEM), confirming the microstructure and spatial distribution of SRO [6]. As the dominant deformation mode, dislocations slip in Ti-6Al would cut through SRO clusters and, therefore, create “diffuse” anti-phase boundaries (DAPB), leading to a localized strain field that has been experimentally observed [6-7]. Despite the successful observation of a reduction in SRO concentration due to dislocation plasticity, the extent and the origin of the residual strain, as well as its relation to the formation of the planar slip, is not straightforward.

With the adoption of nanobeam electron diffraction (NBED), strain mapping with nanometer spatial resolution is possible [8]. Here, we utilized NBED to study the residual strain in slip bands of SRO-aged Ti-6Al. Figure 1 (a) was taken from a dislocation-free section of a slip band, showing the distribution of residual strain of  $[2\bar{1}\bar{1}0]$  orientation. One limitation of our previous effort is the lack of 3-D mapping capability. Here, we propose to acquire 3-D strain information by doing a “tilt-series” of strain mapping, followed by reconstructing the 3-D information according to the crystallographic orientations. Previously, the residual strain caused by the formation of three different anti-phase boundaries (APB) in  $Ti_3Al$  structure has been assessed with first principles calculations [9], but a DAPB in a SRO Ti-6Al is much more complicated and requires a more dedicated calculation. Correlating the results of NBED and first principles calculations could provide direct insights into the multiscale origin of slip planarity. The development of fast direct electron detectors has enabled in situ nanomechanical NBED experiments. The formation of planar slip and the strain evolution could be directly observed and analyzed [10].

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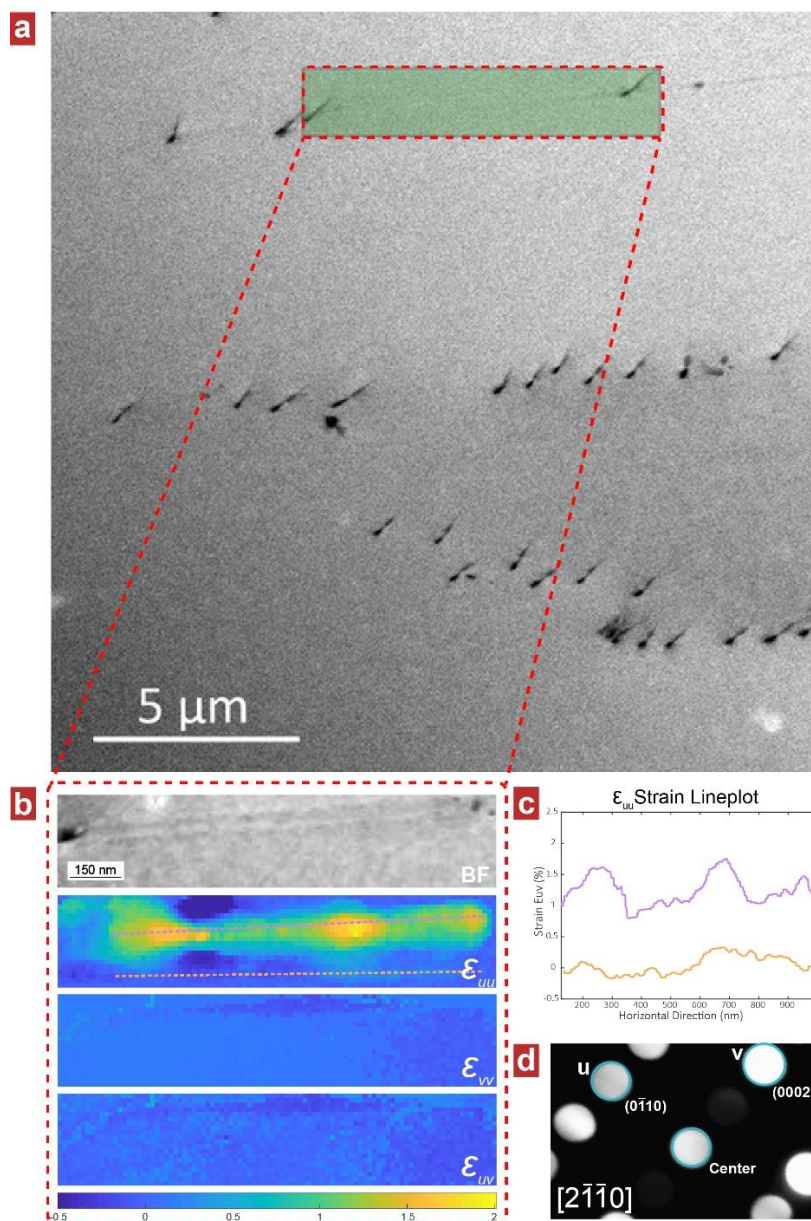
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**Figure 1.** Strain mapping results taken from a dislocation-free slip band; (a), HAADF image showing the region of interest; (b), reconstructed BF image and the 3 different elements of the strain mapping; (c), line plots of strain from in and out of the slip band; (d), averaged diffraction pattern from the nanobeam electron diffraction dataset.