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REVEALING DISLOCATION STRUCTURE AROUND AND UNDERNEATH INDENTATIONS IN (001) STRONTIUM TITANATE SINGLE CRYSTAL AT ROOM TEMPERATURE AND 350^{O}C

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Many crystalline materials exhibit an indentation size effect, i.e., an intrinsic change in hardness with changes in sampled material volume. During indentation testing, the material underneath the indenter is heavily deformed, introducing high local dislocation densities and density gradients. In the present work, dislocation structures around and underneath the Vickers and Berkovich indentations performed at room temperature and 350^{o}C have been resolved in (001) oriented strontium titanate (STO) single crystal via a sequential polishing, etching, and imaging technique. Laser and atomic force microscopy were used to image dislocation etch-pit patterns which were then digitized for calculating dislocation densities, plastic zone sizes, and dislocation spacing at multiple depths within the material. In addition, a simple model for estimating lattice friction stresses from digitized dislocation etch-pit images has been modified to work at large applied loads [1]. At high loads, images consistently exhibited etch-pit arms extending from the indentation aligned along the {010} and {110} directions, regardless of indenter symmetry. However, the size, shape, and density of etch-pits was found to strongly depend on applied load at lower indentation loads, consistent with the idea of a size effect. Interestingly, slip was documented at depths well below indentation depth, where <110> slip was favored. Load-displacement data combined with dislocation etch-pit techniques revealed that incipient plasticity (manifested as sudden indenter displacement bursts) was strongly influenced by pre-existing dislocations. Furthermore, there was a significant decrease in the indentation size effect with an increase in temperature. Results from the model show a significant change in lattice friction stresses between room temperature and 350^{o}C for <010> and <110> slip planes, consistent with compression testing. The above-mentioned results show that STO provides a unique opportunity as a reference material for understanding size effects in crystalline materials. In addition, the sequential polishing, etching, and imaging technique combined with modeling gives rise to estimates of lattice friction stresses from an indentation test.

[1] Y. Gaillard , C. Tromas, J. Woirgard, Acta Materialia 54 (2006) 1409–1417