HYSITRON™

APPLICATION NOTE

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Hardness Mapping

With the Hysitron TriboIndenter™

Introduction

Sandia National Lab's Department 1835 recently acquired a new TriboIndenter™ nanomechanical test system from Hysitron, Inc. Sandia is using this instrument to study lightly deformed polycrystalline copper by creating hardness maps of twinned regions and grain boundaries. Understanding the mechanisms of deformation at nanoscale will supply the information needed to create large-scale deformation models.

The Hysitron probe can be operated in three basic modes: indentation mode, scratch mode, and *in-situ* SPM imaging mode. In indentation mode, load-displacement data is continuously collected while the indenter tip engages the surface in the perpendicular direction. Typical indentations produced with the TriboIndenter are ~10-5000 nm deep. In scratch mode, the perpendicular load data is combined with lateral load data as the tip traverses along the surface of a material.

The machine offers unique characterization through a combination of the three modes. For example, indentations made by the TriboIndenter in the indentation mode can be subsequently imaged in the *in-situ* SPM imaging mode, as shown in Fig. 1. The *in-situ* SPM imaging mode can also be used to characterize the surface topology prior to indentation.

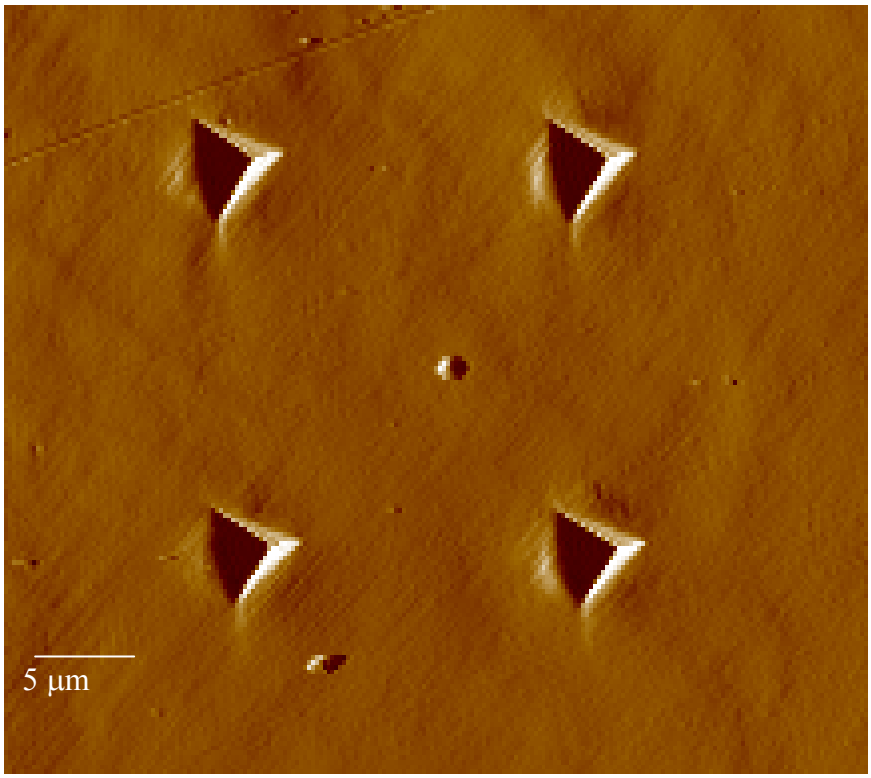

Figure 1: Four indents in copper as imaged by *in-situ* SPM imaging mode.

One of the initial applications of the TriboIndenter is to characterize local hardness variations in the vicinity of microstructural features such as grain and twin boundaries. A grid of ~900 indents, each ~0.7 µm wide (considerably smaller than those in Fig. 1) and 2.5 µm apart was used to interrogate local microstructural features within a lightly deformed (5%) polycrystalline copper specimen. A grid of nanoindents (Fig. 2a) around the site of a twin revealed that the local hardness in the vicinity of the twin boundaries was substantially higher than that of the surrounding matrix, as shown in Fig. 2. Additional hardness maps indicate that some grain boundaries also show signs of local hardening, presumably due to the pile-up of dislocations at the boundary. These experimental results will provide guidance in developing mesoscale plasticity models.

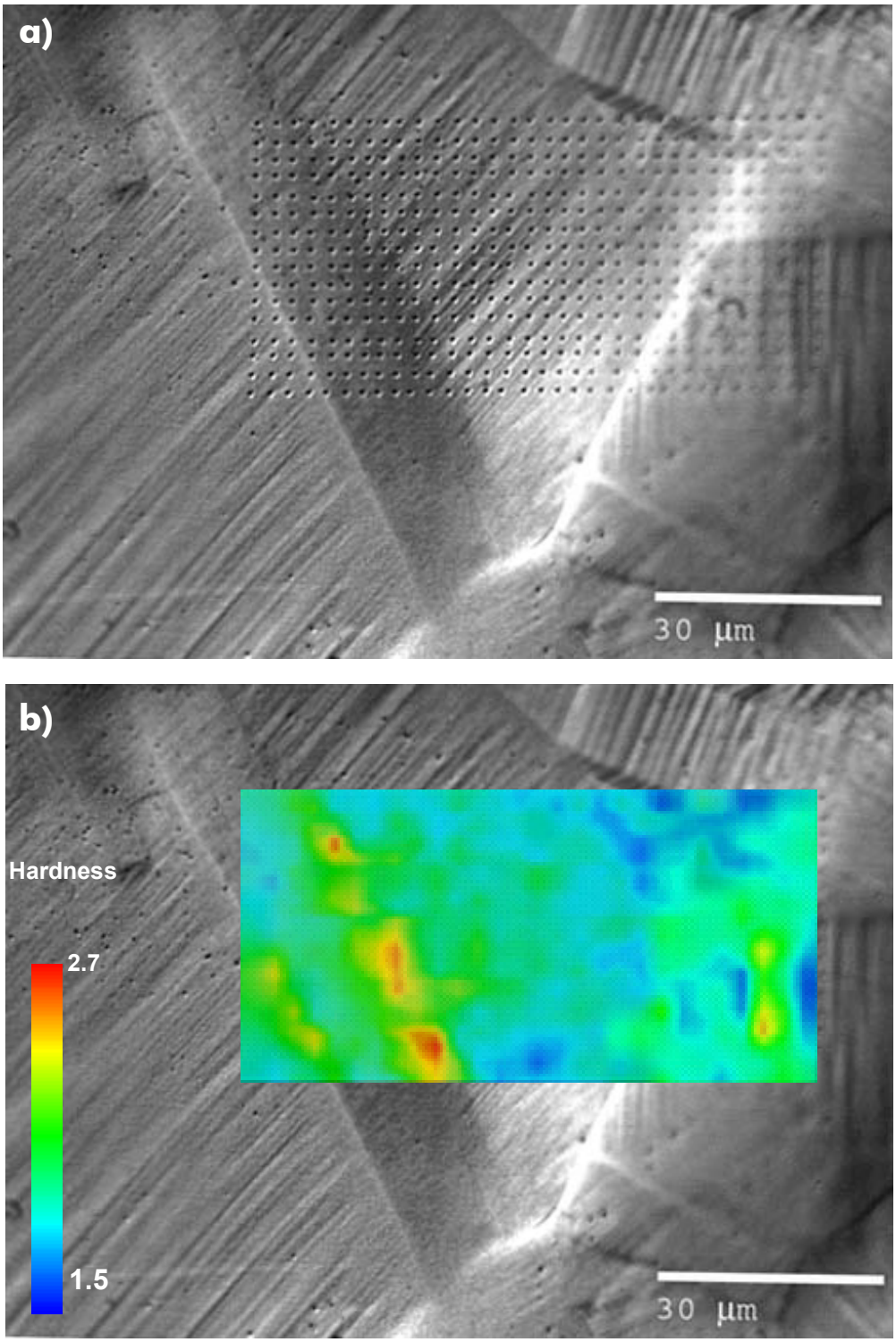

Figure 2: a) Optical micrograph of a grid of TriboIndenter indents superimposed on a twin and grain boundaries in Copper strained to 5%. (b) Corresponding hardness map indicates that the twin boundary is locally harder than the matrix material.

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