SPM

Scanning Probe Microscopy

MATERIALS & SURFACE SCIENCE INSTITUTE

Introduction

Atomic Force Microscopy (AFM), also referred to as SPM or Scanning Probe Microscopy, is a high-resolution imaging technique that can resolve features as small as an atomic lattice in the real space. This allows researchers to observe and manipulate molecular and atomic level features.

In AFM, a cantilever tip is brought into contact with the surface to be imaged. An ionic repulsive force from the surface applied to the tip bends the cantilever upwards (Fig. 1). The amount of bending can be used to calculate the force. The vertical movement of the tip as it follows the surface profile is recorded as the surface topography by the AFM.

Technical Specification

MSSI's Agilent 5500 is a research grade atomic force microscope (AFM) that can accommodate samples of all sizes due to its "top-down" design in which the scanner and tip are mounted above the sample. The instrument is fitted with a hot stage (ambient temperature to 250ºC), a potentiostat for electrochemistry experiments, and Anasys Instrument's nano-TA2 thermal imaging and analysis accessory. Available operating modes include all standard AFM modes, scanning tunnelling microscopy (STM), nano-TA (thermomechanical analysis sub-100 micron resolution), heated tip AFM (HT-AFM) and scanning thermal microscopy (SThM).

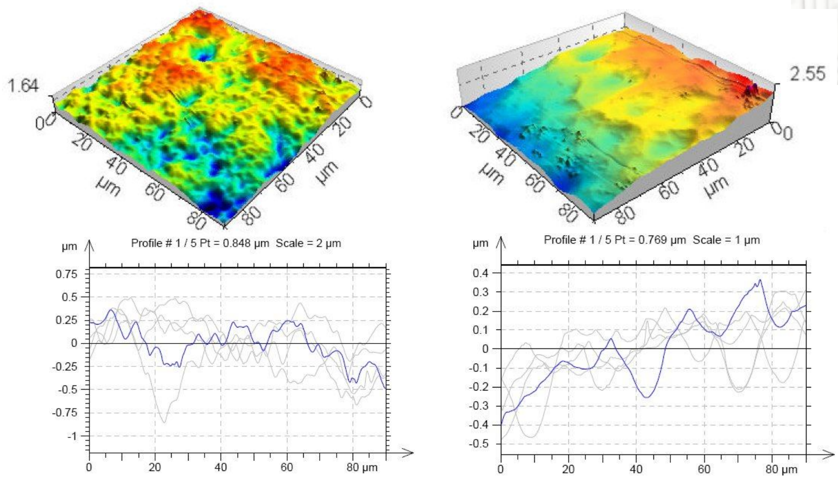

Figure 1. 3D topography image and line profiles are shown after (a) 10 minutes and (b) 30 minutes etching time. (Courtesy Ed Chadwick, Gordon Armstrong and David Tanner, MSSI)

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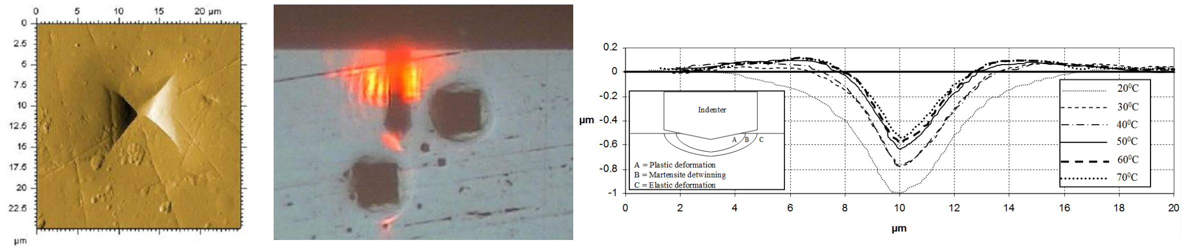
Examples of Work Undertaken at MSSI

AFM was used to investigate the Martensitic to austenite phase transformation in Nitinol shape-memory alloy. After conducting microindentation tests at 4 ºC, the sample was mounted on the heated stage of the AFM, and imaged in contact mode at intervals between 17 ºC and 70 ºC to observe the indent recovery. These observations (cf. figure 2) were found to correspond well with transformation temperatures measured by differential scanning calorimetry and structural information obtained from x-ray diffraction experiments also conducted at MSSI.

AFM was used to optimise experimental conditions for etching of porous silicon. Changes in pore size were determined from line profiles collected at 100 nanometre intervals across the topography images collected from samples etched using hydrofluoric acid for different times, as shown in figure 1.



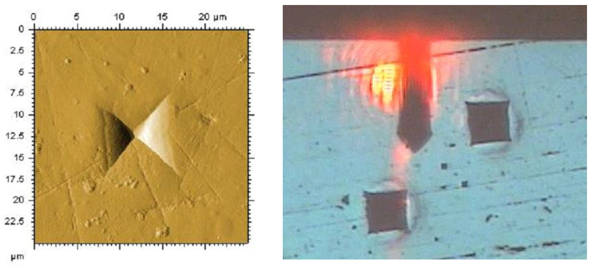


Figure 2. AFM image of Vickers indent before and after recovery. (a) Indent at 17 ºC, (b): indent at 70 ºC, (c) indent recovery versus temperature measured by AFM. (Courtesy Jim Butler, Maros Gregor and Tofail Syed, MSSI)

Detailed Technical Specifications

Multi-purpose AFM scanners, scanning tip design.

- 9 x 9 µm scan area, 2 µm feature height
- 90 x 90 µm scan area, 7 µm feature height

STM scanner: 1 x 1 µm, preamp sensitivity: 1 nA/V.

Operates in air, liquid or controlled atmosphere via environmental chamber.

Controlled temperature sample stage, ambient to 250 ºC.

Potentiostat/galvanostat functionality.

Cantilever spring constant calibration module for point spectroscopy.

Nano-TA2 module: temperature ramp rate up to 600,000 °C/min; max. probe temperature 500 °C; compatible with contact and tapping imaging modes.

Resolution: atomic lattice (AFM), atomic (STM), < 100 µm (NanoTA & SThM).

Available operating modes include all standard AFM modes, scanning tunnelling microscopy (STM), nano-TA (thermomechanical analysis sub-100 micron resolution), heated tip AFM (HT-AFM) and scanning thermal microscopy (SThM).

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