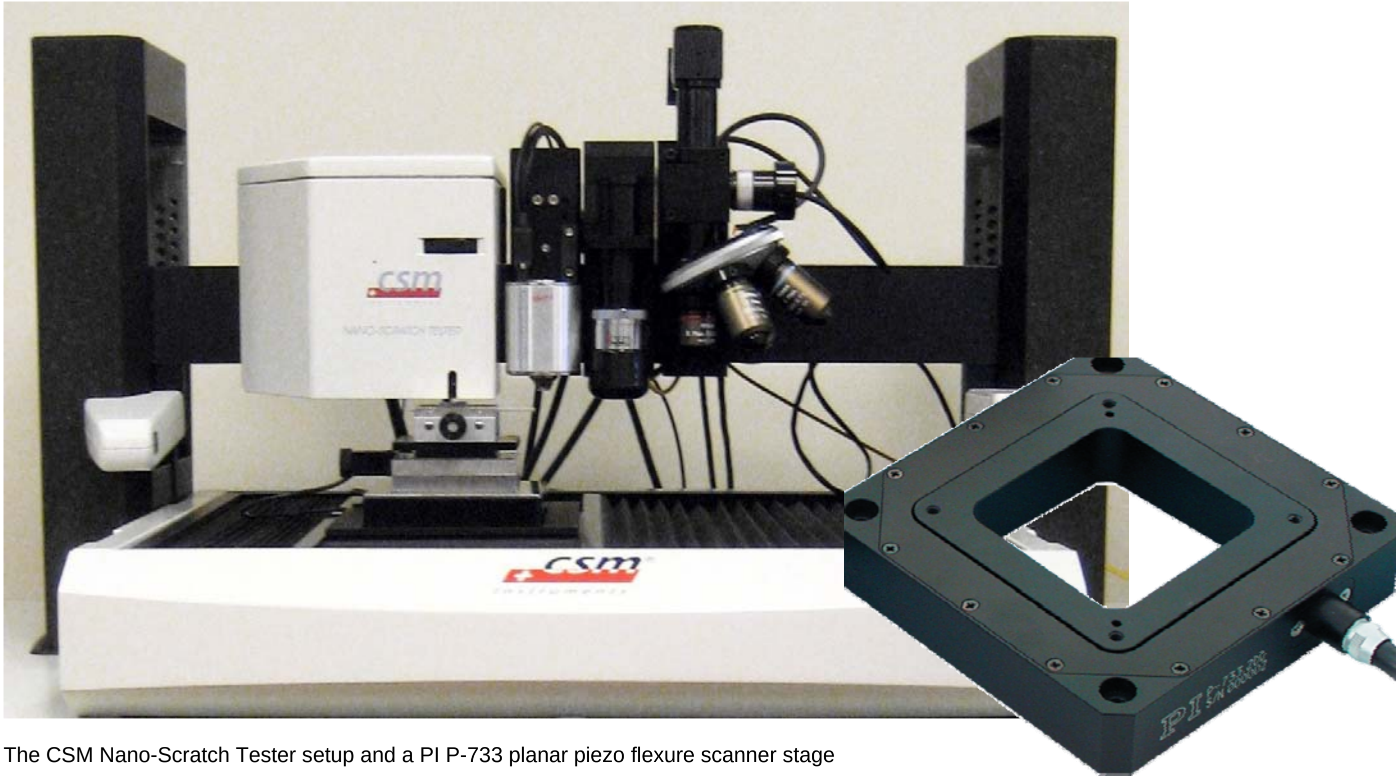
Technote: Indentation Lithography Enables Complex 3D-Nano Patterns



The CSM Nano-Scratch Tester setup and a PI P-733 planar piezo flexure scanner stage

A recent collaboration between the Whitesides Group at Harvard University and CSM Instruments has culminated in an important advance in lithography of different materials at the nanoscale. The motivation for this development was the ability to produce unique lithographical patterns of different shapes and sizes for use in research applications (e.g. lab-on-a-chip) where conventional techniques such as electron-beam lithography (EBL) and photolithography cannot be used. The new method utilizes the standard Ultra Nanoindentation Tester (UNHT) and the Nano Scratch Tester (NST) without any modification. The methodology has the following advantages:

1. It can generate multiple levels of relief (height) by altering the applied load
2. It can control the shape of the pattern by using indenters of different shapes
3. It can produce patterns in very hard materials if a diamond indenter is used
4. It can produce features with a wide range of depths, from a few to several hundred nanometers.

These characteristics produce patterns with three-dimensional relief which would be impossible to achieve using lithographic techniques in which features have a fixed depth and approximately vertical sidewalls.

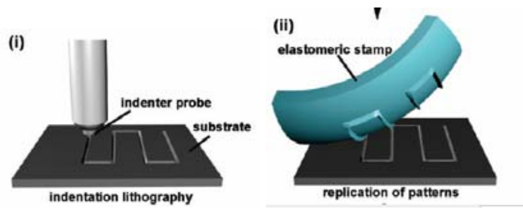


Fig. 1: Pattern produced with a diamond indenter can then be replicated by pouring a polymeric layer over the substrate.

Resultant patterns can then be replicated as shown in Fig. 1 to produce a stamp bearing an inverse replica of the original pattern. Such replicas can in turn be used to pattern other materials in an efficient and cost-effective manner.

The experimental setup consists of a standard CSM Instruments Open Platform fitted with Ultra Nanoindentation (UNHT), Nano Scratch (NST), Atomic Force Microscope (AFM) and Optical Video Microscope modules. Translation of the sample between these modules is positionally synchronized so that any predefined area of a surface can be patterned in an automatic way and subsequently imaged in three dimensions.

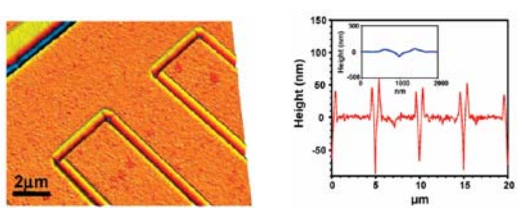


Fig. 2: Continuous channels with 70 µm length and 5 µm spacing produced in an epoxy substrate.

The actual shape of the patterns is achieved with a Physik Instrumente (PI) P-733.2CD stage which is mounted directly on the Open Platform and allows sub-nanometer positioning resolution in the X and Y axes.

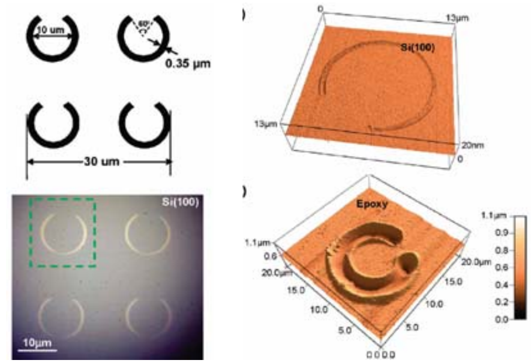


Fig. 3: Typical 2D array of split rings produced in epoxy with an outer diameter of 10 µm, line width of 350 nm and a 60° opening

The combination of nanopositioning, accurate load control and choice of indenter geometry means that almost any shape and depth of feature can be achieved in a fast and reproducible manner.

The full paper is available at
http://pubs.acs.org/doi/abs/10.1021/nl101675s

J. Gong, D. Lipomi, J. Deng, Z. Nie, X. Chen, N. Randall, R. Nair and G. Whitesides, NanoLetters 10 (2010) 2702-2708

Contact:
CSM Instruments:
http://www.csm-instruments.com

PI (Physik Instrumente) L.P.
http://www.pi-usa.us