Nanolithograpy

Advanced Vector Nanolithography Using Closed Loop Scan System

Nanolithography

Normally AFM is used to image a surface without damaging it. However, AFM can be used to modify the surface deliberately, by applying either excessive force, or by applying high-field pulses. Not only scientific literature, but also newspapers and magazines have shown examples of surfaces that have been modified atom by atom. This technique is known as Nanolithography.
Nanolithography patterns are created on the sample surface by two methods as shown in Figure 1. First method is to scratch the sample surface with hard tips, mechanically deforming the sample surface. Second method is to apply bias between the tip and the surface, inducing the change of the chemical properties of the surface. The lithographic patterns can be generated in diverse forms: point or grid. Raster Nanolithography is common where the entire image is scanned.

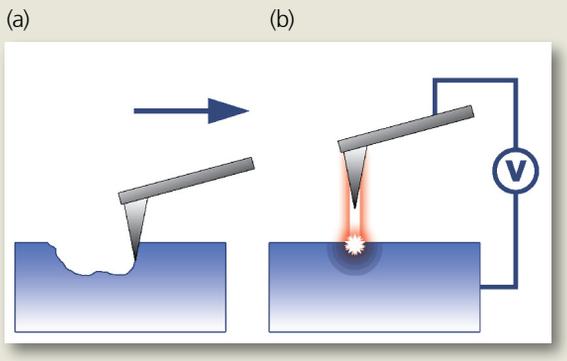


Figure 1.
Pattern created on the surface by plowing the surface with the tip (a) and by changing the surface with applied bias (b).

Vector Nanolithography Means Advanced Closed Loop Scan System

When it comes to Nanolithography, the value of advanced closed-loop system cannot be emphasized enough. It is no exaggeration that the reliability and efficiency of Nanolithography depend on it. With the state-of-the-art closed-loop system offered by the XE-series AFM, the vector Nanolithography can be realized.

The XE-series AFM use the Position Sensitive Photo Detector (PSPD) in the XY-scanner as the closed loop sensor, and PSPD monitors the movement of XY-scanner and controls it in real time. This enables the vector movement of the cantilever in XY direction. In other words, rasterizing, a common method used in Nanolithography of other AFM systems, is not necessary for XE-series AFM even though it is provided by the XE-series AFM. In a way, the vector Nanolithography is the ultimate measure of the performance in one's closed-loop system.

From Figure 2, the advanced performance of vector nanolithography is demonstrated. The Nanolithography image in Figure 2 (b) was written with two circles and two lines, individually in vector as shown in Figure 2 (a). The width of lines depends on several factors such as the applied voltage and/or the atmosphere humidity during the scan. Note that there is no distortion of the image even though the lines were drawn in vector movement, not rasterizing. This shows the superior performance of the closed-loop system of the XE-series AFM.

XEL - Advanced Nanolithography Software

Nanolithography process of the XE-series AFM is controlled by XEL lithography control software. XEL has a convenient user interface which makes the lithography process as easy as drawing a picture with simple graphic software. Just by mouse manipulation, objects can be easily drawn, resized and moved. Bitmap images can be imported for rasterizing and vector Nanolithography respectively.

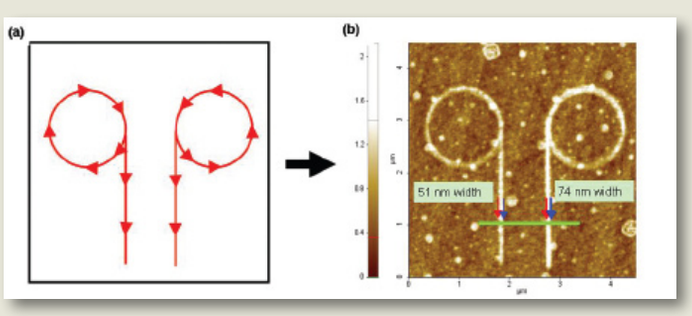


Figure 2.
Vector Nanolithography. The image is generated in vector by applying negative voltage between -5 and -10 V. Scanning rate was varied between 1 and 0.1 μm/s. The height of deposited oxide is about 2-4 nm.

Figure 3.
(Left) Bitmap image pattern generation using (a)domain switching on PZT film, and (b) nanoscratch on polycarbonate film, 30 μm scan size.

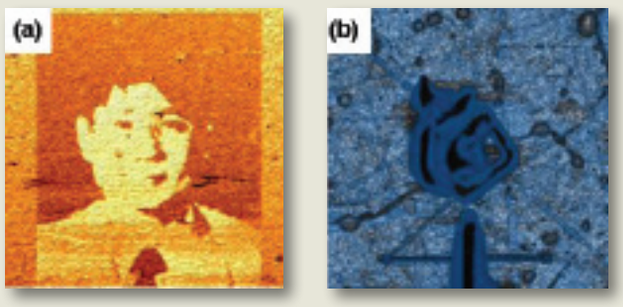
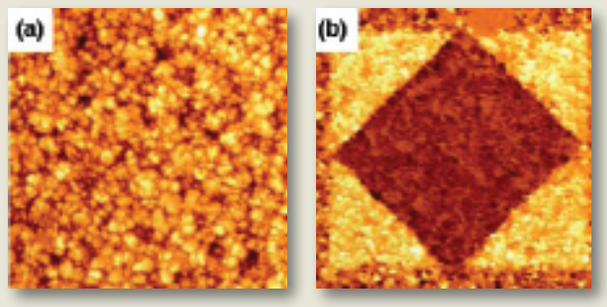


Figure 4.
(Right) EFM image of lithography performed on PZT film (a) before and (b) after the domain switching, 5 μm scan size.



The XEL software has the following advantages:

- A variety of lithography modes
- Separates Background and Object properties.
- Supports both Vector mode and Raster mode
- Provides a convenient Graphic Editor

Figure 3 is a bitmap image pattern generation using voltage induced Si oxidation. Electrical domain of PZT film can be switched by applying different bias between the tip and sample at different position. Figure 4 shows the before as shown in Figure 4 (a) and after as shown in Figure 4 (b) the domain switching of EFM images of the PZT film. Light colored regions are biased by 10 V and dark regions are biased by -10 V.

External High Voltage Lithography

Nanolithography in the XE-series is a technique used to pattern nano-scale shapes on the sample surface. For ordinary Nanolithography mode using the XE-series AFM, the available range of the applied voltage is -10 V to +10 V. For special situations requiring a higher voltage range, High Voltage Nanolithography mode has been developed. With the External High Voltage toolkit, XE AFM can be connected to external voltage amplifier enabling the experiments or measurements with tip or sample bias exceeding 10 V. The available voltage range for High Voltage Lithography depends on the external voltage amplifier.

Applications:

- Develop NanoLithographic media and techniques
- Study minimum feature size
- Minimum line spacing
- Resist exposure speed
- Exposure threshold