SNOM Lithography on positive photoresist

Igor V.Dushkin, Alexey V.Mezin

103460, Moscow, Russia, State research Institute of Physical Problems, NT-MDT Co.

T: (+7095) 535-03-05, 535-24-93, 535-83-69
E-mail: dushkin@ntmdt.ru, mezin@ntmdt.ru
http://www.ntmdt.ru

Introduction

The speed and performance of the chips, their associated packages, and, hence, the computer systems are dictated by the lithographic minimum printable size. In optical projection lithography, resolution is given by the equation

$$W = k_1 \lambda / NA,$$

where λ and NA are the exposure wavelength and numerical aperture of the optical lithography tool, and k_1 is a constant for a specific lithographic process. As the wavelength becomes shorter, the light source becomes more complex and expensive.

The different types of scanning probe microscopies (SPM) allow a novel approach for submicrometer lithography. The slow scanning can be partly compensated by using it in combination with conventional methods (mix- and match-technique). Especially scanning near-field optical microscopy (SNOM) is of interest for lithography, because it can be applied on the existing resist techniques and materials of today's micro-structuring. Scanning near-field optical lithography (SNOL) may satisfy the increasing demands for an inexpensive lab tool to prepare and manipulate nano-structures below 100 nm.

Experiment

In most practical cases the resolution of SNOM is limited by the size of the light source and its distance from the sample. Therefore the potential of near-field optical methods for lithographic purposes can only be fully exploited by applying it to ultrathin or monomolecular photoresists.

The common SNOM lithography process, as described in many papers in detail, includes the following steps:

1. Sample preparation.
2. Adjusting scanning head over the sample and probe approach.
3. Modification of sample surface with suitable wavelength laser light.
4. Developing if the sample, which includes some kind of etching and other manipulations usual for photoresist materials.
5. Repeating of step 2 followed by scanning to control results.

In this scheme the first and 4th steps are perfectly developed in conventional lithography, and the second step is well known from SPM. The third step is of main interest. And 5th step seems to be unnecessary in this scheme. But majority of research works in SNOL includes this step. It is very hard to control result of lithographic process with SPM scanning because area of modified sample is about only several microns in diameter and often it is impossible to find it over the sample after developing.

In our laboratory we are working on new technique of SNOL, which includes only first three steps. Out experimental setup is shown on **fig. 1**. Ar-ion laser light with wavelength of 488 nm is transmitted through single mode fiber probe with Al-Va-coating. The aperture diameter of probe is about 100 nm. Probe approach and scanning are made by Solver

SNOM scanning head (Product of NT-MDT). We use a mechanical shutter to make a light pulses. We can control the shutter directly from Solver SNOM software (Lithography option) through scanning head controller.

In our experiments we used a thin layer of positive photoresist on flat Si substrate. After probe approaching we made a shear force image of sample surface to ensure that it is rather flat and free from artifacts. Then we moved probe over surface by especial marker in software or by programming it behavior. Software allows as to draw raster (pcx files) or vector images (lines, circles and alphabet signs). During probe movements a laser pulses were made. The pulses length was of 0.1-5 seconds. The total power reached probe aperture and hence the sample surface was 1-10 mW. Drawing immediately followed by shear force scanning.

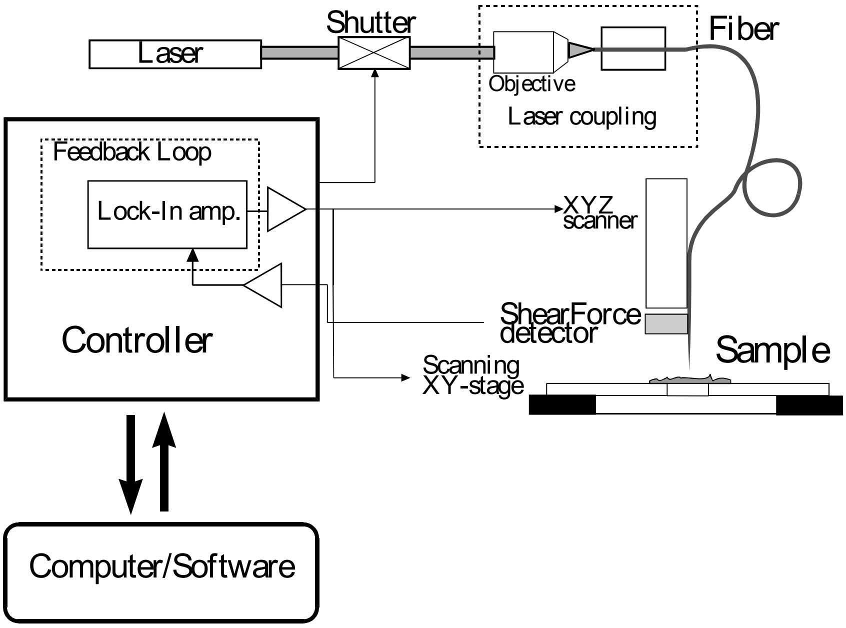

Figure 1. Experimental setup.

Results and conclusion

Obtained results are represented on **fig. 2**. One can see that with the help of this method it is possible to draw nanostructures with 100 nm width or even less.

This is a very first step in developing fast and reliable SNOL. Many things are still to be done and many problems are remains unsolved. But our investigation shows principal possibilities of this technique.

Acknowledgements

The authors are grateful to V. F. Dryakhlushin from Institute for Physics of Microstructure RAS for high quality fiber probes and fruitful discussion about light propagation through probe aperture.

1. V.F.Dryakhlushin, A.Yu.Klimov, V.V.Rogov, *"Probes for a Scanning Near-Field Optical Microscope"*
2. T. Fujimura, T. Itoh, T. Koda, H. Miyazaki and K. Ohtaka, *"Near-field optical images on the surface of ordered dielectric microparticle layer"*

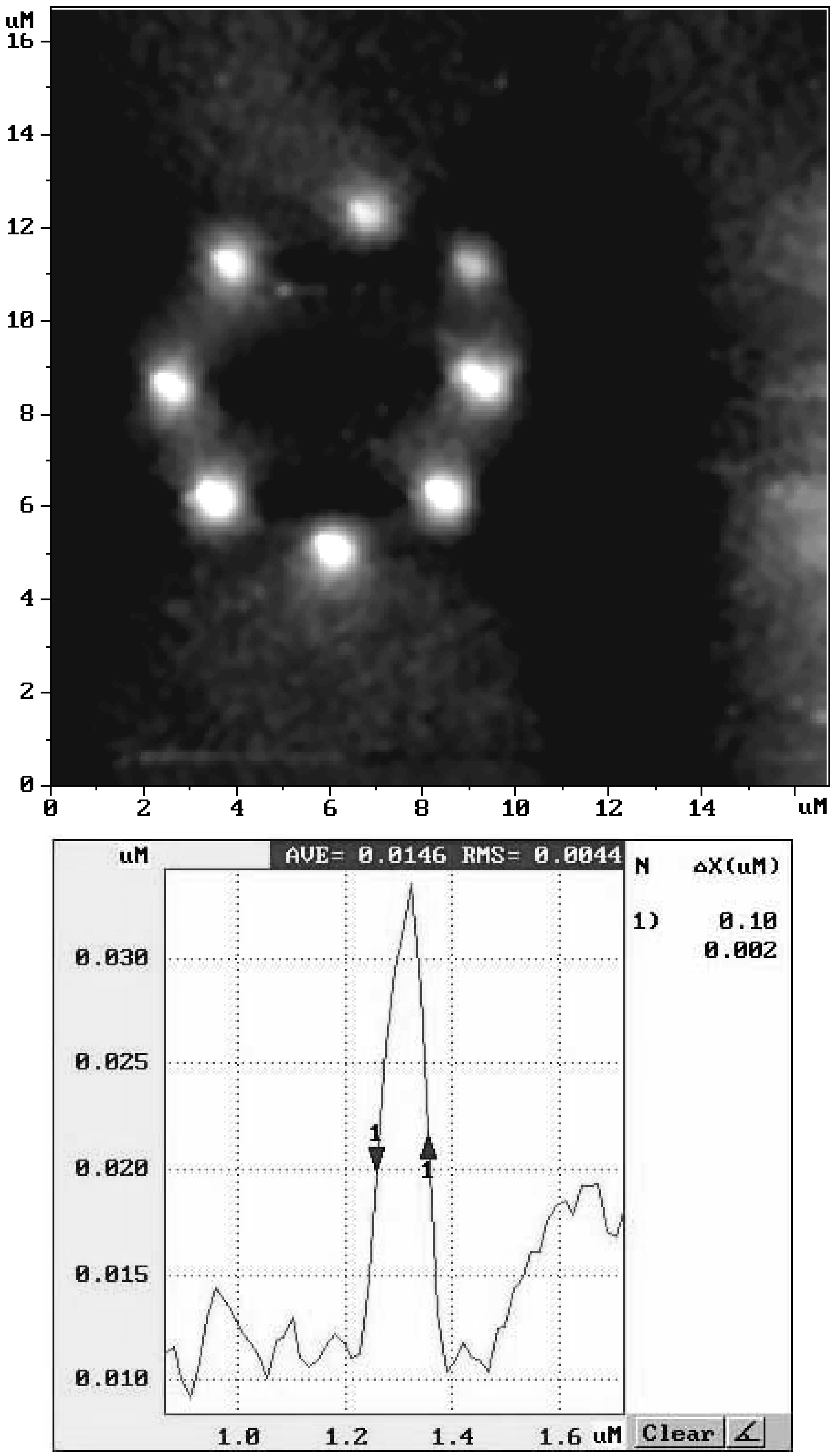

Figure 2. Dots on a positive photoresist and a crossection of one dot.