Poster

NANOIDENTATION TOOL FOR THIN POLYMER FILM DIAGNOSTICS AND 3D SUB-10NM TECHNOLGY

O. Trofimov, S. Dubonos, A. Svintsov, S. Zaitsev.
IMT RAS, Chernogolovka, Moscow distr., Russia, 142432,
E-mail: zaitsev@ipmt-hpm.ac.ru

Demands of high throughput in NIL dictate to make glassy points of polymer matter used in NIL rather low and approach for measurement of viscous properties of tailored polymers should be developed. The method should allow to measure the properties at the state in which the polymer is intended to be used. So polymer films with thickness about hundreds o manometer must be experimentally treated at different temperatures.

It is plan to solve the task with developing an approach based on nanoidentation technique. The solution includes
-construction of a specialized AFM like tool with miniature thermostage
-development/adaptation of specialized software to control measurements
-development of experimental method for measurement
-development of interpretation procedure.

With the approach developed it is intended to perform measurements of rheological data for polymers and also to develop a method for residual resist thickness at nanoscale.

Main idea of the measurements and principal schema of the indentation tool is illustrated in Fig.1. Slope of plastic part of the loading curve is temperature dependent (Fig.2). The slope measured as function of temperature characterizes viscous properties of (polymer) matter. Measurements of the whole loading curve (thousands of points) takes about only one second. The first examples of loading curve and temperature influence on curve slopes are shown in Fig.4. PMMA based resist of 950K molecular weight with 120 C expected glassy point was tested at different steady state temperutures. Black curve demonstrate pure elastic slopes at room temperature where as blue curve is measured at 137 C. Main qualitative result is great decreasing of slopes.

The same tool is suggetsted to use for development of a novel approach for scanning (*local*) nanoimprint lithography when a structure is forming step by step indentation with fine and strong tip similar to conventional e-beam lithography. The novel method could be used in mix and match mode with photolithography, e-beam lithography or NIL. Depending on tip geometry the approach promises nanostructuring below 10nm level. A special method for growth of fine and strong tip was used for carbon tip fabrication. Carbon tip (diameter<10nm, open angle $<10^{O}$) is grown on the commercially available Si tip by lateral growth under e-beam. To realize sub-10nm spacial resolution it is suggested to use metal deposition and inclined dry etching for the later rather high aspect ration (1-2) should be provided.

It is essential that the software developed (like NanoMaker for e-beam lithography) allows to perform design of structures, treatment data for alignment, compensation of delays, distortion, hysteresis etc. The software also control indention process providing given penetration depth of a tip. So the control of tip z-movement allows to fabricate 3D structures with spatial resolution in z-direction also at sub-10nm level.

Examples of dot by dot as well line structures (Fig.3) according to the method are presented. Spatial resolution about 20 at aspect ratio 1 was achieved.

The partial support of the EC-funded project NaPa (Contract no. NMP4-CT-2003-500120) is gratefully acknowledged. The content of this work is the sole responsibility of the authors."

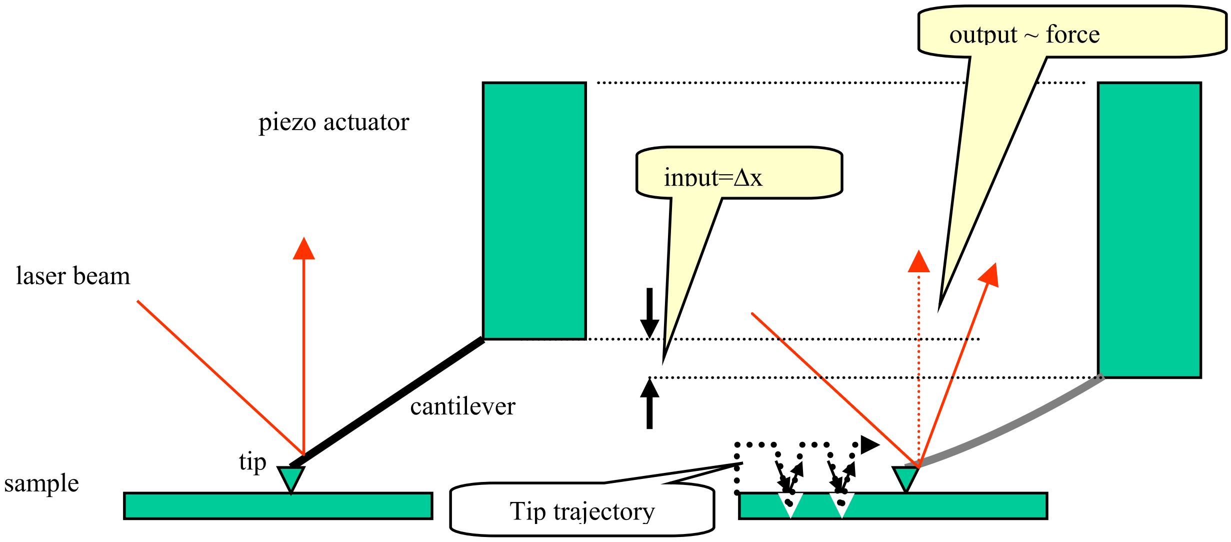

Fig.1 Measurement of loading curve with Atomic Force like set-up. Input signal is elongation of peizo-actuator, Δx, output signal is cantilever bending which is proportional to force.

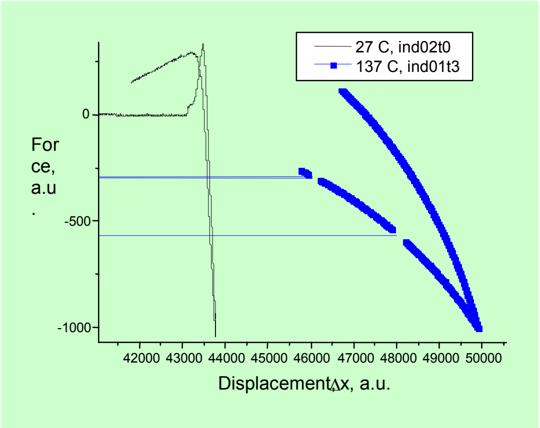

Fig.2 Loading curves at different temperatures 27C (thin curve) and 137C (thick curve) of PMMA based resist (of molecular weight 950K with expected glassy point about 120C) show decreasing of slopes due to changing regime of deformation from elastic to plastic (viscous).

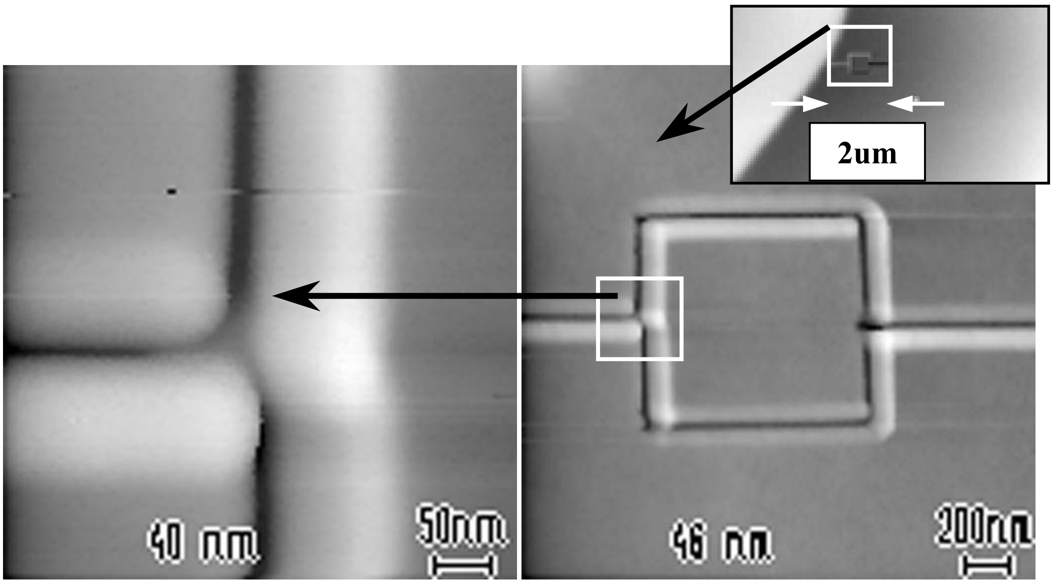

Fig. 4. The AFM images after point by point indentation of PMMA film. Trench width is about 20nm. Observed aspect ratio is about 1 what is close to needed 2.