Auxiliaries for scanning probe microscopes

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Introduction

Scanning probe microscopes (SPM) have currently turned into sophisticated analytical tools aimed at investigating both various surface characteristics (topographical, magnetic, electrical, adhesive, etc.) and physicochemical processes on the surfaces of objects under study (adsorption, desorption, wetting, catalysis, etc.). Both, general-purpose, and customized scanning probe microscopes adjusted for different environments, have been developed to suit these purposes. Yet, to solve some material science problems, the investigation of nonstandard samples in special conditions, can be required.

This determined the objective of the present work: to develop and manufacture the auxiliaries for SPM Solver P4-SPM and Solver P47 by NT-MD. Microscopes, thus modified, could allow a wider range of apparatus capabilities to perform a series of special studies. Two devices are presented in the paper: a precision device for probe positioning and a gas-liquid reactor.

Results

On Fig.1.(I) given is a schematic diagram of a precision device for probe positioning. The device is intended for investigating surface areas with sizes exceeding those of a scanning field in SPM Solver P4-SPM and Solver P47. It also enables a precise positioning of a probe on a surface area of choice after a repeated mounting of a sample into a microscope, as well as the investigation of large samples with a strongly developed relief.

The device-specified area of a probe travel across a sample surface is in the range of 1000 × 1000 μm. A very smooth, jerkless travel with a pitch of 0.5 μm is guaranteed both in a direct and an opposite directions. The positioning precision is as high as 1 μm. To avoid the deformation of SPM dampers, the device parts are fabricated from aluminium and its alloys. Guiding elements 4, inserted into a foundation groove 2, make a ring and supports rotate around the axis Z. Using this rotation, a researcher can find a travel direction of a scanning head probe, precisely along the scanning axes of a piezoscanner, or otherwise. Micrometric screws and spring pushes guarantee a mutual perpendicularity of the reciprocal motion of table 1 along axes X and Y. The device is easily mounted and removed, without affecting the apparatus characteristics.

One of the device features is demonstrated on Fig.1.(II). Actually, the image of a crevice on the sample surface represents a combination of images from neighbouring areas. To achieve this, the micrometric screws were adjusted, so that they can move the scanning head probe along a crevice found on a sample surface. It is seen that the resulting image sizes are 51 × 54 μm. This is 5.3 times as much as the sizes of the maximum scanning area for this microscope.

Also, Fig 2.(a) demonstrates a schematic drawing of a gas-liquid reactor (GLR). This device is useful in making measurements from various gas and liquid environments. Its second asset is the possibility to perform an *in situ* chemical modification of sample surfaces, which can be required in chemical force microscopy. Because the GLR is leak-proof, it is indispensable for a durable handling of volatile liquids. Its construction makes possible an easy replacement of the reactor bottom part and a sealing membrane to suit the investigational tasks and types of liquids. Another asset of the construction is widely variable sizes of a sample (B=10 mm, L=5-15 mm, H=0.5-10 mm). The sample is fixed with a tab screw-washer, while a

clamping plate is used to fix the probe. The latter provides a possibility to use multi-cantilever probes. To fix the GLR no changes in a standard apparatus configuration are required. The upper part of a GLR is mounted onto the scanning head, while the bottom part is located on the piezoscanner under the tabs. The device materials are fluoroplast, stainless steel, quartz glass, and silastic.

Fig.2.(b), fig.2.(c) represents the results of the image reproducibility tests for this device. Measurements were made in air and in liquid. A characteristic small-grained structure of germanium, sputtered onto a polyimide film, determined its choice as a test sample. It can be seen that air- and liquid-measured images are close in their quality.

Conclusion

The test results have shown that the devices suggested are reliable and easy-to-operate, and meet the specified requirements. They can be used both in probe microscopes Solver P4-SPM and Solver P47 by the NT-MDT-company (Zelenograd, Russia) and in other microscopes.

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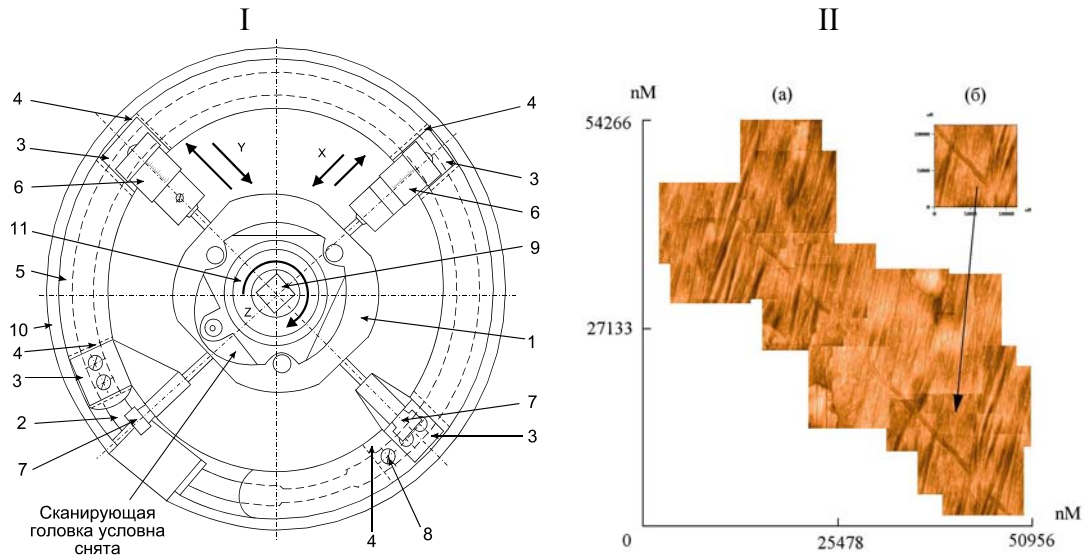
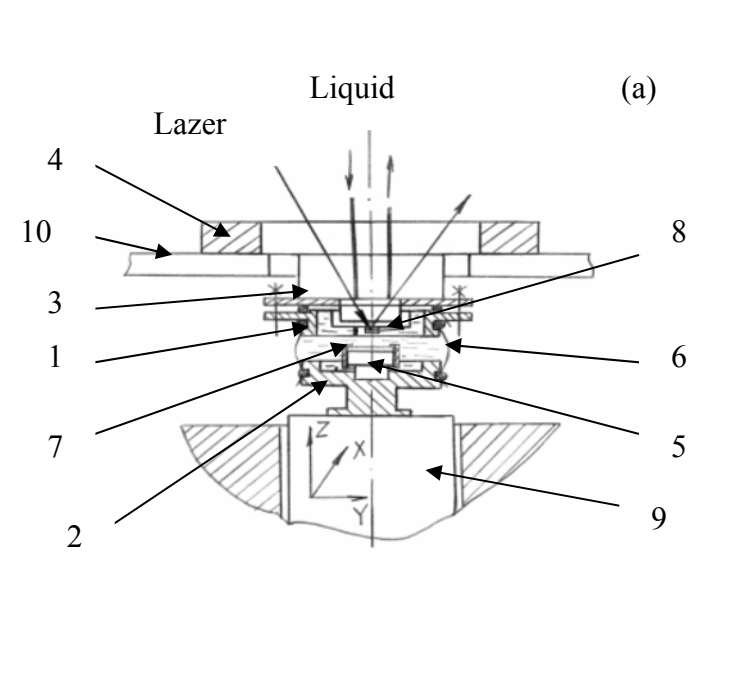


Fig. 1.
(I): Precision device for probe positioning: 1-table; 2-base; 3-support; 4-guide; 5-ring; 6-microscrew; 7-spring pusher; 8-top screw; 9-ample; 10-canning module; 11-piezoscanner.
(II): Images of a crack on the surface of a titanium alloy sample *after fatigue* strength test: (a) image obtained using the positioning device and (b) without the positioning device.



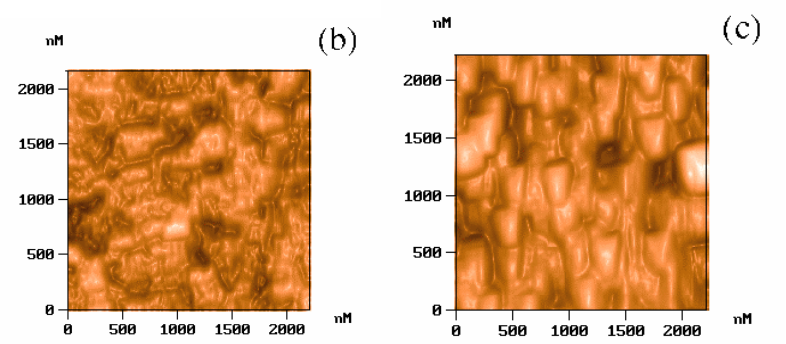


Fig.2.

(a): Gas-liquid reactor: 1-the head of the reactor; 2-the base of the reactor; 3-cover; 4- table; 5-sample table and screw-washer; 6- silastic; 7- sample; 8- probe; 9- piezoscanner; 10- scanning head.

(b): ACM- image of surface sample in the air.

(c): ACM-image of surface sample in the liquid.