特集
研究速報

A Positionner for Local Probing of Three Dimensional Nanometric Features in a Scanning Electron Microscope

走査型電子顕微鏡下でのナノメータオーダの3次元物体へのプロービング機構

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1. Introduction

Recently, there are a lot of studies about scanning probe microscopy[1] and nano fabrication. In these studies, there is a growing need to control the position of probes correctly at a nanometric order. One example of nanometric tip to tip positioning was carried out by R.Möler[2] et al.

In this report, we introduce a three dimensional nanometoric positionner using a piezotube[3] and a DC motor which can be mounted on a commercial scanning electron microscope (SEM).

2. Instrument

Figure 1 and Figure 2 are schematics of the three dimensional nanometric positionner. A micrometer head is used for the z axis coarse positioning of the slider which carries a five electrode tube piezo. The tube piezo is used for fine positioning of the probe in the z direction. The slider rests on the base by forces of magnets, and can move only in the z direction. An inertia drive[4-9] of the tube piezo is used for coarse positioning in the x and y directions. The tube piezo is also used for fine positioning in the x and y directions. The probe holder rests on ruby balls, which are glued on the end of the piezo tube. A spring pulls the probe holder against the ruby balls. The tension of the spring can be adjusted by a wire attached on the spring.

Figure 3 shows the schematic of the probe holder. Parts 2 is used for a stage for the probe, and an optical fiber is held between Parts 1 and Parts 2. Parts 2 is fixed at an angle of 10 degrees to the plane of the probe holder. It prevents the probe holder from touching the sample before the probe.

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The height of this instrument is under 30 mm, and can be put in a commercial SEM to carry out in situ fabrication, manipulation, and observation.

3. Experiment

3.1 Experiment

We assembled the three dimensional nanometoric positionner and put it in the commercial SEM with an inner pressure of 10^{-5}

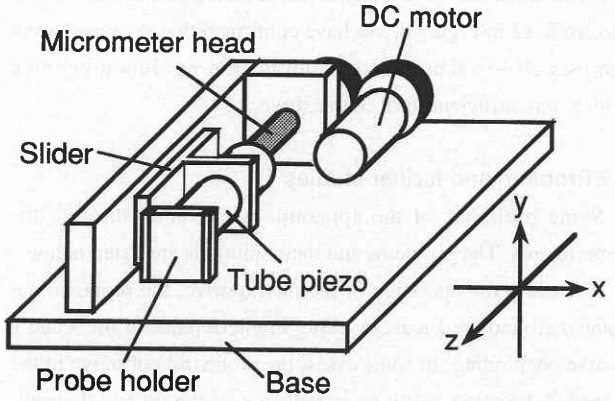

Figure 1　Schematic view of the three dimensional nanometric positionner

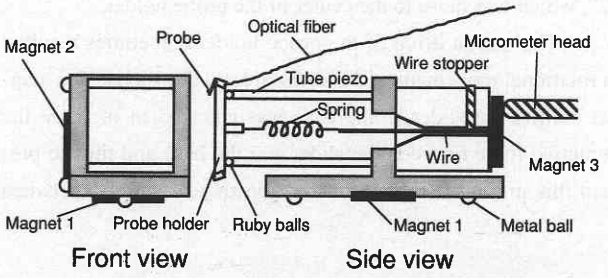

Figure 2　Schematic view of the slider

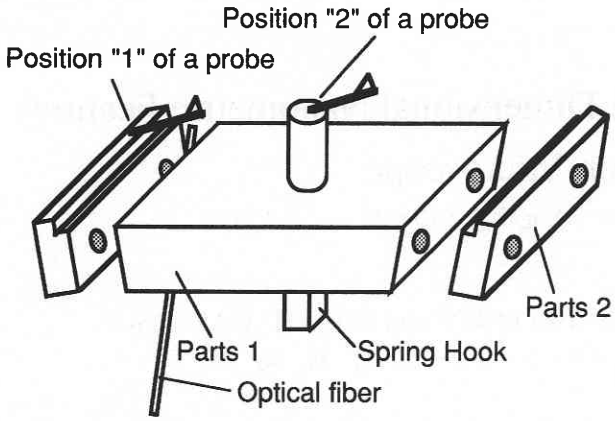

Figure 3　Schematic view of the probe holder

Torr. The aim of the experiment was positioning of the probe to a fixed three dimensional sample, in this case a nanometric oscillator.

To generate an inertia drive for x and y axes coarse positioning, a saw tooth wave with an amplitude of 150 V peak to peak was applied to the electrodes. The inertia drive worked for the saw tooth wave between 20 Hz and 500 Hz. For example, to position the probe in the x direction, we supplied the saw tooth wave to electrode x1 and supplied a reversed saw tooth wave to electrode x2 in Figure 4. We have confirmed that the positionner works well in vacuum with a sub micron resolution per step which was sufficient for a coarse drive.

3.2 Problem and further studies

Some problems of the apparatus were found through the experiments. The problems and their solutions are listed below.

(i) During the operation of the inertia drive, the probe holder rotated around the z axis, resulting in interference of the x and y coarse positioning. In some cases, the probe did not move in the intended direction, resulting in collision of the tip and the sample. Due to this problem, the position of the probe on the probe holder was changed from position "1" in Figure 3, to position "2", which was close to the center of the probe holder.

(ii) The inertia drive of the probe holder sometimes resulted in rotational movement of the slider around the y axis. The magnet pulling the slider to the base was changed to increase the attractive force between the slider and the base and thus to prevent this problem. A good balance needs to be found between

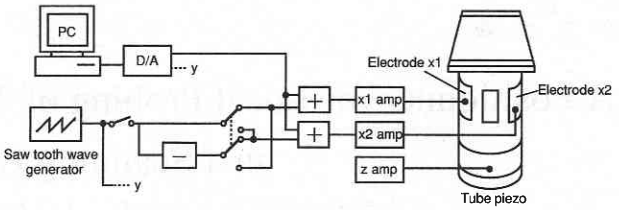

Figure 4　Driver of the five electrode piezo. This figure only show the circuit for the x direction.

the forces of the magnets "1", "2" and "3".

(iii) The lack of perspective of the SEM images made it relatively difficult to position the apexes of the probe and the sample.

4. Conclusion

From the experiment, it appears that the positionner has sufficient accuracy. We will improve the apparatus to facilitate positioning of the probe in the SEM. An optical detection system will be added for AFM operation. But some problems remains such as, the slider rotating around the y axis and the probe holder rotating around the z axis.

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