

**New SPM Measurement Method: ZXY Scanning,
Overcoming the Difficulties of Conventional SPM
Measurement**

The data acquisition method used in scanning probe microscopy (SPM) is generally “XY scanning,” in which the probe follows the sample surface so as to maintain a constant interaction between the probe and sample. XY scanning enables rapid scanning and has high in-plane resolution, and is the basis of various measurement modes. However, at the same time, the difficulty of scanning wide fields of view, soft samples, and samples with large surface irregularity is a weakness of XY scanning as well as SPM measurement. We succeeded in practical application of ZXY scanning, which can overcome these weak points, as reported in this article.

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■ XY Scanning and ZXY Scanning

Fig. 1 shows the principles of the conventional method of XY scanning and the new method of ZXY scanning. XY scanning is the most widely-used method in SPM. As its operating principle, the probe is always positioned in close proximity to the sample and follows the sample surface so as to maintain a constant interaction between the probe and sample. The obtained image consists of 2-dimensional data for the X and Y directions, in which convex areas are expressed as bright and concave areas as dark contrast in the surface height image. Because scanning is fast and this technique has high in-plane resolution, it is basis of a variety of measurement modes. On the other hand, because the probe and sample are always in a condition of close proximity, there is a risk of damage due to strong contact between the probe and sample. For this reason, the XY method has the following problems.

- Measurement of wide fields of view
→ Scanning time is excessive because the scanned area is large.
- Measurement of soft samples
→ The sample may be dragged by the probe, altering the scanning direction.
- Measurement of samples with large surface irregularity
→ The probe cannot follow the uneven surface profile.

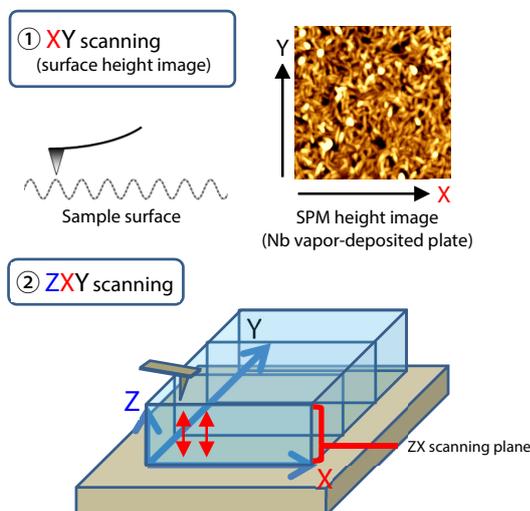


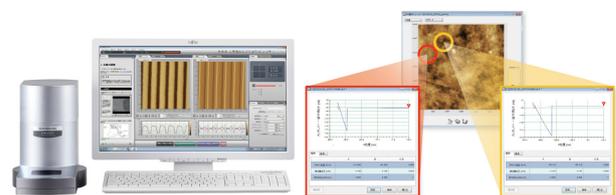
Fig. 1 Principles of XY Scanning and ZXY Scanning

In ZXY scanning, which is a new measurement method, force curve measurement is the basis of measurement. In force curve measurement, the distance (Z) between the probe and the sample is changed greatly in the vertical direction (approach and release), and the force received by the probe in this process is measured. First, a ZX scanning plane is prepared with continuously scanning this in the X direction. Following this, a ZXY scanning plane with three-dimensional information for the Z, X, and Y directions is prepared by continuously scanning the ZX scanning plane in the Y direction.

Since the time when the probe is positioned near the sample is short, and the probe is not moved in the scanning direction at this timing, the weaknesses arising from XY scanning do not occur in this method. Further, it is also possible to create height images, ZX images, adsorption force images, and other types of images from the ZXY scanning data once measured by data analysis. These advantages will be explained by using actual examples.

■ Instruments

Fig. 2 shows the instruments with which ZXY scanning is possible. Although Shimadzu optional Nano 3D Mapping software is required with the SPM-9700 Series, measurements are conducted by using the instrument ZXY scanning mode with the SPM-8100FM.



Nano 3D Mapping software of SPM-9700 Series



SPM-8100FM

Fig. 2 SPM-9700HT™ and SPM-8100FM

■ Measurement of Wide Field of View

Fig. 3 shows a height image of a commercial stretchable film. The scanning range XY was 100 μm , and the height Z was approximately 1.5 μm . In conventional XY scanning, it is necessary to adjust the cantilever amplitude and scanning speed as well as various types of gain, but in ZXY scanning, scanning was possible without adjustment of those items. Moreover, the XY measurement may take 40 min or more, but this image was acquired in roughly 25 min at resolution of 256 \times 256 pixels.

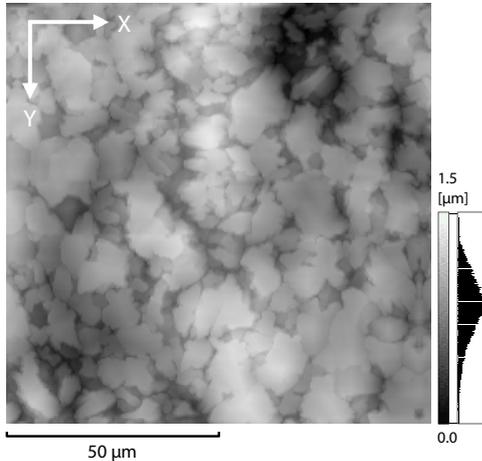


Fig. 3 Height Image of Commercial Stretchable Film

■ Measurement of Soft Sample

Fig. 4 shows an example of measurement of live HeLa cells. Because live cells are extremely soft, accurate measurement is normally difficult, as the probe tends to catch and drag the sample in the scanning direction. However, it is possible to measure the cell shape without deformation by using ZXY scanning. The scanning range is 50 μm , and the height is 7 μm . Fig. 4(b) shows the ZX image at the position of the arrow in Fig. 4(a). In the ZX image, the sample is seen from the cross-sectional direction, and here, the amount of deformation of the sample can also be known. Details of this measurement are described in Application News No. S38.

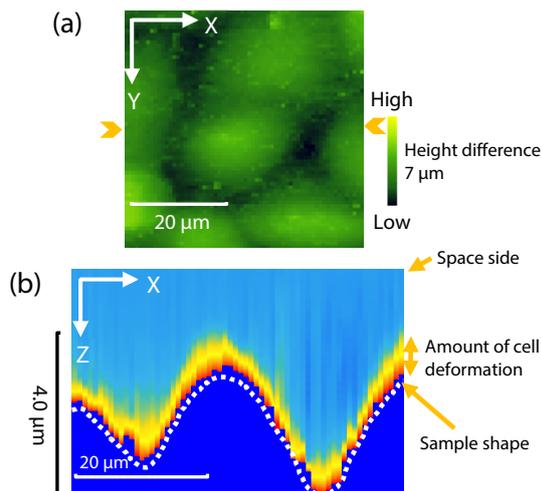


Fig. 4 Live HeLa Cells (a) Height Image, (b) ZX Image

■ Measurement of Sample with Large Surface Irregularity

Fig. 5 shows an example of measurement of the fracture surface of a commercial eraser. The scanning range XY is 50 μm , the height is 5 μm , and steep irregularities of 2 to 3 μm exist on the surface. In conventional XY scanning, the probe cannot pass over steep differences in the surface level, and large noise is produced. Depending on the case, the probe may also be seriously damaged by these surface irregularities. With ZXY scanning, problem-free measurement was possible, including these steep irregularities. Furthermore, in spite of these irregularities, it is also possible to analyze the distribution of adsorption force, and to observe the dispersion of additives in the eraser.

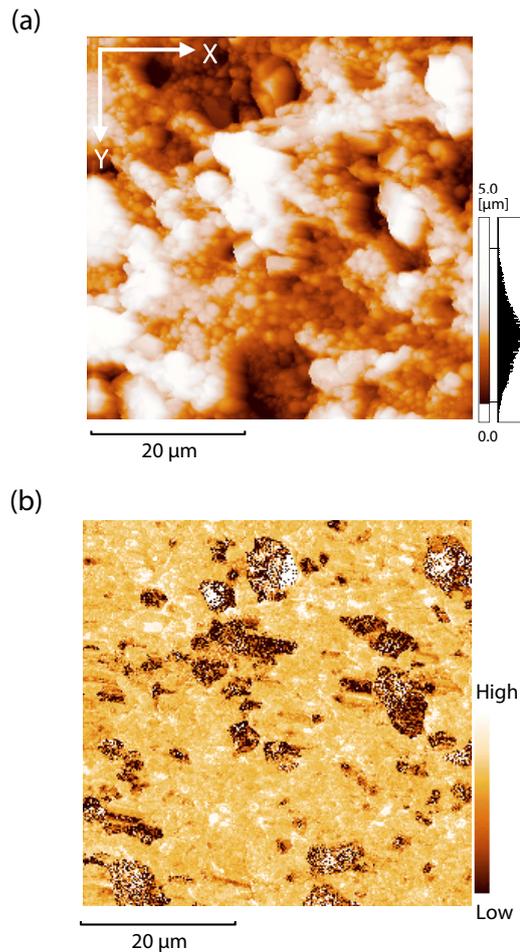


Fig. 5 Fracture Surface of Commercial Eraser (a) Height Image, (b) Adsorption Force Image

■ Conclusion

ZXY scanning is a new SPM measurement technique that overcomes the problems of "wide fields of view," "soft samples," and "samples with large surface irregularity," which had been difficult to measure with conventional SPM.

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