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Application News

SPM-Nanoa™ Scanning Probe Microscope (Atomic Force Microscope)

SPM Observation of Physical Property Distribution in Ultra-Small Regions of Resin Film

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User Benefits

- The distribution of physical properties (adsorption force, sample deformation, elastic modulus, etc.) in an ultra-small region can be measured.
- Targets can be evaluated under atmospheres close to the actual use environment (air, inert gas, low vacuum, etc.).
- The high performance optical microscope integrated into the SPM enables precise target location.

■ Introduction

Resins are widely used in various fields such as packaging materials, industrial parts, and paints due to their diverse characteristics such as durability, transparency, gas barrier properties, and ease of processing. Because of their versatility, resin products are required to have a wide range of functions, and even today the development of such products is being pursued from various perspectives. In the development of new materials, multiple types of resins are often mixed to obtain new characteristics, and checking the mixture state is an important process for the development. However, when the dispersion is on the order of nanometers, it is not easy to evaluate the state of the dispersion.

The scanning probe microscope [SPM (AFM)] is a microscope that can measure the 3D topography and distribution of physical properties of a sample surface on the nanometer order. In this article, we introduce an example of measuring the dispersed state of the constituent resins in a resin film produced by mixing several different types of resins, using the high-speed property mapping of SPM.

■ SPM-Nanoa

SPM is a microscope that observes and measures the 3D topography and local physical properties of a sample at high magnification by scanning the sample surface with a tiny probe (cantilever). Equipped with an advanced high-sensitivity detection system and automatic observation function as standard, SPM-Nanoa is a new SPM which makes it easier, more detailed, and faster to "observe" what you want to observe. It powerfully assists you in diverse tasks, from observation of the topography of microscopic areas to the Observation of physical properties. Fig. 1 shows the external view of SPM-Nanoa. The three features of SPM-Nanoa are as follows:

① Automatic observation : Adjusts the optical axis of the laser, sets the conditions during observation, and automates image processing.

② Extensive functionality : Sharp and clear image both on optical microscope and SPM.

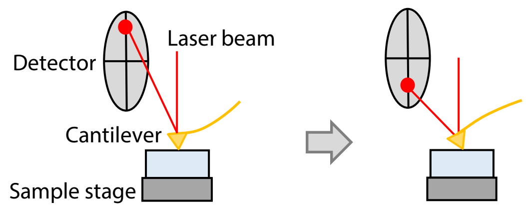
③ Saves time : High throughput observation and high-speed property mapping

This article will introduce an example of measuring the distribution of physical properties in ultra-minute regions on a resin film using high-speed property mapping, which is one of the ③ Saves time features.

Fig. 1 SPM-Nanoa™ Scanning Probe Microscope

■ High-Speed Physical Property Mapping

SPM detects the force acting between the probe and the sample by using a cantilever with a micro probe molded on it. The detection system is set up so that the laser beam is irradiated on the back of the cantilever and the reflected beam enters the detector. The amount of deflection of the cantilever due to the force between the probe and sample is detected by utilizing the vertical change in the laser incident position on the detector caused by the cantilever deflection.



The laser incident position on the detector moves vertically due to cantilever deflection.

Fig. 2 Schematic Diagram of Cantilever Deflection Detection

In high-speed property mapping, the cantilever approaches the sample vertically from above, as shown in Fig. 3(a), and the probe is pressed against the sample until a certain force is applied, and then the cantilever retreats upward again. Fig. 3(b) shows the image of cantilever deflection and sample deformation in this vertical scan. The deflection amount of the cantilever (which can be converted to force) is plotted as a function of Z-position (force curve). Once a vertical scan is completed at a certain position, the cantilever moves horizontally and another vertical scan is performed. By repeating this process of vertical scan, horizontal movement, and vertical scan, the force volume data is obtained.

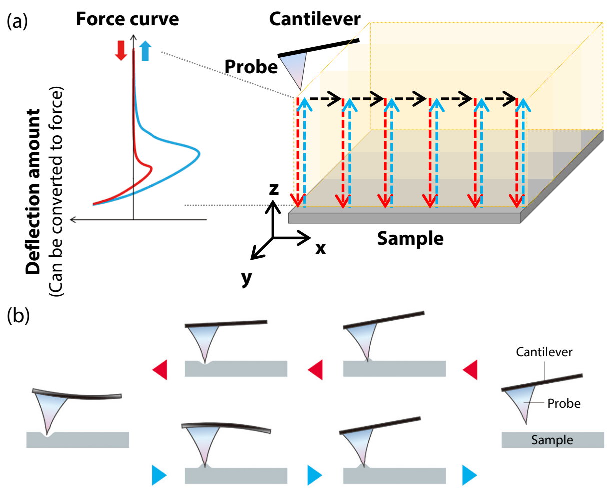
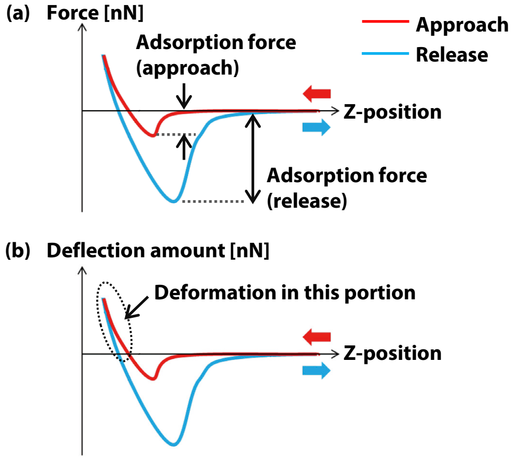


Fig. 3 Operation in High-Speed Property Mapping
(a) Cantilever operation
(b) Cantilever deflection and sample deformation in vertical scan

In the high-speed physical property mapping, the obtained force curve provides a surface topography, as well as the mapping images of the adsorption force (Fig. 4(a)), slopes in the pressing portion (Fig. 4(b)), and elastic modulus.

From these images, the distribution of physical properties in ultra-small regions can be evaluated. It is also possible to compare the physical properties between different samples. We here introduce an example of measuring the distribution of physical properties in an ultra-minute region.



Indicates that the steeper the slope, the more difficult for the sample to deform.

Fig. 4 (a) Adsorption Force and (b) Deformation

■ Physical Property Mapping of Polymer Films

Physical property mapping was performed on a film containing several different polymers. Table 1 shows the observation conditions. Fig. 5 shows the observation results. In Figs. 5(b) and (c), the distributions of adsorption force and elastic modulus in areas of several tens of nm are clearly captured. In Fig. 5(d) and (e), the volume data is analyzed. In this analysis, it is possible to visualize sample characteristics that cannot be identified in adsorption force images, such as the distribution of the distance when the sample and the probe are detached (a feature value related to sample elongation).

Table 1 Observation Conditions

Instrument	: SPM-Nanoa Scanning Probe Microscope
Scanner	: Wide-range scanner (125 µm)
Observation mode	: Nano 3D mapping™ Fast
Observation field	: 400 nm × 400 nm

■ Conclusion

Using SPM, we conducted property mapping on a film containing several different polymers, and successfully visualized the distribution of physical properties (adsorption force, elastic modulus) in an extremely minute region. Analysis of the distribution of physical properties on the nanometer order is an essential factor in determining the final characteristics of resin products, and will strongly support the development of new materials.

Sample provided by MORESCO Corporation

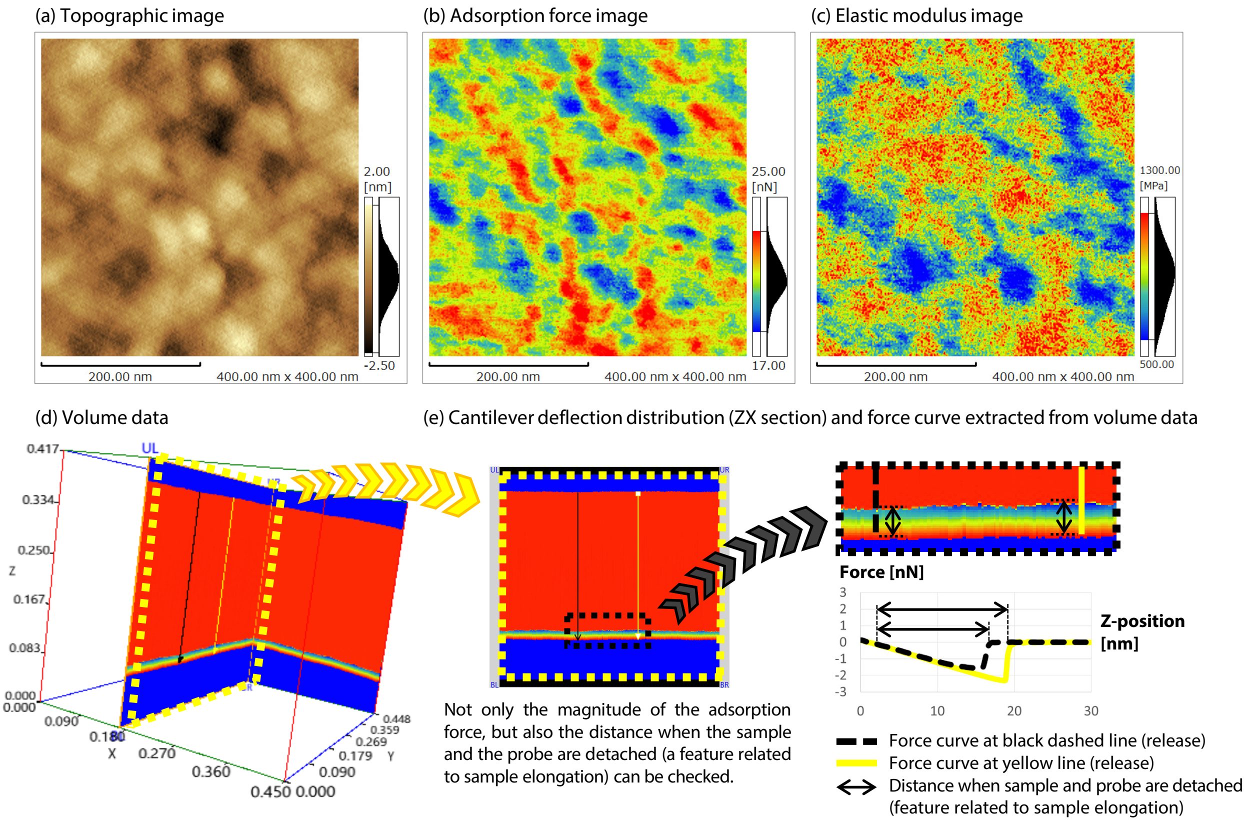


Fig. 5 Results of Physical Property Mapping
(a) Topographic image, (b) Adsorption force image, (c) Elastic modulus image, (d) Volume data
(e) Cantilever deflection distribution (ZX section) and force curve extracted from volume data

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