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Application News

No.S08

Surface Observation

Evaluation of Hydrous Lenses Using SPM

Introduction

We performed comprehensive evaluations of hydrous lenses as typified by contact lenses using a scanning probe microscope (SPM). To improve their performance, various types of surface treatment are applied to hydrous lenses. However, limited analysis methods are available to evaluate the lenses under conditions close to actual use. The SPM permits observations in a liquid and can measure both the surface shape and the surface properties. Thus, it is widely used for the measurement of biological samples and hydrophilic polymers.
We used a Shimadzu SPM-9700 to perform the following measurements on two types of hydrous lenses in artificial tears, in an environment close to actual use: 1. observation of surface shape and phase image, 2. evaluation of hardness, 3. measurement of friction coefficient, and 4. imaging of surface potential distribution in air.

Evaluations

Fig. 1 shows the appearance of the SPM-9700. The following two types of hydrous lenses were evaluated:
A: Ionic lens
B: Non-ionic lens
Table 1 shows the evaluated items and the measurement conditions.

Fig. 1 SPM-9700 Scanning Probe Microscope

Table 1 Measurement Conditions

	Surface Shape and Phase Image	Hardness	Friction Coefficient	Surface Potential Distribution
Instrument	SPM-9700			
Samples	Two Hydrous Lenses (A, B)			
Environment	In Artificial Tears			In Air
Measurement Mode	Phase	Force Curve	LFM	KFM
Cantilever	BL-AC40 (Olympus) 0.1 [N/m] (Typ.) 25 [kHz] (Typ.)	BL-AC40 (Olympus) 0.1 [N/m] (Typ.) 25 [kHz] (Typ.)	OMCL-RC800 (Olympus) 0.05 [N/m] (Typ.)	EFM (NANO WORLD) 2.8 [N/m] (Typ.) 75 [kHz] (Typ.)

Observation of Surface Shape and Phase Image

The surface shape and phase image of lenses were observed in artificial tears. Fig. 2 shows the topographic image (a), (b) and phase image (c), (d) of samples A and B. A difference in surface roughness is apparent between sample A and sample B. A pattern of lines is apparent on Sample B only.

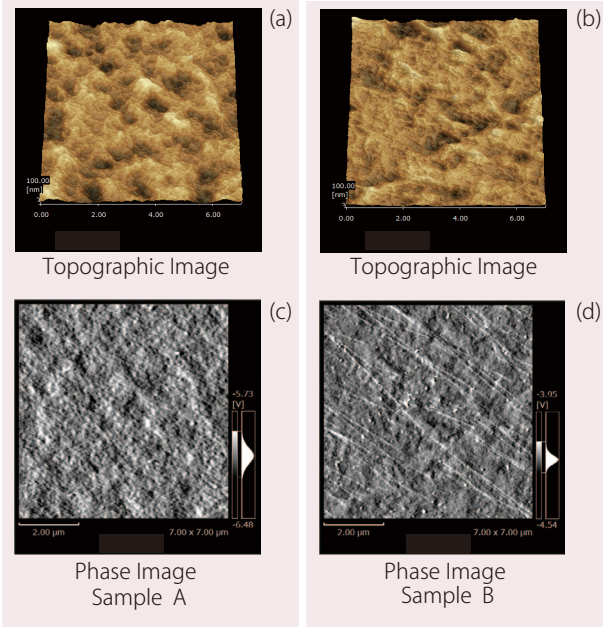
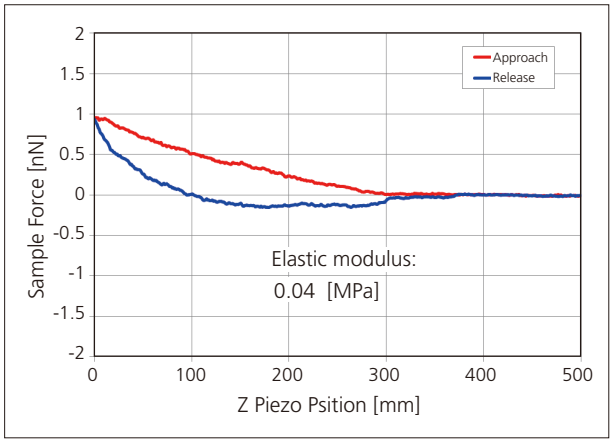


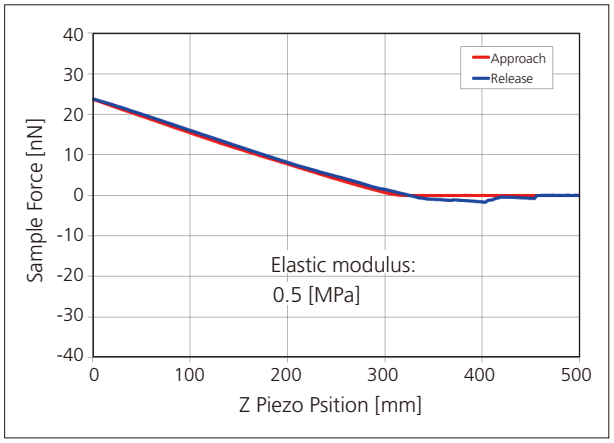
Fig. 2 Topographic Images (a), (b) and Phase Images (c), (d) of Samples A and B

Evaluation of Hardness

The elastic modulus was derived from the force curve, based on the Sneddon's elastic contact model between a conical tip and plane. Fig. 3 shows the force curves for samples A and B. It is apparent that sample B has a ten times higher elastic modulus than sample A.



sample A



sample B

Fig. 3 Force Curve and Elastic Modulus of Samples A and B

Measurement of Friction Coefficient

The relationship between the friction force and normal force is given by the following expression:

$$F = \mu N$$

Where, F is the friction force, μ is the coefficient of friction, and N is the normal force.
Fig. 4 shows a graph of the lateral force (friction force) and normal force measured in the LFM mode. The coefficient of friction μ was calculated from the lateral force and normal force. The results indicate a higher coefficient of friction for sample A than for sample B. The SPM permits quantitative evaluation of the coefficient of friction of sample surfaces.

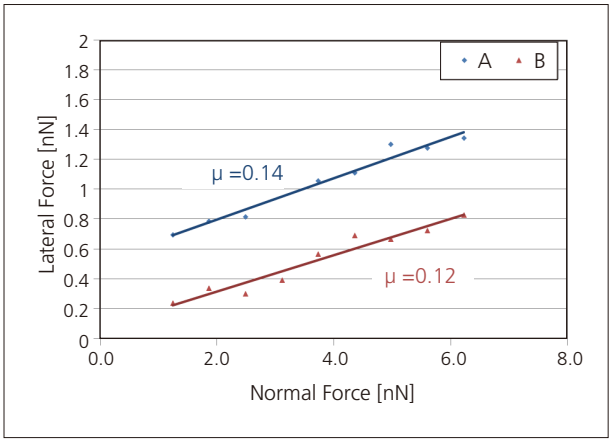
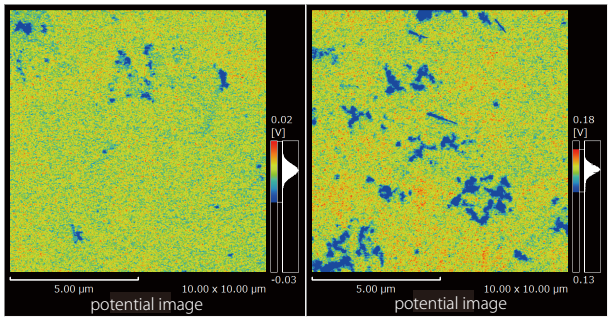


Fig. 4 Relationship between the Lateral Force and the Normal Force

Imaging of Surface Potential Distribution

The surface potential distribution was observed in the KFM mode. Fig. 5 shows the potential images of samples A and B. The results indicate a more uniform potential distribution on sample A than sample B.



Sample A Sample B

Fig. 5 KFM Images of Samples A and B

Conclusion

We comprehensively evaluated two types of hydrous lenses with an SPM. Each evaluation test produced a different result for each type of hydrous lens. These results prove SPM to be effective for the surface evaluation of contact lenses. A feature of SPM is the ability to make observations in artificial tears, which is not possible by any other method.

This report is based on a presentation made at the 20th International Colloquium on Scanning Probe Microscopy (ICSPM20).

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