Quantitative measurement of viscoelastic property with Scanning Probe Microscopy

■ Introduction

Scanning probe microscopy (SPM) is powerful tool for mapping the sample surface property as well as topography. This method, so called phase-contrast imaging or phase imaging with amplitude modulation mode, has been investigated to detect the viscoelastic property of samples (Fig1). However, quantitative measurement of viscoelastic property with phase imaging is difficult because the various complicated problems such as cantilever response and tip-sample interaction remain.

Here, we present a reproducible method that can measure the phase shift between excitation and cantilever response. This is achieved that the sample without viscosity enough hard ideally was used by the standard sample and the zero point of the phase shift was determined.

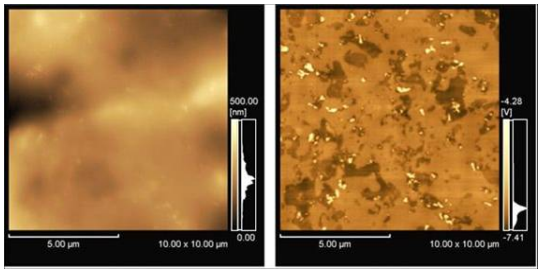

Fig.1 Example for the phase imaging (observation of polymer blends). The topographic image on the left is unclear but, in the phase image on the right, the three phases are clearly separated.

■ Setup

Instruments : SPM-9600
Measurement mode : Phase
Cantilever : NCHR
(Nanoworld)
40N/m (Typ.)
300kHz (Typ.)
Sample : Adhesive compound (from adhesive tape) 3 types
Standard sample : Glass plate
(The glass plate is hard enough compared with polymer samples and there is no viscousity.)

■ Experimental Steps

Step1 For adjustment of the phase origin, the phase image of standard sample was measured in advance and the phase signal was adjust to zero used the phase offset function.

Step2 Measure the phase value of the polymer samples. (2D Imaging)

Step3 Mean phase value of the polymer samples is calculated.

■ Results and Discussion

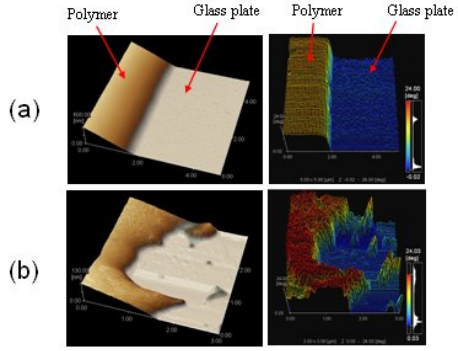

Fig.2 The topographic image and the phase image of polymer and glass interface. (a) Sample A, (b) Sample B. The right part shows the glass and the left part shows the polymer

Table.1 The phase value and the standard deviation of polymer part.

	A	B	C	Glass
Phase value (deg.)	18.2	23.0	33.4	0
Standard deviation	0.76	1.39	10.4	-

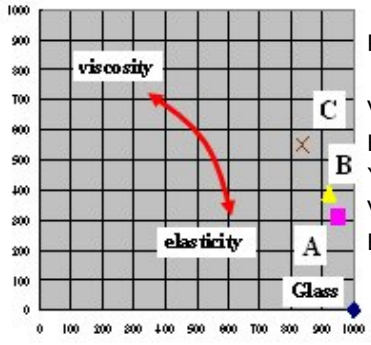

Fig.3 Example for the quantitative analysis of the phase value.
Vertical axis : V=sind x 1000
Horizontal axis : E=cosd x 1000
You can see the tendency, when V is large, viscosity is large, when E is large, elasticity is large

■ Summary

The quantitative data which shows the property which differs polymer three kind was obtained. This is achieved that the sample without viscosity enough hard ideally was used by the standard sample and the zero point of the phase shift was determined. We considered that this phase value of polymer reflects the viscoelastic property of the sample. This tendency is corresponding to the viscoelastic property of the sample well.

Stability (example for the thermal drift) and condition of the cantilever should be improved. Also comparison with the value of Macroscopic viscoelasticity is necessary. However, we think that this method makes quantization of the viscoelasticity of the polymer due to SPM possible.