# Evaluation of Polystyrene Thin Film on the Substrate by Using Scanning Acoustic Microscope

**M. Maebayashi, T. Matsuoka, and S. Koda**
Department of Molecular Design and Engineering, Graduate School of Engineering, Nagoya University, Chikusa-ku Nagoya, 464-8603 Japan

**R. Hashitani, T. Nishio and S. Kimura**
JSR Corporation, 100, Kawajiri-cho, Yokkaichi, Mie, 510-8552 Japan

## Abstract

The hydrophobic modificated glass and the untreated glass are used as a substrate. Those substrates are covered with polystyrene thin film by a spin coat method. Measurements are made on samples ranging in thickness from 0.2 to 5 μm. The morphology of the sample surface and the velocity of leaky surface acoustic waves are investigated by using a scanning acoustic microscope. Velocities of the leaky surface acoustic waves for the glass substrate covered with the thin film are measured in the frequency domain from 170 MHz to 400 MHz.

The reticulation pattern and the bleb are observed in untreated glass samples. Sizes of the reticulation observed in the initial stage of exfoliation depend on thickness of films

For the hydrophobic modificated glass substrate, on the other hand, exfoliation of the film is not observed. Velocities of the leaky surface acoustic waves for these samples are measured. The velocity decreases with an increase in thickness.

## Introduction

Polymer thin films are widely used for the reforming of the surface in fields, such as mechanical engineering and electronics. Therefore, thin films are extensively researched and developed. Evaluation of thin films is necessary to make thin films which have effective properties. But, it is difficult to evaluate various properties of thin films adequately by existing methods for the conglomerate because properties of thin films are different from properties of the conglomerate made from the same material. There are a lot of evaluation items for thin films such as thickness and modulus. Further, it is important to evaluate the interface between film and substrate of thin films.

Though those properties are measured with the optical interferometry and the electron microscopy and so on, the sample is destroyed. On the other hand, a scanning acoustic microscope (SAM) gives velocities of leaky surface acoustic waves (LSAWs) and the morphology of the surface without destroying the sample.[1,2] Velocities of LSAWs are determined by analysis of $V(z)$ curves.[1,3,4]

In this study, we examined the acoustic properties of the glass substrate coated with the thin film by using the SAM.

## Experimental

### Samples

Hydrophobic modificated glasses and untreated glasses are prepared as substrates. The thickness of glasses is 0.5 mm. The hydrophobic modification of the glass substrate is treated by hexamethyldisilazane (HMDS) which is a silane coupling agent.

The polymer used as thin film is the polystyrene (PS). The molecular weight of the PS is c.a. 30,000. The mesitylene (MS) is chosen as a solvent because the boiling point of MS is the highest in the benzene substituted by methyl group.

The solution of PS and MS is adjusted within the range from 5 to 15wt% according to the thickness of the thin film. The solution is spread on those glass substrates by the spin coat method.

The thickness of the thin film on the substrate is measured by the stylus method after a part of thin film is peeled off. Thickness of the PS thin film on the hydrophobic modificated glasses are 0.25, 0.50, 0.98 and 1.49 μm. For the film on the untreated glasses, are 0.24, 0.41, 0.93, 1.41, 1.68 and 4.98 μm.

### Measurements

The SAM (Hitachi Kenki FineTech Co., Ltd.: HSAM-210) is used to obtain acoustic micrographs. All acoustic micrographs are observed by employing the point focus lends (Honda Electronics Co., Ltd.:

UPF-4A). The frequency of the acoustic wave is 450MHz. The height of the lens is adjusted as the focal plane is corresponding to the sample surface. The coupling fluid between the lens and the sample is water.

The method which had been proposed by Kushibiki *et al.* was used to determine the velocity of the LSAWs from the *V*(*z*) curve.[3] Dispersion curves are obtained in the frequency domain from 170 to 400 MHz every 10 MHz. The temperature of samples is controlled at 25℃.

**Result and discussion**

Exfoliation of PS thin films by permeation of water

Figure 1 shows the reticulation of the PS thin film caused by the permeation of water in the acoustic micrograph, as in this work, water is used as a coupling fluid. The reticulation grows with the passage of time. The bright area which looks like net in the figure is region bonding to the substrate. A macula about 50-100 μm in diameter due to forming of blebs is observed in the micrograph. It can be found that the network appears to the first stage of exfoliation and big blebs occur at the latter term. In addition, thickness dependence of reticulation patterns is observed. In the optical micrograph, the removing process of the PS thin film is not observed because the sample is transparent.

As a result, it is found that the reticulation increase in size with an increase in thickness. The reticulation pattern observed for the sample 0.98 μm in thickness is the clearest in our samples.

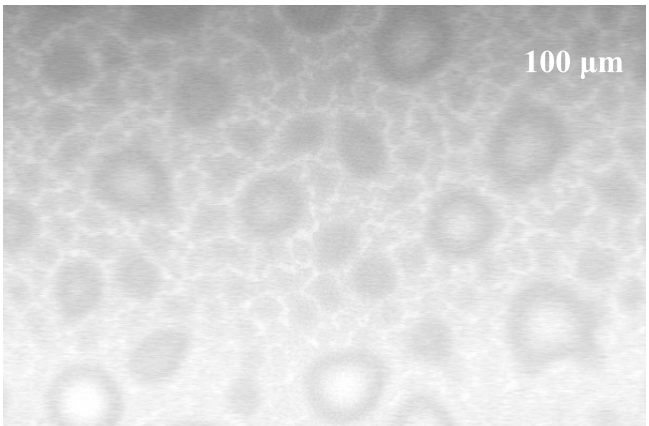


**Figure 1.** Acoustic image of the PS thin film exfoliated by water. The thickness of the PS thin film is 0.24 μm.

Changes of *V*(*z*) curves caused by thin films

Reticulation of the PS thin film is not observed in acoustic micrographs of these samples.

Figure 2 shows the *V*(*z*) curve obtained for the PS thin film on the glass substrate at 290 MHz. A peak observed near -300 μm is a signal caused by multiple reflections from the sample surface. It is found that two components are included in the *V*(*z*) curve. It indicates that a LSAW different from the leaky Rayleigh wave was excited on the substrate by the PS thin film. Similar *V*(*z*) curves are reported for the polymer thin film on the substrate in literatures, but there is no interpretation of this phenomena. [5]

The leaky Rayleigh wave is the predominant component of the *V*(*z*) curve in the low frequency. The velocity of the Rayleigh wave decreases as thickness increases.

**Conclusion**

When the PS thin film is exfoliated by permeation of water, the reticulation observed in the initial stage of the exfoliation grows as thickness increases.

PS thin films strongly stick to the glass substrate treated by the hexamethyldisilazane even if water molecules adhere to the surface.

Two components observed in *V*(*z*) curves by existence of PS thin films above a certain frequency. The characteristic frequency is varied with thickness of PS thin films.

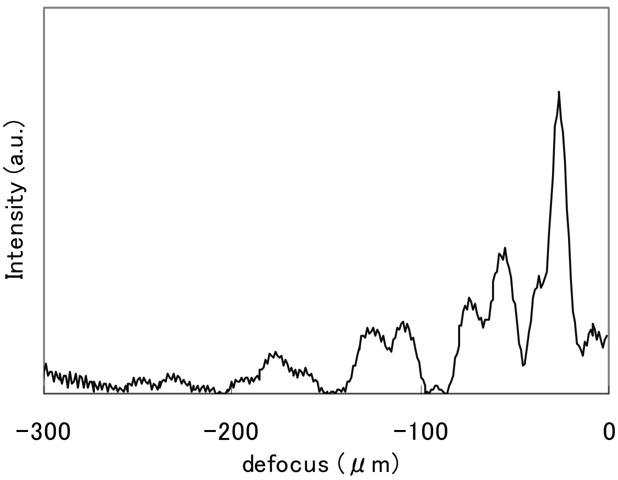


**Figure 2.** *V*(*z*) curve measured on the PS thin film 0.98 μm in thickness on the glass substrate at 290 MHz.

### References

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