An Effect of Thickness of Silicon Oxide Layer on Polymer Diffusion

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The glass transition temperature (Tg) of polymer thin films has been proved to be fairly different from that in the bulk. Many theoretical and experimental efforts have been performed to elucidate, by concentrating on the free surface layer with enhanced chain mobility and/or the restricted interfacial region. When film thickness gets thin enough, the intermolecular forces start to govern the system. It has been reported that the effective interfacial potential, which is a sum of short- and long-range interactions, governs the behavior of the polymer thin film, such as dewetting. So far, we have found an increasing gradient of Tg closer to the interface, and it will be more marked with increasing the affinity between the polymer and substrates (short range interactions) by using various substrates1). In this study, we focused on the effect of long range interaction on chain diffusion. We here selected to study the polymer pair polystyrene (hPS) and deuterated polystyrened (dPS) because it has been extensively studied and are thus well understood. As a sample, a hPS film was spin-coated from a toluene solution onto a silicon wafer, then the hPS film was scored with a blade, and was floated off onto the surface of purified water. Next, it was transferred onto the dPS film by attaching the dPS film from the air side, resulting in the bilayer interface. The thickness of the top hPS and bottom dPS layer were approximately 100 and 20 nm, respectively. The bilayers so prepared were dried under vacuum at room temperature for more than 24 hr to remove adsorbed water and residual solvent. To elucidate the effects of long range interaction, we controlled the long range interaction by changing the thickness of silicon oxide layer. Figure 1 shows NR curves for the hPS/dPS bilayer films as prepared and after thermal annealing at 393 K for 3 h. For clarity, the data set after annealing is off-set by two decades. The NR curve for the bilayer film after annealing showed differences from that of as prepared film. The width of fringes for annealed bilayer film were larger than that of as prepared one. This result means that the thin dPS layer became unclear due to the chain diffusion at the hPS/dPS interface. The obscuration of the fringe amplitude for the annealed film also indicates that the hPS/dPS interface was diffuse in comparison with pristine interface. The detailed knowledge about the relation between long range interaction and chain diffusion will be open in the near future.

[1] K. Tanaka, Y. Tateishi, Y. Okada, T. Nagamura, M. Doi, and H. Morita, J. Phys. Chem. B 113, 4571 (2009).