

Real-time observation on configuration changes of silicon polymer by soft-X-ray PEEM

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Introduction

Thin films of silicon polymers have attracted much attention due to their excellent properties such as high electric conductivity, photoconductivity and ultra-violet electro-luminescence as well as thermal stability. The electric and optical properties in a thin film of such one-dimensional polymers depend on not only electronic structure but also their configuration (orientation of polymer backbone). The averaged configuration in a wide area can be determined by NEXAFS spectroscopy, infrared spectroscopy, X-ray diffraction and so forth. However, it should be noted that the electric and optical properties of a thin film strongly depend on the configuration in microscopic domains. In this report, we present the results for real-time observation of NEXAFS in microscopic areas for a thin film of silicon polymer by means of photoelectron emission microscopy (PEEM) excited by soft X-rays.

Experimental

The experiments were performed at the BL-27A station. The sample investigated was polydimethylsilane (PDMS) deposited on copper surface. The evaporation was performed by electron-bombardment heating. In order to focus the PEEM images, the PDMS was deposited as micro-pattern (15 μm x 15 μm) using a mask. Thickness of the film was 3.0 nm. The PEEM used was Elmitech Co. Model PEEMSPECTOR. The total photoelectrons emitted from the surface were expanded and focused on the YAG screen. The PEEM was horizontally located and the incidence angle of X-rays was 30 degree from the surface. For annealing experiments, the sample surface was heated by YAG laser through optical fiber.

Results and discussion

Fig.1 shows the changes in the PEEM images that were observed during heating. The PDMS molecules scarcely diffuse, and the patterns are still clearly observed at 240°C. The results are fairly different from those previously reported for thin films of phthalocyanines where the molecules diffuse and the image becomes almost homogeneous at 240°C [1].

The brightness of each spot in the PEEM image is proportional to the amount of X-ray absorption in the spot. So if we scan the X-ray energy, the NEXAFS spectra in all domains can be obtained. As an example, the brightness of the spot marked "X" in fig.1 as a function of X-ray energy is displayed in fig.2(a). Recently, it was found that the PDMS molecules stand up or lie flat

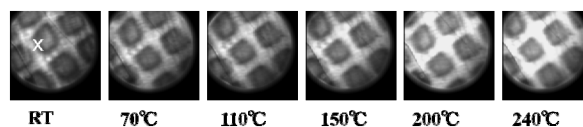


Fig.1 PEEM images of PDMS pattern on Cu observed at real during laser annealing. Field of view was 100 μm . Mercury lamp ($h\nu=4.8$ eV) was used as an excitation source.

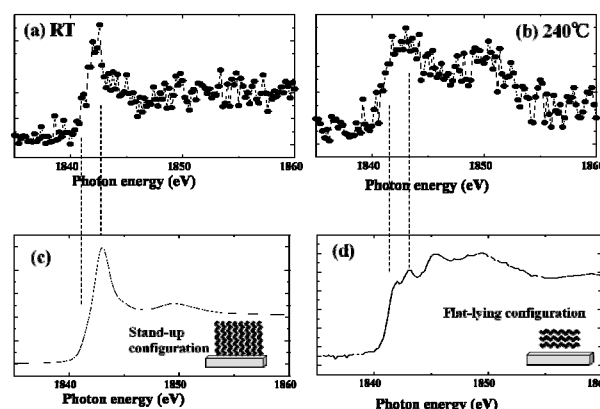


Fig.2 Brightness of the spot "X" in fig.1 as a function of X-ray energy for the samples at room temperature (a) and 240°C (b). NEXAFS spectra at 30 degree incidence for stand-up and flat-lying layers are shown in (c) and (d), respectively.

depending on the substrate [2]. Figs.2(c) and (d) show the NEXAFS spectra taken with total electron yield for standing-up and flat-lying PDMS films, respectively, at 30 degree incidence. The brightness plot for room temperature (fig.2(a)) is similar to the NEXAFS spectrum for standing-up layer (fig.2(c)). On the other hand, the shape of the plot for the 240°C drastically changes, and it becomes rather similar to the NEXAFS spectrum for flat-lying layer (fig.2(d)). The results suggest that the backbone of the polymer changes from perpendicular to parallel orientations without diffusion.

Although it is difficult to determine the precise tilted angle of polymer backbones, the present method shed light on the real-time observation of electronic structures and molecular orientation in microscopic domains for thin films of organic molecules with anisotropic shape.

References

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