Polycrystalline domain structures and epitaxial structures of Pn thin film crystals on a H-Si(111) surface

Susumu Nishikata[1], Gen Sazaki[1,2], Jerzy T. Sadowski[1], Abdullah Al-Mahboob[1], Shozo Suto[3], Toshio Sakurai[1], Kazuo Nakajima[1]

[1]*IMR, Tohoku University, 2-1-1 Katahira, Aoba-ku, Sendai 980-8577, Japan,*
[2]*CIR, Tohoku University, Aramaki, Aoba-ku, Sendai 980-8578, Japan,*
[3]*Department of Physics, Graduate School of Science, Tohoku University, Aramaki, Aoba-ku, Sendai 980-8578, Japan*

Introduction To establish the general method to grow high-quality organic semiconductor thin film crystals, one has to observe changes in morphology and measure kinetics of nucleation and growth, etc *in situ*. Low-energy electron microscopy (LEEM) is a method of great promise to observe such processes during the growth of organic thin film crystals. In this study, we observed the dendrite growth process of pentacene (Pn) thin film crystals on a H-Si(111) surface by LEEM *in situ*, and demonstrated the multi-domain structures inside the Pn thin film crystals and their epitaxial structures.

Experiment A H-Si(111) surface was prepared by chemical etching, and transferred to an observation chamber (base pressure: 5×10^{-10} Torr) and heated up at 150 °C for 12 hrs to degas the substrate. Pn thin film crystals were grown by thermal evaporation, and observed by LEEM and low-energy electron diffraction (LEED) modes.

Results Figs. 1(a)-(d) show LEEM images and LEED patterns of Pn thin film crystals on a H-Si(111) surface. Since a Pn island with a dendritic shape grew on a H-Si(111) surface (Fig. 1(a)), surface diffusion of Pn molecules on a H-Si(111) surface limited the growth of Pn thin film crystals. A LEED pattern taken from a Pn island using a selected area of five micron in diameter (a circle in Fig. 1(a)) presents 24 diffraction spots (Fig. 1(b)). Hence, a Pn island in Fig. 1(a) is a polycrystalline dendrite. Using a tilted bright-field mode and changing an acceleration voltage, we succeeded in observing domain structures inside the Pn island with three kinds of contrasts (white, gray and black) (Fig. 1(c)). In addition, a micro-LEED pattern taken from a single-contrast area using a selected area of two micron in diameter (a circle in Fig. 1(c)) presents four diffraction spots of a single-crystalline domain (Fig. 1(d)). From the analyses of systematic LEED observations, we concluded that Pn molecules grow in the "standing-up" orientation with the Pn(001) plane parallel to the substrate surface and there are two kinds of epitaxial relations between Pn thin film crystals and H-Si(111). We found that each epitaxial relation has six equivalent orientations of two-dimensional unit cells, and the two kinds of epitaxial relations have almost same molecular packing but their angular relations with a H-Si(111) surface are different.

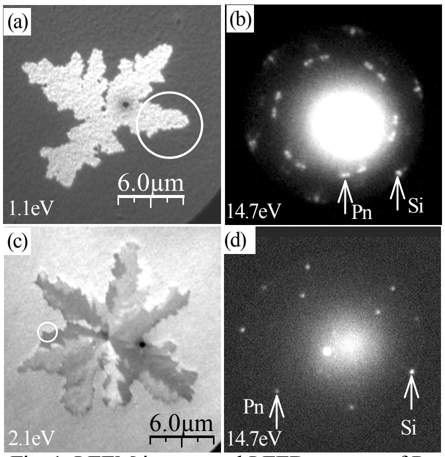

Fig. 1. LEEM images and LEED patterns of Pn thin film crystals on H-Si(111). (a) A bright-field LEEM image. (b) A LEED pattern from the area of the circle in Fig. 1(a). (c) A tilted bright-field LEEM image. (d) A micro-LEED pattern from the single-contrast area of the circle in Fig. 1(c).

Conclusion: We succeeded in visualizing the domain structures inside the polycrystalline Pn dendrite *in situ* by LEEM. From the systematic LEED observations, we determined the epitaxial structures of Pn thin film crystals on a H-Si(111) surface.