Evolution mechanisms of polycrystalline domain structures of pentacene thin films epitaxially grown on a H-Si(111) surface

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To fabricate organic thin film crystals with improved electrical properties, it should be important to elucidate the morphology and time evolution of organic thin films. Among currently investigated organic materials, pentacene (Pn) appears to be particularly promising because of its high mobility. It is well known that Pn thin film crystals exhibit a dendritic shape on various inert substrates. In the present study, we studied the evolution mechanism of a polycrystalline domain structure inside a Pn dendrite using low-energy electron microscopy (LEEM) and micro-beam low-energy electron diffraction (μ-LEED).

Single-monolayer high Pn dendrites were epitaxially grown on H-Si(111) under ultra-high vacuum at room temperature. As shown in Fig. 1, the domain structure inside a polycrystalline dendrite was clearly depicted in three distinctively different contrasts (white, gray and black) by a tilted bright-field mole. The domains with different contrasts correspond to the areas in which the orientations of Pn molecules are different. A dendritic branch was always composed of three domains. Orientations of the 2D unit cells inside these domains, determined from μ-LEED [1], are also illustrated in Fig. 1. The ***b*** (long) axis of the "center" domain is parallel to the growth direction of the dendritic branch, whereas the ***b*** axes of the "outer" domains are rotated ±60 deg in relation to that of the center domain. As shown on the tip of the dendritic branch (an open circle), the center (white) domain always grew faster than the outer (black and gray) domains on each side of the center domain. This result indicates that the direction parallel to the ***b*** axis of the 2D unit cell is a preferential growth direction of the domains. From systematic LEEM observations, we concluded that the growth of the dendritic branch started with a center domain, and then outer domains nucleated and grew on each side of the center domain. Once the dendritic branches with three domains developed, "further outer" domains were not formed, since the "outer" directions were the preferential growth directions of the "outer" domains that had been already formed. In this way, the preferential growth direction fully governed the morphology and evolution of multi-domain polycrystalline Pn dendrites.

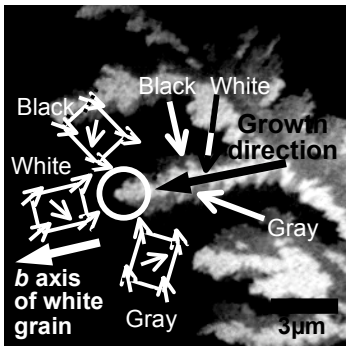

Fig. 1. A LEEM image of single-monolayer high Pn thin film crystals grown on H-Si(111). The orientations of the 2D unit cells inside individual domains are also illustrated.

[1] S. Nishikata, et al., The 5th International Conference on LEEM/PEEM, Oct. 15-19, 2006, Himeji, Japan.