Non-Equilibrium Processes and Three-Dimensional Morphologies in Soft Matter Systems

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1. INTRODUCTION

Block copolymers exhibit highly periodic and various types of microphase-separated structures due to the immiscibility between the dissimilar sequences. The equilibrium phase behavior of the system has been experimentally and theoretically investigated, from which the phase diagram has been well-established. Despite the success in the understanding of the equilibrium phase behaviors, many of the problems on the dynamical properties are still open. The order-order transitions (OOTs) between the two phases are typical example. The OOTs are induced by changing the temperature or by imposing an external field such as a flow or an electric fields.

The growth processes of OOTs can be examined by the boundary morphologies between two co-existing structures that were frozen during the OOTs. Since such boundary morphologies are often complicated, transmission electron microtomography (TEMT) [1] was used. In the present study, an OOT during the hexagonally-packed layer (HPL) → double-gyroid (DG) [2] was studied.

2. EXPERIMENTAL SECTION

A poly(styrene-*block*-isoprene) (PS-*b*-PI) block copolymer was used. The diblock copolymer solution was spin-coated on freshly cleaved mica. The polymer film was vacuum-dried at room temperature for 4h and then annealed at 120 °C for 30h in vacuo. It was embedded in epoxy resin after carbon coating and the sample was microtomed (RMC Ultracut) normal to the film plane.

TEMT experiments were performed using an energy-filtering transmission electron microscope (JEM-2200FS, JEOL Co., Ltd., Japan). A series of TEM micrographs were acquired as a function of tilt angles, which were then reconstructed [1].

3. RESULTS AND DISCUSSION

Figure 1 shows a 3D image of the boundary between the two morphologies where every other HPL layers were beautifully connect to one of the two non-intersecting DG networks [4]. Moreover, nature of epitaxy can be found: $\{1\bar{1}1\}$, $\{2\bar{0}2\}$ and $\{121\}$ planes are at the boundary with the $\{121\}$ plane being parallel to the HPL layers. Details of the boundary structure and possible mechanism of the OOT will be discussed at the symposium.

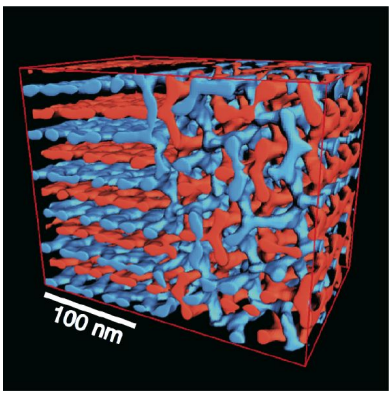

Figure 1: 3D morphology of PS-*b*-PI block copolymer during OOT from HPL structure (left) to DG structure (right) [3]. Scale bar is 100 *nm*.

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