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Structural analysis of spatial inhomogeneity in Injection-molded Polypropylene by Microbeam WAXS

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Introduction

Injection molding is one of the most industrially important fabrication processes for polymeric materials. The engineering performance of product made from semicrystalline polymer is influenced by not only the degree of crystallinity and orientation of crystallites but also their spatial inhomogeneity. Usually, injection moldings have a skin region in which polymer chains are highly oriented in the flow direction and a core region in which they are not.

Conventional X-ray scattering provides spatially averaged structural information in a sample area, where an X-ray beam irradiates. On the other hand microbeam X-ray scattering can provide information on local spatial inhomogeneity of subnano-structures in a micron scale [1][2].

By scanning microbeam WAXS, we investigated the spatial inhomogeneity of the oriented structure in injection-molded polypropylene (PP). In this report, we present the results of scanning microbeam WAXS measurement.

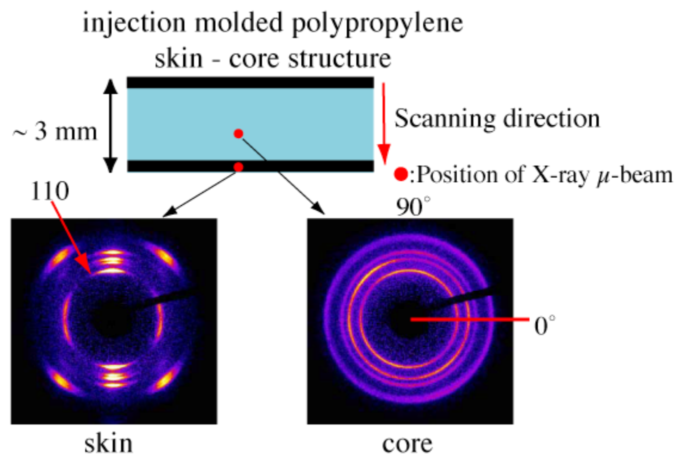

Fig. 1: (upper) Schematic view of sample and (lower) typical WAXS images (left: skin region, right: core region). The definition of azimuthal angle is shown in the figure of core.

Experiment

Microbeam WAXS experiment was performed at BL-4A. The sample used here is typical injection molded PP with a thickness of 3.0 mm. The X-ray beam size was focused to 5 μm × 5 μm (FWHM) at a sample position with Kirpatrik-Baez mirror. The microbeam scanned the sample along the depth direction with a 10 μm step. WAXS was measured with an X-ray CCD detector coupled with an X-ray Image Intensifier [3]. The X-ray wavelength was 1.13 Å. The distance between the sample and the detector was around 170 mm.

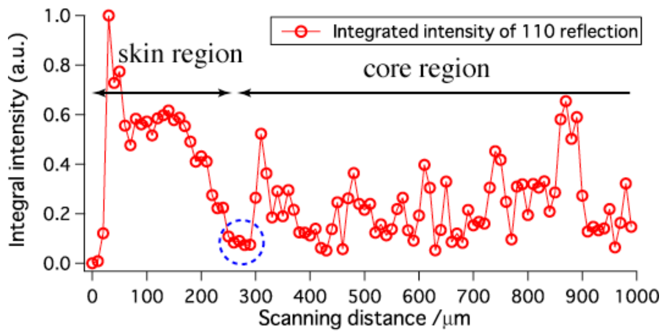

Fig. 2 The integrated intensity of 110 to radial direction
A circle of blue dotted line shows dip region.

Result and Discussion

WAXS images in Fig. 1 show that the degree of crystal orientation was high in the skin region and that it was low in the core region.

Fig. 2 shows the integrated intensity of WAXS 110 reflection as a function of scanning distance. 110 reflection was azimuthally averaged from 80˚ to 100˚ after background subtraction and then fitted with Gaussian. Fig. 2 indicates that a dip exists at around 270 μm. The dip is considered to correspond to the skin-core transition region. Fig. 2 also shows the crystal orientations fluctuate in the core region.

More detailed data analysis is now in progress.

References

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