Measurement of three-dimensional residual stress distribution in single laser pulse irradiated area

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Residual stress profile across laser irradiated spots was measured by synchrotron radiation from BL46XU of SPring-8 to study the fundamental process of laser peening.

X-ray with energy of 12keV was collimated to 0.1 × 0.1mm and irradiated to a high tensile strength steel (HT1000) specimen placed on the center of a goniometer. The specimens were prepared by underwater irradiation of a single laser pulse with a constant power density as shown in Table 1, so as to clarify the spot size effect on the stress profile.

Table 1 Irradiation conditions of single laser pulse

Test specimen	Pulse energy (mJ)	Spot diameter (mm)	Power density (MW/mm^2)
1	320	1.2	40
2	34	0.4	39
3	8.6	0.2	39

The α-Fe (332) was selected as the diffraction plane, considering the intensity and angle (2θ) of diffraction X-ray counted by a scintillator through receiving slits. Residual stress was derived from the slope of the 2θ-$\sin^2\psi$ plot, where ψ was varied from 0 to 45 degrees in Ω diffractometer method.

The measured residual stress profile on and around spots was shown in Fig.1, together with results obtained at BL3A of KEK-PF (Photon Factory of High Energy Accelerator Research Organization) with synchrotron radiation collimated to 0.2mm in diameter.

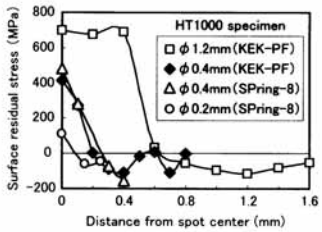

Fig.1 Residual stress profile on and around laser-irradiated spots

The result shows tensile components exist on the irradiated spots, which would be attributed to the thermal effect of laser irradiation. However, compressive ones were observed outside the spot, due to a plastic strain by the impulsive effect. The absolute value of the tensile components decreases drastically with reducing the spot size. This means the reduction of the laser-irradiation area enhances the cooling of the specimen surface, even if the laser power density is constant.

Molecular Orientation Analysis in Strong Fibers of Biodegradable Polyesters

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Introduction

Poly([*R*]-3-hydroxybutyrate) (P(3HB)) and its copolymers are accumulated by a wide variety of microorganisms as intracellular carbon and energy storage material, and is extensively studied as a biodegradable and biocompatible thermoplastic.

Recently, we have developed a new processing method (cold-drawing and two-step drawing from amorphous state) and succeeded to obtain P(3HB) fibers with high tensile strength from ultra-high-molecular-weight P(3HB) produced by using a recombinant *Escherichia coli* XL-1 Blue (pSYL105). In this experiment, we have attempted to obtain more insight into the orientation and generation mechanism of planar zigzag conformation of molecular chain in P(3HB) fiber by micro-beam diffraction using Fresnel Zone Plate technique.

Experiment

The X-ray experiment was carried out at BL47XU, with wavelength of 1.5497Å at 8keV. The experimental focus beam size was obtained as 0.5μm by using Fresnel Zone Plate. The P(3HB) fiber with 40 μm diameter, fixed on the hand-made stretching machine, was linearly scanned perpendicular to the fiber axis with a step width of 2 μm between the individual frames. Diffraction patterns were recorded with CCD detector (exposure time/frame: 5s).

Results

The micro-beam X-ray fiber diagrams of P(3HB) mono-filament during two-step drawing with necking behavior are shown in Figure 1. It was suggested that during the two-step drawing the core region is elongated higher than the sheath region, and that the planar zigzag conformation (β-form) is much generated, as shown in No. 12 ~ 14 and 19 ~ 21 diagrams of Figure 1. The X-ray fiber diagrams of sheath region (No. 1 ~ 7) show the rotation of α-form crystallites, while in the core region (No. 15 ~ 21) the orientation of crystal region increased with increase in the draw ratio. Thus, the two-step drawing directly effects on core region, while this effect is avoided in sheath region by the crystal rotation. These results are seemed to be very important to understand the processing mechanism of the strong fiber not only for P(3HB) but also for common plastics.

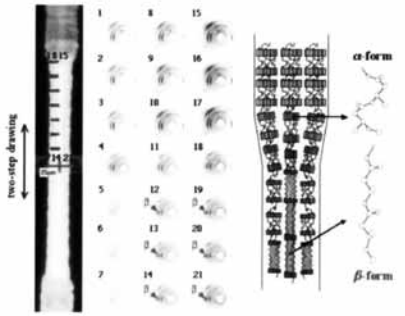

Figure 1. Micro-beam X-ray fiber diagrams (center part) of P(3HB) mono-filament during two-step drawing at room temperature. Left picture indicates the microscope image of mono-filament during two-step drawing. Right side shows the schematic display of two-step drawing fiber; lamellar crystals have α-form and β-form generates from the amorphous region between adjacent lamellar crystals(α-form).