Depth profile measurement of residual stress of welded stainless steels with X-ray micro beam

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In stainless steel, residual strain or stress is an important factor to understand the occurring mechanism of the stress corrosion crack (SCC). In the last experiment (2004A0798-RI-np), we obtained the distribution of residual stress by 0.5mm step at the HAZ of stainless steel. In this experiment, residual stress measurement was examined with X-ray micro beam in order to obtain the depth profile of residual strain at the HAZ.

The preparation of measured sample and the experimental procedure are as follows. Two pieces of SUS316 plate were used as specimens. The plates were ground to be 10mm in thickness with a milling machine. The ground plates having a single V-groove were welded with TIG welding process. The measured sample was mounted on the sample stage for measurement of the distribution of residual strain and stress. The sample stage consists of a stepper motorized XY stage, a manual θ stage and a stepper motorized swivel stage. The sample on the stage can move to X and Y directions by 0.1mm step. The X-ray beam was collimated with incident and receiving apertures. The gage volume of measurement area was shown in Fig.1. The incident X-ray energy was 66keV, which was the third harmonic of the fundamental X-ray energy (22keV) in BL46XU.

Figure 2 shows the example of X-ray diffraction profile obtained at 20μm in depth from the specimen surface. The diffraction peak has asymmetrical shape although the peak obtained at 6μm in depth has symmetrical shape as shown in Fig. 3. In order to reduce asymmetry in the peak, we obtained 10 diffraction peaks from the area of 10mm×5mm and summed them. The peaks were obtained at 20μm in depth from the specimen surface. Figure 4 shows the summation of the obtained peaks. The peak still has asymmetrical shape and it is difficult to decide the peak position. It is considered that the measured sample has coarse grains, which affect to the symmetry of peak profile, at 20μm in depth and under from the specimen surface. Therefore, it is difficult to obtain residual strain or stress at the depth by the $\sin^2\psi$ method.

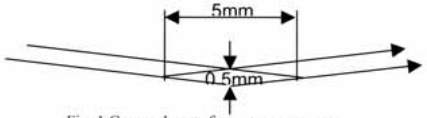

Fig. 1 Gage volume of measurement area

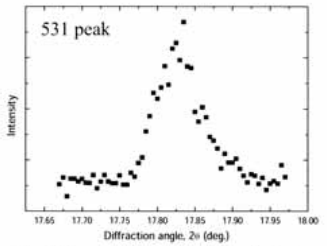

Fig. 2 X-ray diffraction profile obtained at 20μm in depth from the specimen surface.

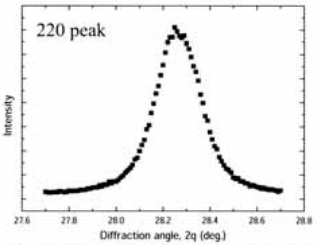

Fig. 3 X-ray diffraction profile obtained at 6μm in depth from the specimen surface. (Incident X-ray energy: 20keV)

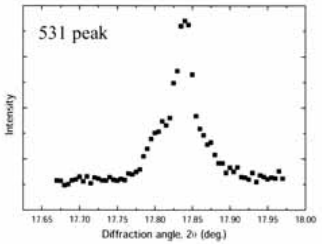

Fig. 4 Summation of the 10 peaks obtained from the area of 10mm × 5mm. The peaks were obtained at 20μm in depth from the specimen surface.

Single Fiber Measurement of Stress Induced Crystalline Structural Change in New High Performance Polyimide

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Poly(*p*-phenylenepyromellitimide) (PPPI) has a rigid-rod backbone structure that exhibit an intrinsically high modulus and high thermal stability. We focused on the high mechanical property of PPPI, and developed a new high performance PPPI fiber. In this study, we investigated the relationship between structures and mechanical properties in PPPI fibers from single-fiber deformation experiments by X-ray diffraction method using synchrotron radiation.

PPPI fibers were obtained by chemical imidization of polyamic acid precursor. Three types of PPPI fibers were investigated, AS (as-spun), HT (heat-treated), and HT+ (heat-treated with stretching). The PPPI fibers were approximately 30 μm diameter. Single fiber deformation experiments were carried out using same procedure as the previous study (2004A0147-ND1b-np). X-ray beam energy was 12 keV.

Fig.1 shows the interplanar spacing d_{006} calculated from meridional 006 diffraction peaks of sample HT+ for loading up to fiber breakage. The spacing d_{006} increase linearly with the applied stress, which corresponds to the lattice extension. The lattice strain has been calculated from the change in spacing d_{006} with stress. The crystal modulus of HT+ was 205 GPa, and the fiber Young's modulus was 87 GPa. Fig.2 shows the micro strain analysis using the integral breadth of meridional 00h peaks of HT+ before and under loading. The peak breadths are independent from stress that is uniform across the fiber cross-section. The crystal imperfection parameters, lattice distortion and crystal size, are evaluated from these plot. The crystal modulus was slightly changed by annealing condition, and the lattice distortion of HT+ was smaller than HT and AS (Table.1). The Young's modulus of PPPI fiber is assumed to results from these crystalline structural parameters.

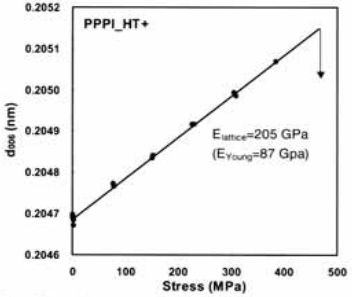

Fig.1 Spacing d_{006} plotted against applied stress.

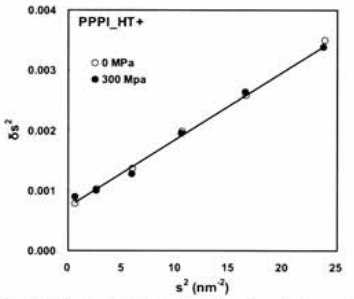

Fig.2 Micro strain analysis using integral breadth, L ;crystal size, Δd/d ;lattice distortion.

Table1 Mechanical properties and crystalline parameters of PPPPI fibers.

		AS	HT	HT+
$E_{lattice}$	(GPa)	-	184	205
E_{Young}	(GPa)	-	76	87
L	(nm)	36.3	37.3	37.8
Δd/d	(%)	0.95	0.70	0.54