Coextensive observation on magnetization and magnetostriction of iron

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Magnetostrictive coefficients have been seldom observed by X-rays, because the sensitivity was poor. Recently, a new technique of X-rays has been developed and overcome the sensitivity [1]. Usually, a confirmation on saturation magnetization is always necessary to measure the quantitative magnetostrictive coefficients. We noticed that the technique could be extended to observe the magnetostrictive behaviors during magnetization process [2, 3]. An extended technique was possible to observe the magnetostriction as a function of both intensities of the magnetic field and the magnetization [2, 3]. We tried to apply the extended new technique to iron specimens at room temperature.

White X-rays from a bending magnet were monochromatized at Fe K absorption edge, 7.111 keV, 1.744 Å, by a Si(331) double-crystal monochromator. The X-ray beam was incident on the specimen of (100)- or (110)-oriented iron single crystal, 99.94+% (Monocrystals Co.) as π-polarization. The beam irradiated area at specimen surface was 2.0 mm horizontal × 2.0 mm vertical. Each specimen was a disk of 6.0 mm diameter and 2.0 mm thick in size. The surface side used was polished sub-micron. The specimen was set on a goniometer so that the iron 200 or 220 symmetry diffraction, corresponding Bragg angle was 37.4˚ or 59.3˚, would take place in the horizontal plane. The [001] axis was set parallel to the vertical direction. The specimen was magnetized along the [001] axis by an electromagnet for a resonant X-ray magnetic diffraction in the transverse configuration of the magnetization. Applied maximum magnetic fields were 12 kOe. We measured the diffraction intensity with a small sized Si solid-state-detector (SSD) [3].

As shown in Fig. 1, the magnetostrictive behaviors as a function of the magnetization for the specimens of (100) and (110) planes were observed [3]. The magnetostriction and the magnetization in the figure were exhibited as normalized magnetostriction, λ(H)/λ100, and relative magnetization, M(H)/M_s, where a parameter H was the magnetic field applied. It should be emphasized that they were simultaneously observed at exactly coextensive specimen volumes by X-ray diffraction at arbitrary H [2, 3]. Note that the magnetostriction observed in this configuration was converted from its perpendicular component [1, 3].

We would be able to discuss the magnetostrictive behaviors during cyclic magnetization with this technique [3]. This would be one of the advantage points on our extended new technique.

The magnetostrictive behaviors of the iron specimens in Fig. 1 also showed dependency on their indices of diffraction or surface planes. Our technique was sensitive to the indices [3]. This would be one of the useful examples to apply our new technique.

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