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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.

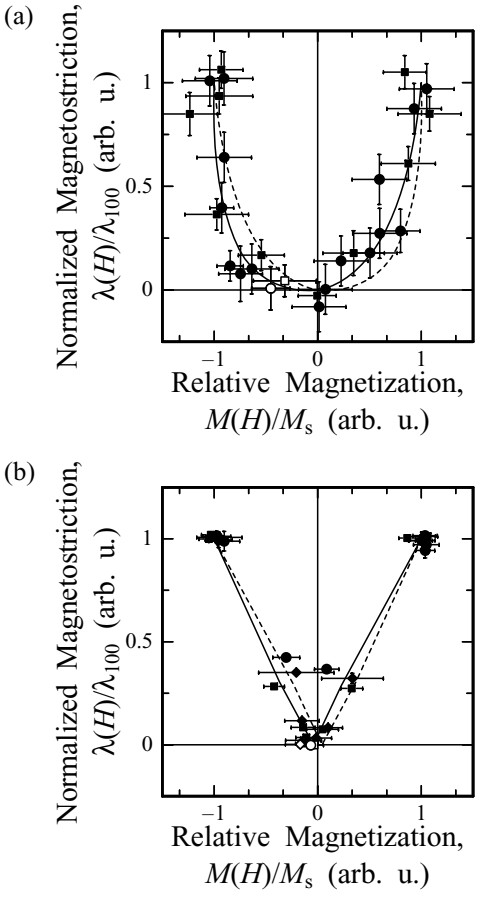

Fig. 1. Magnetostrictive behaviors during cyclic magnetization at room temperature, (a) (100) and (b) (110) specimen surfaces. Solid marks of circles and squares were observed when H is ascending. Open marks of them indicated the points measured at zero applied magnetic fields. Solid and broken curves were guides to the eye for ascending and descending H, respectively. The broken curves were replication of the solid curves for descending H. After Arakawa *et. al,* [3].

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, $\lambda(H)/\lambda_{100}$, 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.

[1] Etsuo Arakawa *et al,* accepted in *IEEE Trans. Magn.* (2005).
[2] Etsuo Arakawa *et. al,* submitting to *Japan Patent,* Patent Application Number 2005-093200 (2005).
[3] Etsuo Arakawa *et al*, to be submitting.

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