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Rocking curves of iron borate single crystal in rf magnetic field

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Introduction

Recently, from the viewpoints of fundamental physics research, many scientists have paid attention to the acoustic vibration phenomenon of $FeBO_3$ crystal, which is exposed to rf magnetic field or ultrasonic wave. Because, in such non-equilibrium systems, this crystal can display nonlinear effects [1,2,3], and even magneto acoustic solitons [4]. The influence of acoustic vibration on the crystal deformation of $FeBO_3$ single crystal is a very interesting research subject. Therefore, we carried out the stroboscopic measurements of double crystal X-ray diffraction by using single bunch mode of SR. Then, the acoustic vibration of $FeBO_3$ crystal was excited by rf magnetic field synchronized with SR X-ray pulse.

Experimental Set-up

The synchrotron beam was tuned to λ=1.24Å by Si(111) double crystal monochromator, and was collimated by Si(400) asymmetric reflection (1/b=4.39, ω_h=1.35arcs). The delivered X-ray beam then becomes parallel in comparison with the diffraction width of $FeBO_3$(444) Bragg reflection (ω_h =35 6 arcs), and these crystals fulfill a condition of (+-) parallel setting. An external rf magnetic field was applied parallel to $FeBO_3$(111) plane and perpendicular to scattering plane with various peak amplitudes (0～16.8Oe) and frequency of 9.61728MHz. The frequency was six times as large as the frequency of SR X-ray pulse (1.60288MHz) exactly. In phase locking, the timing of SR X-ray incidence was fixed in the phase of zero amplitude of rf magnetic field for all measurements.

Rocking curve of $FeBO_3$ (444) in H_{rf}

The rocking curves of $FeBO_3$ (444) reflection were measured with various strengths of rf magnetic field. They are shown in Fig.1. At the strength of rf magnetic field below 4.2Oe (See Figs.1(a) and 1(b)), the measured rocking curves show both sub-peaks and broad tails in a very large angular range (~ 100arcs). These results indicate that this $FeBO_3$ crystal has some defects (misorientations between growth boundaries and crystal bent) in the range of 100 arcs. But, in contrast, at the strength of rf magnetic field over 8.4Oe, the rocking curves change into a sharp form of single peak abruptly. At the same time, strong narrowing of FWHM and enhancement of peak intensity are caused (See Figs.1(c)). Finally, the value of FWHM reaches to 8.0arcs (See Figs.1 (d) and 1(e)). This value is the same order of theoretical the value (the intrinsic FWHM of $FeBO_3$ (444) reflection is about 4.0arcs at λ=1.24Å).

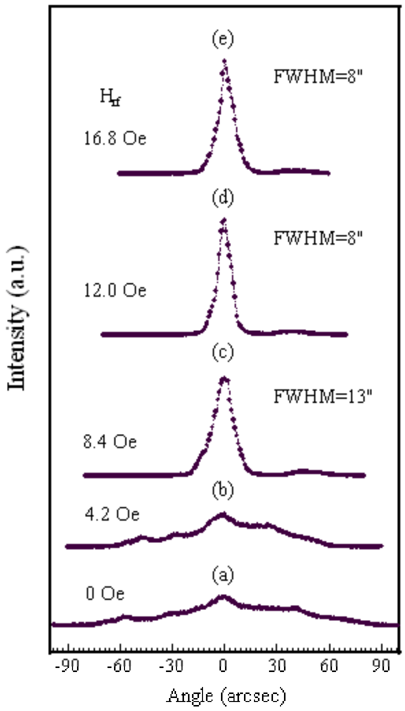

Fig.1. Rocking curves of $FeBO_3$ (444) reflection placed in external fields

These results indicate that rf magnetic field excites the acoustic wave resonantly and it makes a dramatic deformation for $FeBO_3$ crystal surface through magnetostrictive interaction. Surprisingly, the excited magneto acoustic standing wave makes improve $FeBO_3$ crystal perfection extremely. It may be a very important phenomenon for the future's application researches. In recent stroboscopic topography experiment, we could record the visual images of excited magneto acoustic standing wave of $FeBO_3$ crystal too [5].

References

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