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The observation of spin reorientation transition of $^{57}Fe_3BO_6$ single crystal by synchrotron mössbauer diffraction method

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Introduction

Time domain synchrotron radiation (SR) mössbauer diffraction spectra offers following advantages for the study of magnetic structures of crystals.
1: Site selective determination of the effective magnetic fields at the mössbauer nuclei have different values.[1]
2: High sensitivity for the spin (hyper-fine magnetic field) direction which originates in the linear polarization property of incident SR X-ray.
3: High sensitivity for the magnetostrictive strain.

These properties are very useful for the study of the magnetic ordering of crystal, especially, which contains mössbauer nuclei in nonequivalent crystallographic positions. In present investigation, we measured the time domain nuclear Bragg diffraction spectra from anti-ferro magnet $^{57}Fe_3BO_6$ single crystal at temperatures in the vicinity of spin reorientation transition point (T_{SR}=415K). Then, $^{57}Fe_3BO_6$ single crystal is a typical sub-lattice material. The iron ions in $^{57}Fe_3BO_6$ are in particular 4c and general 8d crystallographic positions.

Experimental

The experiments were performed at NE3 undulator beam line of KEK. The experimental set-up is shown in Fig.1. A 4-bounce precision monochromator produced the σ-polarized X-ray with the energy width of 6.4meV at 14.4KeV nuclear resonance in ^{57}Fe. The beam size was restricted to 0.5x0.5mm^2 by a precision slit. Mössbauer time spectra of $^{57}Fe_3BO_6$ (4 0 0) reflection were measured at several temperatures in the vicinity of T_{SR}=415K.

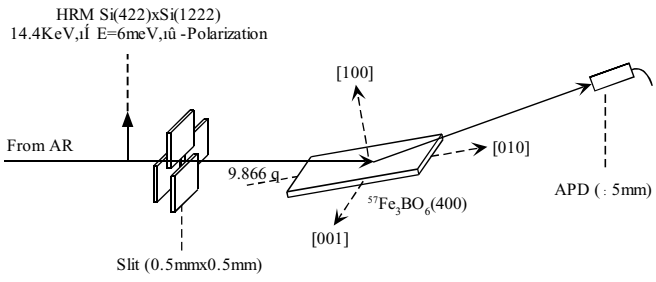

Fig.1. Optics for mössbauer diffraction of $^{57}Fe_3BO_6$(400).

Results

Figure 2 show the measured time spectra of $^{57}Fe_3BO_6$ (400) reflection at several temperatures close to T_{SR}. In the range $T<T_{SR}$, clearly, quantum beat (QB) pattern corresponding to the $\Delta m=\pm1$ transitions are appeared in time spectra. It indicates that both lattices have their spontaneous antiferromagnetic axis aligned with the [0 0 1]-axis. On the contrary, In the range $T>T_{SR}$, the diffraction time spectra show the simple QB pattern corresponding to the $\Delta m=0$ transitions. It indicates that the both spin systems are aligned with the [1 0 0]-axis above the spin reorientation temperature. These results proved the high sensitivity of diffraction mössbauer spectrum for the spin direction change of $^{57}Fe_3BO_6$ crystal.

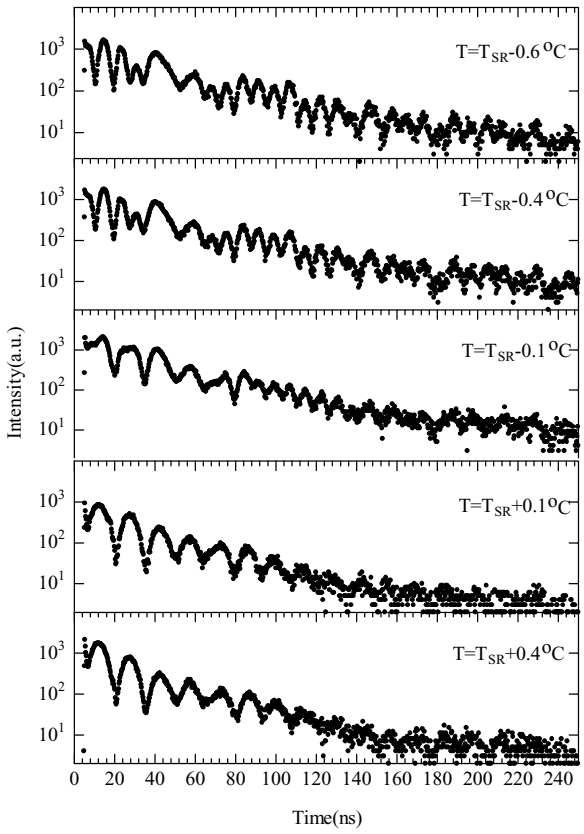

Fig.2. Time domain mössbauer diffraction spectra of $^{57}Fe_3BO_6$ (400) single crystal at temperatures in the vicinity of spin reorientation transition point.

References

[1] P.P.Kovalenko et al., Sov.Phys.Solid State **26**(10),1849 (1984).