NE3/2005G088

Nuclear Resonant Small-Angle Scattering of Nanoparticles

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Introduction

The nuclear forward scattering (NFS) is powerful technique to measure the hyperfine fields of the nuclear. On NFS measurement, we can use the X-ray optical technique. It is the advantage over the other hyperfine field measurement techniques. On this study, we used small-angle scattering technique with NFS. From the nuclear resonant small-angle scattering, we can obtain the information of the hyperfine field from the specific size scattering material [1].

Experimental Procedure

The experimental arrangement is shown in Fig. 1. It is typical setting of Bonse-Hart camera. The energy of the synchrotron radiation was tuned into 14.4 keV and monochromatized into 6.4 meV width by the high-resonance monochromator. The angular profiles were measured by the rotation of second Si 111 channel cut monochromator. So far we have used two Si 111 mono-chromator upper and lower the sample. In this time, we used one Si 111 monochromator to analyze the scattering angle in order to suppress the loss of beam flux and to get more nuclear resonant scattering. The photons were detected by the Avalanche Photo Diode (APD), which is fast X-ray detector.

The sample was magnetic fluid, which is a mixture of Fe_3O_4 nanoparticles and oil. The diameters of the particles were not controlled, so they were uneven, 10~200 nm. The Fe was enriched by ^{57}Fe. At the measurement, the sample was cooled at 80 K.

Results and Discussion

The observed angular profiles are shown in Fig. 2. Because of the higher flux, we measured the scattering in wider angular range than previous our experiments. On the angular profile, the electronic and nuclear resonant scattering shows same profile. There is no special scattering on nuclear resonant scattering (for example, scattering of magnetic domain). From the Guinier plot, the radius of the scattering material is estimated at 0.2 μm. So this scattering is due to the largish particles in the magnetic fluid.

References

[1] Yu. V. Shvyd'ko et al., Phys. Rev. B, 54, 14942 (1996).

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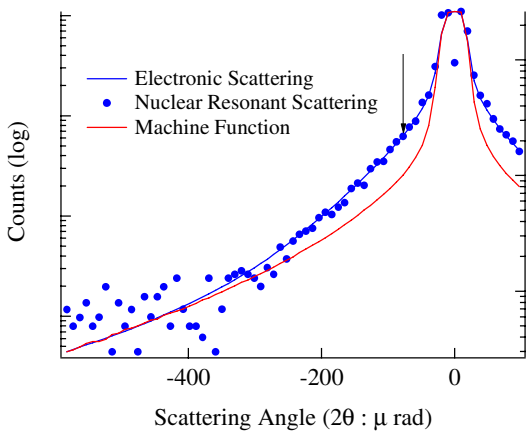

Fig. 2. The scattering angular profiles of Fe_3O_4 nanoparticles at 80K.

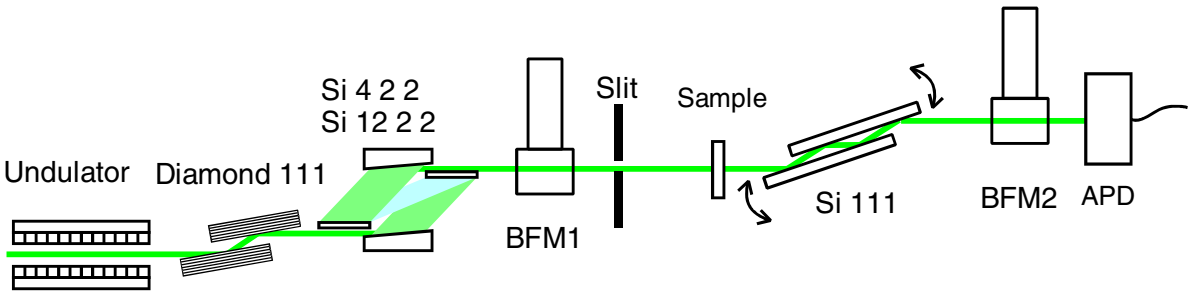

Fig. 1. Schematic drawing of experimental arrangement. Components are not in scale.