Nuclear Resonant Diffraction in Nearly Perfect Synthetic Hematite Crystals Containing Various Contents of ^{57}Fe

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Introduction

It is well known that in a nearly perfect single crystal, both x-ray diffractions of electrons and nuclei can be dealt with dynamical diffraction theory. For the pure nuclear resonant diffractions hhh (h = odd) of hematite containing various contents of ^{57}Fe, our interest is in the change of the intensity ratios of nuclear to atomic diffraction versus various contents of ^{57}Fe. Because when the content of ^{57}Fe is reduced, the non-resonant nuclei ^{56}Fe will bring ideal point defects into the crystal from the point of view of nuclear level.

Experiment

The ring was operated under the conditions of 21-bunch and 20mA initial storage current. The experimental setup is shown in Fig.1.

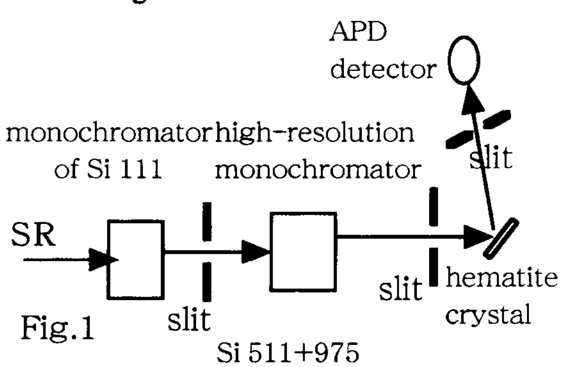

Fig.1

The band-width of the high-resolution monochromator is 3.2meV for the 14.4keV Mössbauer level of ^{57}Fe, and the throughput was 5×10^8 cps with full beam size of 0.5(V) x 0.3(H)mm^2. A 5mm square avalanche photo-diode (APD) and a TAC time-resolved electronics system were used for detecting atomic and nuclear diffractions. For counting time-delayed nuclear resonant scattering signals, the time gate was set from 5ns to 210ns; for counting atomic prompt scattering, the gate was set between ±0.5ns. Four hematite crystals with contents of 95%, 50%, 20% and 2% ^{57}Fe were measured from 1 1 1 to 10 10 10 diffractions.

Results

Nuclear resonant diffractions of the hematite crystal with contents of 50% ^{57}Fe from 222 to 101010 are shown in the top part of Fig.2, where the intensities were normalized by the peak value of 666 atomic diffraction. Atomic diffractions are shown in the bottom of the figure with the same normalization factor.

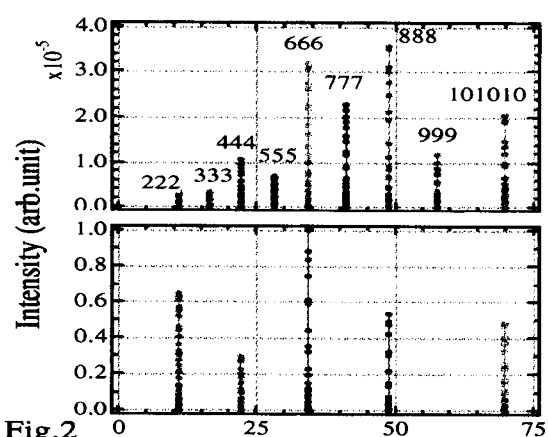

Fig.2

The diffractions from the hematite crystal containing 20% ^{57}Fe are presented in Fig.3. It is quite clear that diffractions of odd index (pure NBS) may lose their intensities more than those of even index (NBS accompanying with atomic x-ray diffraction), when the content of ^{57}Fe was reduced from 50% to 20%.

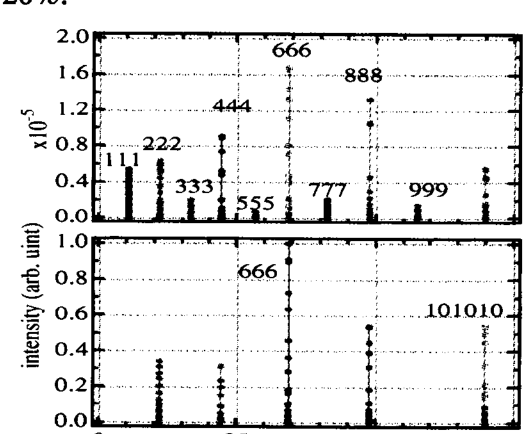

Fig.3