NE3/2003G150

Precision Measurement of the ^{83}Kr Mössbauer Wavelength

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Introduction

The ^{83}Kr Mössbauer wavelength was precisely measured by using two diffractions of (733) and $(55\bar{1})$ in an FZ silicon crystal. The interval of the two diffraction peaks was only 0.0631°, which could be easily determined with high accuracy. The value of the wavelength of the ^{83}Kr first excitation level was 0.13184021±4 nm, corresponding to an energy of 9404.130±3 eV.

Experiment

The experiment was carried out at the NE3 station of PF-AR;[1] its experimental arrangement is shown in Fig. 1.

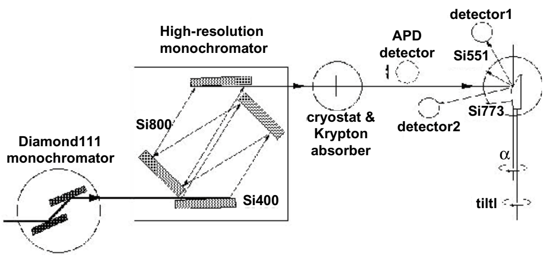

Fig. 1 schematic side view of the configuration.

Synchrotron radiation was narrowed by a diamond monochromator, and then by a high-resolution monochromator containing Si (400) and Si (800) nest channel-cuts. Kr gas was sprayed through a micro-channel plate onto a Be foil at a temperature of 20 K; Kr ice with uniform thickness was grown on the foil. The Si (800) channel cut of the high-resolution monochromator was rotated for tuning the x-ray energy to match to the resonance; time-delayed nuclear resonant signal was detected by an avalanche photo-diode (APD). One observation of nuclear resonant scattering is shown in Fig.2, where there is a peak of the time-delayed signal around a specific wavelength that contrasts with no change on the intensity of electronic scattering.

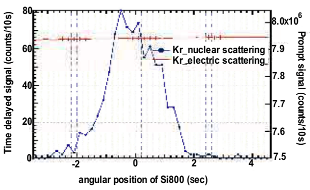

Fig. 2. Signals of time-delayed nuclear resonant scattering and electronic scattering versus the Si (800) channel cut angular position.

Because the nuclear resonant energy level is invariable, and its width is a few neV, the intensity distribution of the time-delayed signal provides the instrumentation function of the high-resolution monochromator; its resolution, defined by the half bandwidth, is 1.5×10^{-6}, which corresponds to an energy band width of 15 meV. By tuning the angular position of Si (800) at the center of the resonance peak and moving the APD out of the beam path, the x-ray wavelength is measured by a piece of peculiarly cut silicon crystal. Because the signal of the nuclear resonant scattering was weak, two reflection profiles of (733) and $(55\bar{1})$ were measured by electronic scattering. It is considered that the central wavelength of the high-resolution monochromator should be consistent with the nuclear resonance wavelength.

Angle b between (733) and $(55\bar{1})$ is 36.48276°, which can be calculated from the crystal symmetry. Regarding the resonant wavelength, the Bragg angles of these two indexes are 83.435° and 60.082°, respectively. Because 83.435° + 60.082° + 36.48276° is near to 180°, two diffraction peaks can be observed by rotating the crystal within about 0.07°.

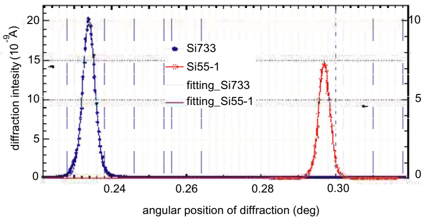

Fig. 3. Diffractions of (733) and $(55\bar{1})$ and their Gaussian fittings.

Results

The interval of two peaks was measured as 0.06313 degree. From a detailed calculation the Mössbauer wavelength of ^{83}Kr is 0.13184021(2) nm; in energy unit this is 9.404130(2) keV.[2]

References

[1] Zhang xiaowei, Tetsuro Mochizuki, Hiroshi Sugiyama, Shigeru Yamamoto, Hidoo Kitamura, Tatsuya Shioya, Masami Ando, Yoshitaka Yoda, Tetsuya Ishikawa, Seishi Kikuta and Carlos K. Suzuki: Rev. Sci. Instrum. **63** (1992) 404-407

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