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Resonant Coherent Excitation of Hydrogenlike Fe^{25+} in a Ge crystal

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Synopsis An extremely-thin Germanium crystal (0.8 μm-thick) has been firstly exploited in the resonant coherent excitation (RCE) experiment. The 460 MeV/u H-like Fe^{25+} ions were incident on the Ge crystal under the (220) planar channeling as well as non-channeling conditions. The RCE from $1s$ to $2p_{1/2}$ and $2p_{3/2}$ states were successfully observed as an enhancement of the x-ray fluorescence.

When energetic ions pass through a crystal, they experience a periodical oscillation of electric fields originating from the lattice structure of the crystal. If this oscillating frequency corresponds to a transition energy of the ions, they can be resonantly excited, i.e., the resonant coherent excitation (RCE) takes place [1]. Because the frequency of the oscillating field in the projectile frame increases with their velocity, the use of higher energy ions allows the RCE of higher transition energies in the x-ray domain. So far we have performed various schemes of RCE experiments mostly with Si crystals, because of their high crystalline quality and purity [2, 3, 4]. On the other hand, characteristic parameters in the RCE process, for example, the frequency and amplitude of the oscillating field are determined by the physical properties of the target crystal. Therefore the study of target dependence of the RCE process is important to understanding the resonance dynamics. Here, we report on the first observation of the RCE process in a Ge crystal.

A thin Ge crystal was manufactured by epitaxial growth on a Si substrate. The crystal thickness was measured to be 0.8 μm from the energy loss of 5.5 MeV α particles from an Am-241 source. After the annealing at 900 K, the Ge crystal was installed in a vacuum chamber at NIRS-HIMAC (National Institute of Radiological Sciences - Heavy Ion Medical Accelerator in Chiba). The H-like Fe^{25+} ions were accelerated to 460 MeV/u and incident on the Ge crystal mounted on a high-precision goniometer. The x-ray fluorescence from the ions were observed by a silicon drift detector (SDD) having an active detection area of 80 mm^2. Figure 1 shows the typical x-ray spectrum observed by the SDD installed at 34° from the beam, in which both the target characteristic x-rays and Fe^{25+} fluorescence were observed. Note that the energy of x-rays emitted from the beam is Doppler shifted in the spectrum. By measuring the x-ray yield from Fe^{25+} ions as a function of the ion incident angle with respect to the crystal orientation, the RCE from $1s$ to $2p_{1/2}$ and $2p_{3/2}$ states were clearly observed at transition energies of 6951.96 and 6973.17 eV, respectively. A comparison of the resonance profile obtained with Si and Ge crystals showed the target dependences of the RCE probabilities, background fluorescence and collision cross-sections. The observed resonance width were a few times broader than those observed in Si crystals, possibly reflecting the quality of the target crystal.

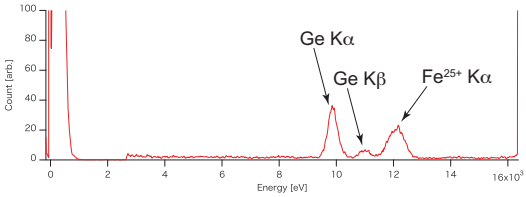

Figure 1. X-ray energy spectra observed by a Silicon Drift Detector (SDD).

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