Observation of nuclear excitation by electron transition with an APD electron detector

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Introduction

We succeeded in observing nuclear excitation by electron transition (NEET) on ^{197}Au in *K*-shell photoionization with synchrotron radiation[1]. The NEET on ^{197}Au occurs between the $K(1S_{1/2})\rightarrow M_1(3S_{1/2})$ atomic hole transition (77.300keV) and the 77.351-keV nuclear transition (3/2+→1/2+, half life: 1.91ns). We have tested an APD detector for the NEET experiments under this project. The APD is used to detect internal-conversion electrons emitted from excited nuclei. The outputs from the APD were processed in a time spectroscopy system using a fast amplifier. The energy spectrum was investigated to confirm what radiations the detector observed and to decide a ratio of the conversion electrons measured by the spectroscopy system to that detected by the APD.

Experiments

The energy spectra of the APD detector were measured at beamline BL-14A. An X-ray beam from a Si(553) double crystal monochromator was defined to $^{H}1.0\times^{V}1.0$ mm. A charge-sensitive preamplifier, Canberra 2001A was used to investigate energy spectra of an APD (Hamamatsu SPL4583). This device was 3 mm in diameter and had a depletion layer 30μm thick. The APD was installed in a vacuum chamber for the NEET experiment[2]. The APD was located on a plane perpendicular to the vertically polarized beam. We used gold targets of metal foil (3μm thick) covered with and without 36-μm Aluminum foil.

In order directly to measure a pulse-height distribution of a fast amplifier's outputs, we took a single-channel scanning method with a constant fraction discriminator and a scaler. A fast amplifier, Philips Scientific 6954 was used.

Results

Figure 1 shows energy spectra measured at an incident X-ray energy of 80.77keV. In Fig. 1(a), a spectrum measured without aluminum foil is shown. A profile of *L*-photoelectrons is mainly observed and peaks of *L* X-rays are seen at 9-11-keV region. *KLL*-Auger electrons are observed as a hump around 50 keV. While in a spectrum using a gold target covered with aluminum foil, Fig. 1(b), profiles of electrons are not seen because the aluminum stopped all of electrons emitted from the surface of gold foil. Peaks of *K* X-rays (67-69 and 79 keV) are not seen in Fig. 1(a) though the fluorescence yield is high, 0.96. It is due to a small efficiency of the thin silicon APD. In a logarithmic scale of counts, *K* X-rays can slightly be distinguished in Fig. 1(b).

Pulse-height distributions of the fast amplifier were measured at 77.351keV and at 57.351keV. The peak of *L*-photoelectrons was seen as a main profile in each spectrum. By comparing the peak position of *L*-photoelectrons, we knew that the threshold level of CFD, 20mV corresponded to 35keV. It can be seen that the profile of *L*-photoelectrons measured at 77.351keV is the same as the spectrum of the *L*-internal conversion electrons. From these results, it was estimated that more than 71% contributed to the time spectrum in the *L*-internal conversion electrons detected by the APD.

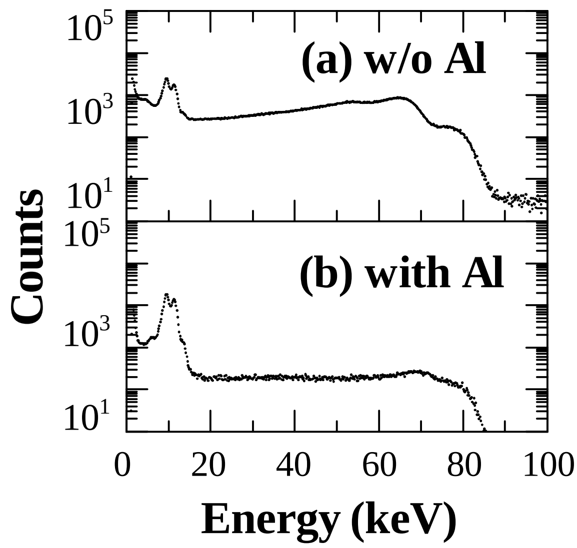

Fig. 1 Energy spectra of radiations emitted from gold covered (a) without and (b) with aluminum foil. Energy of the incident X-rays was 80.77keV.

References

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