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Array of silicon avalanche diodes as an electron detector

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Introduction

We have used a silicon avalanche diode as an electron detector in experiments of Nuclear Excitation by Electron Transition (NEET)[1]. The diode detects radiations emitted from a target irradiated with an X-ray beam. In order to observe NEET, the detector has to distinguish internal-conversion electrons emitted from excited nuclei while intense atomic scattering radiation is promptly emitted. Intensity of the internal conversion electrons decays with a nanosecond lifetime of a nuclear level. Therefore, sub-nanosecond time resolution is also important for the detector.

NEET experiments on ^{197}Au, ^{193}Ir and ^{189}Os are going on at BL09XU of SPring-8. At BL-14A, we have developed the electron detectors and have tested their performance. Compared with NEET on ^{197}Au, the energy difference between the atomic and nuclear transitions in ^{193}Ir and ^{189}Os is large. Thus, the NEET probabilities for them are expected to be 2.3×10^{-9} and 1×10^{-10}, one or two order less than that of ^{197}Au [2]. We need a better efficiency of the detector for the conversion electrons. An array of diodes will have a better efficiency for detecting electrons with a larger solid angle. We have developed an array of silicon avalanche diodes and tested performance for NEET experiments.

Experiments

The array of silicon avalanche diodes (Si-ADs) was produced by Hamamatsu Photonics Co. The device (SPL1704) has three pixels of 3 mm in diameter and of a depletion layer 30μm thick. A pitch of the pixels is 3.2-mm. The energy spectra of the avalanche diodes were investigated at BL-14A. An X-ray beam from a Si(553) double crystal monochromator was defined to $^{H}1.0\times^{V}1.0$ mm. We used gold foil of 3μm thick as a target. The energy of the incident X-rays was 77.35keV that is the resonance level of ^{197}Au. The array of Si-ADs was installed in a vacuum chamber for the NEET experiment and was located 2.5mm above the target. A charge-sensitive preamplifier, Canberra 2001A, was used to measure energy spectra while a fast amplifier, Philips Scientific 6954, was used for recording time spectra. A constant-fraction discriminator (ORTEC935) and a time-to-amplitude converter (Tenelec TC-863) were also used.

Results

Figure 1 shows an energy spectrum of a pixel at the center of the array (No.105), measured by the charge-sensitive preamplifier. The main peak by *L*-photoelectrons and peaks of *L* X-rays at 9-11 keV are seen. The energy resolution was roughly the same as a single device of SPL1106 at the same gain. A sum of efficiency for three pixels was about two times larger than that of a single device. Figure 3 shows a time spectrum, measured at a multibunch operation of the PF ring. The peak shows a time resolution of 0.33ns (FWHM). Other pixels show the same resolution at a common bias voltage.

The device will be tested for a NEET experiment.

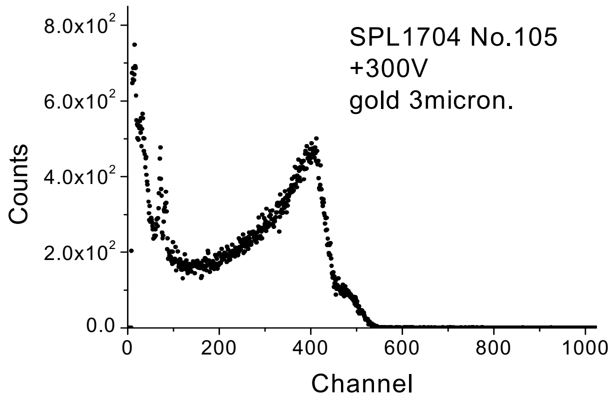

Fig. 1 Energy spectra of radiations emitted from the gold target measured with (a) a charge-sensitive preamplifier and a normal spectroscopy system.

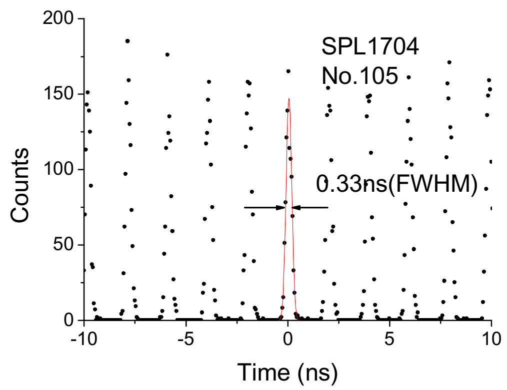

Fig. 2 Peak profile measured with a fast amplifier in a multibunch mode of the PF ring; Energy of the incident X-rays was 77.35keV.

References

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