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Detectors of stacked avalanche photodiodes for nuclear resonant scattering experiments

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Introduction

A silicon avalanche photodiode (Si-APD) detector is now a standard for the synchrotron radiation experiments on nuclear resonant scattering, since it was developed in 1991 [1]. A stacked Si-APD detector was provided for X-ray diffraction experiments at PF more than 7 years ago [2], but was not used for the nuclear resonance scattering in PF. We have recently developed a couple of stacked Si-APD detectors for the nuclear resonant scattering experiments carried out at beamline NE3A of the PF-AR ring. They were tested for time resolution, efficiency, and time spectrum by using 14.4-keV X-rays.

Detectors and performance test

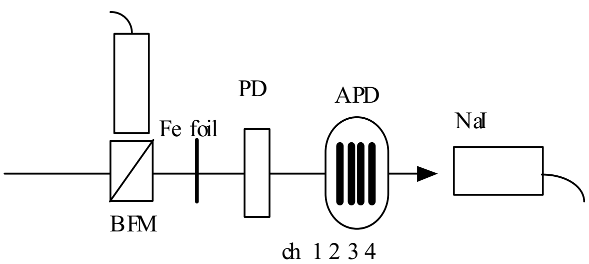
Si-APDs

Three types of Si-APD were used for each detector. :
A.3mm in diameter, 30µm thick (Hamamatsu SPL3158).
B.3mm in diameter, 130µm thick (Hamamatsu SPL2207).
C. 3×5mm, 130µm thick (Hamamatsu SPL3160).

Set-up

In Fig. 1, our set-up for the detector test is schematically shown. Intensity of the incident beam was monitored during a measuring period with a PIN photodiode of transmission type. An absolute intensity of the incident beam was obtained by using a NaI(Tl) scintillation counter and zirconium metal filters. Outputs of each APD channels were independently processed with an amplifier, a discriminator and a scaler. Energy spectra were measured per channel with a charge-sensitive preamplifier to check the APD performance and to get efficiency. Mössbauer time spectra for ^{57}Fe foil were recorded to obtain time resolution using a time-to-amplitude converter. We also obtained a dead time from a measured time spectrum, which is defined as a time when a signal can again be recorded in time spectrum after a prompt peak caused by electron scattering.

Fig. 1: Set-up for the detector test



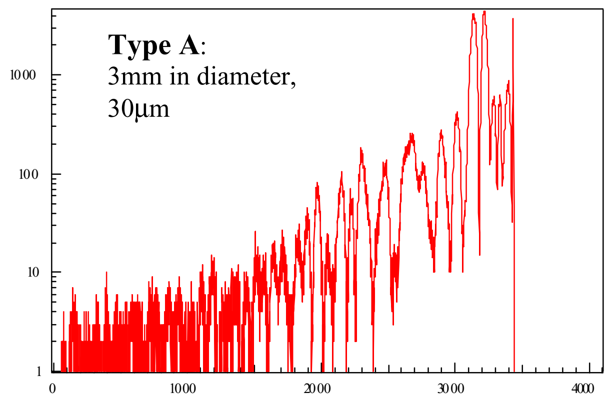
Experimental results

The results are shown in Table 1. Figure 2 indicates one of time spectra, measured with the detector of Type A. The error of the efficiency was ±0.3%. The time resolution of the prompt peak and the dead time were measured at rate of >10^8 s^{-1}. The values of time resolution were somewhat modified from those measured at a low rate due to pulse pile-up of the huge prompt pulses, although their errors were less than ±0.1 ns.

Table 1: Performance of the stacked Si-APD detectors

Type	Efficiency (%)	Time resolution (FWHM, ns)	Dead time (ns)
A	18.8	0.36	2.6
B	78.2	0.43	13.6
C	79.5	0.55	14.5

Fig. 2: Time spectrum for ^{57}Fe foil, measured with Type A



References

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