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Performance of energy-dispersive superconducting detectors in a low-energy soft X-ray region

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Introduction

Superconducting detectors are promising for energy-dispersive X-ray spectroscopy. One type of the superconducting detectors employs a photon absorber having superconducting energy gap (2Δ) and a tunnel junction as a read-out device, which is called superconducting tunnel junction (STJ).

We have previously reported that STJ detectors of 100 –200 μm^2 suffer serious degradation in energy resolution because of spatial nonuniformity in a photon energy region between 6 keV and 12 keV. This study has confirmed that the spatial uniformity can be improved by changing layer structure of superconducting proximity electrodes and that performance in a low energy soft X-ray region exceeds those of conventional semiconducting X-ray detectors by a factor of seven [1,2].

Experiment

Detector fabrication

The STJ detectors were fabricated by photolithographic techniques at AIST. For soft X-ray detection, insulating layers, which normally cover detector surface, were removed by a selective etching technique or a lift-off technique. There is no dead layer, so that the detector has a high detection sensitivity to low energy photons. The detector sizes were between 100 μm^2 or 200 μm^2.

SR experiment

Spatial distributions of detector output were measured by scanning X-ray microbeam at BL13B2 in an energy range between 6 keV and 12 keV. In a low energy range between 200 eV and 2 keV, full illumination experiments were performed at BL11A.

Results

Dependence of layer structures of superconducting proximity electrodes was reported in ref. [1]. Better spatial uniformity can be obtained in superconducting electrodes with stronger proximity effects at 6 keV. Furthermore, it has been revealed that spatial uniformity is improved for low energy X-rays [2]. Figure 1 shows photon energy dependence of energy resolution in fwhm. One of the STJ detectors in Fig. 1 has energy resolution values exceeding those of a Si drift detector in 200 eV – 1.2 keV. An example of pulse height spectra for 200 eV photons is shown in Fig. 2. The events in one of the electrodes indicate an energy resolution of10 eV, which is 7 times better than that of the Si detector..

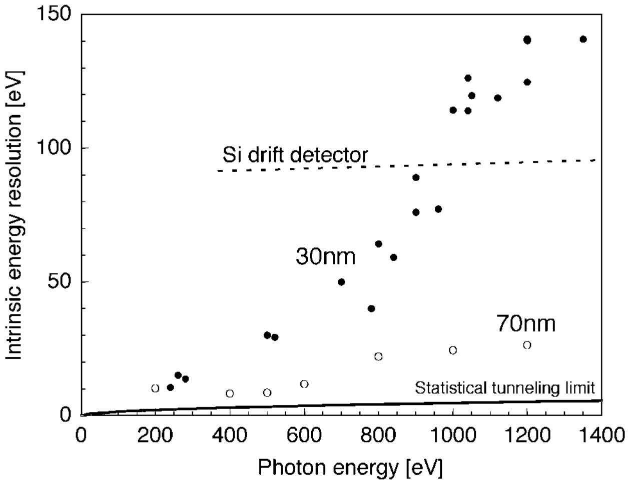

Fig. 1 Energy resolution (fwhm) of an 100μm-square detector as a function of photon energy. The closed and open circles show data for different layer structures of superconducting proximity electrodes.

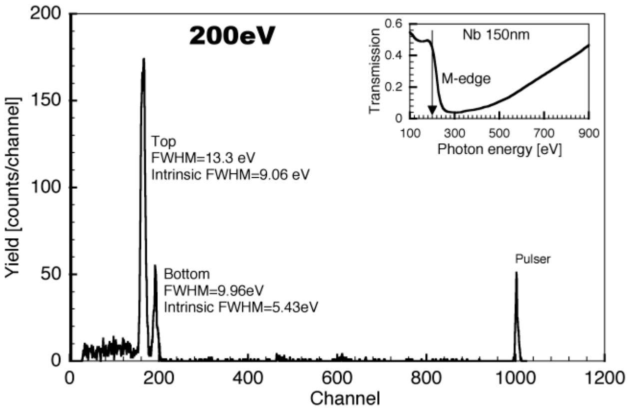

Fig. 2. Pulse height spectrum for X-rays of 200 eV. The best energy resolution is 10 eV.

References

[1] M. Ukibe *et al.*, Nucl. Instrum. Methods in Phys. Res. A **520**, 260 (2004).
[2] M. Ohkubo *et al.*, Nucl. Instrum. Methods in Phys. Res. A **520**, 231 (2004).

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