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Soft X-ray Spectrometer using 100-pixel Superconducting Tunnel Junction

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Introduction

X-ray absorption fine structure (XAFS) is an important tool for material analysis, especially for the measurement of chemical states or local structures of elements. Superconducting tunnel junction (STJ) detectors are promising for measuring fluorescent yield in a soft X-ray region, which cannot be covered by semiconductor detectors, because of an excellent energy resolution well better than 100 eV, and a counting rante of over 10 kcps/pixel, and a high detection efficiency.

In order to realize a fluorescent-yield XAFS spectrometer with high sensitivity and user friendly operation, we are constructing an energy-dispersive 100-pixel STJ array detector mounted on a cryogen-free ^{3}He cryostat. Here we present test results of the cryostat and STJ detector on BL-11A in KEK PF.

Results

Cryogenic Performance of ^{3}He Cryostat

A cryogen-free ^{3}He cryostat with base temperature of less than 0.5 K is required to reduce thermal excitation of carriers (quasiparticles) and shot noise due to tunnel current of superconductor-insulator-superconductor junction structure. The cryostat must be operated without cryogenic knowledge, because the constructed spectrometer is planned to be open to users.

Here we describe briefly the test run results. It takes approximately 40 hours for the cryostat to reach the base temperature from room temperature, and the recycle of ^{3}He requires 2-3 hours. The cooling of the cryostat and recycling of ^{3}He are done automatically, so that the operation is easy. The base temperature of the cryostat is 300 mK with a holding time of longer than 80 hours. It is concluded that the current cooling performance is enough for the operation of the STJ detectors.

Current-Voltage Characters of 100-Pixel STJ Detector

Since the spectrometer requires a large solid angle coverage to achieve a high sensitivity for low concentration elements in matrix materials, the number of working pixels for the entire 100-pixel array is important.

The current-voltage curves of the 100 junctions were measured. Each STJ detector has a layer structure of Nb (100 nm) / Al (40 nm) / AlO_x (~1 nm) / Al (40nm) / Nb (100 nm) with a size of 200 µm-square. The magnetic field of approximately 20 mT was applied to suppress the DC Josephson effect so that quasiparticle tunneling can be measured.. More than 40 pixels out of the 100 pixels showed excellent *I-V* curves having subgap currents less than 100 nA at 0.3 mV. The number of the working pixels should be increased as close to 100 as possible in future.

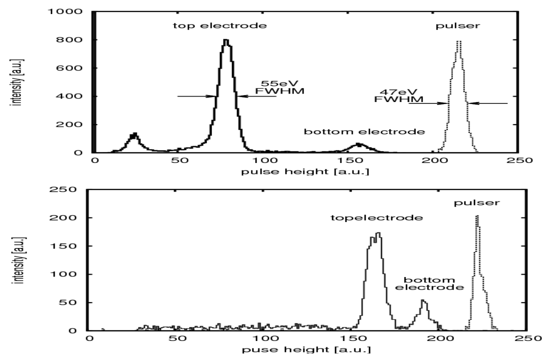

FIGURE 1. (a) Pulse height spectrum for 400 eV X-ray. Thick line indicates a spectrum of a 200 µm STJ detector. Thin dotted line represents a spectrum for a pulser. (b) Pulse height spectrum for 200 eV X-ray using another 100 µm-sized STJ detector having 70nm thick Al trap layer.

Energy Resolution in Storage Ring Beam Line

The spectrometer requires good energy resolution for resolving each X-ray for Kα lines of C, N, and O, and L lines of various elements.

A 200µm-square STJ detector in the array was tested at X-ray energy of 400 eV. A pulse height spectrum is shown in Fig. 1 (a). The FWHM energy resolution value is 55 eV. The resolution is enough to resolve Kα lines of C, N, and O clearly. However, a good energy resolution of ~15 eV for 200eV X-ray was recorded (Fig. 1 (b)) in a previous experiment [1]. The energy resolution depends on its size and thickness of the Al trap layers [2]. We plan to use an array detector of STJs with the size of 100 µm square and with Al layers of 70- nm-thick.

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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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