7B, 11A/2005G248

Performance of X-ray detection by array detectors with 100 superconducting tunnel junctions and Ta X-ray absorbers

M. Ukibe, Y. Chen, Y. Shimizugawa, K. Suzuki, S. Shiki, M. Ohkubo
AIST-RIIF, 1-1-1, Umezono, Tsukuba-city, Ibaraki, 305-8568, JAPAN

Introduction

We have developed superconducting tunnel junction (STJ) X-ray array detectors with a large detection area, a high detection efficiency, and a high counting rate. The STJ array detectors consist of one hundred Nb/Al-AlOx/Al/Nb STJs with a size of 200 x 200 μ m. Each STJ has a 500 nm-thick Ta absorber connected to the top Nb layer through a thin insulating layer. The absorbers act as energy converter from high X-ray energies to phonon energies, which are compatible with superconducting energy gaps. The array detectors realize a total detection area of 4 mm^2 and a detection efficiency of ~70% for X-rays up to 2keV.

Experiment

Our fabrication process of Nb-based STJs is described in detail elsewhere.[1] Figure 1 shows a 100 Nb-based STJ array. Each STJ has a symmetric layer structure of Nb(100 nm)/Al(70 nm)/AlOx/Al(70 nm)/Nb(100 nm). The STJ detector studied in this paper is a single pixel of the STJ array. The STJs were cooled on a cold stage of a ^{3}He cryostat. The bias points were near Δ/e by constant bias currents. A magnetic field of about 16mT was applied along the diagonal direction of the STJs. Low Temperature Scanning Synchrotron Microscope (LTSSM) measurements,[2] which used X-ray microbeam of a diameter of 10μm and energies between 0.4 and 1.2 keV, were performed at the beam line BL-11.

Results and Discussion

Figure 2 shows a 0.8keV X-ray spectrum obtained by the single STJ. The X-ray microbeam with a 10 μm-diameter irradiated at the center of the single STJ. The rise time of the X-ray signals is about 1.5 μs. The energy resolution of the X-ray peak is about 190 eV. The responsivity of the STJ is 90 charges per eV. The electronic noise is 150 eV, which corresponds to 13500 charges. It is considered that the X-ray peak is produced by the Nb electrode because of the X-ray energy dependence of the peak area, which the peak area decrease rapidly below 0.8 keV, and the result of the LTSSM measurement for 0.8 keV X-rays, which the intensity of the peak signals increases near the STJ edges, where the Nb electrodes can be irradiated by X-rays directly. The X-ray peak generated by the Ta absorber can not be obtained by our STJ. It is speculated that this performance is mainly induced by a high normal resistance of the Ta layer of 6 μΩcm, which leads to a considerable loss of excited quasiparticles in the Ta absorber during the signal producing process.

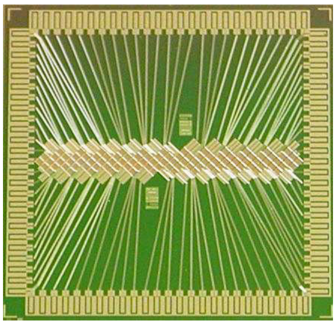

Figure 1. Photograph of an array of 100 Nb-based STJs with Ta X-ray absorbers.

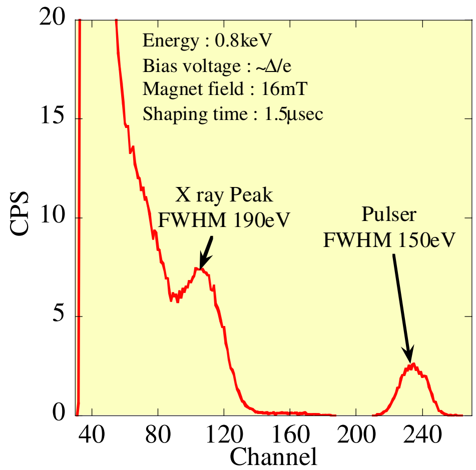

Figure 2. 0.8keV X-ray spectrum of the single STJ.

Conclusion

We fabricated a STJ X-ray array detector of a detection area of 4 mm^2, a detection efficiency of ~70% for X-rays up to 2keV, which is constructed by 100 Nb-based STJs with a size of 200 x 200 μm. The detector response to the X-rays was directly measured by LTSSM. Our detector can not produce the single peak like spectra for X-rays of single energy due to a high normal resistance of the Ta absorber. The energy resolution was about 190 eV for 0.8 keV X-rays. The electronic noise is 150 eV.

References

[1] M. Ukibe, A. Kushino, Y. Chen, M. Ohkubo, X-Ray Spec. (2007).
[2] H. Pressler, M. Ohkubo, M. Koike, M. Ukibe, T. Zama, T. Nakamura, M. Katagiri. Appl. Phys. Lett. 77, 4055 (2000).

*ukibe-m @aist.go.jp