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X-ray detection performance of superconducting tunnel junctions with new layer structure

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X-ray detectors based on superconducting tunnel junctions (STJs) have exhibited excellent energy resolution, high detection efficiency, and high counting rate in the soft X-ray energy range, which is suitable for synchrotron radiation facilities. Our STJs with 100 μm square have an asymmetric layer structure of Nb (300 nm)/Al (70 nm)/AlOx/Al (70 nm)/Nb (50 nm) (hereafter abbreviated "asymmetric STJ") in order to solve the double peak problem [1]. A soft X-ray spectrometer using 100-pixel array of the asymmetric STJs has a mean energy resolution (dE) of 14.0 +/- 2.8 eV for O-Kalpha (525 eV) photons and a counting rate of several 100 k cps[2]. It was possible to measure X-ray absorption fine structure (XAFS) spectra of nitrogen dopants of 300 ppm in a SiC compound semiconductor. However, with such high dE, it is difficult to achieve clear separation of the L-lines of transition elements and the K-lines. Thus, to improve dE, the new layer structure of STJs was investigated by evaluating the dependence of dE on the layer structure. We have fabricated three types of 100-pixel arrays by our normal fabrication process in CRAVITY (Clean Room for Analog & digital superconductiVITY) in AIST[3]. Each array consisted of STJs with different Nb/Al/AlOx/Al/Nb layer structures, which were 100/70/70/100, 300/70/70/100, and 300/70/70/300 nm. The critical current density (JC) of all STJ arrays was designed to be same of about 200 A/cm^2. Current - voltage (I -V) curves, gap values, and X-ray detection performances of all STJ arrays were evaluated. It was found that I-V curves and gap values were almost same but the decay times of X-ray signals were quite different in the three STJ arrays. An operational yields of an array consisting of STJs with Nb (300 nm)/Al (70 nm)/AlOx/Al (70 nm)/Nb (300 nm) was 89 %. An leak current and energy gap value of an STJ in the

array were 4 nA and 0.45 meV, respectively. The decay time of X-ray signals for above STJ was long of 7.5 micro sec, which led to the enhancement of the signal charge. The mean dE@O-Kalpha for the STJ array was 9.1 +/- 1.4 eV. This result was the best dE in our STJ array detectors.

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