Fabrication of Microabsorber Array for X-ray Microcalorimeter by Sn Electrodeposition

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X-ray microcalorimeter is a precision detector for the energy of X-ray photon by sensing the temperature rise of several mK caused by its incidence. An array of such microcalorimeters is a prospective candidate for the next generation spectroscopic imaging applications in X-ray astronomy. It is reported that high energy resolution up to 2.6 eV (at 1 keV) was achieved by using a transition edge sensor (TES) as a temperature sensor for the X-ray microcalorimeter [1-2], which uses transition edge of a superconducting thin film. On the other hand, absorber installed on top of the TES for the X-ray microcalorimeter requires high X-ray absorptivity and high speed of heating. At the same time, higher superconductivity transition temperature than that of TES (0.3 K) is required since specific heat capacity of superconducting material is lower than that of normal conducting material. From these view points, Sn was selected as a material for absorber for the X-ray microcalorimeter.

Figure 1 shows design of the absorber for X-ray microcalorimeter for the present work. For the absorber, thick and uniform Sn layer is required. In the present work, electrodeposition was applied to fabricate the Sn absorber. The array of the “mold” for the structure of the absorber was formed by photolithographic technique. Au/Cr layer was vacuum evaporated on the mold to form a conductive seed layer. Then Sn was electrodeposited up to some 20 μm thick whose surface was polished down to the designed thickness to form separate elements of the array. The photoresist was removed by O_2 plasma ashing. Superconductivity transition temperature of the deposition film was measured using a cryostat. Structure of the fabricated absorber array was observed by a scanning electron microscope (SEM).

First, deposition condition of Sn was optimized. Initially, the bath including only $SnSO_4$ and H_2SO_4 was used, however, the deposited film was dendritic. Therefore cresol sulfonic acid and polyethyleneglycol (PEG, the polymerization degree is 10000) were applied to the bath, which resulted in flat and smooth film. The deposition rate was 43 μm/hour at the current density of 15 mA/cm^2. The superconductivity transition temperature of the deposition film was estimated to be 3.8K, indicating the suitability of the Sn film in the present work for the use of the absorber.

Next, the Sn electrodeposition was applied to the fabrication of the absorber array.

Figure 2 shows SEM image of the floating region of the fabricated absorber. It was confirmed that the absorber array was fabricated without deposit defect and internal stress.

From these results, it is clarified that Sn electrodeposition is effective in fabrication of the functional microstructures such as the absorber of X-ray microcalorimeter.

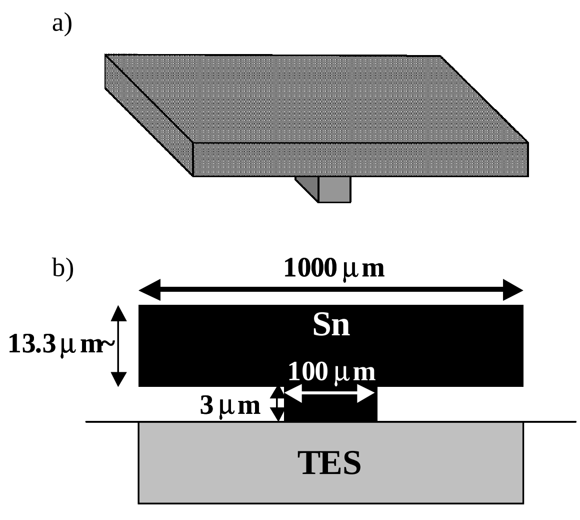

Fig. 1 Design of the absorber for X-ray microcalorimeter; a) 3-dimensional view, b) cross sectional view.

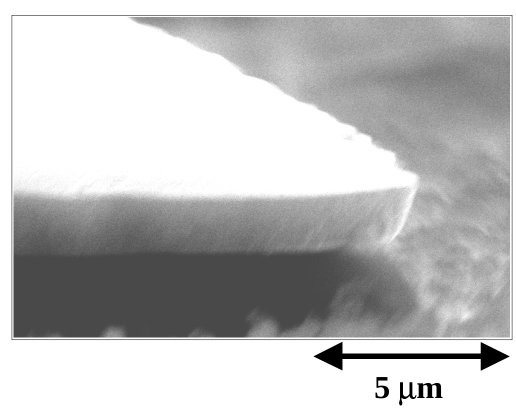

Fig.2 SEM image of the floating portion of the absorber of X-ray microcalorimeter.

[1] H. Kudo et.al. *SPIE Design, Characterization, and Packaging for MEMS and microelectronics*, **3893** 241 (1999)
[2] H. Kudo et.al. *SPIE Microelectronics and Assembly, Micromachining and Microfabrication,* **4230** 58 (2000)