Design and performance of a TES X-ray microcalorimeter array for energy dispersive spectroscopy on scanning transmission electron microscope

Main author:

MURAMATSU Haruka

Co-authors:

Hara Toru, NIMS

Hayashi Tasuku, Japan Aerospace Exploration Agency

Maehata Kyousuke, Kyusyu Uni.

Mitsuda Kazuhisa, Japan Aerospace Exploration Agency

MURAMATSU Haruka, ISAS/JAXA

Nagayoshi Kenichiro, Japan Aerospace Exploration Agency

Sakai Kazuhiro, Japan Aerospace Exploration Agency

Yamasaki Noriko, Japan Aerospace Exploration Agency

We present the design and performance of a superconducting TES X-ray microcalorimeter array optimized for high-energy resolution Energy dispersive X-ray spectroscopy (EDS) on an Scanning Transmission electron microscope (STEM) (Maehata et al. in this workshop).

EDS performed with STEM now play an important role for compositional analysis in various fields such as material science and biotechnology. Presently, Si solid-state detectors are commonly used for EDS. However the energy resolution (typically ~130 eV at 6 keV) is often inadequate in order to resolve emission lines with small energy separations and thus prevents to accurately determine the line intensities. In order to improve the energy resolution, we have been developing a detector system utilizing TES microcalorimeters (Hara et al. 2010). TES can cover a wide energy band (e.g. >10 keV) with a high energy resolution (~2 eV) that is the reason we use it. On the other hand, it is difficult to cover a wide energy band with wavelength dispersive spectrometers.

The STEM-EDS system makes it possible to map the distribution of those elements on a sample. Requirements for STEM-EDS system are a high counting rate (>5 kcps), wide energy band (0.5-15 keV) and good energy resolution (FWHM < 10 eV). In order to accommodate the high counting rate, we adopted an 8x8 format, 64-pixel array on which X-rays from STEM will be approximately uniformly distributed by an focusing capillary optics (Takano et al. in this workshop) with enough efficiency. Transition temperatures of our previous TES's are all around 100 mK. However, we further selected 200 mK to obtain a fast response and to accommodate the high counting rate requirement. The energy resolution may not be best because of a relatively high transition temperature of 200 mK but can satisfy 10 eV. Actually, the decay time is around 50 micro second, this is faster than a typically TES decay time (~100 micro second). The X-ray absorber is 2.5 micron thickness gold so that the detection efficiency at 10 keV is 40% and it expands energy band to 14 keV. The FWHM energy resolution of one pixel is 7.8 eV at Mn k alpha (5.9 keV) with a single pixel read out system and 9.5 eV with a two pixels read out system. We did all design and fabrication of the device in house. With the device we have fabricated most recently, we have confirmed that all 64 pixels are intact. We measured the superconducting transition temperature of 7 pixels and found that it is almost uniform at about 200 mK. Thus we consider that the device meets all requirements although we need wait full read out test to confirm them experimentally.