Superconductor X-ray detectors for synchrotron radiation facilities: two directions of a-few-eV energy resolution and sub-micron spatial resolution

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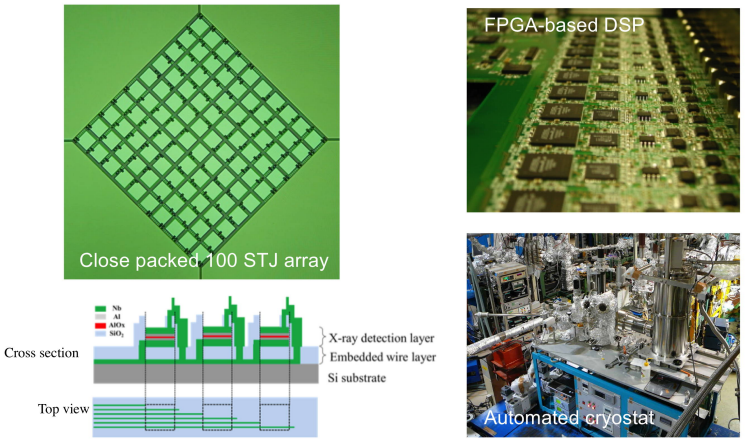
Superconductivity brings extremely high performance in X-ray energy-dispersive spectroscopy (EDS). Several types of superconductor X-ray energy dispersive detectors have been reported in last 20 years. Pros and cons of these detector types should be considered to find out proper usage. We are focusing on a soft X-ray region less than 2 keV, in which energy resolution of conventional semiconductor detectors is insufficient. Our choice is the superconductor tunnel junction (STJ) type for fluorescence-yield X-ray absorption fine structure (XAFS) for trace light elements in solids: for example, N dopant in SiC, Mg dopant in GaN compound semiconductors, B and N in heat resistant alloys for power stations and aircrafts. These samples cannot be measured with conventional beamline instrumentation, and the device and material developers came to us. STJ array detectors have a few eV energy resolution, which is better than natural line widths of fluorescent X-rays of atoms in solids and a high counting rate of 200 kcps. The STJ EDS system includes a fully automated 0.3-K cryostat and an FPGA-based real-time signal processing unit unlike other superconductor detectors that require off-line data processing before constructing pulse height spectra. The 100-STJ-pixel system is in routine use, and a 512-pixel system is under development.

Recent new direction of superconductor detectors is high spatial resolution for soft X-ray Resonant Inelastic X-ray Scattering (RIXS) spectrometers. Conventional CCD imagers have a physical spatial resolution of over 10 μm, which limits the energy resolution of RIXS. On the other hand, the spatial resolution of Superconductor Strip (SS) type is determined simply by the width of nano-strip. Proper device design enables the spatial resolution of a few 100 nm with a significantly high detection efficiency. The cooperation project with AIST and NSRRC will be initiated soon.

Superconducting detectors may contribute to the SR users by enabling high energy resolution, high counting rate, and high spatial resolution.



STJ array EDS system for fluorescence-yield X-ray absorption fine structure (XAFS) with an energy resolution of 4 eV and a counting rate of 200 kcps.