Design of Superconducting Microcalorimeter for Sensitive X-ray Detectors

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We are developing a low-noise x-ray detector using a superconducting microcalorimeter. As the x-ray photons are absorbed by the microcalorimeter, the temperature of the microcalorimeter increases in proportion to the photon energy. By measuring this temperature rise, we can measure the photon energy. The microcalorimeter consists basically of a superconducting transition-edge sensor (TES) and SQUID. Because of the steep transition characteristics of the TES near its transition temperature, and the high sensitivity of the SQUID, superconducting microcalorimeters provide high energy resolution. The TES is made of Mo/Cu bilayer with the transition temperature of about 0.1 K. By varying the thicknesses of Mo and Cu films, we can tune the critical temperature of the bilayer. To reduce the heat capacity of the microcalorimeter, the TES is deposited on a thin membrane, fabricated using a micromaching process. In a voltage bias mode, the temperature increase is converted into current change, which is detected by SQUID. Since the current pulses are very small and short, we need a low-noise and wide-bandwidth SQUID current amplifier system. As the SQUID, we used the double relaxation oscillation SQUID, which has large flux-to-voltage transfer and large modulation voltage, compared with DC SQUID. Since the energy resolution of the microcalorimeter improves by lowering the operating temperature, the TES is cooled using an adiabatic demagnetization refrigerator. Design of the microcalorimeter system and technical elements will be represneted.

keywords : microcalorimeter, x-ray detector, superconducting bilayer, SQUID