Development of Superconducting Low Pass Filter for Ultra Low Noise Measurement System of Microwave Kinetic Inductance Detector

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Microwave Kinetic Inductance Detector (MKID) is a cooper pair breaking superconducting detector [1]. MKID consists of a superconducting resonance circuit which resonance frequency is typically designed around 2-8 GHz where a HEMT low noise amplifier can be used for readout. MKID is a promising technology for multiplexing, which can contribute to produce high-sensitive large-scale camera array for radio astronomy.

We developed MKID camera for astronomical observations such as CMB B-mode search or Antarctica telescope. MKID performances were measured with 100 mK dilution refrigerator and the best Noise Equivalent Power (NEP) we got was 6e-18 W/sqrt(Hz) [2]. However, this is slightly low-performance compared to the world best NEP of MKID [3]. The sensitivity is probably limited by our measurement system. In particular, the system is weak against stray light (or thermal radiation) coming through signal cables from higher temperature stages of the refrigerator, as we have not installed any low pass filter before the 100 mK stage. The thermal radiation coming through signal cables might generate excess quasi-particles on MKID causing the reduction of the sensitivity.

In order to suppress such stray light, wide-band low pass filter is required and should be placed right before the MKID device (i.e. on 100 mK stage). We developed superconducting low pass filter which can suppress microwave in 10-100 GHz band down to more than 30 dB, while the insertion loss in 1-10 GHz range is smaller than 1 dB. It consists of various sizes of microstrip stub filters. The material of these filters is niobium (Nb) on silicon (Si) substrate and chassis, made of gold plated copper, acts as the ground plane of the microstrip structure. The design of stub filters and chassis has been optimized using 3D electromagnetic simulator, HFSS.

We would like to present the design specifications and performance assessments of the developed superconducting low pass filter. The effect of the filter on the noise performance of MKID will be also discussed.

References

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