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Optical Performance of SIS Photon Detectors at Terahertz Frequencies

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Astronomy and astrophysics have been continuously seeking observing capabilities with higher angular resolution and better sensitivity. Fast photon detection would be one of the key technologies to advance the detector performance, which may improve the signal-to-noise ratio by resolving each photons, or may lead to photon statistics for high precision measurements in photon-counting mode. SIS junctions (or STJ) can be used as single terahertz photon detectors, which exhibit the post detection bandwidth in the order of GHz. Recently we have developed an SIS junction of Nb/Al/AlOx/Al/Nb, which exhibits leakage currents as low as 1 pA at a cryogenic temperature of T <0.7 K, where the NEP of 3×10^{-17} W/$\sqrt{\text{Hz}}$ can be realized.
Following the success, we have integrated the junction to an antenna coupled detector: The detector consists of a twin slot antenna, coplanar waveguide, and a choke filter. The first detector was fabricated using the CRAVITY facility at AIST, which exhibits the low leakage current of 1-2 pA at T <0.7 K. The initial photoresponse of the detector was evaluated with a blackbody source, and its frequency response was measured with a Fourier transform spectrometer. The experiments are showing encouraging results towards the photon counting capability. We are planning to cool the detector with a ^{4}He single stage sorption fridge, which can realize a high cooling power of 400 μW. This will enable us to mount the first stage readout electronics adjacent to the SIS to realize high sensitivity, however the cryogenic temperature may be limited to 0.8-1 K. We are modifying the SIS junction design to extend its low leakage feature for this operating temperature.
Smaller junctions with higher critical current densities are also considered for future space-borne applications, to receive supra-THz photons with wider bandwidth. Current achievements and future prospects of SIS photon detectors will be discussed in the presentation.

Less than 5 years of experience since completion of Ph.D

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