SIS Detectors for Terahertz Photon Counting System

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We are developing an SIS photon counting detector, which is to operate SIS (or STJ; Superconductive Tunnel Junction) in a photon counting mode. Our major application is to integrate this into an intensity interferometer system at Terahertz wavelength (300 GHz - 10 THz). The system aims to realize a high sensitivity, high angular resolution imaging for spaceborne astronomical observations, which enables us to explore various objects including exo-planets or black holes.
Direct detectors are superior to heterodyne systems in terms of sensitivity, being free from quantum limits as well as its capability for wide bandwidth. In fact, the advantage of intensity interferometer over conventional interferometers is that direct detectors can be utilized instead of heterodyne technology. Typical photon rate from bright astronomical objects is expected to be in the range of 1-100 M photons/sec in Terahertz frequency. Numbers of application are realized with TES or KIDs detectors, however these are too slow to deal with the fast photon rate. We consider the SIS photon counting detector to be a candidate for our purpose.
Several developments are needed towards realizing SIS photon counting detector, including fast SIS detector itself to match Terahertz waves, and, fast and low noise readout electronics to be operated at cryogenic temperature.
Recently a SIS junction (or STJ) with a current density of 200 A/cm^2 and leakage current density of 10 nA has been realized with junction size of 100 um x 100 um (Ukibe et al. 2012, JJAP 51, 010115). Based on this achievement, we are aiming for a smaller junction in order to reduce its effective capacitance, considering the coupling with our target RF frequency.

Requirements for the readout circuit include low noise, low power, high impedance, and low gate capacitance at a cryogenic temperature within 0.3 K-1 K. We are considering to utilize GaAs JFET or JPHEMT, followed by a SiGe low noise cryogenic amplifier. Based on our recent development (Hibi et al. 2013, IEEE Trans. THz Sci. Tech. 3, 422), we are aiming to realize a fast readout of 1 GHz at cryogenic temperature.
Technical requirements, performance of the junction, design of the readout circuit, as well as the schematics of the future intensity interferometer system, will be discussed in the presentation.