Power Load Dependencies of Cold Electron Bolometer Optical Response at 350 GHz

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Cold electron bolometers integrated with twin-slot antennas have been designed and fabricated. Optical response was measured in 0.06-0.6 K temperature range using black body radiation source at temperature 2-15 K. The responsivity of $0.3*10^9$ V/W was measured at 2.7 K radiation temperature that is close to cosmic microwave background radiation level. Ratio of radiated and absorbed power corresponds to microwave matching efficiency up to 0.6 for low phonon temperature and low signal level. Estimations for bolometer responsivity were made for practical range of operation temperature and blackbody radiation temperature. For obtaining NEP=$2*10^{-18}$ W/Hz$^{1/2}$, that is required for many space-borne projects, the phonon temperature should be below 0.1 K, the background radiation temperature below 1.6 K, and signal power below 1 fW at 350 GHz. The estimated ultimate dark responsivity at 100 mK can approach $S_v=10^{10}$ V/W and reduces down to $1.1*10^8$ V/W at 300 mK for the sample with absorber volume of $5*10^{-20}$ m^3.

At high power load levels and low temperatures the changes of tunneling current, dynamic resistance and voltage response have been explained by non-thermal energy distribution of excited electrons. Voltage response is rather broad and can be attributed to two mechanisms of detection: first around a half-gap bias is bolometric response, and the second at lower bias due to direct detection at high nonlinearity of SIN junction at temperatures below 100 mK. Distribution of excited electrons in such system is of none-Fermi type, electrons with energies of the order of 1 K tunnel from normal metal absorber to superconductor instead of relaxing down to thermal energy kT_e. This effect can reduce quantum efficiency of bolometer from hf/kT_{ph} in ideal case down to hf/kT_{excit} in the high power case. For phonon temperature of 100 mK in the low power limit and our frequency of 350 GHz the maximum expected quantum efficiency can be over 100 and reduce below 1 in the high power case when effective temperature of excited electrons increase. Such mechanism of suppression of response can enhance saturation power of SINIS bolometers.