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Proposal and Fabrication of Hot Electron Bolometer Mixer using a Magnetic Thin Film

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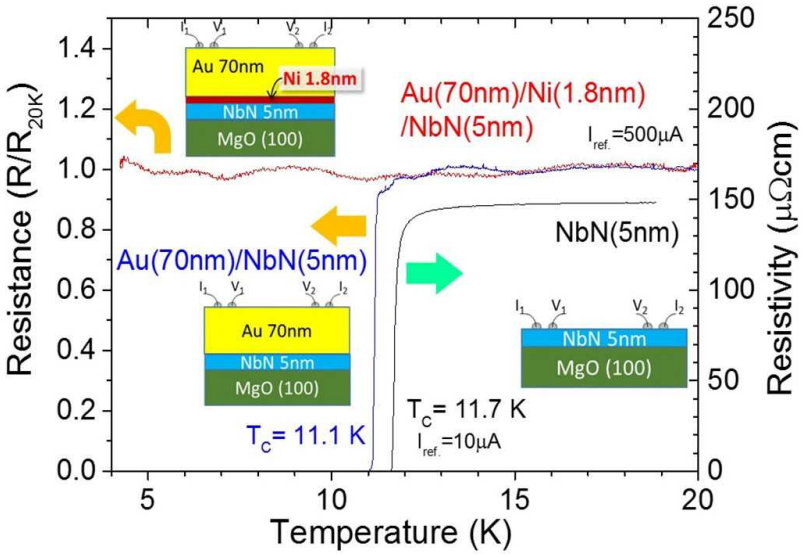
Hot-electron bolometer mixers (HEBMs) are expected to replace SIS mixers as extremely low-noise mixer in applications beyond 1.5 THz. However, the IF bandwidth of an HEBM remains limited to typically 3–5 GHz and it is not sufficient when compared to that of an SIS mixer. Therefore, we proposed a new HEBM structure (Ni-HEBM) using a nickel (Ni) magnetic thin film [1]. Ni-HEBM aims to expand IF bandwidth and improve sensitivity by miniaturizing HEBM which was realized by the controlling the superconducting region with Ni thin film.

HEBM structure comprises with a thin superconducting strip placed between two metal electrodes, and it uses a sudden impedance change in the superconducting transition of the strip. To ensure a good electrical contact, the strip and both electrodes are usually connected via an overlap region on the strip. However, usually superconductivity remained in the region and it has been prevented the miniaturization of conventional HEBM. We found that it is possible to suppress the superconductivity of the niobium nitride (NbN) thin film by the addition of a Ni thin film. Figure shows the temperature dependence of the resistance of the Au (70 nm)/ Ni (1.8 nm)/ NbN (5 nm) trilayer for forming the overlap region of the Ni-HEBM electrodes. For comparison, another bilayer of Au (70 nm)/NbN (5 nm) was prepared (without Ni), which is the structure used for electrodes in a conventional HEBM. The Au/Ni/NbN trilayer film did not show superconductivity until 4.2 K. However, the Au/NbN bilayer film showed superconductivity at 11.1 K.

We fabricated Ni-HEBM with a NbN strip of 0.1 μm-length, and the IF bandwidth was evaluated at 1.9 THz. We confirmed that the IF bandwidth expands, and it was evaluated about 6.9 GHz at 4 K. The uncorrected receiver noise temperature of same Ni-HEBM was also evaluated at 4 K, and it was about 1220 K(DSB) at 2 THz.

Figure. Suppression of the NbN superconductivity under the HEBM metal electrode due to the insertion of the Ni thin film.



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