Characterization of MgB$_2$ Superconducting Hot Electron Bolometers

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Abstract — Hot-Electron Bolometer (HEB) mixers have proven to be the best tool for high-resolution spectroscopy at the Terahertz frequencies. However, the current state of the art NbN mixers suffer from a small intermediate frequency (IF) bandwidth as well as a low operating temperature. MgB$_2$ is a promising material for HEB mixer technology in view of its high critical temperature and fast thermal relaxation allowing for a large IF bandwidth. In this work, we have fabricated and characterized thin-film (~ 15 nm) MgB$_2$-based spiral antenna-coupled HEB mixers on SiC substrate. We achieved the IF bandwidth greater than 8 GHz at 25 K and the device noise temperature < 4000 K at 9 K using a 600 GHz source. Using temperature dependencies of the radiation power dissipated in the device we have identified the optical loss in the integrated microantenna responsible as a cause of the limited sensitivity of the current mixer devices. From the analysis of the current-voltage (IV) characteristics, we have derived the effective thermal conductance of the mixer device and estimated the required local oscillator power in an optimized device to be ~ 1 µW.

Keywords (Index Terms) — Hot Electron Bolometers, MgB$_2$, Superconducting Devices, Terahertz Mixers