Systematic Study of IF Bandwidth in HTS Hot-Electron Bolometer Mixers

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The hot-electron bolometer (HEB) mixer made from a high-T_C superconductor (HTS) thin film was introduced recently as an alternative to a Schottky mixer at THz frequencies. The mixer performance depends on the total thermal conductance for heat removal from the phonon subsystem due to either phonon escape to the substrate or phonon diffusion to the normal metal electrodes. We present a systematic study of the length, thickness, temperature, and local oscillator (LO) frequency dependencies of the thermal relaxation times, as inferred from the -3dB intermediate frequency (IF) bandwidth of HTS HEB mixers on MgO and CeO_2/sapphire substrates.

While a significant length dependence was not found, the bandwidth of a 30 nm thick device at 65 K increased from about 100 MHz to 420 MHz as the device thickness was reduced to 10 nm in accordance with the two-temperature (2T) model.

As reported earlier, at temperatures close to T_C the IF bandwidths increased to unexpected high values of about 2-3 GHz, and as discovered recently, the IF bandwidth also strongly depends on the bias voltage in this regime. However, these effects gradually vanish as the LO frequency was increased from 1 GHz to 100 GHz, 300 GHz and 480 GHz. At 480 GHz, pure 2T model behavior was observed. We attribute these frequency-dependent effects to the dynamics of vortices in the microbridge. The impact of the device geometry and the use of buffer layers for the optimization of the total thermal conductance will be discussed.