MgB_2 THz HEB mixer operation from 5K till 20K

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Abstract—It has been already demonstrated that MgB_2 hot-electron bolometer (HEB) mixers can provide simultaneously both low noise sensitivity and wide bandwidth operation (see also "MgB_2 HEB mixer with an 11GHz bandwidth" on this conference). However, a receiver noise of MgB_2 HEB mixers increases if a bath temperature is raised, especially above ½ of a device critical temperature (T_c). In order to study the origin of such behavior HEB mixers should be characterized at various conditions (bath temperatures, local oscillator (LO) frequencies, LO powers, biasing) and intrinsic mixer parameter should be extracted.

Here we present the detailed study of one of the devices which has demonstrated good receiver performance. Studied device was fabricated from a 5-7nm thick MgB_2 film deposited with a custom in-house built Hybrid Physical Chemical Vapor Deposition (HPCVD) system. The HEB size is $1x1\mu m^2$ and has a T_c of 30K. A room temperature resistance R_{295} is 230Ohm, and a critical current I_c is 1mA at 4.2K. Device has been tested with two LOs (0.7THz and 1.6THz) using Y-factor and U-factor techniques and has demonstrated high sensitivity (about 1000K at 5K bath temperature and wide noise bandwidth (11GHz) at both frequencies. The HEB mixers was also characterized at 15K and 20K bath temperatures and showed that the increase of the noise temperature corresponds to the reduction of the mixer conversion gain, while the output mixer noise stays constant (210K). The HEB noise performance was studied at various bias points on the IV-plane at 0.7THz and 1.6THz. The bias point region providing the minimum receiver noise is wide (5-10mV and 0.2-0.4mA). The noise characterization was supplemented by independent heterodyne mixing measurements at 0.7THz in order to define mixer gain bandwidth (GBW) and study mixer gain behavior. The GBW is appeared to be at least 8GHz.

Since the MgB_2 HEB mixers has both a higher conversion gain (-9.5dB at 5K) and output noise temperature compare to a typical NbN HEB mixer (-12dB, 60K) the intermediate frequency (IF) chain is less critical and increase of the IF chain noise should result in a smaller increase of the receiver noise temperature. The device was also tested with a room temperature readout which led to increase of receiver noise temperature by about factor of 2 while the noise bandwidth was kept the same.