Terahertz MgB_2 HEB mixers with a 13GHz gain bandwidth

Narendra Acharya, Evgenii Novoselov and Sergey Cherednichenko

Broad intermediate frequency (IF) bandwidth is a crucial feature for heterodyne receivers utilized in terahertz astronomy [1]. Whereas below 1.2 THz superconductor-insulator- superconductor (SIS) mixers have demonstrated an IF bandwidth in excess of 20GHz , at frequencies > 1.2THz superconducting hot-electron bolometer (HEB) mixers have not come to such level of performance yet.

We believe that utilizing MgB_2 ultra-thin [2] films the IF bandwidth for HEB mixers can be extended way above 20 GHz, hence satisfying the most demanding astronomical tasks. The key for a large IF bandwidth in HEB mixers is fast electron- phonon interaction and short phonon escape time from the superconducting film into the substrate. Recently we have shown that MgB_2 films as thin as 5nm can be made on SiC substrates, with a critical temperature of 30K. The minimum receiver noise temperature has been shown to be at 1000K (1.6THz) [3]. However, though the demonstrated IF bandwidth was 11GHz, we had some reasons to believe that this is far to be the limit.

By performing mixing experiments in a broadband cryogenic probe station we have been able to show that the gain bandwidth (3dB gain roll-off) in our MgB_2 HEB mixers is 13-14GHz, whereas the mixer noise temperature was nearly constant up to an intermediate frequency of 20GHz (Fig.1). These experiments were conducted at a rather low LO frequency of 100GHz, yet results have clearly shown that the full potential of MgB_2 HEB mixers is far not reached.

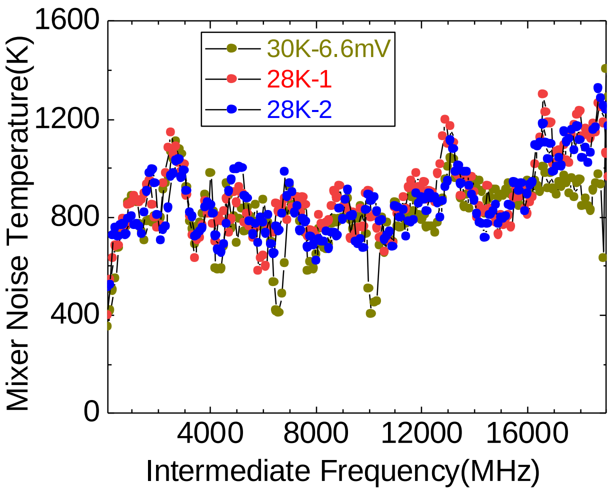

Fig. 1. The MgB_2 HEB mixer noise temperature spectrum.

In order to justify applicability of low LO frequency experiments for modeling the high LO frequency ν ($h\nu$>2Δ, where Δ is the superconducting energy gap) we designed a set of experiments where MgB_2 HEB mixer performance (gain, noise, IF bandwidth) is studies vs LO frequency and operation temperature (which affects the superconducting energy gap Δ). Δ can be obtained from the measured kinetic inductance (from 5K and up to the critical temperature T_c).

References

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[1] All authors work at the Department of Microtechnology and Nanoscience, Chalmers University of Technology, Fysikgrand 3, Gothenburg, Sweden, (e-mail: serguei@chalmers.se) (*Corresponding author Sergey Cherednichenko*).

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