Prospects with low noise and wide bandwidth MgB_2 HEB THz mixers

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Abstract—Research in low noise terahertz (THz) mixers is motivated by great interest from astronomical community. As THz wave sensors in heterodyne receiver, such mixers would allow for detection of faint emission of molecular and atomic lines of multiple species in interstellar medium, stars, comets, planetary atmospheres, etc. A frequency of 1THz has become so to say a border line between technologies. Below 1THz, either SIS mixers (close to quantum limit noise, wide IF bandwidth, 2-4K operation) or Schottky mixers (yet low noise, operation up to room temperature) are of prime interest for astronomical applications. Above 1THz, noise in both SIS and Schottky mixers increases rather significantly. On contrary, superconducting hot-electron bolometer (HEB) mixers show a low THz frequency variation of noise, which becomes much lower than for any other mixer technologies. Examples of successful HEB mixer applications are NbN HEB devices in Herschel Space Observatory, SOFIA, APEX, SAO Receiver Lab instruments, etc. Despite the progress, a major limitation for HEB mixers was a limited IF bandwidth (3-5GHz). This limitation originates from electron energy cooling rate. The key material properties for HEB mixers are: fast inelastic electron-phonon scattering, critical temperature at least above 7K, ability to deposit very thin films (<10nm).

Ten years ago, MgB_2 HEB mixers emerged with a promise of much wider IF bandwidth. Since then, both MBE and HPCDV deposition technologies for MgB_2 films have been explored. HPCVD allows for reliable deposition of films as thin as 5-8nm, with a Tc>28K. Such films have been obtained either by thinning down thicker films, or by direct deposition at a low deposition rate (our group). Using our in-house film and HEB fabrication processes we have obtained an unprecedented for HEBs 11GHz noise bandwidth and a noise temperature of 930K at 1.63THz LO frequency.

In this presentation we will discuss our studies MgB_2 HEB mixers of various thicknesses at different LO frequencies (from 700GHz to 4.7THz), and at temperatures from 4K to 30K. With a 5nm film, we obtain a 13GHz noise bandwidth. Optimizing HEBs for high temperature operation, we achieve low noise performance up to 30K operation. A concept of a compact (portable) cooling system for MgB_2 HEB mixers will also be presented. Finally, we will discuss our view on prospects of MgB_2 HEB mixers for astronomy and other application.