MgB_2 Hot Electron Bolometers for Array Receivers

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Abstract—MgB_2 Hot Electron Bolometers (HEBs) offer a larger IF bandwidth and higher operating temperature than NbN HEBs. Recent results from JPL and Chalmers University have shown IF bandwidths from 7-11 GHz and operation at 15-20 K without significant changes in sensitivity, which is currently within a factor of 3 compared with reports on NbN HEB mixers. Scientifically, the large bandwidth is more significant for high-resolution line spectroscopy across the galaxy as high frequencies (> 3 THz) where the radial velocity spread up to 600 km/s leads to a large Doppler broadening. The higher operating temperature of the mixer should allow for cryogen-free heterodyne instruments which will enable long duration space telescopes for high-resolution THz heterodyne spectroscopy in the future. The required local oscillator (LO) power is necessarily higher than that for the state-of-the-art NbN devices. This can be offset by making the MgB_2 device area of the order of 10^{-2} μm^2 while still maintaining the large enough normal resistance required for the impedance match with a micro-antenna. Operating at higher temperature will also reduce the LO power requirements. In our recent experiments, we operated some mixer devices using an LO power < 1 μW, with a noise temperature ≈ 2000 K from 0.6 THz to 4.3 THz. With more work on the material optimization, the sensitivity of the MgB_2 mixers is expected to improve.

A challenge for implementation of these MgB_2 devices in the future instruments is to develop a suitable array architecture in order to simplify LO distribution for multi-pixel instruments. The scientific community pushes for a 100+ pixel heterodyne receiver for efficient mapping of the sky. Here quasi-optical mixers become bulky and the small packaging enabled by a waveguide architecture is necessary.

In this work, we take the first step towards waveguide coupled MgB_2 HEBs by moving to devices fabricated on Si substrates. In the past, this was not possible because of the high pressure, high temperature process used to synthesize the high quality MgB_2 thin films, but recent advances by the group at Temple University have enabled deposition on high resistivity Si substrates. These films were used to fabricate antenna-coupled HEBs to show the devices still have the same performance as the devices made previously on SiC and Sapphire substrates. We will present the results from these devices and our plan to move forward towards waveguide-coupled devices made on SOI substrates.