Sensitivity and IF bandwidth of waveguide NbN phonon-cooled HEB mixers based on crystalline quartz substrate with MgO buffer layer

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Receivers with large IF gain bandwidth are very important for spectral line radio astronomy, especially for the observation of distant galaxies where spectral line widths are large. Since the available local oscillator (LO) power from solid state sources is limited at terahertz frequencies, it is desirable to couple signal and LO power using Martin-Puplett interferometer, hence it is desirable to operate at relatively high IF frequency to keep the usable IF bandwidth sufficiently wide.

Traditional waveguide-based THz mixers employ quartz as the substrate of choice due primarily to its low dielectric constant, and ease of processing and handling. However, phonon-cooled NbN HEB mixers, made from film deposited directly on crystalline quartz, exhibit a limited IF bandwidth of about 2 GHz. In comparison, planar antenna mixers typically employ Si, sapphire, or MgO as the substrate material, and the NbN film has a higher critical temperature (T_c) and better acoustic transparency. This results in a considerable broadening of the IF bandwidth for planar antenna HEB mixers employing a 3-4 nm thick NbN film, up to 5 GHz. The IF bandwidth of waveguide-based HEB mixers may be increased by including a buffer layer, deposited on the quartz substrate, to improve the acoustic match between the film and substrate. A number of NbN films have been deposited on crystalline quartz on top of a 200 nm thick MgO buffer layer. Devices made from these films exhibit a T_c of about 8 K and a transition width of about 0.8 K.

We will present receiver noise temperature measurements in the THz frequency range for phonon-cooled NbN HEB mixers made on crystalline quartz substrates incorporating a 200 nm MgO buffer layer. Measurements of the IF bandwidth of these mixers will also be presented.