MgB_2 Hot Electron Bolometers Operating Above 20 K

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Terahertz high-resolution spectroscopy of interstellar molecular clouds greatly relies on hot-electron superconducting bolometric (HEB) mixers. Current state-of-the-art receivers use mixer devices made from ultrathin (~ 3-5 nm) films of NbN with critical temperature ~ 9-11 K. Such mixers have been deployed on a number of ground based, suborbital, and orbital platform including the HIFI instrument on the Hershel Space Observatory. Despite its good sensitivity and well-established fabrication process, the NbN HEB mixer suffers from the narrow intermediate frequency (IF) bandwidth ~ 2-3 GHz and is requires operation at near-liquid helium temperature. As the heterodyne receivers are now trending towards “high THz” frequencies, the need for a larger IF bandwidth becomes more pressing since the same velocity span at 5 THz becomes 5-times greater than at 1 THz.

Our work is focusing on the realization of HEB mixers using ultrathin (8-20 nm) MgB_2 films. They are prepared using a Hybrid Physical-Chemical Vapor Deposition (HPCVD) process yielding ultrathin films with critical temperature ~ 38 K. This is a major advantage over previous experiments [1] of HEB devices using this material. The expectation is that the combination of small thickness, high acoustic phonon transparency at the interface with the substrate, and very short electron-phonon relaxation time may lead to IF bandwidth ~ 10 GHz or even higher. Currently films are passivated using a thin MgO layer which is deposited ex-situ via sputtering. Micron-sized spiral antenna-coupled HEB mixers have been fabricated using MgB_2 films as thin as 10 nm. Fabrication was done using UV lithography and Ar Ion milling, with E-beam evaporated Au films deposited for the antenna. Measurements have been carried out on these devices in the DC, Microwave, and THz regimes.

The devices are capable of mixing signals above 30 K indicating that operation may be possible using a cryogen-free cooling system which may be the greatest impact of these devices on the future THz heterodyne receivers for space. We will report the results of the measurements taken to indicate the local oscillator power requirements, the IF bandwidth, IF impedance, and noise temperature of these devices. We will also discuss the procedures necessary to mature this technology to the point of practical field receiver as well as discuss trade-offs and advantages associated with this novel material for HEB mixers.

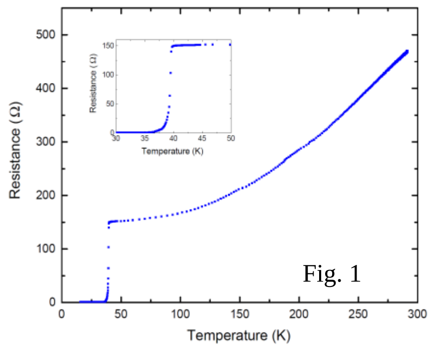

Fig. 1

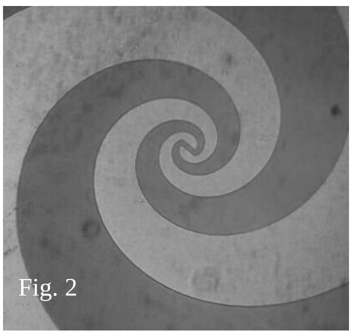

Fig. 2

REFERENCES

1. S. Bevilacqua et al., “Study of IF Bandwidth of MgB_2 Phonon-Cooled Hot-Electron Bolometer Mixers,” *IEEE Trans. THz Sci. Technol.* 3, pp. 409-415, July 2013.