Gain bandwidth and noise temperature of NbN HEB mixers with simultaneous phonon and diffusion cooling

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Abstract

The space observatory Millimetron will be operating in the millimeter, sub-millimeter and infrared ranges using a 12-m cryogenic telescope in a single-dish mode, and as an interferometer with the space-earth and space-space baselines (the latter after the launch of the second identical space telescope). The observatory will allow performing astronomical observations with an unprecedented sensitivity (down to nJy level) in the single-dish mode, and observations with a high angular resolution in the interferometer mode. The total spectral range 20 μm – 2 cm is separated into 10 bands. HEB mixers with two cooling channels (diffusion and phonon) have been chosen to be the detectors of choice of the system covering the range from 1 THz to 6 THz as the best detectors in terahertz receivers.

This type of HEB has already shown good work in the terahertz range. A gain bandwidth of 6 GHz at an LO frequency of 300 GHz and a noise temperature of 750 K at an LO frequency of 2.5 THz are the best values for HEB mixers with two cooling channels [1]. Theoretical estimations predict a bandwidth up to 12 GHz. Reaching such good result demands more systematic and thorough research.

We present the results of the gain bandwidth and noise temperature measurements for superconducting hot-electron bolometer mixers with two cooling channels. These characteristics of the devices of lengths varying from 50 to 200 nm were measured for the purposes of Millimetron at frequencies of 600 GHz, 2.5 THz, and 3.8 THz. For gain bandwidth measurements we use two BWO's operating at 600 GHz: one as the signal and the second as the LO. The noise temperature measurements were performed using a gas discharge laser as the LO and blackbodies at 77 K and 295 K as input signals.

The devices studied consist of 3.5-nm-thick NbN bridges connected to thick (10 nm) high conductivity Au leads fabricated *in situ*. This method of fabricating devices has already proved promising by opening the diffusion cooling channel. [2] Fig. 1 shows a SEM photograph of a log-spiral antenna with an HEB at its apex.

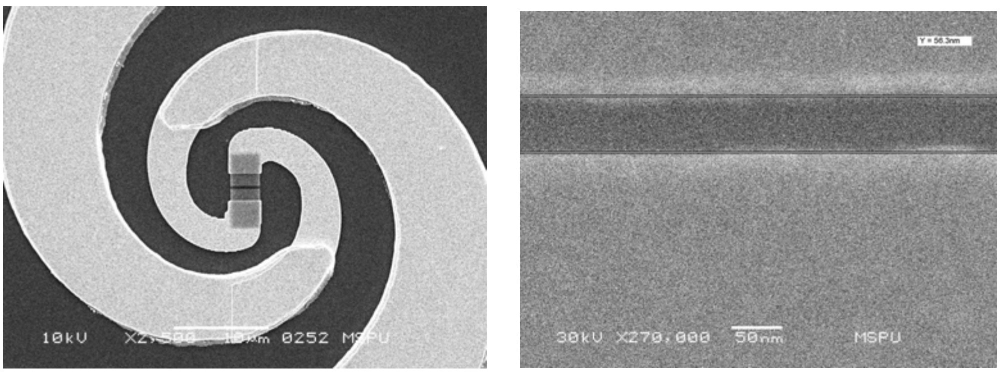

Fig. 1. Left: a SEM photograph of a log-spiral antenna with an HEB at its apex; right: a close-up of the HEB at the antenna apex.

[1] S. A. Ryabchun, I. V. Tretyakov, M. I. Finkel, S. N. Maslennikov, N. S. Kaurova, V. A. Seleznev, B. M. Voronov, and G. N. Gol'tsman, NbN phonon-cooled hot-electron bolometer mixer with additional diffusion cooling, Proc. of the 20th Int. Symp. Space. Technol., Charlottesville, Virginia, USA, April 20 – 22, 2009.

[2] S. A. Ryabchun*, I. V. Tretyakov, M. I. Finkel, S. N. Maslennikov, N. S. Kaurova, V. A. Seleznev, B. M. Voronov and G. N. Goltsman, Fabrication and characterisation of NbN HEB mixers with *in situ* gold contacts, Proc. of the 19th Int. Symp. Space. Technol., Groningen, The Netherlands, April 28-30, 2008