Wide bandwidth measurements of microwave and millimeter wave impedance in MgB_2 HEB mixers

Narendra Acharya, Usman Ul-Haq, Sergey Cherednichenko*

Terahertz and Millimetre Wave Laboratory, Department of Microtechnology and Nanoscience, Chalmers University of Technology, SE-412 96 Gothenburg, Sweden
*Contact: serguei@chalmers.se

Abstract—Superconducting Hot electron Bolometer (HEB) mixers are used in many terahertz astronomical receivers. At frequencies above 1THz, HEB mixers have noise temperature lower than any other mixers working at that range. There have been some studies conducted to investigate THz performance for HEB mixers made of both NbN and MgB_2 thin films. However, experimental data for HEB mixer characteristics at microwave (intermediate frequency) frequencies are very scarce and noisy. There are no accurate and systematic IF impedance data. The problem is explained by difficulty of system calibration at cryogenic environment, and device fixture de-embedding. From theoretical models and some experiments, it is expected that IF impedance varies strongly with IF, with a significant imaginary part. With the lack of such data, accurate HEB-to-LNA impedance matching is rarely conducted. As a consequence, electrical standing waves are observed, leading to ripples in the receiver gain and the system noise temperature.

In this work we studied IF impedance of MgB_2 HEB mixers from 20MHz to 67GHz in a continuous sweep, using an advanced cryogenic microwave/millimeter wave probing station and Vector Network Analyzer. HEB devices were fabricated from high quality 5-10nm MgB_2 thin films with many bridge dimensions, integrated with one-port CPW contacts. Device temperature was adjusted from 5K to 40K (normal state). On-wafer calibration kit was mounted next to HEB wafers, and allowed for accurate system calibration up to 67GHz using a 100μm Ground-Signal-Ground (GSG) probe. This way, impedance was measured directly, without any need for de-embedding, in a frequency range far exceeding any other previous studies.

HEB devices were set on different temperatures, and different bias voltages were applied. We clearly observe correlation of the measured impedance with dc characteristics of HEB devices. Using measured complex-S11 data, we analyze scenarios for HEB-LNA matching.