Development and Characterization of THz Planar Schottky Diode Mixers and Detectors

Jeffrey L. Hesler[1,2,*], Haiyong Xu[2], Alex Brissette[1], and William L. Bishop[1]
[1]Virginia Diodes Inc, Charlottesville, VA 22902, USA
[2]University of Virginia, Charlottesville, VA 22902, USA
* Contact: Hesler@virginiadiodes.com, phone +01-434-297-3257

***Abstract*— The characterization of a 1.1-1.7 THz planar Schottky-diode mixer is described. Initial measurements yielded a mixer noise temperature of 5900 K (DSB) and conversion loss of 12 dB (DSB) at 1.57 THz. The responsivity of the mixer was measured to be higher than 200-400 V/W over the frequency range 1.1-1.5 THz. Also, the same diode was used as a 2nd harmonic mixer as part of a solid-state 1.45-1.5 THz transceiver, with measured dynamic range of > 40-50 dB.**

I. Introduction

The Schottky diode has a long history of use for both heterodyne and direct detection of power at submm-wavelengths. Schottky diodes have the advantage that they can operate at ambient or cryogenic temperature, allow for long integration times, and also have an extremely fast response time compared with other detection technologies. This paper describes the development and characterization of planar Schottky diode mixers and detectors in the frequency band 1.1-1.7 THz.

II. Mixer Characterization

The mixer, pictured in Figure 1, consists of a waveguide housing with an integral smooth-walled diagonal feedhorn. These mixers are single-moded waveguide-based devices without any tuners. The basic mixer design is similar to that described in [1], and consists of a planar Schottky diode integrated onto a quartz substrate.

The initial characterization consisted of measurements of the voltage responsivity of the mixers. The mixers were biased to a constant current of 3 uA and the voltage video response to applied RF power was measured. The source was a solid-state 1.1-1.5 THz VDI multiplier chain with output power 0.5-2 uW typical. The power was calibrated using an Erickson PM4 calorimeter [2].

In order to speed up the initial characterization a simple quasi-optical setup was used, consisting of pointing the two horns at each other with a very small (~0.5 mm) distance between them. No lenses were used. In addition to the simple alignment, this setup minimizes the effect of water losses on the measurements. The two horns are smooth-walled diagonal feedhorns with directivity of approximately 22 dB. No corrections were made for the quasi-optical loss. The measured responsivity is shown in Figure 1. A standing wave is evident in the measured responsivity. Detailed measurements with a full quasi-optical setup are underway to determine the responsivity more accurately.

In addition to the responsivity measurements, the device was also characterized as a mixer. A CO2 pumped FIR cavity laser at 1.57 THz was used as the local oscillator, with available power about 3 mW. A Martin-Puplett diplexer was used to combine the RF and LO signals. The measured mixer performance was a noise temperature of 5900 K (DSB) and a conversion loss of 12 dB (DSB).

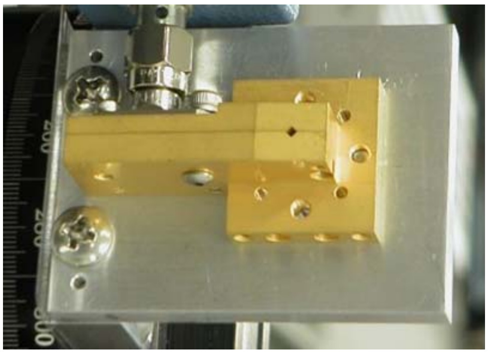

Fig. 10 Photograph of the WR-0.65FM 1.1-1.7 THz fundamental mixer

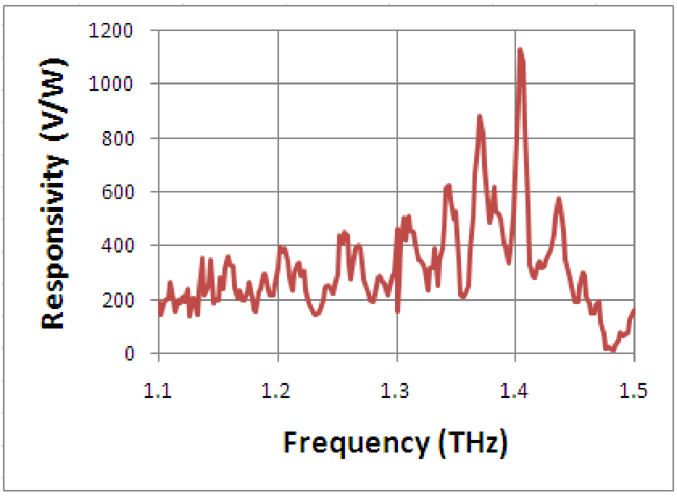

Fig. 2 Measured responsivity of the WR-0.65FM 1.1-1.7 THz fundamental mixer. Measured with 3 uA bias current, and horn-to-horn coupling without intervening lenses

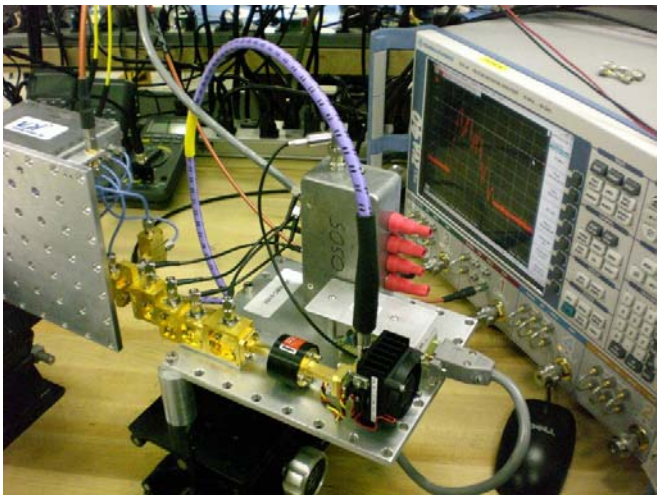

Fig. 3 Photograph of the 1.43-1.54 THz transmitter and receiver during testing. The transmitter has typical output power 5-20 uW over the band

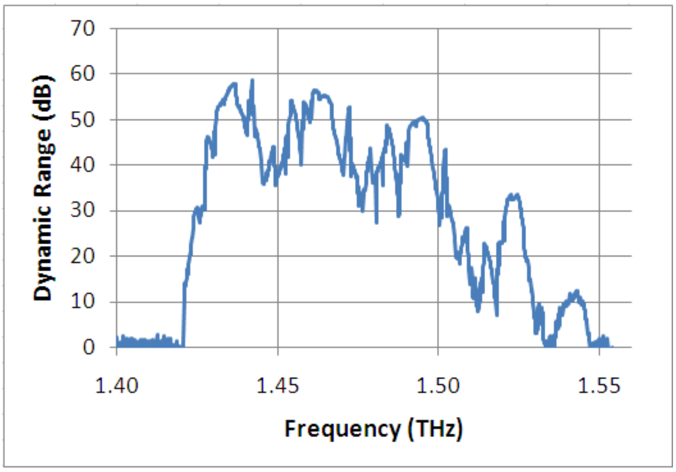

Fig. 4 Measured dynamic range of the THz transceiver with 100 Hz IF bandwidth. Measured with horn-to-horn coupling without intervening lenses.

III. THz Transceiver

THz planar Schottky-diodes from the same fabrication run were also used in a subharmonic mixer configuration to build a solid-state THz transceiver. The transmitter, pictured in Figure 3, consisted of an amplifier followed by a series of frequency multipliers, and had an output power of 5-20 uW over the frequency range from 1440-1540 GHz. The final tripler in the transmitter has an integral smooth-walled diagonal horn with nominal 22 dB directivity.

The receiver was a subharmonically pumped single-diode mixer. The local oscillator pump was provided by a solid-state amplifier multiplier chain with 0.2-0.6 mW over the frequency range from 710-760 GHz. The mixer was biased at 0.5 mA constant current through a bias tee. The transceiver was driven by dual synthesizers from a Rohde & Schwarz ZVA40 Vector Network Analyzer (which can be seen in Figure 3). The synthesizers were set to a fixed offset to provide a fixed IF over the band. The integral feedhorns of the transmitter and receiver were pointed at each other without intervening optics, and no corrections were made for quasi-optical loss. The measured dynamic range of the system is shown in Figure 4, and was measured to be about 40-50 dB over the frequency range.

Conclusions

A 1.1-1.7 THz planar Schottky-diode mixer with excellent sensitivity has been successfully developed. The mixer has a noise temperature of 5900 K (DSB) and a conversion loss of 12 dB (DSB) at 1.57 THz. Initial measurements of the responsivity of a Schottky mixer indicated a responsivity of better than 200-400 V/W over the range 1.1-1.5 THz. A solid-state transceiver was developed using this mixer in a second harmonic configuration, which exhibited 40-50 dB dynamic range over a bandwidth of 70 GHz. Further measurements are underway to test zero-bias detectors and sideband generators.

References

[1] J.L. Hesler et al, “Fixed-Tuned Submillimeter Wavelength Waveguide Mixers Using Planar Schottky-Barrier Diodes,” IEEE Trans. Microwave Theory Tech., vol. 45, pp. 653-658, May 1997.

[2] Erickson Instruments Ltd., www.ericksoninstruments.com.