

Quasi-Planar Schottky Diode Design

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Abstract

In the THz region up to now no planar mixer designs are available. In order to improve the performance of GaAs Schottky diode mixers at 2.5THz the classical open structure with corner cube and whisker antenna was modified. In this new design the diode chip is mounted on a ceramic plate with a photolithographic structure leading to more reproducible and defined conditions for the incoupling radiation. This structure will allow to build a planar amplifier and impedance transformer in immediate neighbourhood to the diode chip. A reduction of the IF losses due to the short distances and the missing SMA connectors is expected. The impedance transformer will be designed as an active element which can adapt the impedance of the pumped diode to the input impedance of the first low noise amplifier. The first measurements of the system-noise temperature are presented.

1 Introduction

At the DLR in Oberpfaffenhofen an heterodyne system at 2.5 THz is used to measure stratospheric OH. The receiver was installed in the DLR jet airplane FALCON and has shown its performance during several flights in 1994 and 1995 [Titz *et al.*, 1995]. The system is a modified version of the heterodyne system, which was developed for astronomical observations at the Max-Planck-Institute for Radioastronomy, Bonn, Germany [Röser, 1991].

2 Heterodyne System

Fig. 1 shows the schematic of the receiver used for atmospheric measurements aboard the DLR jet airplane FALCON. The thermal radiation emitted by the OH molecules enters the fuselage through a polyethelene window whose thickness of 8mm is a compromise between the safety requirements and an acceptable transmission of the signal radiation. The local oscillator (LO) is an optically pumped gas laser emitting at 2.522 THz. The LO and signal radiation are spatially overlapped in a Martin-Puplett diplexer and focused on to the Schottky diode with an off-axis parabolic mirror. The diode operates at ambient temperature, where the first low noise HEMT amplifier sits in a 77K dewar.

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3 Open structure mixer

The open structure mixer with corner cube and whisker antenna has showed its performance for astronomical and atmospherical measurements for more than 10 years [Betz and Boreiko, 1989; Röser, 1991]. The schematic of the structure as we used it for the 2.5 THz measurements is shown in Fig. 2. However, for the THz application it has some disadvantages:

- The diode sits on the inner post of a SMA connector. The coupling of the THz currents to the ground is bad due to the gap between the SMA post and the mixer block. This gap is about 3 times the wavelength ($119\mu\text{m}$).
- At least two SMA connectors are necessary to connect the mixer and the first amplifier using a semi rigid cable.
- Impedance matching between diode and amplifier is done with a quarter wavelength transformer. It is a passive element which allows matching only over a small bandwidth and a fixed bias point.

4 New design

To improve the coupling of the THz currents to ground the gap should be as small as possible. On the other hand the electrical path for the IF frequencies should be as short as possible.

In the new design the SMA connector has been replaced by an Al_2O_3 ceramic (Fig. 3). The ceramic is about 12.7mm to 12.7mm. The top side is covered with a $10\mu\text{m}$ gold layer. In the center of the ceramic a hole is drilled with a diameter of about $500\mu\text{m}$. In this hole a gold rivet is placed which has several functions. The rivet is the mechanical carrier of the diode and connects the IF path through the ceramic to the microstrip line. The diode is soldered with indium on the rivet. Around the rivet a circular gap is left in the gold layer with a width of $30\mu\text{m}$. The gap isolates the diode from ground. The gap should be a shortcut for the THz currents. For the IF currents the gap is nearly an open. The electrical path for the IF signal to the amplifier has been shortened to about 0.3mm. In Fig. 4 the impedance of the mixer block with the SMA connector is shown. The impedance spins round the smith chart, which makes it impossible to match the diode to an amplifier over a broad bandwidth. Fig. 5 shows the impedance of the new design which only weakly depends on the frequency. Therefore, a tunable and integrated matching network between the diode and the amplifier will allow to match the diode for optimal noise figure at different bias currents and laser power.

5 First Results

First measurements were done with the new designed mixer block. With the laser operating at 2.5THz and 5mWatt output a video signal of 400mV (peak-to-peak) was measured, which is comparable with the values obtained with the old structure [Peatman *et al.*, 1992]. The system-noise-temperature measured with hot and cold load at 1.4GHz IF was 24.000K (DSB). Due to the bad geometrical alignment of the whisker there were two antenna lobes which obviously decreases the incoupling efficiency of the radiation. So we expect better results in the near future.

References

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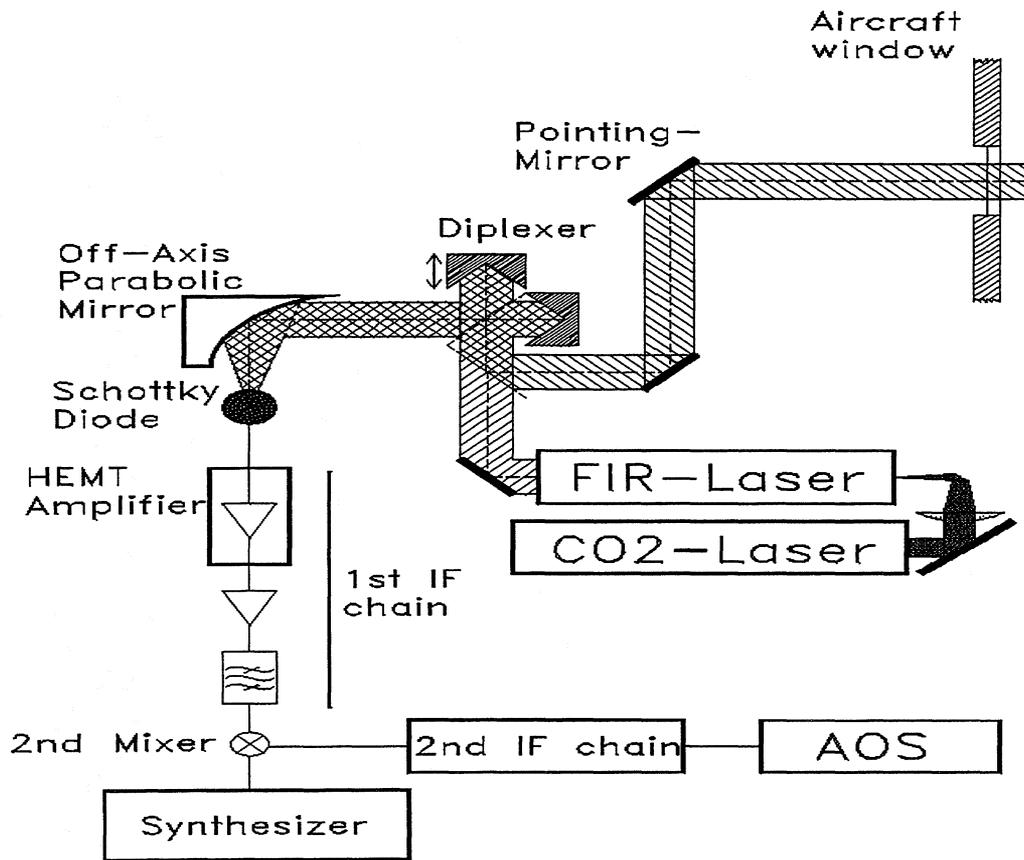


Figure 1: Airborne heterodyne system for measurement of stratospheric OH at 2.5 THz

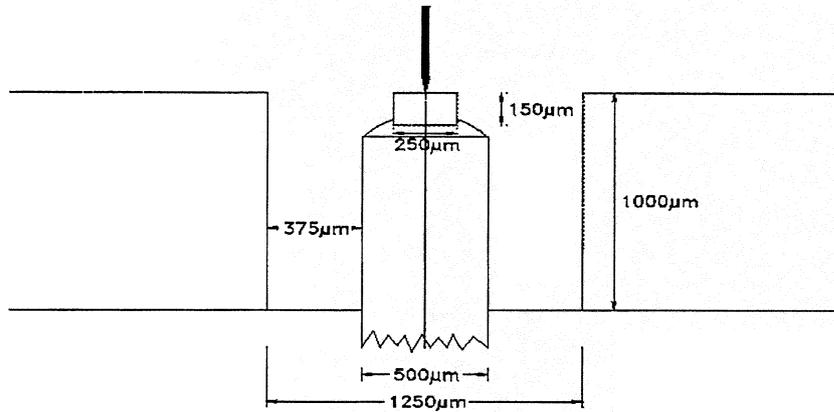


Figure 2: Schematic of the open structure mixer with corner cube and whisker antenna

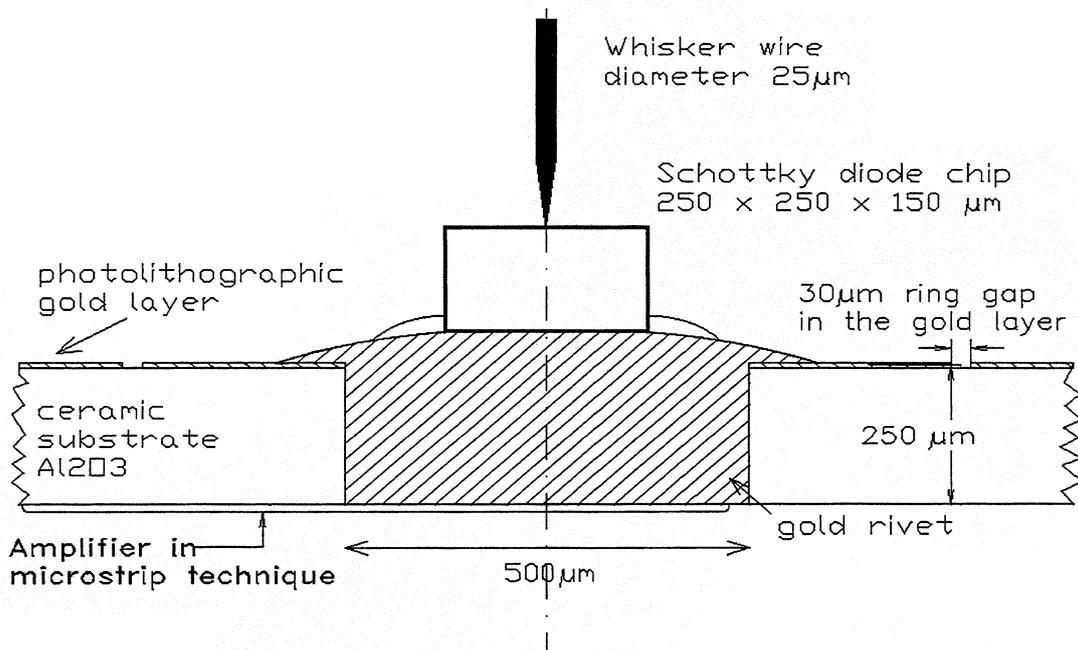


Figure 3: Schematic of the new design

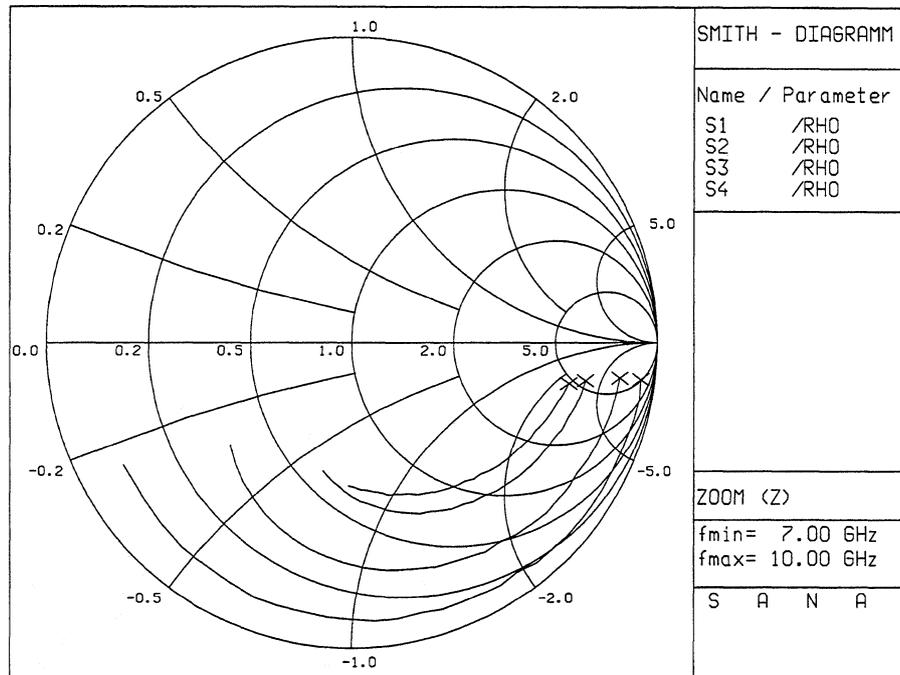


Figure 4: Impedance of the old mixer block measured at different currents: $10\mu\text{A}$ for the outermost circle, $140\mu\text{A}$, $500\mu\text{A}$, and $1040\mu\text{A}$ at the center.

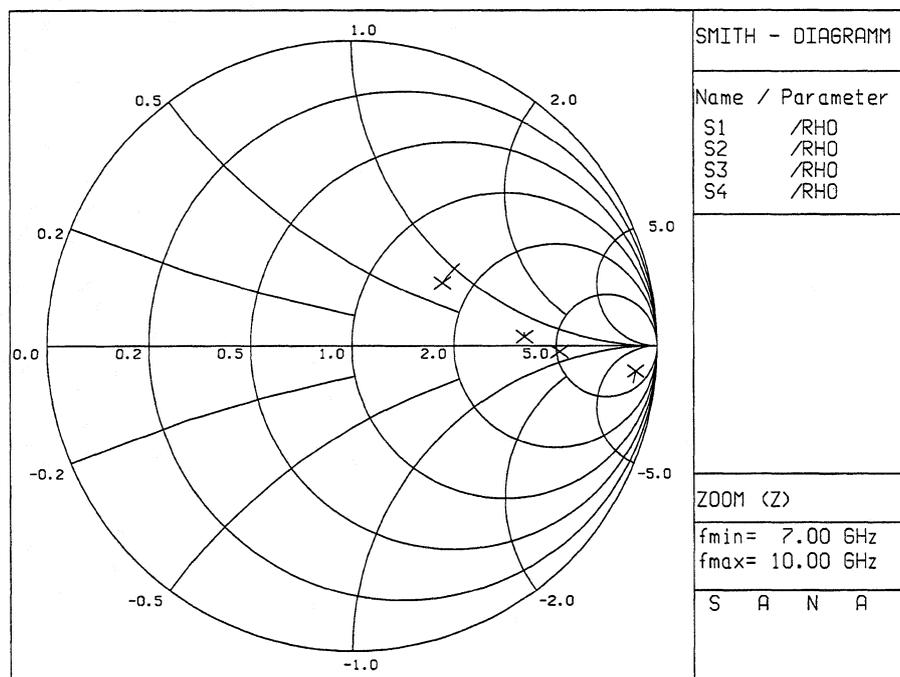


Figure 5: Impedance of the new mixer block measured at different currents: $1040\mu\text{A}$ from the upper left, $500\mu\text{A}$, and $140\mu\text{A}$, $10\mu\text{A}$ to the lower right.