Compact Quasi-Optical Schottky Detector with fast Voltage Response

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Abstract—**Zero-bias Schottky diode detectors operated at room-temperature are the choice for applications, where the ultimate sensitivity of a cryogenic detector is not needed. Furthermore Schottky detectors are intrinsically much faster than the latter ones.**
This paper describes a compact quasi-optically coupled zero-bias planar Schottky-diode detector with monolithically integrated log-spiral antenna for monitoring picosecond pulses of intense, coherent far-infrared radiation from the free-electron laser (FEL) FELBE at HZDR, Germany. The detector offers an intrinsic response time of less than 16.8 ps for short collimated THz pulses at 1.315 THz.

I. INTRODUCTION

THE increasing demand for ultra-wideband THz detectors operating at room-temperature for applications such as scientific instrumentation, spectroscopy, imaging or high bit rate data transfer accounts for the development of novel THz detectors with ultra-large video-bandwidth and compact size.
For free-electron lasers, such as FELBE and the new broadband THz source TELBE at HZDR, these kind of detectors are essential for the diagnostics and control of the accelerator. [1]

Pyro electric detectors as well as Golay cells are common room-temperature detectors for THz frequencies, featuring Noise-Equivalent Powers (NEP) down to 100 pW/√Hz. However, they are limited by their quite long response times.
A new type of zero-biased quasi-optical Schottky detector modules consisting of monolithically integrated log-spiral antenna utilized on collimating hemispherical lenses exhibit a broad-band response up to at least 2 THz, minimum noise-equivalent power of 10 pW/√Hz and response times down to 25 ps without a pre-amplifier [2-4]. Fig 1 on the left side shows the commercial available detector module from ACST GmbH. Due to different options of the video chain the housing of the detector is quite large.

II. DETECTOR OPTIMIZATION

For the application as a direct detector without a preamplifier, the detector was redesigned in two steps to reduce the size and at the same time to increase the video bandwidth. In the intermediate step only the video chain was exchanged by a microstrip transmission line realized on a 25 mil Rogers RO3010 substrate and an Anritsu K connector that operates up to 40 GHz.
In a second step also the detector housing was optimized to reduce its size and thus, the length of the video chain. The compact detector module is shown in Fig 1 on the right side. Compared to the conventional design, a significant improvement of the response time and thus the bandwidth of the video chain could be observed.

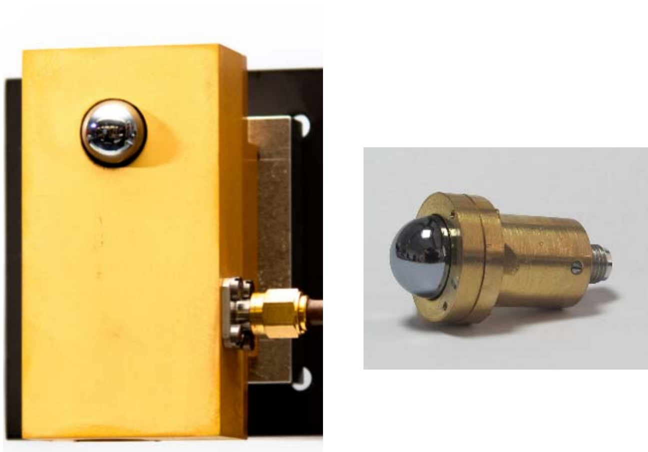

Fig. 1: Commercial available UWB quasi-optical detector operating at frequencies from 50 GHz up to beyond 2 THz on the left side, and compact redesigned module with improved video chain on the right side.

The IV characteristic of the compact module is shown in Fig. 2. The diode shows a differential resistance of 16.7 kΩ and a current responsivity of 14.8 A/W at zero-bias. Due to the high differential resistance of the diode compared to the log-spiral antenna, matching is not possible, but it ensures a constant sensitivity over a broad frequency range.

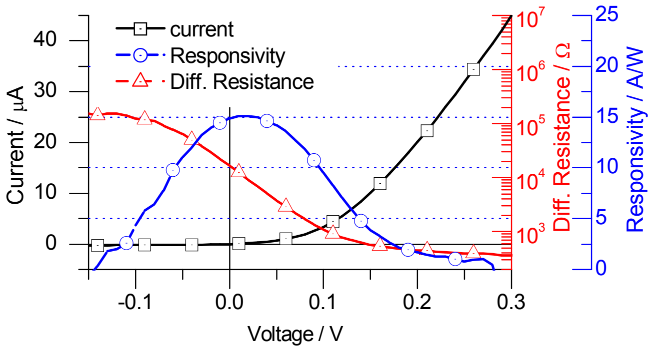

Fig. 2: IV characteristic for the compact detector module. It has a differential resistance of about 16 kΩ and a current responsivity of about 14.8 A/W at Zero-Bias.

III. RESULTS

Measurements at the free electron laser source FELBE at the

Helmholtz-Zentrum Dresden-Rossendorf were carried out in order to compare the state of the art detector with two improved detector versions. All three detectors have identical hemispherical lenses, antenna structures and diodes, only housing and video chain varies. Fig. 3 shows the measurement results of all detector modules for short collimated THz pulses of a few ps with a frequency of 1.315 GHz.

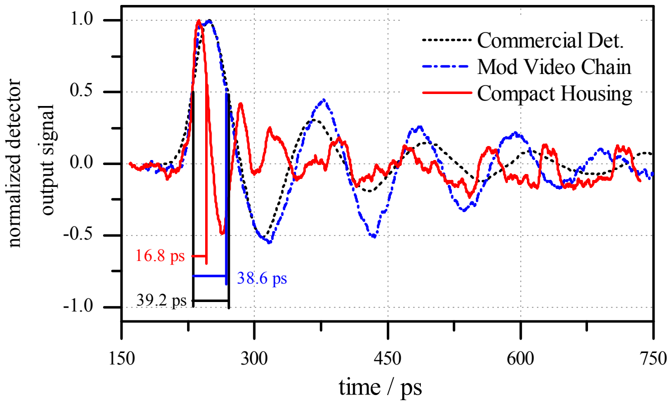

Fig. 3: Normalized detector output signal obtained by a 30 GHz sampling oscilloscope. The compact Housing increases the video bandwidth by more than a factor of two and at the same time reduces the ringing of the signal significantly.

It can be seen, that the modification of the video chain itself has nearly no effect on the detectors response time. The compact detector module with a video chain matched up to 40 GHz allows a significant reduction of the response time from 39.2 ps for the conventional detector down to 16.8 ps for the compact one. According to the author's knowledge this is the fastest response time measured with such a detector. At the same time the ringing of the detector signal could be reduced by a factor of three. The results are in line with [2], where the authors claimed an intrinsic response time of about 19 ps for the detector itself.

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