Application of Zero-Bias Quasi-Optical Schottky-Diode Detectors for Monitoring Short-Pulse and Weak Terahertz Radiation

Alexei Semenov, Oleg Cojocari, Heinz-Wilhelm Hübers, Fengbin Song, Alexander Klushin, and Anke-Susanne Müller

***Abstract*—Schottky diodes are well-known nonlinear elements allowing for effective detection and mixing of electromagnetic radiation in the range through microwave to terahertz. Although less sensitive than their superconducting counterparts, they generally do not require cooling that makes them the devices of choice for applications where the ultimate sensitivity is not needed. In the emerging field of terahertz technology, there is a long-time quest for cheap and handy detectors for laboratory use, as well as for serial compact and midsize instruments. We describe the use of a quasi-optically coupled zero-bias planar Schottky-diode detector for monitoring picosecond pulses of synchrotron terahertz radiation and weak continuous-wave emission from an array of Josephson junctions.**

***Index Terms*—Planar Schottky diodes, terahertz radiation.**

I. Introduction

COMPARED to room-temperature calorimetric terahertz detectors, such as microbolometers [1] or Golay cell detectors, Schottky-diode detectors have a much shorter response time. The quest for larger bandwidth and lower noise drives the development of Schottky diodes in binary and ternary compounds [2] and heterostructure detectors [3]. According to the scheme of radiation coupling, these detectors are either waveguide-mounted or open-beam devices. In the latter case, the detector is either mounted in a corner-cube reflector or integrated into a planar antenna, which is usually combined with an immersion lens. Recent development of zero-bias low-noise detectors utilizing planar low-barrier InGaAs Schottky diodes [4] has made it possible to reduce drastically the sizes of diode chips and integrate them in different planar broadband antennas. Achieved level of miniaturization extends the detection capability of these devices well into the terahertz range where the diode performance is largely limited by its own parasitic capacitance. In this letter, we demonstrate the ultimate capabilities of such Schottky-diode detector by recording picosecond terahertz pulses and continuous nanowatt microwave radiation.

Coherent synchrotron radiation (CSR) is emitted by electron bunches in a storage ring at wavelengths that are equal to or larger than the bunch length [5]. CSR typically covers the frequency range up to approximately 1.5 THz and is limited at low frequencies due to a finite cross section of the beam line. The expected duration of CSR pulses (a few picoseconds) is associated with the time needed for an electron bunch to travel through the area where a gradient of magnetic field exists. Due to their picosecond intrinsic response time and relatively large sensitivity, Schottky-diode detectors appear to be good candidates for resolving CSR pulses and, hence, for studying physics of electron bunches.

Josephson junction arrays can potentially become an alternative for on-chip integrated local oscillators, e.g., flux-flow oscillators, in all-solid-state heterodyne receivers, where submicrowatt power is required. However, in the development stage, broadband control of the output power requires a dedicated detection system.

In the following, we describe a specific broadband design, which was implemented in a zero-bias quasi-optical InGaAs Schottky-diode detector. The same detector was used for monitoring coherent terahertz radiation from the synchrotron storage ring at ANKA [6], as well as nanowatt continuous-wave emission from an array of discrete synchronized Nb Josephson junctions [7].

II. Zero-Bias Schottky Diode

InGaAs/InP appears to be a very promising material system for the detection of millimeter and submillimeter waves. In comparison with GaAs, its lower Schottky barrier provides zero-bias detection ability that not only eliminates shot noise and hence improves crucially signal-to-noise ratio but also simplifies the detection system. Reducing chip dimensions makes it increasingly difficult to mount precisely the diode chip and to

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A. Semenov is with the Institute of Planetary Research, German Aerospace Center (DLR), 12489 Berlin, Germany (e-mail: Alexei.semenov@dlr.de).

O. Cojocari is with ACST GmbH, 63284 Darmstadt, Germany (e-mail: cojocari@acst.de).

H.-W. Hübers is with the Institute of Optics and Atomic Physics, Technical University of Berlin, 10623 Berlin, Germany, and also with the Institute of Planetary Research, German Aerospace center (DLR), 12489 Berlin, Germany (e-mail: heinz-wilhelm.huebers@dlr.de).

F. Song is with the Institute of Bio- and Nanosystems, FZ Jülich, 52425 Jülich, Germany, and also with Nankai University, Tianjin 300071, China (e-mail: F.Song@fz-juelich.de).

A. Klushin is with the Institute of Bio- and Nanosystems, FZ Jülich, 52425 Jülich, Germany (e-mail: A.Klushin@fz-juelich.de).

A.-S. Müller is with the Institute of Synchrotron Radiation, Karlsruhe Institute of Technology, 76021 Karlsruhe, Germany (e-mail: Anke-Susanne.Mueller@iss.fzk.de).

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