TECHNISCHE UNIVERSITÄT DRESDEN

Faculty of Electrical and Computer Engineering, Chair for RF and Photonics Engineering

SAMoS - On-chip THz diagnostics

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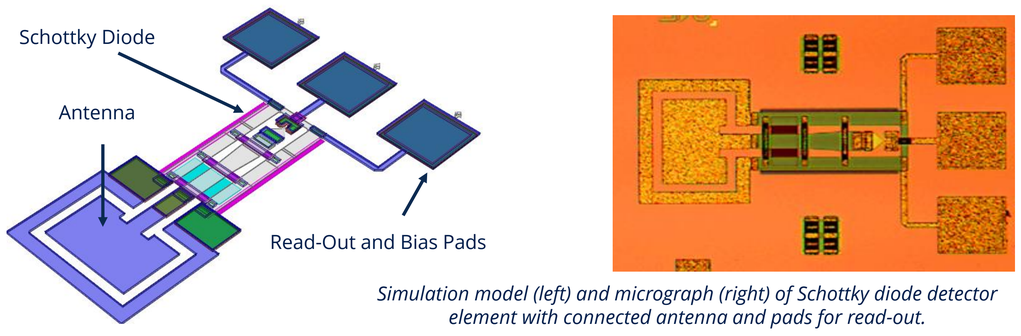
Motivation

GaAs Schottky diode detectors

- Accelerators emit THz signals that can be detected with semiconductor detectors
- Small size, on-chip realization with additional elements (e.g. antennas) is possible
- Room temperature operation and good sensitivity
- High video bandwidth possible (GHz)
- Sensitivity enhancement possible with transimpedance amplifiers and / or lock-in techniques



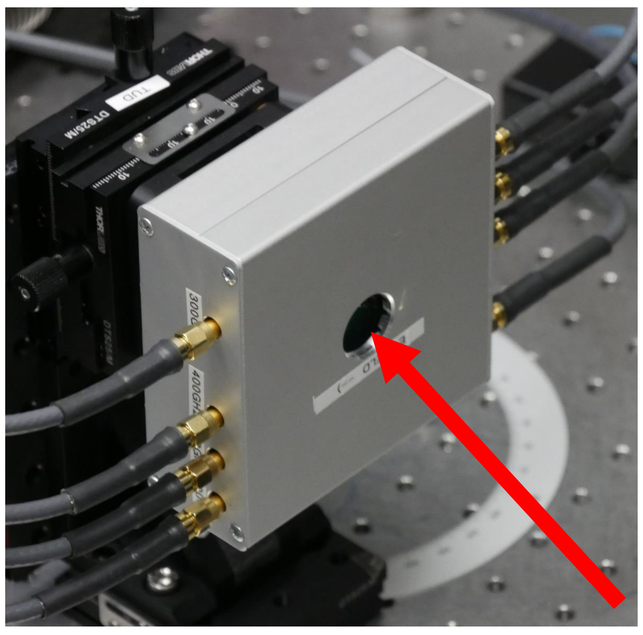
Simulation model (left) and micrograph (right) of Schottky diode detector element with connected antenna and pads for read-out.

Present and future on-chip devices

- Manufactured in standard semiconductor process → potentially cheap
- High level of integration: multiple detectors on one chip as well as on-chip antennas are possible

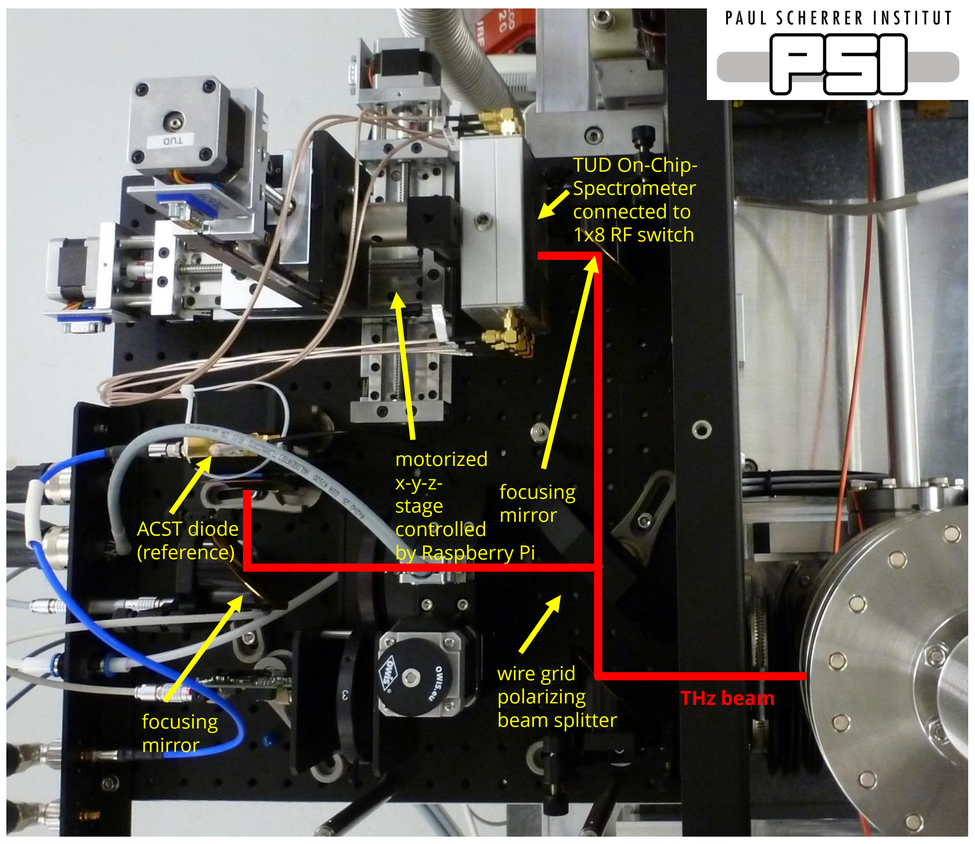
On-chip spectrometer

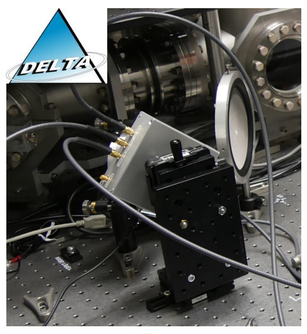
- 8 detector elements:
  50 GHz / 100 GHz / 200 GHz / 300 GHz / 400 GHz / 500 GHz / 600 GHz / 700 GHz with ~10% relative bandwidth
- Provides spectral footprint (not absolutely calibrated in frequency or power)
- Single shot spectra are possible
- Fast response (ns), 100 ps would be possible with improved electronics after the detector

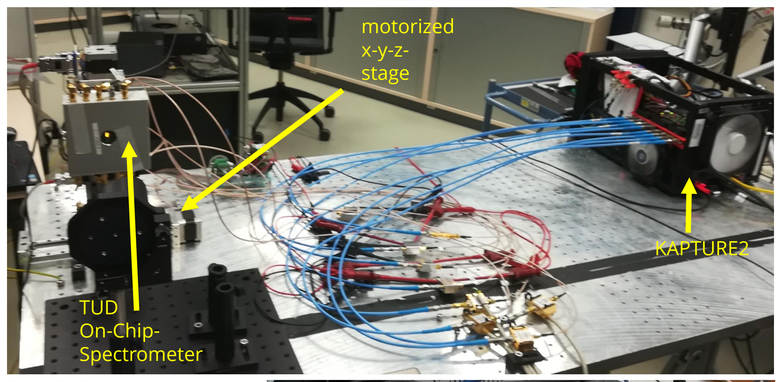


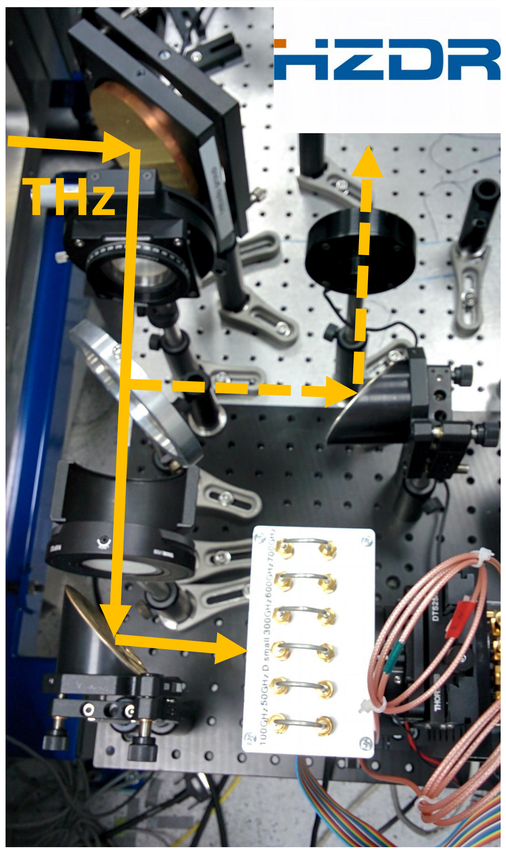
Tests at HZDR, DESY, TU Dortmund, PSI, …

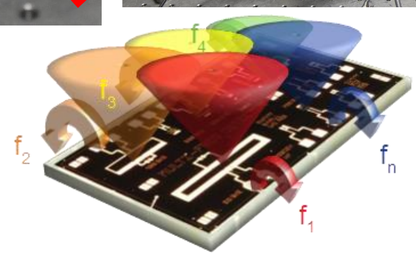
- DELTA: spectral response, detector comparison (noise, sensitivity, …)
- FLASH: spectral response and polarization dependency, electronics for MTCA based readout
- HZDR: demonstration of fingerprinting: [Laabs, M., Neumann, N., Green, B., Awari, N., Deinert, J., Kovalev, S., … & Gensch, M. (2018). On-chip THz spectrometer for bunch compression fingerprinting at fourth-generation light sources. Journal of synchrotron radiation.]
- KARA: Single-shot spectral fingerprints for characterization of behavior during decrease of bunch current taken with KAPTURE2
- SwissFEL: THz spectrum vs. compression phase scan, bunch charge dependency, remote-controlled installation near the beamline

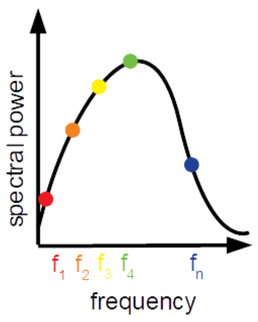


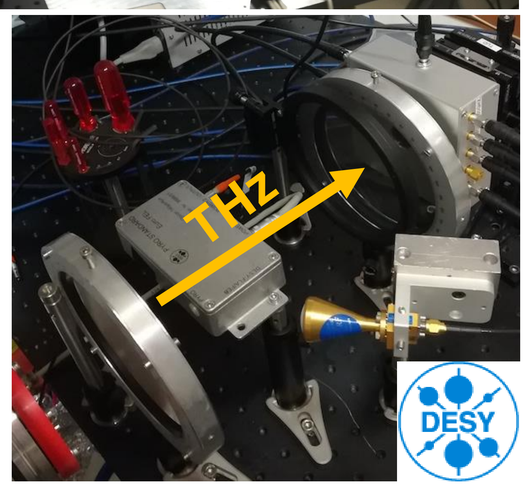






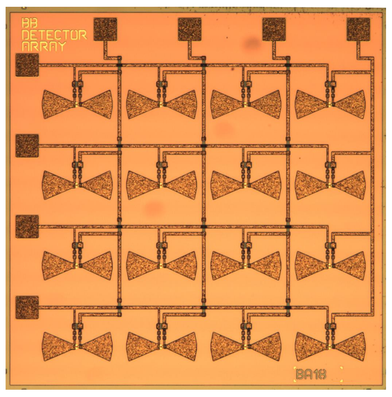


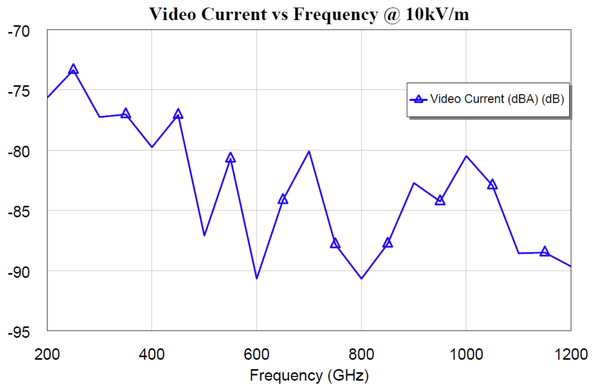




Broadband Schottky THz detector array

- 4x4 array
- sequential read-out via bias pads
- broadband detector elements 200 GHz → >1 THz
- possible use case: (fast) THz beam profiler for alignment





Future ideas / requests

- single shot line array (i.e. synchronous read-out), spacing > 1 mm for spectrometer use
- beam position monitoring, e.g. slow (kHz) line array operated in vacuum, smallest size and 4-quadrant THz beam position monitor
- polarization dependent power measurements
- signal processing, e.g. SNR estimation with cross-correlation of detector channels
- direct integration with read-out electronics like KAPTURE

Mitglied im Netzwerk von:
DRESDEN concept

Collaboration
This work has been carried out in collaboration with HZDR, KIT, TU Dortmund, DESY and PSI.

Funding
"SAMoS" is part of the collaborative research project "Neue elektronische und optische Detektorsysteme und Methoden zur Untersuchung der Dynamik hochrepetitiver kurzer Elektronenpakete". The project is funded by the German Federal Ministry of Education and Research (BMBF) under grant identifier 05K16ODB.

SPONSORED BY THE
Federal Ministry of Education and Research