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TERA OPTICS

Comparison of Rhodium- and Iron-doped InGaAs Photoconductive Antennas for Continuous-Wave Terahertz Emission

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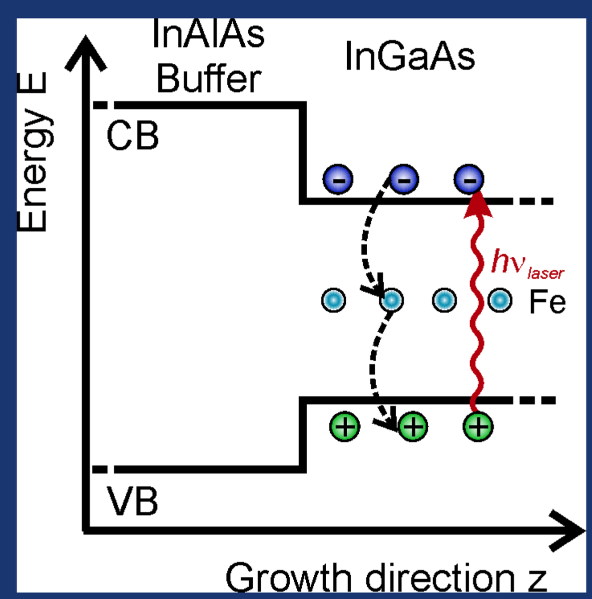
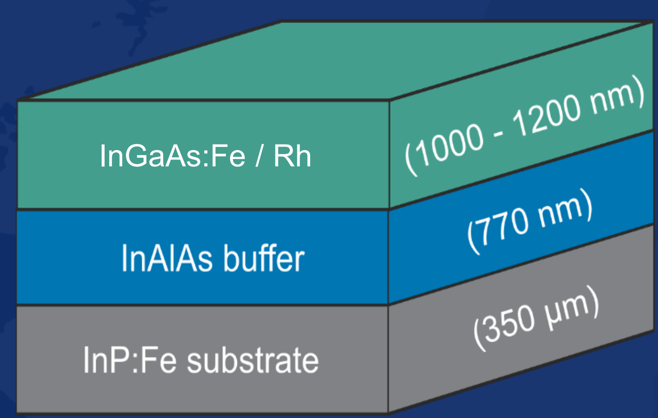
Motivation

- **Iron- (Fe) and Rhodium- (Rh) doped InGaAs based photoconductive antennas (PCA) for THz-TDS show [1] [2] [3]**
  - **Record levels of emitted THz power and unprecended responsivity**
- **CW-THz receivers based on InGaAs:Fe improve on the state-of-the-art material, low-temperatue-grown InGaAs [4]**
- **Here: First comparison of InGaAs:Rh and InGaAs:Fe as CW-THz emitters**
- **Caveat: Antenna structure (25 µm gap with strip-line antenna) not optimized for CW-THz operation**



Schematic band edge diagram

PCAs for pulsed operation
25 µm photoconductive gap structured as mesa between stripline contacts

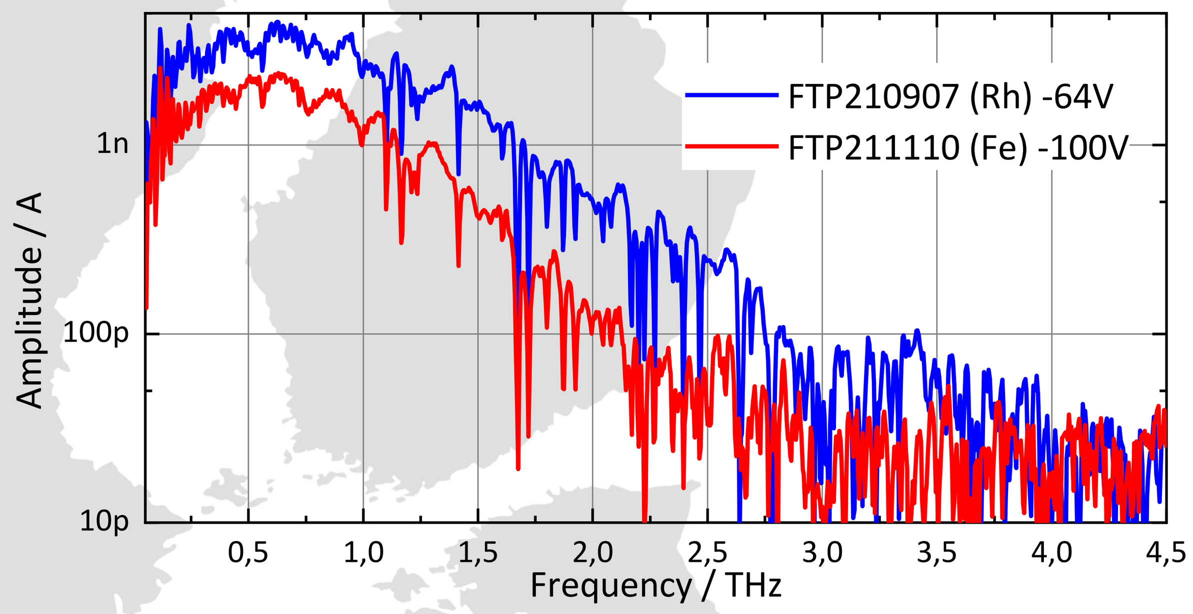


Material properties
Carrier lifetime < 300 fs
Resistivity $> 1000\ \Omega$ cm
Mobility $\sim 1000\ \mathrm{cm}^2/\mathrm{V}$

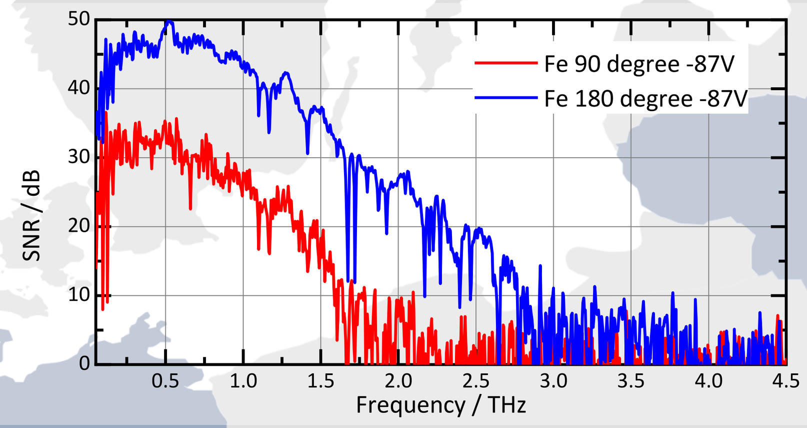
[1] B. Globisch et al., J. Appl. Phys. **121**, 053102 (2017).
[2] R. Kohlhaas et al., Appl. Phys. Lett. 114, 221103 (2019).
[3] R. Kohlhaas et al., Appl. Phys. Lett. **117**, 131105 (2020).
[4] M. Deumer et al., Opt. Express 29, 41819-41826 (2021)

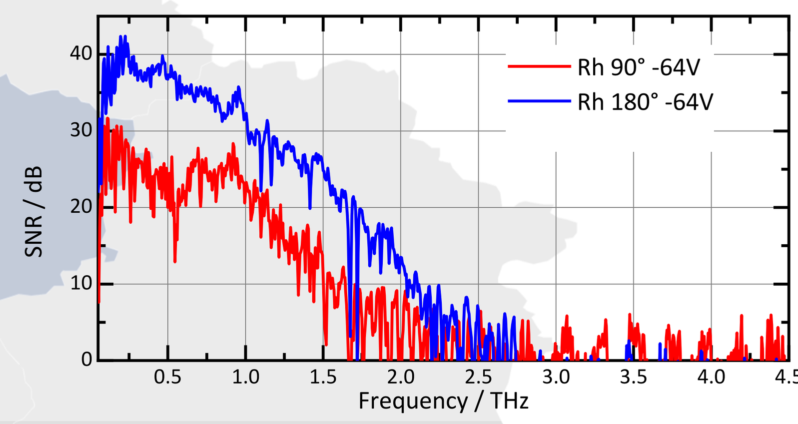
Qualitative Comparison as CW-THz Emitters

- **Operating conditions:**
  - **20 mW optical power, photocurrent limited to 140 µA**
  - **State-of-the-art CW-THz receiver based on low-temperature InGaAs**
- **Up to 4 THz / 3 THz bandwidth with Rh / Fe**



Analysis of linear polarization of emitted THz radiation:

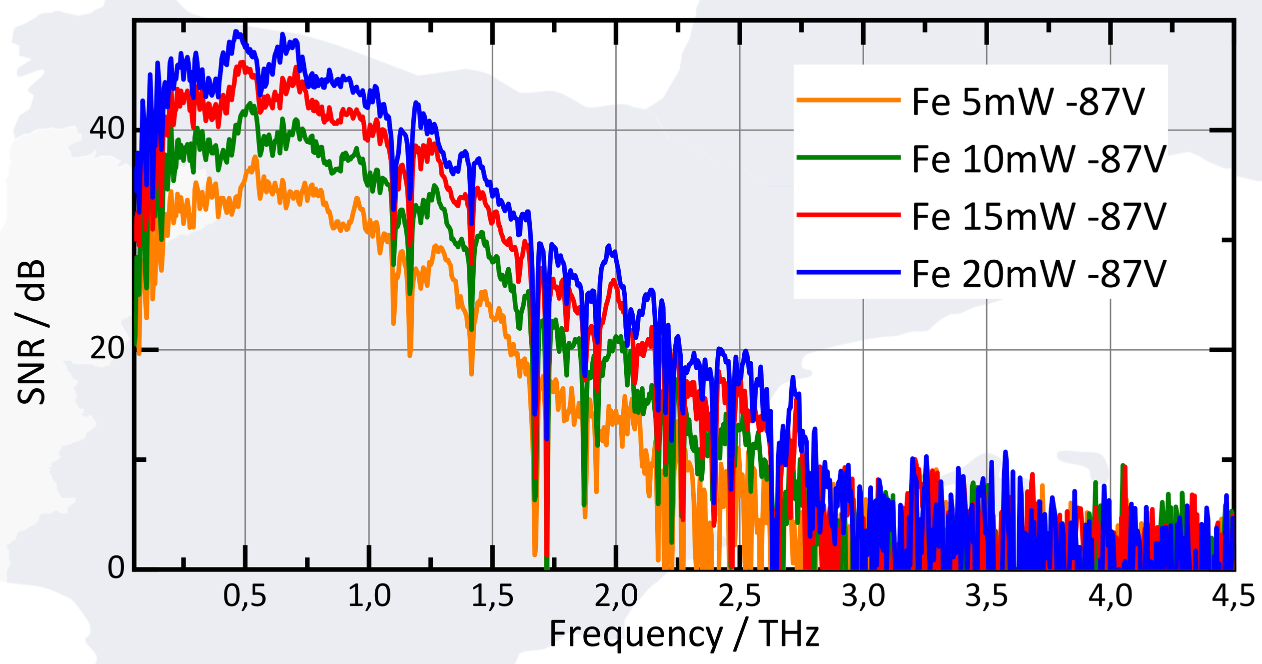


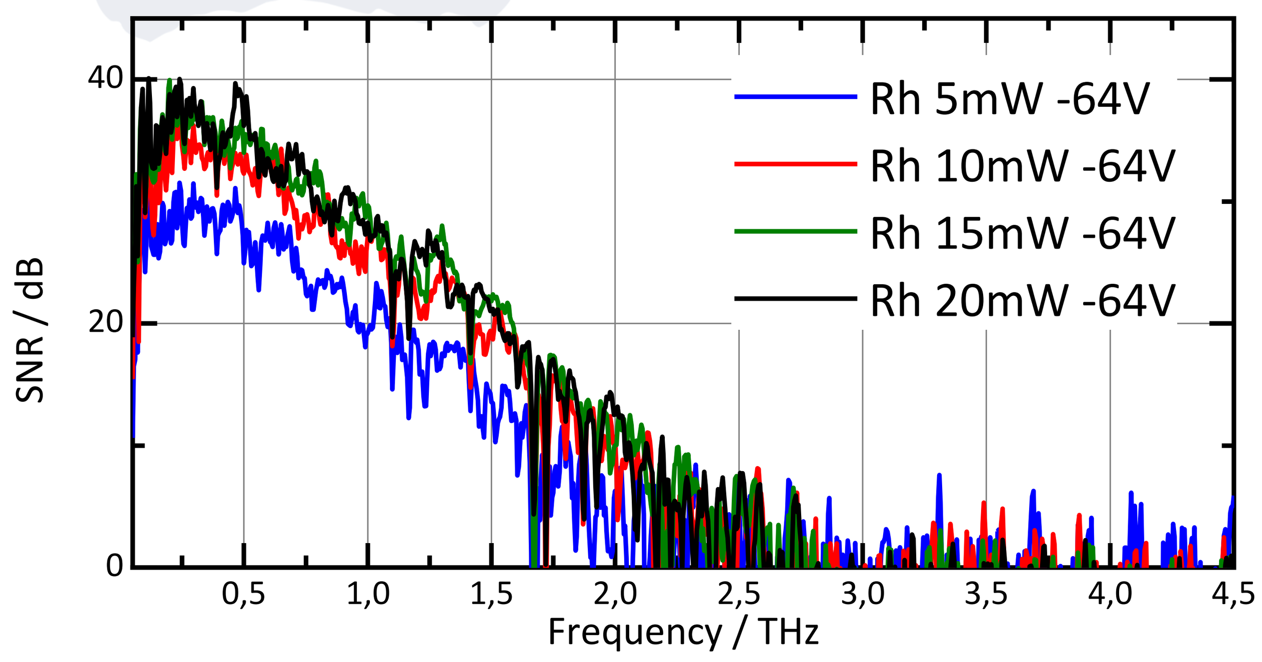


- **Antenna structure optimized for pulsed operation leads to 0.23%(Fe) & 0.09%(Rh) linear polarization at spectral maximum (0.5 THz)**

Saturation Behavior: Optical power

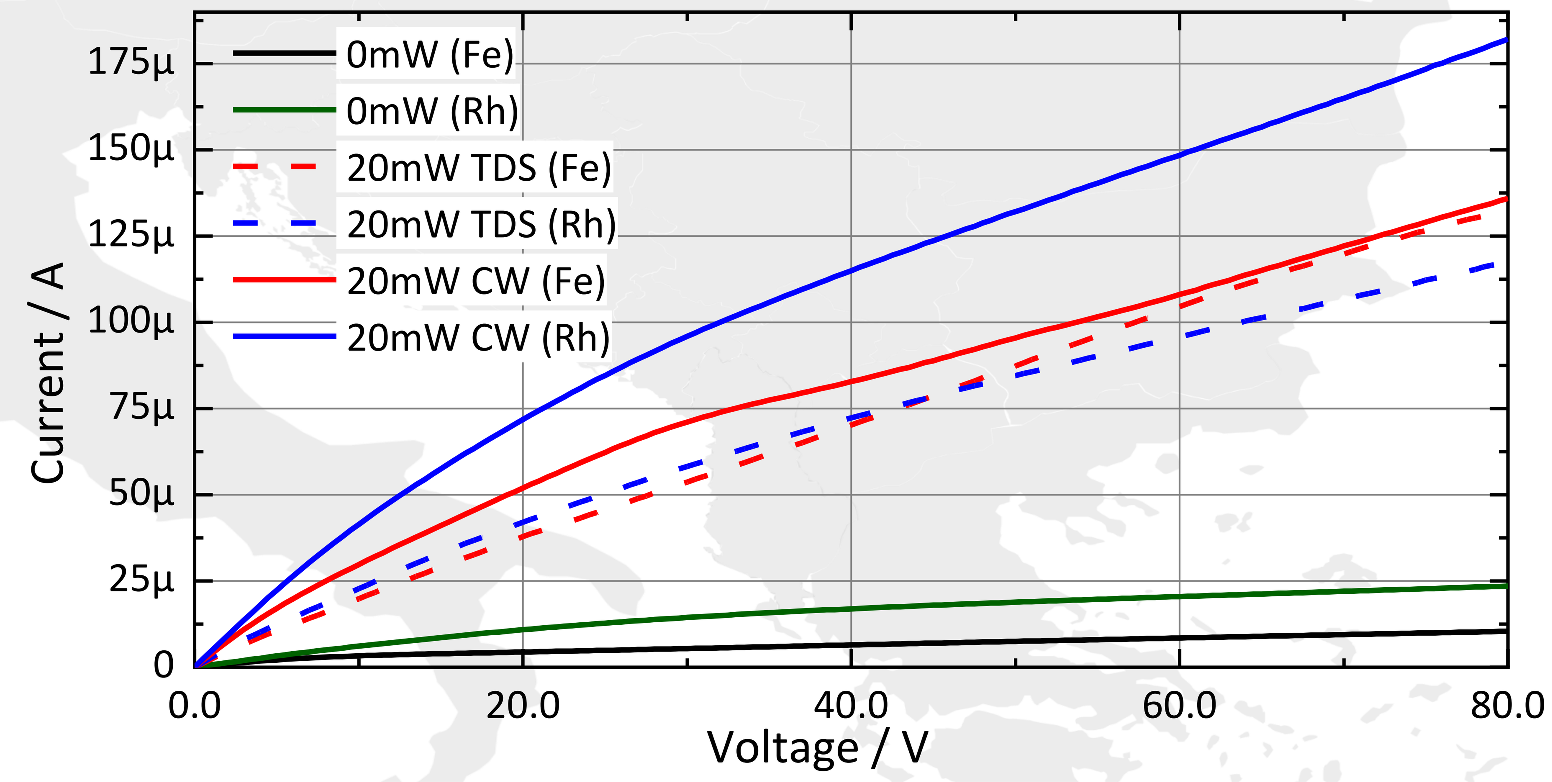
- **Emitted spectral power saturates with increasing optical power for Rh-based antennas → possibly due to slow recombination dynamics**
- **No saturation for Fe-based PCAs**





Saturation Behavior: *I-V*-Characteristics

- **Saturation of IV Characteristic for TDS-Setup for Rh emitters**



Conclusion and Outlook

- **Broadband emission capability demonstrated: Up to 4 THz / 3 THz bandwidth for Rh / Fe**
- **Higher peak dynamic range for Rh-based emitter**
- **InGaAs:Rh shows stronger saturation with optical power**
- **Further investigation with optimied CW-antennas necessary**

Fraunhofer HHI

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