Integrated Photoconductive THz Emitters and Detectors made of Fe-doped InGaAs

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In non-destructive testing and industrial process monitoring, reflection geometry is commonly preferred over transmission, because only one-side access to the sample is possible. State-of-the-art terahertz (THz) time domain spectroscopy (TDS) systems hitherto use different emitter and detector devices [2-4], such that either an angled THz beam path or a beam splitter is required to enable reflection measurements. This leads to rather bulky and complex setups. An integrated THz device, combining the emitter and detector on a single chip, would significantly facilitate reflection measurements. Thus, the ideal photoconductive material for competitive integrated devices is compatible to the excitation with 1550 nm femtosecond pulses and can be used as THz emitter and THz receiver (i.e. detector) at the same time.

Here, we show that Fe-doped InGaAs grown at temperatures around 400 °C by gas-source molecular beam epitaxy (GSMBE) combines all these properties [1]. Due to the relatively low growth temperature during Fe doping, concentrations up to 5×10^{20} cm^{-3} can be obtained. In addition, the material features an electron lifetime of 300 fs, a resistivity above 2 kΩ cm and an electron mobility higher than 900 cm^2/Vs. Thus, InGaAs:Fe combines the sub-picosecond lifetime required for broadband photoconductive receivers with the high resistivity and the high mobility needed for efficient THz emitters.

We fabricated THz emitter and receiver antennas from Fe-doped InGaAs and compared the THz performance to the respective state-of-the-art photoconductors [2-4]. The InGaAs:Fe emitter reaches an output power of 75 µW for a bias voltage of 150 V, which is comparable to the standard device [3]. In Fig. 1 the power spectrum detected by an antenna made of Be-doped

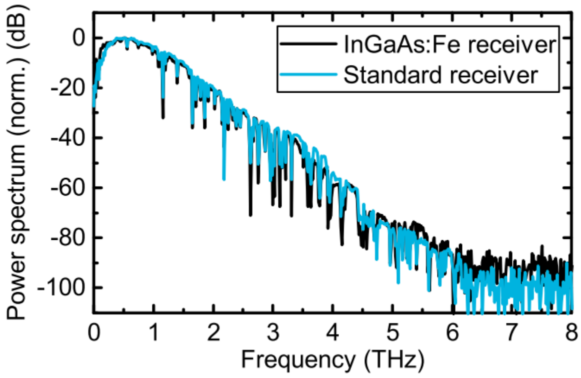

Fig. 1: Power spectrum of an InGaAs:Fe receiver (black) [1] and a standard receiver (blue) [4] detected in a standard THz-TDS system with the same photoconductive emitter.

low-temperature-grown InGaAs/InAlAs [4] (blue) is compared with an InGaAs:Fe standard receiver. The measurements were performed with the same photoconductive emitter in a THz-TDS setup based on commercially available components [2]. Both receivers show 6 THz bandwidth with a peak dynamic range above 90 dB. Hence, MBE-grown InGaAs:Fe is a promising material for integrated THz devices, thus allowing lower system prices.

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