# Photoconductive Antennas Based on Low Temperature Grown GaAs on Silicon Substrates for Broadband Terahertz Generation and Detection

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***Abstract*—We present investigations of photoconductive antennas (PCA) based on low temperature grown GaAs (LT GaAs) on silicon substrates for terahertz (THz) detection and generation. The PCAs consist of 2 µm thick layers of LT GaAs bonded on a high resistivity silicon substrate in order to reduce the intrinsic absorption losses around 8 THz due to a strong phonon resonance in GaAs. Using 20 fs long pump pulses around 800 nm and dipole antennas with dipole length between 20 µm and 60 µm a maximum bandwidth above 10 THz and a maximum dynamic range exceeding 90 dB at 0.5 THz were obtained. The average output power was measured with a calibrated detector to be 5 µW at a repetition rate of 80 MHz.**

## I. INTRODUCTION AND BACKGROUND

The generation and detection of THz radiation using femtosecond lasers and photoconductive antennas is a well-established technique. Recently a dramatic increase in output power and efficiency was reported using plasmonic PCAs [1]. Here we report on investigations aimed at the generation of broad bandwidth using "classical" PCAs based on LT GaAs. GaAs shows a strong phonon absorption around 8 THz which limits the useful bandwidth. In transmission geometry the generated THz pulse has to travel through the GaAs substrate which is typically between 300 and 500 µm thick. This can be avoided using reflection geometry [2]. However, in this case a broad area emitter has to be used in order to minimize diffraction losses caused by a tight focus of the generating NIR pulse. However, an unfocussed fs laser for THz generation requires higher average powers. In addition no silicon lens can be applied directly on the chip for collimation of the THz beam.

Our PCAs consist of thin only 2 µm thick layers of LT GaAs bonded on high resistivity silicon substrates [3].

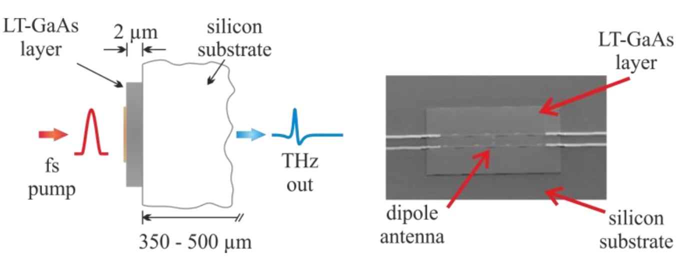


**Fig. 1:** Principle of the LT GaAs on Si photoconductive switch showing the layer structure (left) and the antenna layout (right, IEMN).

The layer structure and the antenna design is shown in Fig. 1. In order to utilize the drastically reduced absorption in the thin GaAs layer for generation of broadband THz radiation we have processed dipole antennas with dipole length between 20 µm and 60 µm. The larger diploe length is used in the emitter chip whereas the short dipole is used for detection. Our test system for THz generation consists of a typical time domain THz setup with a 20 fs pump laser at a repetition rate of 80 MHz.

## II. RESULTS

A typical spectrum obtained with a combination of a 60 µm emitter and a 20 µm detector is shown in Fig. 2. The scanning range in the time domain was 50 ps with a scanning speed of 1 ps/s and an averaging time constant of 30 ms. The spectrum extents up to 12 THz with a maximum dynamic range of 90 dB at 0.5 THz. There is still an absorption around 8 THz caused by the thin LT GaAs layer. Compared to regular PCAs fabricated on a GaAs wafer there is a clear increase in bandwidth with a dynamic range of more than 45 dB at 5 THz.

The absolute THz power generated from a 60 µm dipole antenna was measured with a calibrated THz detector [4]. For a pump power of 10 mW and a bias voltage of 35 V we obtained 45 µW of average power.

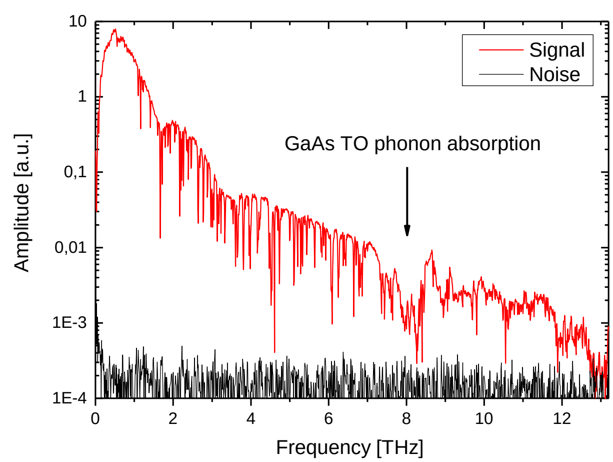


**Fig. 2:** Amplitude spectrum obtained from a 60 µm dipole antenna as emitter and a 20 µm dipole as detector fabricated on a LT GaAs layer on a Si substrate

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