Terahertz Subwavelength Waveguide Emitters

M. Martl, J. Darmo, K. Unterrainer, and E. Gornik
Vienna University of Technology, Vienna, A-1040 Austria

Abstract—**Terahertz (THz) waveguide emitters are presented as an alternative to conventional THz generation using, e.g. a photoconductive switch. Especially their ability to launch THz waves in subwavelength size waveguides is studied and the emitters are demonstrated to be useful THz sources to explore nanofabricated devices such as microcavity quantum cascade lasers.**

I. Introduction

Terahertz (THz) generation by the use of photoconductive switches is known for more than 20 years now[1]. Photoconductive switches became a standard component in THz time-domain spectroscopy where the outgoing THz beam is captured by the use of optical components like parabolic mirrors or lenses. On the other hand parallel plate waveguides in the THz frequency region have been studied extensively and were used for manifold applications[2,3]. The study of those waveguides required a lossy coupling of free radiation into them. Consequently a combination of photoconductive switch and parallel plate waveguide was shown to solve this problem[4]. Furthermore THz generation by optical rectification was investigated[5].

The coupling efficiency of THz free space radiation to parallel plate waveguides is decreasing rapidly when reaching subwavelength dimensions of waveguide cross-section. For the laser excitation pulse which is in the visible the diffraction limit is only <1% that of the THz radiation giving rise to excite the THz wave direct at the waveguide.

In this contribution we show the excitation of broadband THz transients in dielectric loaded subwavelength structures and discuss their properties with respect to future use in spectroscopy. The results show the THz waveguide emitter to be a promising tool for the probing of nanostructured devices such as quantum cascade lasers.

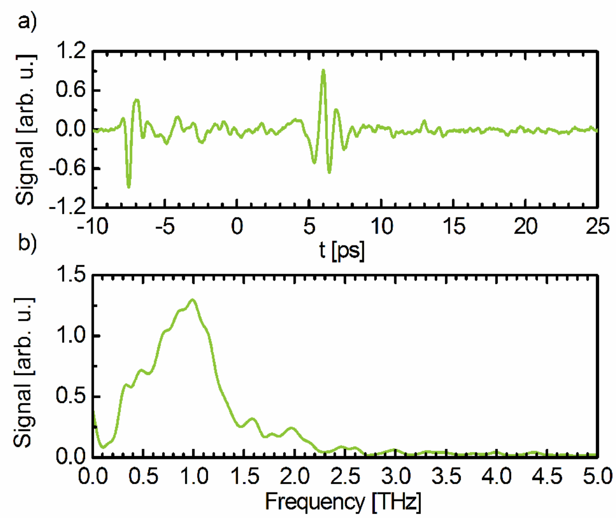
II. Results

The THz waveguide emitters were fabricated out of semi-insulating gallium-arsenide by the use of a wafer-bonding technique. The waveguide height of 31 µm was obtained by polishing and subsequently the ridges were defined by lithography and etched down by reactive ion etching (RIE). On top and bottom gold was used as the mode confinement material. For the measurement of the transmitted THz transient we used a standard THz time-domain spectroscopy setup including an electro-optic detection part.

Figure 1(a) shows a THz transient observed of an waveguide emitter with height h = 31 µm, width w = 120 µm and length l = 1.5 mm. The earlier pulse represents the air-side propagated signal while the later pulse shows the THz beam propagated inside the waveguide. In accordance with the theory the air-side pulse is shifted 180° in phase.

Figure 1(b) shows the corresponding spectrum of the waveguided THz pulse with a maximum around 1 THz. For the air-side pulse the shape was similar. Analysis of the waveguide modes reveals the main part of the energy to be propagated in TEM mode.

Samples with different lengths and widths were measured and showed waveguide losses in the range of 5 to 8 cm^{-1}. For increasing ridge-width the bandwidth was found to be higher which can be attributed to the high divergence of small apertures[6]. The bias dependence was studied and found to be basically linear. Finally finite element simulation results show good accordance with the measurements.



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