# Terahertz Metallic Ridge Waveguide Mach-Zehnder Interferometer

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***Abstract*—We present phase-sensitive measurements of terahertz electric fields using a Mach-Zehnder interferometer integrated in a metallic ridge waveguide. The deposition of lactose into one interferometer arm showed that the output amplitude signal carries information of the investigated lactose. The specimen phase information gets mapped onto the amplitude spectrum.**

## I. INTRODUCTION

WHILE terahertz (THz) time-domain spectroscopy directly measures amplitude and phase of the electric field, an alternative approach is the application of interferometric measurements to obtain the phase information of the specimen. Since constructive and destructive interference are governed by the relative phase of the superimposing fields at the output of the interferometer, the phase information can be retrieved from the output amplitude modulation signal. Here, we present a Mach-Zehnder interferometer based on a THz metallic ridge waveguide that provides sub-wavelength field confinement, efficient coupling, and a comparably large bandwidth[1,2].

## II. DESIGN AND FABRICATION

Fig. 1a shows a cross-section of the applied waveguide. The strong confinement by the centered metallic ridge provided a large single-mode bandwidth from 0.3 THz to 0.9 THz[1]. The interferometer consisted of two opposing 3dB-splitters of the type shown in Fig. 1b. The splitters divided the waveguide cross-section into two identical arms each having the same dimensions as the initial waveguide. A careful numerical analysis of the 3dB-splitter revealed the S-parameters of the component and confirmed the 50/50 % power splitting.

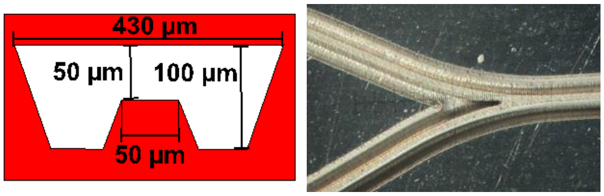

Fig. 1: Waveguide profile (left) and laser inscribed channels yielding a 3dB-splitter (right)

We fabricated the waveguide in a two-step process of conventional CNC machining and subsequent laser micro machining of channels of the required depth into parallel aluminum plates. This allowed the realization of a macroscopic coupling taper and a microscopic structure of the ridge, respectively.

## III. MEASUREMENT SETUP AND RESULTS

For our measurements we detuned the interferometer by filling lactose powder into one of the arms. For a proof-of-principle demonstration, we measured the transmission of broadband THz radiation through the interferometer with a time-domain spectroscope, where we only evaluated the amplitude spectrum. The obtained data were normalized to a reference measurement of an empty, straight ridge waveguide of similar length. Moreover, we measured the transmission of the straight waveguide filled with the same amount of lactose as the interferometer.

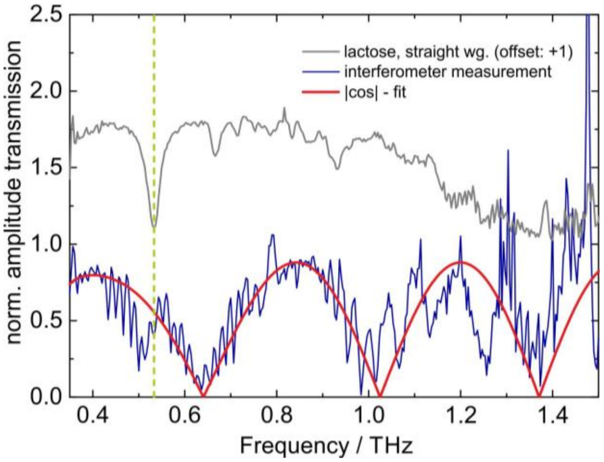

Fig. 2: Interferometer amplitude transmission spectrum

Fig. 2 shows the normalized transmission spectrum of the interferometer together with the transmission of the filled straight waveguide. Due to the dispersion of the refractive index of lactose we clearly recognize an oscillation of the amplitude spectrum at the strong resonance frequency of 0.53 THz. Unfortunately, a superimposed etalon effect due to reflections at the 3dB-splitters, which was expected from the calculated S-parameters, limits the readability of this measurement. Nevertheless, the result agrees well with an analytic description of the transmission, additionally indicated in Fig. 2. A comparison to the measured data clearly reveals the mapping of the sample phase information onto the amplitude spectrum.

## REFERENCES

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