Workpackage: B5: Micromechanical Switchable Waveguides

Author: David Lämmle

5.2.5 Micromechanical Switchable Waveguides

For the signal transmission between different THz-components waveguides are needed. For THz-sensors and other applications it is helpful to switch between different signal paths. This enables to switch over between a measuring channel and a reference channel. In this work package the fabrication of suitable waveguides and the integration of switches will be investigated.

Comparison of different THz-Waveguides

Due to the high attenuation in coplanar waveguides and microstrips, in the past several other approaches were tested in THz-spectroscopy [YSS05],[MG01],[WM04]. There are parallel plate waveguides, free-standing wires and dielectric ribbons. The problem with these waveguides is the lack of effective methods to integrate them on chip level. In addition, for space applications rectangular waveguides in the THz range were successfully implemented [Des+08]. Taking a look at the different kinds of THz-sensor-systems it can be seen that rectangular waveguides are normally not used in THz-spectroscopy due to mode-dispersion and the transition of the fundamental mode into higher order modes for frequencies larger than the operating band. This is a problem in time-domain-spectroscopy where broadband THz-pulses are used to determine the spectral behavior of materials. In contrast, in this project continuous-wave-systems should be used for sensor applications. Only one frequency at a time is sent through the system. Mode-dispersion is no problem in this setup and the rectangular waveguide can be dimensioned for a desired frequency range. Due to the low attenuation and the ability to fabricate them on a chip, rectangular waveguides are the perfect choice for these systems and will therefore be used for the integration of switches.
As a proof of concept, waveguides for the frequency-range from 75-110 GHz (WR-10) were fabricated. The height of the waveguide was reduced to 200 μm in order to get used to the problems at higher frequencies. Two different ways of fabrication were tested (Fig 5.39). For the characterization, a taper is needed to connect the fabricated structure to a Vector Network Analyzer (VNA). For the alignment of the taper to the microstructure, two thin metal foils are clamped into the taper and the side of the microstructure (Fig 5.40).

Fig. 5.39: Two different ways to fabricate rectangular waveguides

Fig. 5.40: Image of the fabricated taper and an attached microstructured waveguide.
The results of the measurements performed with this setup are shown in fig. 5.41. It can be seen that the microstructures fabricated in the first approach have a very high attenuation. It is expected that the surface of the photoresist is not as planar as required. This results in a bad electrical contact between the two parts of the waveguide. The second approach where a lapped metal surface is brought in contact with the upper part of the split-block, the transmission is nearly the same as the transmission through the taper itself. This method seems to be promising and will therefore be further used for the integration of switches.

![Graph showing transmission results](image)

**Fig. 5.41:** Results of the measurements performed at the VNA.

### Integration of Micromechanical Switches

In order to change the signal path, electrostatic curled beam actuators should be integrated into the system. These actuators have the advantage that relatively large deflections >1 mm can be achieved. Connecting the top and bottom of the waveguide with the movable electrode creates a shortcut and prevents the wave from traveling through the waveguide (fig 5.42). By applying an adequate voltage between the two electrodes, the movable electrode is pulled onto the insulator and therefore opens the signal path.

During the last year, the fabrication of these actuators with intrinsically stressed electroplated nickel was studied. The influence of different parameters on the reliability and the performance has been investigated. The results can be found in [LSS13].
**Fig. 5.42:** Schematic of the integrated waveguide switch and the functional principle of the electrostatic curled beam actuator [LSS13].

**References**


