Contactless rotating MEMS waveguide switch for water detection at 557 GHz

Sofia Rahiminejad[1], Cecile Jung-Kubiak[1], Mina Rais-Zadeh[1,2], and Goutam Chattopadhyay[1]

Detecting water on other planets and heavenly bodies has been a long time goal of NASA. High-resolution heterodyne spectrometers are well suited to carry out such measurements. It can be used to detect unique molecular signatures, such as water molecules, with a high spectral resolution and precision over a wide range of wavelengths.

Calibration of the spectrometer is one of the critical aspect for such systems and typically a flip-mirror based calibration scheme is used to switch the signal between the antenna and the load for calibration of the receiver. Silicon-based radio frequency micro-electromechanical systems (RF MEMS) waveguide switches can be used for the same task, and take significantly less volume, mass and energy.

RF MEMS have shown to be compatible with waveguide components for submillimeter wave applications, since silicon micromachining allows for fabrication of 3D geometries, micrometer sized features, and high-aspect-ratio structures. In the past few years, waveguide components such as tunable capacitors, phase shifters, and waveguide switches have emerged for THz applications. Specifically, MEMS waveguide switches operating at frequencies from 400 GHz up to 750 GHz have been reported, with a 460 GHz single-pole double-throw waveguide switch demonstrated [1, 2].

To the best of the authors knowledge, all of the MEMS waveguide switches, developed to-date need electrical and mechanical contacts to block the wave, creating issues such as mechanical stress/stiction, poor life time, and if cycled many times, problems with ohmic contact resistance can arise. A contactless in-plane MEMS waveguide switch would therefore be greatly beneficial for THz applications.

In this paper, we present a contactless rotating MEMS waveguide switch operating between 500-750 GHz.

The switch has a U-bend waveguide attached to a rotating MEMS motor, as shown in Fig. 1a. The U-bend switches between connecting the Receiver (1) and the Antenna (2), or the Receiver (1) and the Load (3). By surrounding the U-bend waveguide with an electromagnetic bandgap (EBG) surface, the opposing waveguides do not need to be in contact with each other.

Simulations show that if there is a 10 μm air gap between the U-bend and the opposing waveguides, the isolation is larger than 30 dB, the insertion loss is less than 0.6 dB throughout the in-band, and the return loss at the receiver is larger than 25 dB between 500-722 GHz, and larger than 23 dB throughout the in-band.

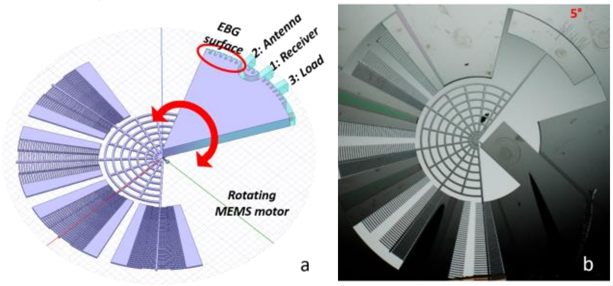

Fig. 1. a) A schematic of the MEMS motor with its four arms, defined in the 50 μm device layer of a SOI wafer, acting as levers to rotate the U-bend between two positions. The U-bend is surrounded by an EBG surface to confine the wave without any electrical contact to the opposing waveguides. b) The fabricated MEMS motor, shows a 5° rotation while actuated.

The MEMS motor has four arms that can be actuated to move together, both clockwise and counter clockwise. The MEMS motor was fabricated using an SOI (50 μm/2 μm/380 μm) wafer. The rotating motor is defined in the 50 μm device layer, while the U-bend waveguide is defined in the 380 μm handle layer. The U-bend waveguide needs to move 9° to switch between the two positions. The MEMS motor was measured to move up to ±5°, Fig. 1b.

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REFERENCES

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[1] Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, USA.

[2] University of Michigan, Ann Arbor, MI 48105, USA.

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