Silicon Micromachined Receiver Calibration Waveguide Switch for THz Frequencies

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Radiofrequency (RF) switches are commonly used for the calibration of radioastronomy microwave instruments [1]. Optical systems, based on moving mirrors, are generally preferred when approaching the THz frequency range, due to the challenges to fabricate waveguide-based switches at such high frequencies.

One of the main challenges for the fabrication of THz waveguide components is their reduced size, in the micrometer range, which makes most traditional machining techniques highly unreliable for such applications. Silicon micromachining has been demonstrated to be a promising alternative for the fabrication of THz waveguide components [2], [3].

The authors recently demonstrated a silicon micromachined turnstile orthomode transducer [2] that could replace the bulky wire-grid polarizers currently used above the sub-millimeter wave range in many receiver architectures [1]. Here, we present a waveguide-integrated single pole double throw (SPDT) microelectromechanical system (MEMS) switch. This novel switch concept is based on a reconfigurable MEMS surface [3] that separates a stack of two hybrid couplers, see Fig. 1a, b.

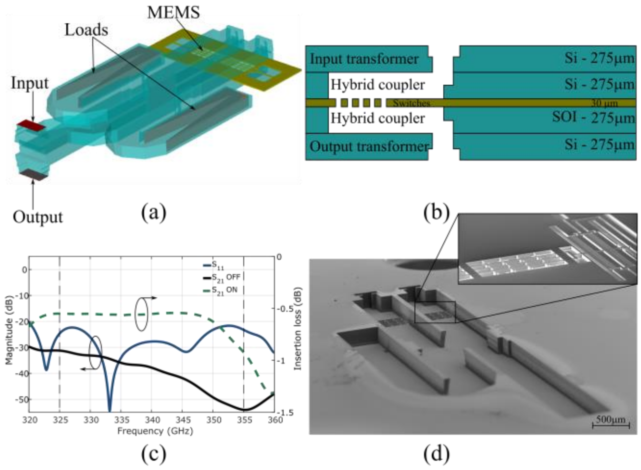

Fig. 1. On/load switch concept showing: (a) 3D drawing of the structure, (b) cross-section of the micromachined wafers (not to scale), (c) simulated performance, and (d) SEM image of the fabricated prototype.

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The SPDT switch can be used for receiver calibration by loading one of the outputs of the switch with an integrated micromachined absorber. This configuration provides the ability to switch between an 'ON' state and a 'LOAD' state in the receiver. The simulated RF performance for both states is depicted in Fig. 1c.

The design of the switch is based on a stack of four micromachined chips. A cross-section of the chip stack is shown in Fig. 1b. The top and bottom chips include stepped impedance transformers, and E-plane bends to feed the in-plane micromachined waveguides. The signal is then split by an H-plane hybrid coupler that feeds the two MEMS reconfigurable surfaces. When the surfaces are in the open state, the signal is routed to the lower chip and recombined by the second coupler into the output port; if the surfaces are in the closed state, the signal is reflected and recombined in the loaded port. More information about the MEMS reconfigurable surface can be found in [3].

The fabrication of the SPDT switch is based on the multistep deep reactive ion etching (DRIE) technique described in [2], and on the waveguide-integrated MEMS technology described in [3]. Fig. 1d shows a scanning electron microscope (SEM) image of a fabricated prototype. After micromachining, the four silicon chips are gold-sputtered, and thermal compression bonded.

The SPDT switch in the ON/LOAD configuration, designed for 340 GHz, shows a simulated insertion loss in the 'ON' state of 0.5 dB with a return loss better than 20dB. In the 'LOAD' state, the predicted return loss is better than 20dB with isolation better than 30dB. A more complex architecture with several calibration loads could also be implemented by integrating additional cascaded switches in the same chip.

References

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[3] U. Shah et al., "A 500–750 GHz RF MEMS Waveguide Switch," IEEE Trans. THz Sci. Technol., vol. 7, no. 3, pp. 326–334, May 2017.

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