STUDIES ON MICROMACHINED CIRCUITS FOR MICROWAVE TO SUB-THz APPLICATIONS

by

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Submitted
in fulfillment of the requirements of the degree of Doctor of Philosophy

to the

INDIAN INSTITUTE OF TECHNOLOGY DELHI (IITD)

AUGUST 2022

ABSTRACT

In this thesis, detailed studies are reported on: (a) the design aspects of microwave and mmWave micromachined series and shunt switches; (b) back to back rectangular waveguide to CPW transition for characterization of CPW based series/shunt switches in X- and W-band; (c) CPW to slotline transition based broadband micromachined coupler; (d) realization of 2-Bit reflection type phase shifter (RTPS) utilizing micro- machined shunt switch and coupler; (e) performance improvement of micromachined shunt switch utilizing defected ground structures (DGS); and (f) frequency selective surfaces (FSS) and multiband absorbers for application in mmWave to Sub-THz region.

To start with, analysis and the design of the micromachined switches is carried out. Both types of micromachined switches *viz.* series and shunt are studied with their specific application areas, working frequency ranges in different bands, power handling capacity, and most importantly the fabrication steps for both in-house fabrication as well as following well-established foundry process design rules. The micromachined switches are mainly designed for application in phase shifters, up to *Ka*-band, especially in the frequency range of 8 to 40 GHz. In addition, other micro-machined shunt switches are designed and fabricated at 60 GHz and 75-110 GHz. The topology chosen for the phase shifter design is of reflection type to keep control of size and preferred frequency less than 30GHz. The 2-Bit reflection type phase shifter (RTPS) is designed at 20GHz with bandwidth (BW) of approximately 2GHz. The design of RTPS basically involves design of a micromachined shunt switch and broadband micromachined coupler.

In order to characterize micromachined shunt switches realized in CPW configuration, back-to-back rectangular waveguide to CPW transition is designed, developed, and characterized in both X-band (8GHz-12GHz) and W-band (75GHz-110 GHz). Simulation-based study of the micromachined shunt switches integrated with the transition has also been carried out.

Micromachined shunt switches are next explored with defected ground structure (DGS) in the ground planes of the CPW line. In the case of DGS, the isolation improvement was observed in simulations. The isolation parameter of the shunt switch in the downstate is improved by incorporating DGS structures and further insertion loss performance improvement achieved by the introduction of the secondary switches over DGS. The complete structure observed as a MTM unit cell designed to improve the isolation of a shunt switch and improvement of the insertion loss in the frequency range from 60- 140 GHz.

Lastly, metamaterial structures are studied for application as frequency selective surfaces (FSS) and multiband absorbers in the sub-THz frequency region. A novel FSS structure as a unit cell is designed, fabricated, and characterized in the frequency range from 100- 600GHz. It is observed that simulation results are in good agreement with experimental results. The same structure when studied as an absorber with backside metal (gold) coating shows absorption peaks within the THz range (441GHz to 592GHz).

Wherever possible, the attempt was made to verify the simulated results. In some cases, due to fabrication complexities and limited in house facilities available, only simulation-based studies are reported.