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Design of H-Band SiGe Chip-to-Waveguide Packaging

Haojie Chang(1), Zhongxia Simon He(1), and Herbert Zirath(1)
(1) Chalmers University of Technology, Gothenburg, Sweden

Abstract

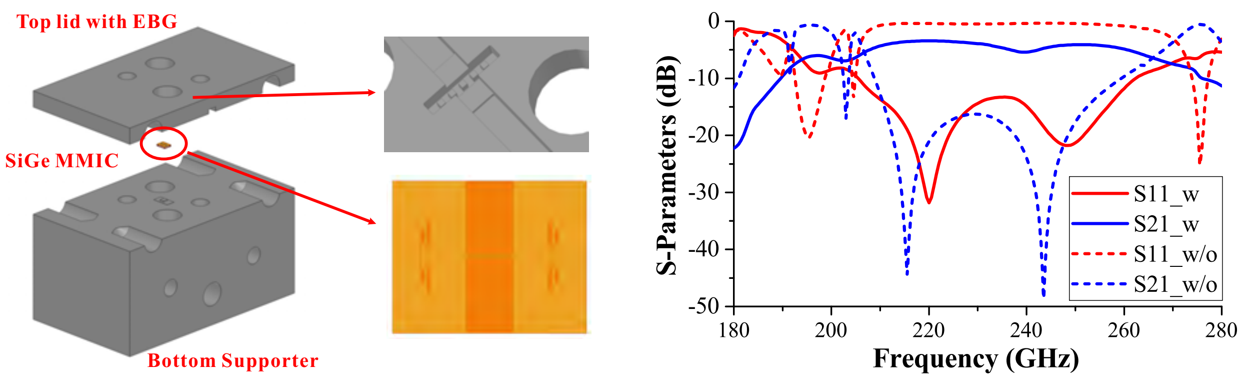
A contactless chip-to-waveguide packaging suitable for SiGe monolithic microwave integrated circuits (MMIC) in H-band is presented. The packaging relies on two on-chip slots radiator coupled to WR-4.3 metal waveguide, with a quarter-wavelength step for impedance matching. A row of pins are set in middle of a back-to-back (B2B) packaging prototype to suppress waveguide transition model. Simulated results show the proposed B2B prototype achieves 1.6 dB insertion loss per transition in average within 206-262 GHz.

1 Introduction

With improvement of fully integrated MMIC RF front-end within 110-300 GHz these years, sub-THz shows good potential in high data rate communication up to multi-gigabit per second (Gb/s) [1, 2]. A suitable packaging design becomes necessary and urgent for sub-THz MMIC integration in practical system. Traditional packaging methods like wire bonding and flip-chip are not suitable in sub-THz due to performance deterioration from extra compensation designs [3]. Some advanced packaging technologies are proposed then to realize MMIC packaging above 100 GHz based on MMIC-waveguide transition, embedded wafer-level ball grind array and silicon-micromachined Waveguide [4–6]. In this work, a B2B H-band contactless transition prototype is presented based on SiGe BiCMOS process. Simulated results show the prototype has 4.4 dB insertion loss including connection line loss of 1.2 dB from 206 to 262 GHz.

2 Design and Simulation

To realized contactless transmission between MMIC and waveguide, coupling or radiation is required. Two Half-wavelength slots in MMIC ground are then introduced as aperture antennas for radiation. As complementary format of dipole antenna, the characteristic impedance of radiation slot can be calculated by $Z_{dipole} \times Z_{apeture} = \mu^2/4$. And two slots resonating at different frequencies help to improve the bandwidth as well as in-band performance. Due to high characteristic impedance of waveguide, a quarter-wavelength waveguide step is added for impedance match and the impedance difference is reduced by patches over the slots. When considering B2B transition performance inserted in a whole waveguide, it is necessary to avoid being a pure through waveguide without transition effect. In this prototype, a row of pins are used as electromagnetic band gap (EBG) structure to suppress waveguide model.



(a) Model **(b)** Simulation

Figure 1. Model and simulated results of proposed B2B MMIC-waveguide packaging (solid line: with MMIC; dash line: without MMIC)

The final model of B2B chip-to-waveguide transition is given in Fig. 1 after HFSS simulation. Simulated results prove the transition performance from the stopband without the MMIC chip. And the impedance bandwidth of the proposed B2B MMIC-waveguide packaging prototype is from 206 to 262 GHz (23.9%), with average 4.4 dB insertion loss. The simulated connection line loss is 1.2 dB, meaning a single transition has insertion loss of 1.6 dB.

3 Conclusion

A H-band SiGe MMIC-waveguide packaging is proposed. Two slots etched in MMIC ground plane as radiator and step waveguide is used as impedance transformation. Simulated results show the proposed prototype has 1.6 dB insertion loss per transition within 206-262 GHz bandwidth. And the through waveguide model is suppressed by introduced EBG pins.

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