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► **To cite this version:**

Julian Thevenard, Philippe Minard, Dominique Lo Hine Tong, Corinne Nicolas, Ali Louzir, et al.. Surface mountable waveguide devices based on metallized dielectric foam for millimetre wave band applications. International workshop on microwave filters, CNES/ESA, Sep 2004, Toulouse, France. ⟨hal-02359514⟩

HAL Id: hal-02359514

<https://hal.science/hal-02359514v1>

Submitted on 5 Apr 2022

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Surface mountable waveguide devices based on metallized dielectric foam for millimeter wave band applications.

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Abstract

A novel transition structure between microstrip line and surface mounted dielectric foam waveguide is presented. The waveguide flange is ended by a cavity and allows a fully automated assembly onto an RF printed circuit board (PCB) in order to minimize high volume production cost of millimeter-wave products. The new concept has been applied for the integration of two waveguide filters, presenting respectively a Chebyshev and a pseudo-elliptic response, and that can be surface-mounted in a transmission chain of a VSAT system operating in the [29.5-30.0] GHz band.

Introduction

Surfaced mounted millimeter-wave and RF components are highly demanded to cut down manufacturing costs and to increase performance of wireless multimedia systems, such as 2-way by satellite systems operating at 20/30GHz, 42GHz point-to-multipoint systems and 60GHz WLAN systems. Nowadays, SMD packaging technology can be applied to MMIC up to 40GHz. For waveguided functions, such as filters that allow high-Q factor resonator, SMD technology has also to be applied. That's why low cost and high performance transitions, between microstrip line and waveguide, have to be addressed.

The solution proposed in this paper is based on metallized dielectric foam materials [1] that can be machined or moulded and that promise innovative designs, thanks to their use flexibility, as previously described in [2-3]. The behavior of the structure is EM 3D simulated in the VSAT 30GHz band with the design of two SMD foam waveguide filters [4-5].

Principle of the microstrip-to-waveguide transition

Fig. 1 shows the proposed microstrip to waveguide transition. The transition is composed of a metallized dielectric foam waveguide integrating a flange, a board comprising a printed probe and a microstrip line, and a carrier including a cavity. The probe and the cavity dimensions are optimized to get the best coupling between the waveguide TE₁₀ mode and the quasi-TEM mode of the microstrip line in the [29.5-30.0] GHz band. Simulation results show return loss better than 20dB and low insertion loss (0.5 dB) over the frequency band of interest.

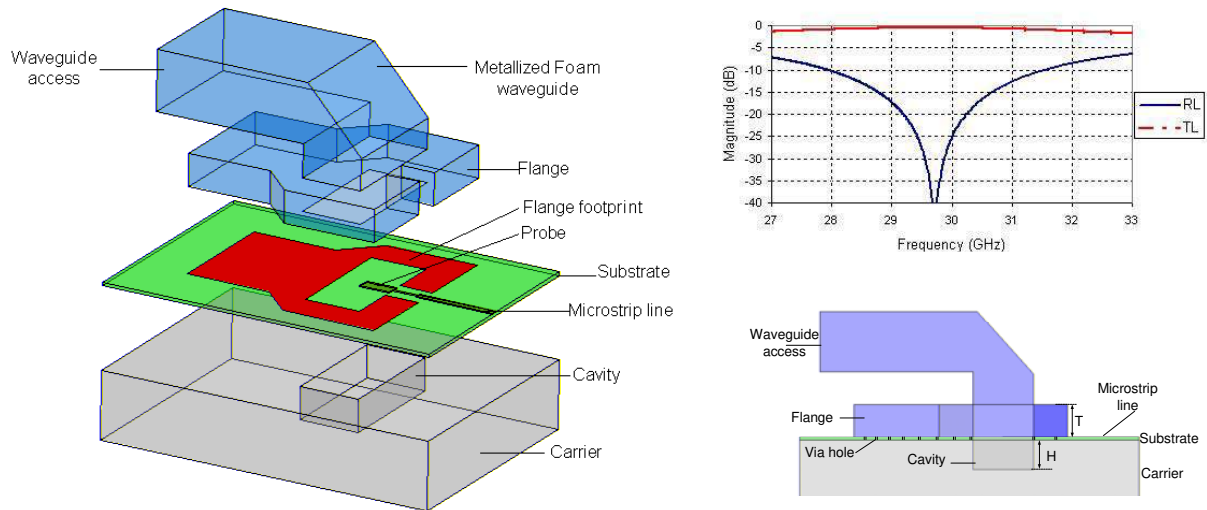


Fig. 1: The SMD microstrip to waveguide transition, before/after assembly.

To allow an experimental validation, the transition design has been also simulated in a back-to-back configuration, inserting a straight waveguide of 42 mm between two transitions. A Ka-band prototype of the transition is designed and fabricated in a RO4003 substrate ($\epsilon_r=3.51$, $\tan\delta=0.002$ at 30 GHz), and in a Rohacell HF71 foam waveguide ($\epsilon_r=1.07$, $\tan\delta=0.001$, [3]). Fig 2 depicts the realized prototype, and the implementation flexibility of the transition to be reported on the PCB with existing SMD MMICs. The simulated and measured insertion losses are respectively around 1.8dB and 2.5dB, and return loss better than 20dB (fig 2). The central frequency shift between simulation and measurement response is due to the manual assembling of the device.

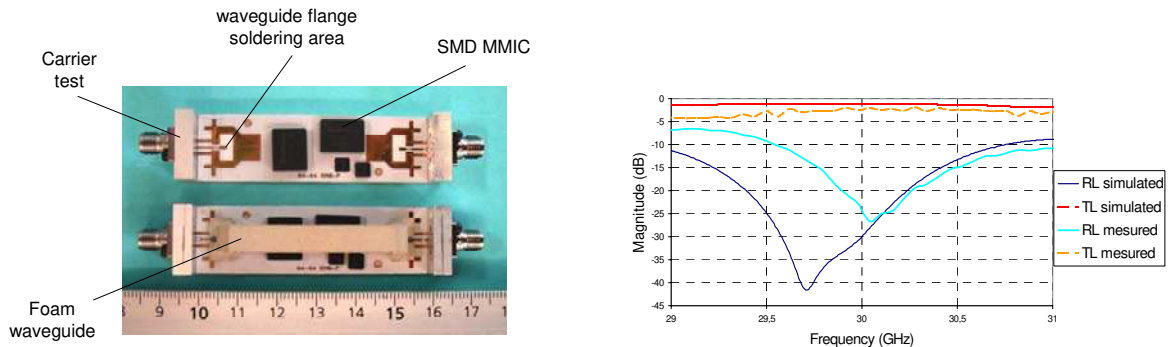


Fig. 2: prototype of the back-to-back microstrip-to-waveguide transition (cm) ; simulated and measured results.

Filter Integration

Once the new SMD transition validated, it has been applied for filter integration. The first design is a 3-pole bandpass filter made up by inductive iris coupled cavities and featuring a Chebyshev response. Fig.3 describes the dielectric foam waveguide filter with its two flanges that can be soldered onto the carrier test. The EM simulation with the microstrip input/output access lines shows insertion loss lower than 1.5dB, and return loss close to -20dB in the useful band.

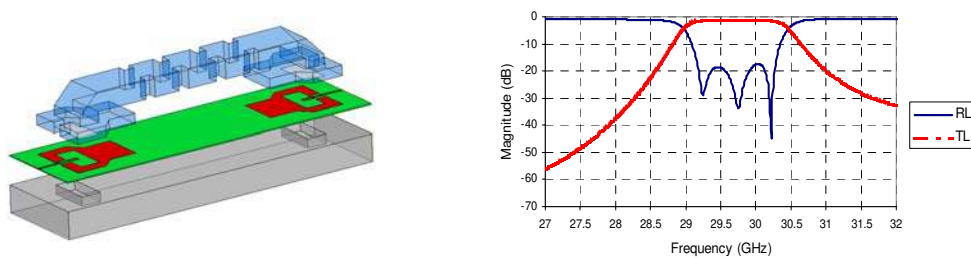


Fig. 3: The Chebyshev response SMD-type filter and relating simulated performances.

Fig. 4 shows another filter that features an asymmetrical transmission response. Two stubs have been added to the previous design in order to create two transmission zeros [6] and to provide 50dB attenuation around 28.5GHz, complying so with ETSI specifications. With this pseudo-elliptic response filter return loss around -18dB and insertion loss lower than 1.8dB in simulation.

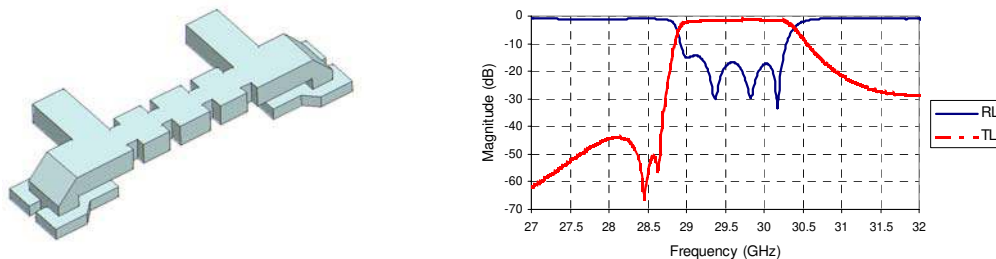


Fig. 4: The pseudo-elliptic response SMD-type filter and relating simulated performances.

Measured results of the both filters will be included in the final version of this paper.

Conclusion

A novel design and results of an SMD-type transition between a dielectric foam waveguide and a microstrip line have been introduced. This transition structure can be made of varied low-cost foam material and enables mass producible milled/molded designs. The proof-of-concept of this novel approach has been performed around 30GHz by the design of two SMD-type filters for VSAT applications. However, the transition presented will also permit interconnection of PCB to other 3D structures, such as orthomode transducer, feed, horn and antenna.

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