SU-8 Micromachining process for Millimeter and Submillimeter-wave Waveguide Circuit Fabrication

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I. Introduction And Background

There is an increasing interest in the millimeter and submillimeter-wave frequency range for various applications such as compact-range radar, biological detection and terahertz imaging. The frequency band for these applications is in the range of 300GHz to 3THz corresponding to a wavelength of 1mm to 100um. Below this frequency range transmission media such as microstrip and coplanar waveguide are widely used forms of transmission. However, as the frequency increases above 100 GHz these transmission media become very lossy. As a result, rectangular waveguides are used extensively because of their low loss characteristic. However, waveguide dimensions become smaller with increasing frequency therefore escalating the complexity and cost of fabrication with conventional machining techniques. This paper presents a fabrication technique that utilizes a combination of photolithography and mechanical lapping to achieve a micromachining process to overcome the limitations of conventional machining for realization of millimeter and submillimeter waveguide components.

In this work WR3.4 is chosen to characterize the fabrication process because of the availability of test equipment and relative ease of testing; however this technique is scalable to the Terahertz range as demonstrated by previous work [2]. A micromachined waveguide is fabricated that has the ability to mate with current off-the-shelf components that are available in the submillimeter-wave frequency range. This is achieved by using a flange fabricated by Custom Microwave Inc. that is then patterned with SU-8 columns to align the flange with the micromachined waveguides as shown in figure 1. One of the major concerns with mating to the waveguide block is the lack of intimate contact with the micromachined waveguide and standard flange. Typically pins are used to align the flange and screws are used to insure a tight fit with standard waveguide flanges. However this attachment method would greatly complicate the design of the micromachined waveguide. So, to mitigate this issue a photonic bandgap structure is patterned on the flange face to relax the requirements of the fit to the micromachined part. [1]. HFSS simulations are used to determine the effectiveness of the bandgap structures. As shown in figure 2 a gap of 20 μm can be tolerated and still

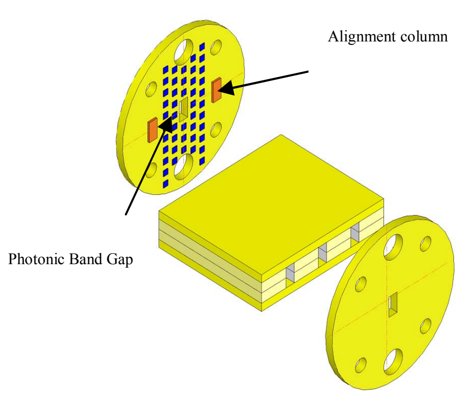

Figure 1: Illustration of the flange with photonic bandgap structures and the SU-8 micromachined waveguide.

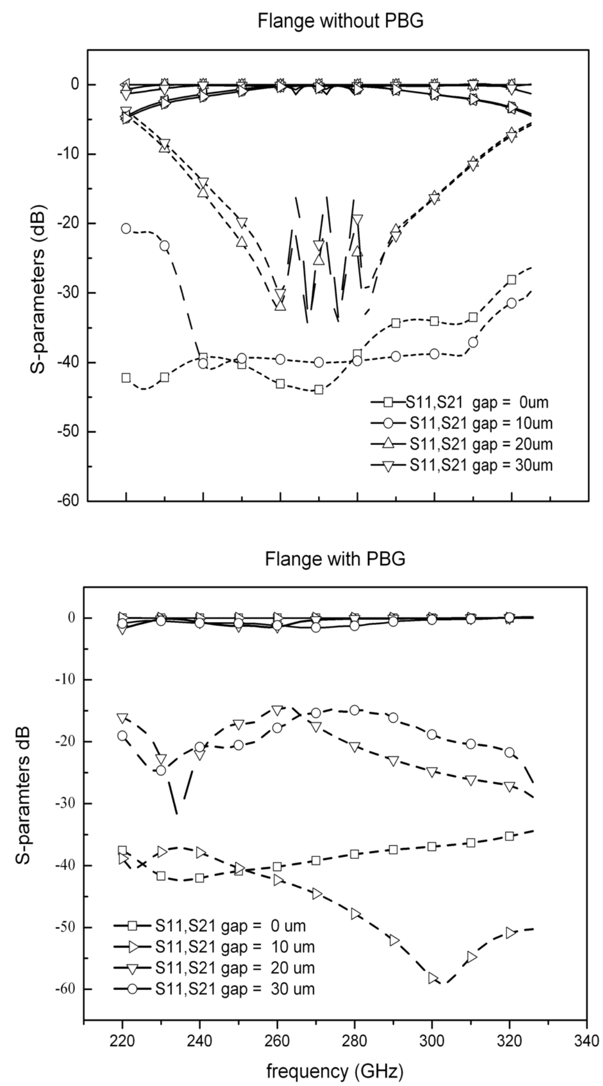

Figure 2: Simulations results of the flange with and without the photonic band gap structures.

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have a return loss below 15 dB. Therefore a screw tight fit will not be required to mate the SU-8 micromachined waveguide with the standard flange.

II. Fabrication

The fabrication process for the waveguide sections begins with spin cleaning a silicon wafer. Next an application of SU-8 photoresist is applied to the wafer. Following the

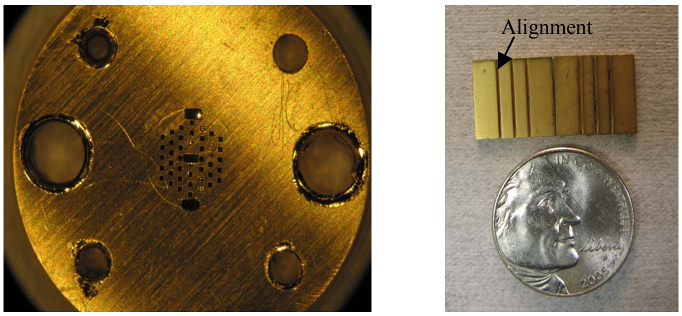

Figure 3: Photomicrograph of the flange and the WR 3.4 waveguide.

application, the SU-8 photoresist is exposed and developed. After completion of the development step, the patterned SU-8 photoresist is metalized. This process is also used to fabricate the photonic bandgap structure and alignment columns on the flange. Figure 3 is a photomicrograph of a fabricated waveguide section and flange. The alignment columns will be inserted in the alignment grooves in order to align the SU-8 waveguide to the waveguide opening of the standard metal flange.

III. Measurements

The SU-8 micromachined part will be assembled to the flange and measurements will be taken of the waveguide sections to characterize the micromachined waveguides.

IV. References

[1] Jeffery Hesler, “A Photonic Crystal Joint (PCJ) for Metal Waveguides,” 2001 IEEE MTT-s Digest. pp.783-786.

[2] Charlie H. Smith, Hiayoug Xu, and N. Scott Barker, “ Development of a multi-layer SU-8 process for terahertz frequency waveguide blocks,” Microwave Symposium Digest 2005 IEEE MTT-S International, June, 2005