A Broadband Waveguide Thermal Isolator

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This talk will describe the design and measurement of a WR-10 (75-110 GHz) waveguide thermal isolator. The isolator is based on the a recently developed photonic crystal joint (PCJ) [1], a periodic bandgap structure which suppresses microwave fields propagating between two parallel conducting surfaces. When such a bandgap structure is placed between a pair of waveguide flanges, the flanges can be separated by a few percent of a wavelength before the leakage and mismatch become significant. One advantage of this design over other thermal isolators [2-4] is that the PCJ is immune to cocking as long as the gap does not exceed a critical size.

A PCJ uses a periodic two-dimensional array of reflecting elements with a half-wave period at the center wavelength. For this application, an array of metal posts is machined on one flange face, as shown in Fig. 1(a). Simulations of the waveguide structure with various post spacings and gap widths were performed using Ansoft-HFSS and QuickWave. The simulated results shown in Fig. 2 indicate low leakage and return loss over the full waveguide band. The height of the posts is not critical, and the gap between the flanges has little effect on the results, up to some critical gap size. For WR–10 (inside dimensions 0.050" x 0.100") a gap as large as 0.007" was found acceptable for most applications. Measurements on a WR-10 thermal isolator will be presented at the symposium.

To ensure good alignment between the two waveguide sections while maintaining thermal isolation, they are glued into a thin walled G-10 glass-epoxy tube, as shown in Fig. 1(b). Differential contraction between the metal waveguide and the G-10 tube must be taken into account to ensure that the desired gap is obtained when the ends of the isolator are at the intended operating temperatures. Heat flow calculations will be given comparing the isolator with a stainless steel waveguide of equal length, with and without copper plating inside the waveguide to reduce its microwave loss. It is found that the G-10 supported isolator is thermally superior except when both ends are at very low temperatures (*e.g.*, 4-20 K); then the unplated stainless steel waveguide is superior (but has higher loss).

[1] J. L. Hesler, "A Photonic Crystal Joint (PCJ) for Metal Waveguides," *IEEE 2001 MTT-S Intl. Microwave Symp. Digest*, Phoenix, Arizona, June 21-25, 2001, pp. 783-786.

[2] K. Tomiyasu and J. J. Bolus, "Characteristics of a New Serrated. Choke," *IRE Trans. Microwave Theory Tech..*, vol. 4, no. 1, pp. 33-36, Jan 1956.

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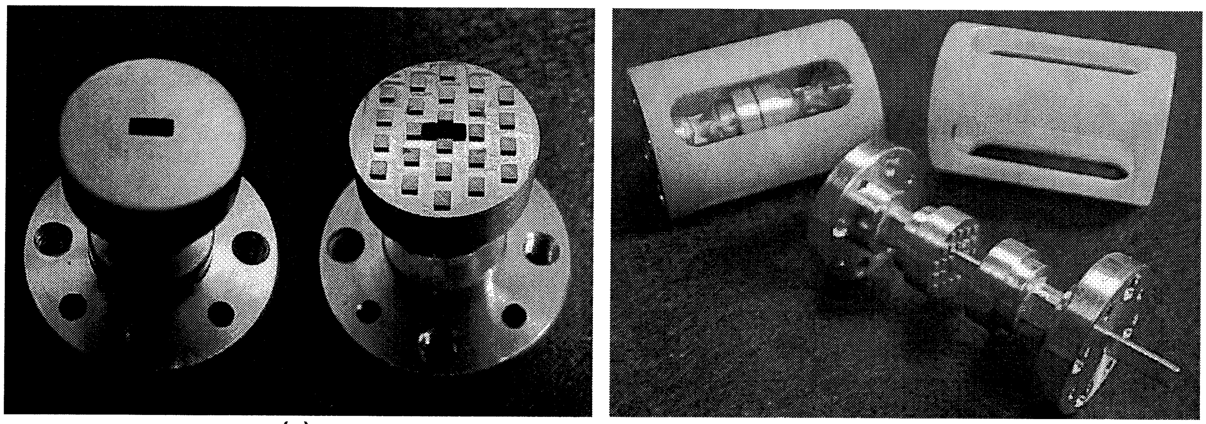
[3] S. Weinreb, H. Dill, and R. Harris, "Low-noise, 8.4 GHz, cryogenic GASFET front-end," VLBA Tech. Rep. no. 1, NRAO, Charlottesville, VA, Aug 1984.

[4] M. Davidovitz, "A Low-Loss Thermal Isolator for Waveguides and Coaxial Transmission Lines," *IEEE Microwave and Guided Wave Letters*, vol. 6, no. 1, pp. 25-27, January 1996.



(a) (b)

Fig. 1. (a) The two waveguide sections of the isolator, showing the flat flange and the flange with the periodic bandgap structure. (b) The assembled thermal isolator and the individual parts (the waveguide sections are shown on the alignment mandrel used during assembly).

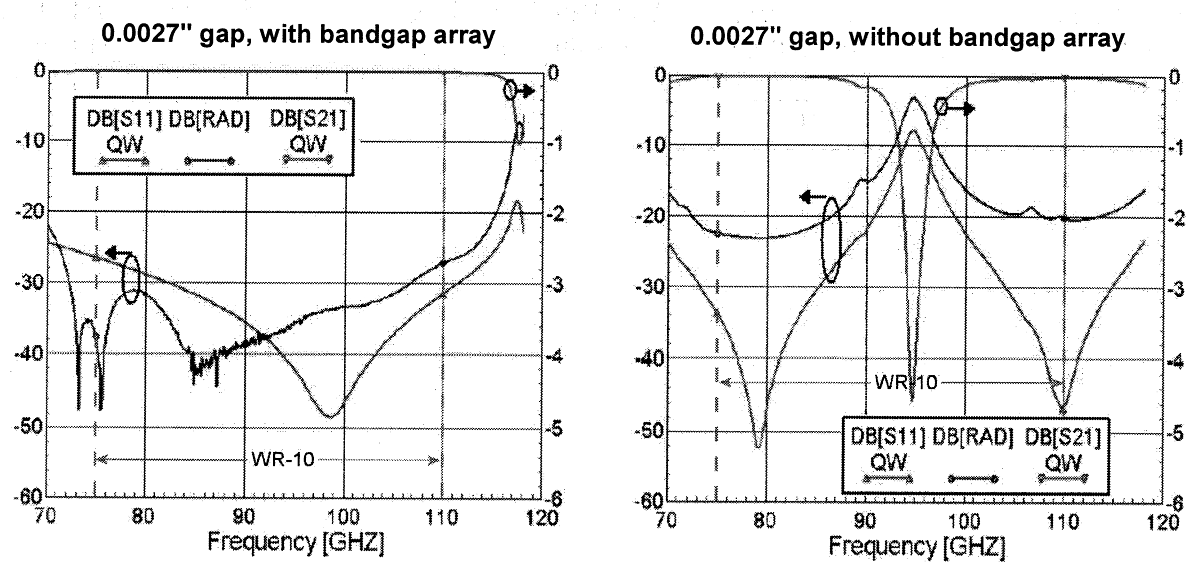


Fig. 2. Simulated characteristics of the thermal isolator with the periodic bandgap structure (left) and without the periodic structure (right). In both cases the gap between the flanges is 0.0027". Simulations using QuickWave: |S11| dB (—▲—), |S21| dB (—▼—), power radiated from gap dB (—◆—).