A Low-Loss Dielectric Waveguide Structure for Terahertz Applications

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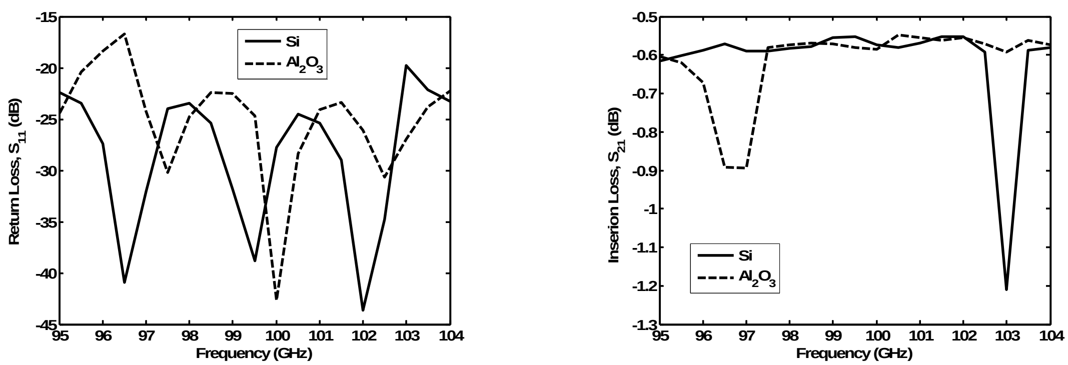
The most challenging issue in designing dielectric waveguide structures is to achieve high efficiency coupling into and out of the waveguides. The coupling efficiency becomes more important at the millimeter-wave and terahertz frequencies, where the available power from the sources is limited. In this paper, we present a dielectric waveguide structure with extremely low return loss and insertion loss at the millimeter-wave and terahertz frequencies. The proposed structure consists of a dielectric waveguide made of high dielectric constant and low loss materials, such as Alumina, high-resistive silicon, and GaAs, located above a dielectric support substrate, such as Teflon and Plexiglas. The power is coupled into and out of the waveguide by means of two metallic rectangular waveguides without any horn type extensions, which makes the metallic waveguide structure easy to fabricate and low-cost. Both the waveguide and the substrate are linearly tapered at the input and output ends to increase coupling efficiency and decrease losses due to reflection and scattering at the discontinuities. The taper length is optimized to have maximum coupling efficiency. The dielectric waveguide is designed to be single mode at the given frequency range in order to minimize the dispersion and to have maximum overlap between the field distribution inside the rectangular waveguide and that of the dielectric waveguide. The designed structures are simulated by the Ansoft HFSS software, a commercial full-wave electromagnetic simulator based on finite element method (FEM). Fig. 1 shows the S_{11} and S_{21} parameters of the designed structure for the frequency range of 95-104 GHz. The dielectric waveguide is made of Alumina with ε_r=9.8 and the loss tangent of $\tan\delta = 1.5\times10^{-4}$ and high-resistive silicon with ε_r=11.65 and the loss tangent of $\tan\delta = 2\times10^{-3}$. The dielectric support substrate is made of Teflon with ε_r=2.08 and the loss tangent of $\tan\delta = 6\times10^{-4}$. The dimensions of the waveguide are $a = b = 0.4$ mm, $L = 20$ mm, and $t = 5$ mm. The return loss is less than -20 dB over a 7 GHz bandwidth and the insertion loss is less than 0.9 dB.

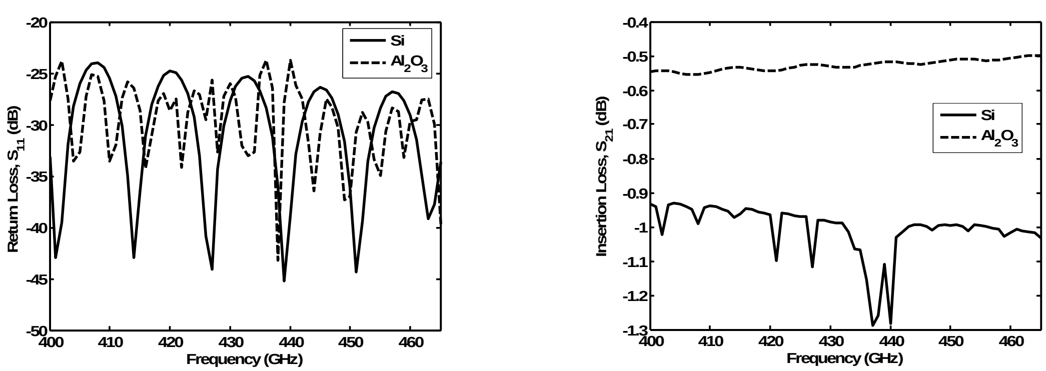
Shown in Fig. 2 are the S_{11} and S_{21} parameters for the frequency range of 400-465 GHz. At this frequency range, the loss tangent for Alumina is $\tan\delta = 6\times10^{-4}$ and for high-resistive silicon is $\tan\delta = 1\times10^{-3}$. The dimensions of the waveguide are $a = b = 0.15$ mm, $L = 20$ mm, and $t = 2$ mm. The structure shows 65 GHz bandwidth, over which the return loss is less than -24 dB and the insertion loss is less than 0.6 dB for Alumina waveguide and less than 1.3 dB for silicon waveguide.

The measurement and characterization of the device is under way.



(a) (b)

Fig. 1 (a) Return loss (b) insertion loss of dielectric waveguide made of Alumina and Silicon for 95-104 GHz



(a) (b)

Fig. 2 (a) Return loss (b) insertion loss of dielectric waveguide made of Alumina and Silicon for 400-465 GHz