Design and Loss Measurement of Substrate Integrated Waveguides at Terahertz Frequencies

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At Terahertz frequencies, integration is a key aspect in the development of the next generation of high-sensitivity receivers, for example, for multibeam receivers. In order to integrate superconductor- and/or semiconductor-based devices, receivers will require low-loss waveguides and passive components integrated on a substrate. Substrate integrated waveguides (SIWs) are a suitable candidate for new THz receivers, because of the easy transition to two-dimensional circuits (e.g. CPW, microstrip lines) and because they have the same fundamental propagation mode TE_{10} as a rectangular waveguide. In this frequency range, although SIW can be fabricated, it is difficult to characterize their electrical performance. Therefore, the design of a test fixture is necessary in addition to the design of the SIW.

We have designed a THz SIW and a test fixture to evaluate it. The SIW was designed using a 76-µm-thick quartz substrate with permittivity of 3.8 and loss tangent of 0.003 at 0.9 THz at room temperature. For the SIW, the diameter of all the plated-through holes was set to 45 µm and their spacing was chosen as 60 µm. The distance between the holes used as sidewalls is 187 µm. These agree with the design rule described in [1]. 2-µm-thick aluminum has been used for the top and bottom metallization of the substrate. The test fixture for the mount and evaluation of the SIW consists of waveguide flanges, impedance transformers, and waveguide to SIW transitions. In order to tolerate a small H-plane gap when the SIW is mounted on the test fixture, a groove gap waveguide was used as the transmission line of the test fixture [2]. The size of the waveguide is the same as WR-1.2 (0.304 mm x 0.152 mm), but the side wall is composed of periodically-placed metal pins.

We evaluated the SIW using a vector network analyzer in the frequency range of 0.8 to 0.9 THz with a dynamic range of more than 60 dB [3]. The test fixture including the SIW is put between the transmitter and the receiver and the insertion loss is measured. Three SIWs with lengths of 5.0, 8.7, and 11.6 mm were evaluated to determine the associated insertion loss. Results showed waveguide loss of about 3 dB/mm at room temperature. The loss is attributed to the imperfect shape of the through holes. Proper fabrication will improve the loss.

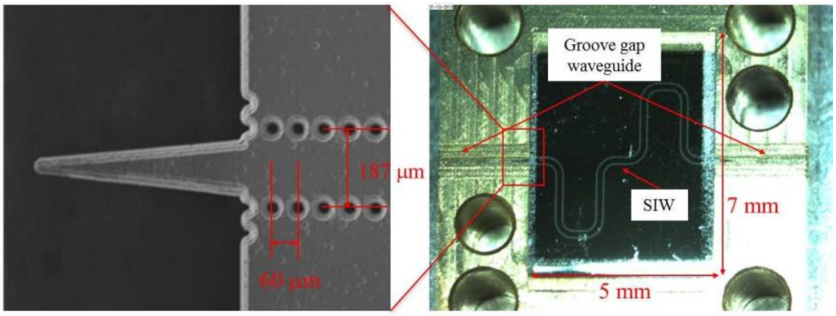

Fig. 1 A scanning electron microscope image of the SIW and optical microscope image of the test fixture including the SIW.

References
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