Design of NRD Guide at 94GHz band

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The NRD guide, consisting of rectangular-shaped dielectric strips inserted in a below cutoff parallel plate waveguide, features no radiation at curved sections and discontinuities in dielectric strips and has low loss nature at millimeter-wave frequencies. To realize fully-integrated dielectric circuits, the NRD guide was investigated at 35 GHz and 60 GHz, respectively, and was confirmed its usefulness. In this paper, we designed the NRD guide at 94 GHz, which is expected to applications such as several types of radars and imaging systems.

At first we decided the height and the width of the dielectric strip by calculating the design diagram of the NRD guide.

The non-radiating modes are classified into LSM and LSE modes, respectively. The LSM mode is characterized by the magnetic fields in parallel to the air-dielectric interfaces, while the LSE mode is characterized by the electric fields in parallel to those interfaces. Generally, the LSM mode is used as the operating mode of the NRD guide. The PTFE, having low loss nature at millimeter-wave frequencies, was assumed as the dielectric strip, whose relative permittivity and dielectric loss tangent are 2.04 and $1.5\text{x}10^{-4}$, respectively. Assuming that a and b are height and width of the dielectric strip, the cut-off curves of the LSM_{01} operating mode and LSE_{11} mode, being the first high order mode, were calculated.

In the dimensions, the bandwidth of the NRD guide is 17 GHz at a center frequency of 94 GHz.

Because the RF current flows in the only transverse direction, the conductive loss decreases with increasing frequency. The total transmission loss was small to be calculated at 9 dB/m at 94 GHz when the copper material with a conductivity of 5.8×10^7 S/m was selected as the parallel metal plates. Assuming the material of the parallel metal plates to be the conventional aluminum featuring the lightweight and toughness, the transmission loss was calculated to be 20 dB/m. Although the transmission loss was slightly higher than that using the copper material, it is extremely smaller than those of the printed transmission lines.

The next step of this study will be to fabricate the NRD guide at 94 GHz.