Measurement on Effective Conductivities on Over and Under Surfaces of Copper-coated Substrates at Millimeter Wavelengths

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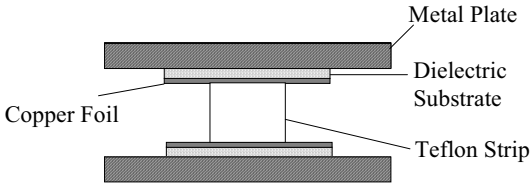
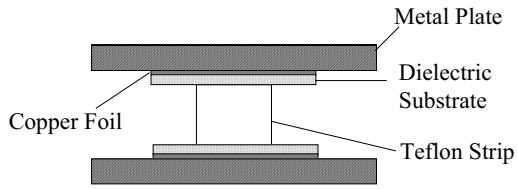
It was found out that conductivities of both surfaces of copper foils coated on dielectric substrates have different values at centimeter frequencies since the one side of surface of the dielectric substrate is roughened due to tight copper-coating (R. Takaichi, T. Aoki, and Y. Kobayashi, Tech. Rep. of IEICE, Vol. MW2003-141, No. MW2003-9, 2003). Having this fact in mind, we evaluated the effective conductivities of both sides of copper foil by measuring Q-factors of an NRD guide resonator at millimeter-wave frequencies. Figure 1 shows a structure of the NRD guide resonator which consists of Teflon strip sandwiched by copper-coated glass-Teflon substrate. In Fig. 1 (a), the over surface of the copper foil faced the NRD guide resonator, while the under surface of that faced the NRD guide resonator in Fig. 1 (b). In advance, the relative dielectric constants and loss tangents were measured to be 2.04 and 1.5 x 10^{-4} for the Teflon NRD guide resonator and to be 3.0 and 4.9 x 10^{-3} for the glass-Teflon substrate, respectively, and the conductivity of the metal plates consisting of the below-cutoff parallel metal plate waveguide was also measured to be 1.8 x 10^{7}. Based on this structure, we measured the unloaded Q factors and evaluated the effective conductivities at 10, 35, and 60 GHz. Figure 2 shows the measured results. It is obvious that the effective conductivities of both surfaces at 60 GHz degrade compared with that of the standard copper balk. The notable point is that the effective conductivity of the under surface more degraded compared with that of the over surface. This reason is considered that the under surface is roughened due to tight copper-coating. Having this fact in mind, the bilaterally metal-loaded tri-plate strip transmission line is a promising candidate for loss-reduced structure at millimeter-wave frequencies (F. Kuroki, Y. Omote, and R. Masumoto, Proceedings of National Radio Science Meeting, 2008).



(a) The over surface of the copper faced the NRD guide.



(b) The under surface of the copper faced the NRD guide.

Fig. 1 Cross sectional view of NRD guide resonators

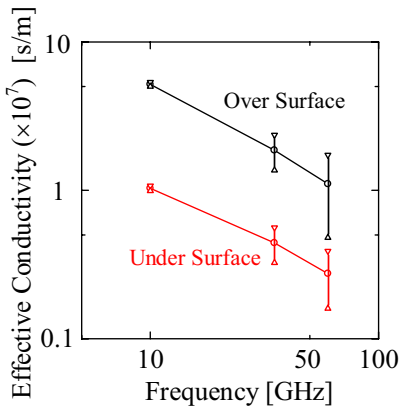


Fig. 2 Measured results