PROPAGATION CHARACTERISTICS OF MICROSTRIP TRANSMISSION LINE ON ROUGH DIELECTRIC SUBSTRATE SURFACE

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Abstract: The effect of surface roughness of dielectric substrates on the propagation characteristics of microstrip transmission line is investigated in this paper. Different models are used to simulate the surface roughness of the dielectric substrate. The versatile semi-analytical numerical technique, Method of Lines, is used here to compute the normalized phase velocity of a microstrip line as a function of frequency up to 200GHz. The preliminary results show that the root mean square height of the rough surface affects the propagation phase velocity of the microstrip line more than the shape of the roughness itself. Moreover, significant effect of the surface roughness is observed when the dielectric surface roughness extends beneath the metallic strip.

I. FORMULATION OF THE PROBLEM

The surface roughness of the dielectric substrate is modeled in different shapes either in one level as shown in Fig. 1a or in two levels as shown in Fig. 1b.

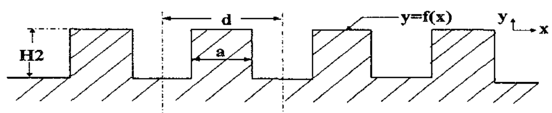


Fig. 1a, One level rough surface model.

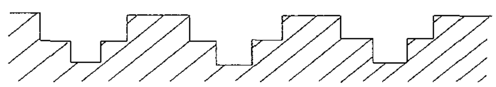


Fig. 1b, Two level rough surface model.

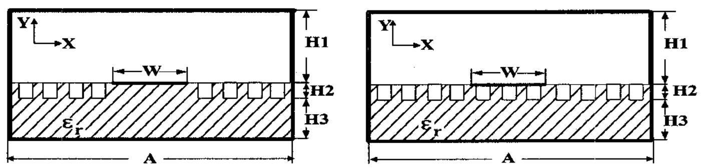
Considering the model shown in Fig.1a, the mean value of the height is defined as [1]:

$$\mu = \frac{1}{d}\int_{-d/2}^{d/2} f(x)dx = -\frac{(d-a)H_2}{d} \tag{1a}$$

and the root mean square deviation of the height from the mean value μ is defined as:

$$\Delta = \sqrt{\frac{1}{d}\int_{-d/2}^{d/2}\left(f(x)-\mu\right)^2 dx} = \frac{H_2}{d}\sqrt{a(d-a)} \quad (1b)$$

In all cases treated in this work, the surface roughness is assumed to consist of infinitely long parallel grooves in the dielectric substrate parallel to the microstrip line as shown in Fig. 2. In some cases, the roughness of the substrate extends beneath the strip as shown in Fig. 2b, [2]. The metallic strip is assumed to be perfect conductor of zero thickness and perfect smooth surface. The details of the method of lines (MoL) is not given here since it is well described in published literature [3].



(a) (b)

Fig. 2, Microstrip transmission line on rough surface dielectric substrate.

II. NUMERICAL EXAMPLES

The normalized phase velocity is plotted versus frequency for the microstrip transmission line shown in Fig.2. The width of the metallic enclosure is A=12.7mm, the width of the metallic strip is W=1.27mm, H1=11.43mm, H2+H3=1.27mm, and the dielectric constant of the substrate is $\varepsilon_r = 8.875$. The results are shown in Fig. 3, where the hollow circles represent the plane surface case (H2=0 and H3=1.27mm). For the two rough surface cases (solid circles and hollow triangles), the heights H2 and H3 are 100μ.m and 1.17mm, respectively. The results of Fig. 3 show significant effect of the surface roughness on the phase velocity especially when the roughness of the dielectric surface extends beneath the metallic strip as shown in Fig.2b. In Fig. 4, the normalized phase velocity is plotted versus frequency for different roughness heights from H2=0 to H2=100μ.m. The results show that the normalized phase velocity increases with the increase of the roughness height H2. Three different sets of values for d and a (shown in Fig. 1a) are defined as models 1, 2 and 3. They are d=4h and a=2h for model#1, d=6h and a=4h, for model#2, and d=5h and a=2h for model#3, where h=0.1104mm. Thus, the values of μ and Δ are -0.5H2 and 0.5H2, -0.33H2 and 0.47H2, and -0.6H2 and 0.49H2, for models 1, 2 and 3, respectively. The normalized phase velocities for those three models are plotted versus frequency in Fig. 5. The roughness height is H2=100μ.m for the three models. The results in

Fig. 5 show that there is no significant difference between the results of the three models. More investigations will be conducted especially on the two level rough surface model shown in Fig. 1b. In this work, the discretization distance used in the MoL technique is h=0.1104mm and the number of electric and magnetic lines on half the strip are 5 and 6, respectively.

CONCLUSIONS

The preliminary results show that the roughness of the dielectric substrate surface significantly affects the propagation phase velocity of the microstrip line especially if the roughness of the substrate extends beneath the metallic strip.

REFERENCES

[1]Samuel. P. Morgan, Jr., "Effect of Surface Roughness on Eddy Losses at Microwave Frequencies," Journal of Applied Physics, Vol. 20, pp. 353-362, April 1949.

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[3] Pregla, R., Pascher, W., Numerical Techniques for Microwave and Millimeter Wave Passive Structures, edited by: T. Itoh, (chapter 6), New York, Wiley, 1989.

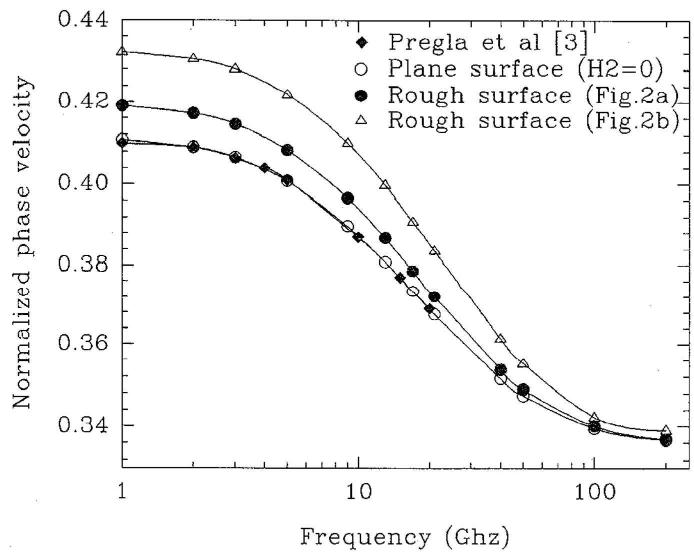

Fig. 3, The normalized phase velocity versus frequency, A=12.7mm, W=H2+H3=1.27mm, ϵ_r=8.875, H1=11.43mm, and H2=100μ.m. for rough surfaces.

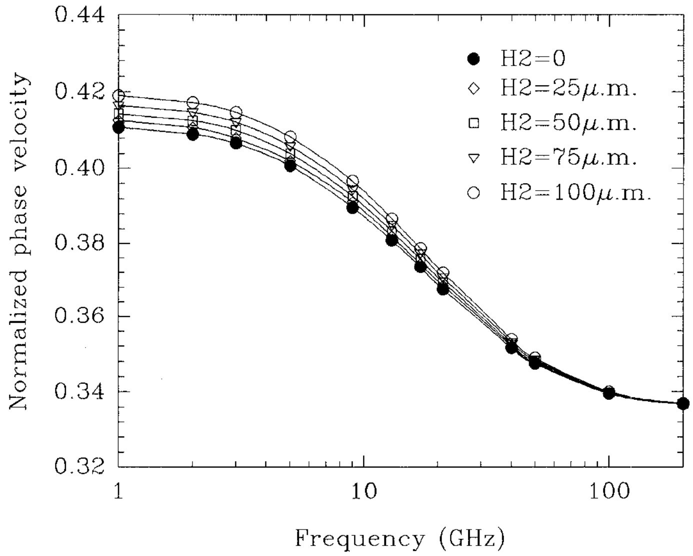

Fig. 4, The normalized phase velocity versus frequency, A=12.7mm, W=H2+H3=1.27mm, H1=11.43mm, and ϵ_r=8.875.

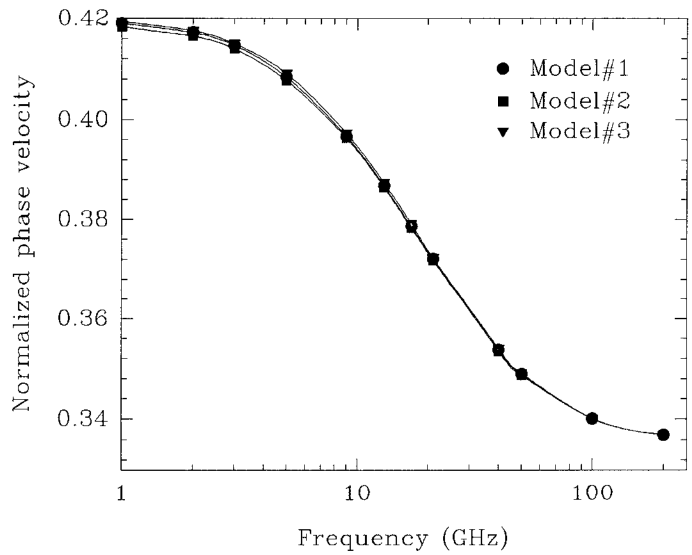

Fig. 5, The normalized phase velocity versus frequency, A=12.7mm, W=H2+H3=1.27mm, H2=100μ.m., H1=11.43mm, and ϵ_r=8.875.