Electrical Characterization of Interconnects on FlexTrate

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Introduction

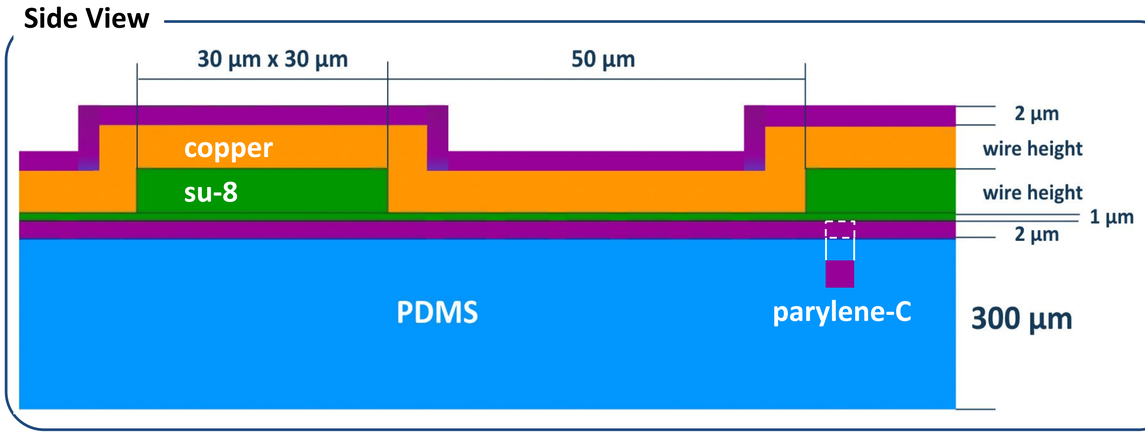
Goal: to characterize the electrical parameters of FlexTrateTM over a range of frequencies for different line widths/heights

- Achieved through simulation
- Over 0.1-5 GHz for interconnect behavior at high frequencies
- 5 µm, 10 µm, and 20 µm to cover range of valid fabrication widths

Simulation Set Up

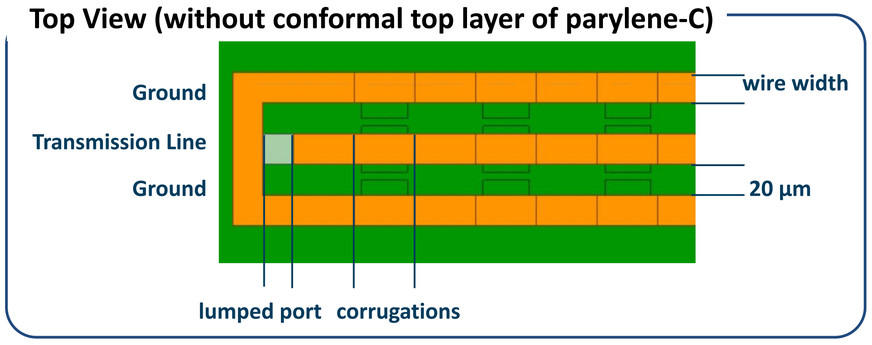
Full 3D Coplanar Waveguide Model in ANSYS HFSS

Side View



*not to scale

Top View (without conformal top layer of parylene-C)



Wire Width	Wire Height
2.5 µm	1 µm
5 µm	1 µm
10 µm	2.5 µm
20 µm	5 µm

Dielectric Constants Used (determined through research papers/production):

Material	Parylene-C **[1]**	Su-8 **[2]**	PDMS **[3]**
Dielectric Constant (K)	3.1	2.85	2.75

[1] https://vsiparylene.com/parylene-properties/
[2] Ayad Ghannam, e.g., EuMC, 2009
[3] N. J. Farcich, e.g., IEEE Transactions on Microwave Theory and Techniques, 2008

Simulation Settings

- Driven terminal solution type with 50 Ω port impedance for each width/height

Conversion to RLGC

Conversion:

- Matlab script converts Z-parameter simulation results to RLGC using following equations:

Script Verification:

- comparison of hand-calculated RLGC results with converted z parameters of simple microstrip line to verify accuracy of code
- lengths: 1 mm, 10 mm, and 100 mm

$$\bar{T} = \begin{bmatrix} \bar{A} & \bar{B} \\ \bar{C} & \bar{D} \end{bmatrix} = \begin{bmatrix} \bar{Z}_{11}\bar{Z}_{21}^{-1} & \bar{Z}_{11}\bar{Z}_{21}^{-1}\bar{Z}_{22} - \bar{Z}_{12} \\ \bar{Z}_{21}^{-1} & \bar{Z}_{21}^{-1}\bar{Z}_{22} \end{bmatrix}$$

$$M_1 = \left(YX^{-1} + XY^{-1}\right)\left(XY^{-1} - YX^{-1}\right) \qquad M_2 = \left(XY^{-1} - YX^{-1}\right)^{-1}$$

$$X = T_1 + T_2 \qquad Y = T_1 - T_2 \qquad \bar{l} = l_1 - l_2$$

$$M_1 = \begin{bmatrix} A_{M1} & B_{M1} \\ C_{M1} & D_{M1} \end{bmatrix} = \begin{bmatrix} \cosh(\gamma\bar{l}) & 0 \\ 0 & \cosh(\gamma\bar{l}) \end{bmatrix}$$

$$M_2 = \begin{bmatrix} A_{M2} & B_{M2} \\ C_{M2} & D_{M2} \end{bmatrix} = \begin{bmatrix} 0 & \frac{1}{2}Z_0\sinh(\gamma\bar{l}) \\ \frac{1}{2}\sinh(\gamma\bar{l})Z_0^{-1} & 0 \end{bmatrix}$$

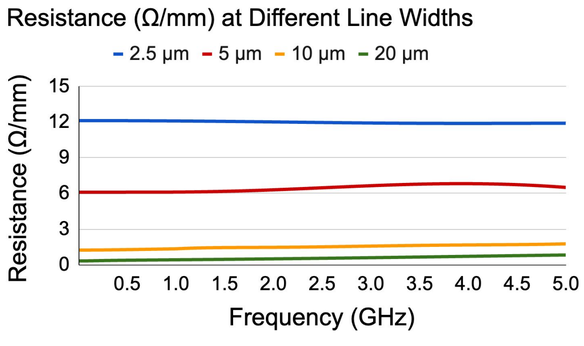
$$\gamma = \frac{1}{\bar{l}}\cosh^{-1}(D_{M1}) \qquad Z_0 = \frac{1}{2}C_{M2}^{-1}\sinh(\gamma\bar{l})$$

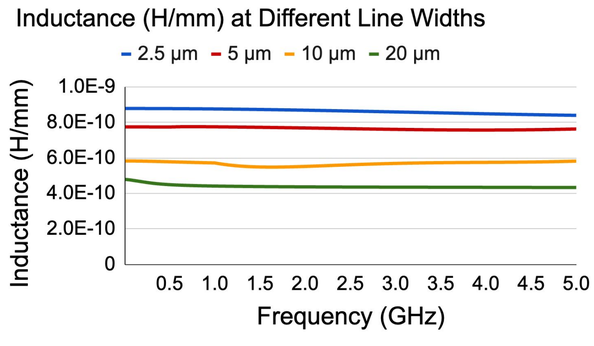
$$R_m(\omega) = Re(Z_0\gamma) \qquad L_m(\omega) = \frac{1}{\omega}Im(Z_0\gamma)$$

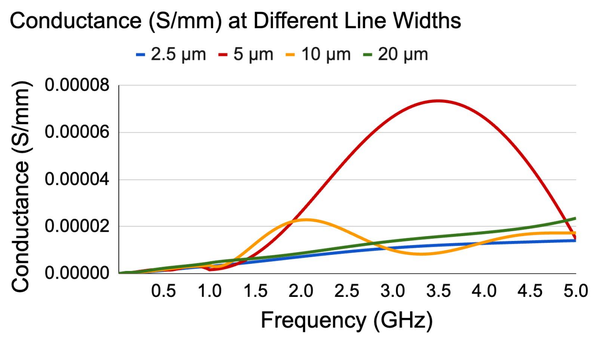
$$G_m(\omega) = Re(\gamma Z_0^{-1}) \qquad C_m(\omega) = \frac{1}{\omega}Im(\gamma Z_0^{-1}) \quad [4]$$

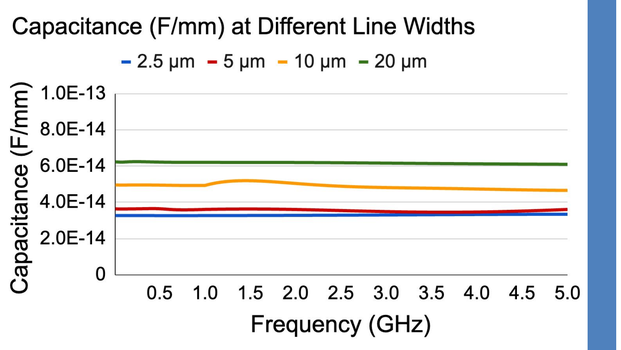
[4] M. K. Sampath IEEE-EPEP 2008

RLGC Graphs for Each Line Width







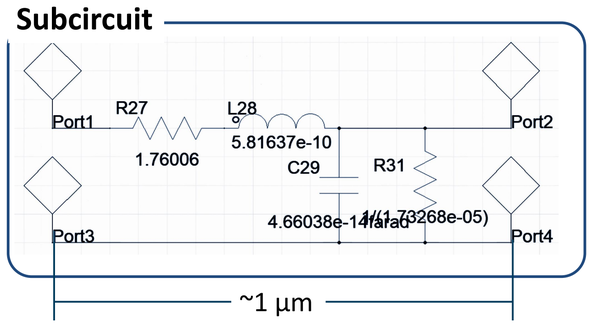


RLGC Verification

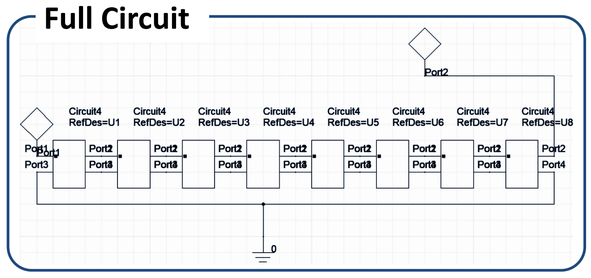
Confirming RLGC Simulation Results:

- Model of transmission line (~8 µm) with SPICE RLGC circuit in HFSS

Subcircuit

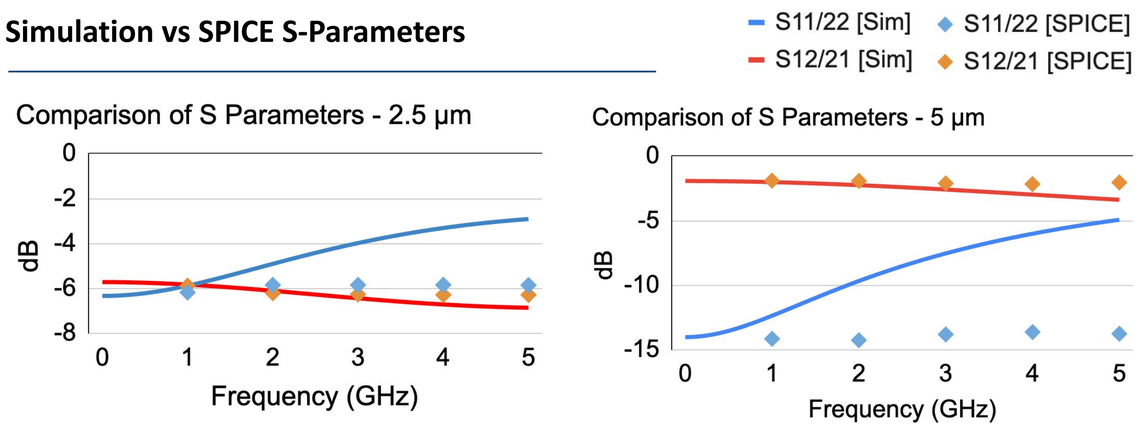


Full Circuit



- Circuit solved for S-parameters at 1, 2, 3, 4, and 5 GHz for each wire width/height pair

Simulation vs SPICE S-Parameters



- Insertion loss from the simulation is similar to the SPICE model for all line widths
- Reflection from simulation starts around the same value as SPICE model before large deviation

Conclusions and Future Work

- The electrical parameters of the interconnects of FlexTrate are reasonably found through simulation and verified through circuits
- Will fabricate samples and measure RLGC experimentally for further verification
- Data is to be applied in Design Manual for FlexTrate

Acknowledgements

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