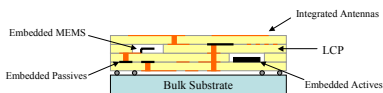


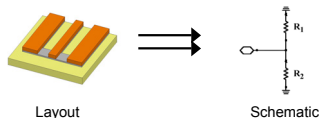
Low Cost Thin Film Resistors for Microwave Applications

Stephen Horst, Swapan Bhattacharya
Faculty Advisors: Manos Tentzeris, John Papapolymerou

RF SOP Concept on LCP



Basic DC Resistance Calculation

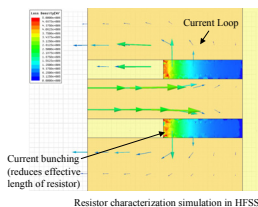


For 25 Ω/sq material:

25||25 = 12.5 Ω 50||50 = 25 Ω 75||75 = 37.5 Ω 100||100 = 50 Ω

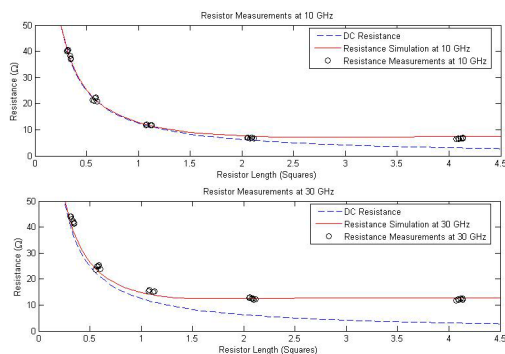


High Frequency Simulations



- High frequency effects:
- Parallel plate capacitance
 - Skin effect
 - Current bunching
 - Conductor and dielectric losses
 - Series inductance parasitics

DC and RF Measurement Variation



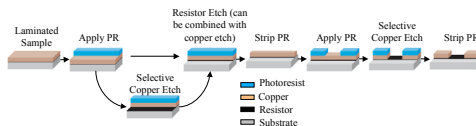
Two alternative low cost fabrication approaches



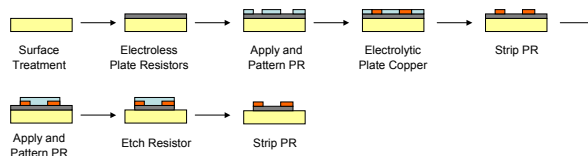
Thermocompression bonding adheres the foil to LCP

Foil Transfer Process

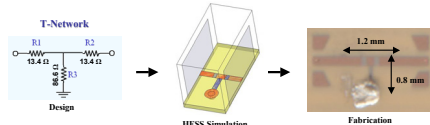
Commercially available for analog applications



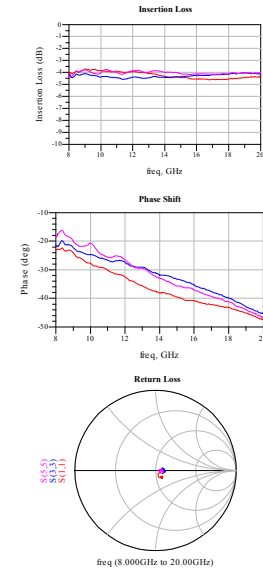
Electroless Plating Process



Resistor Application: Attenuator



Measurements of three attenuator samples



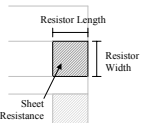
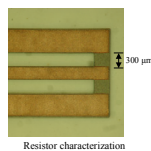
Processing Variations and Measurements

Measured sheet resistance on 25 Ω/sq material ranged from 25.7 to 27.0 Ω/sq. The higher values are expected due to lamination process

Resistor Size (LxW)	Physical Dimensions (LxW) μm	Ideal DC Value (25 Ω/sq)	Average Error	Standard Deviation
4x1	1200x300	3.125 Ω	3.06 %	2.795
2x1	600x300	6.25 Ω	3.57 %	2.397
1x1	300x300	12.5 Ω	2.19 %	1.708
1x2	150x300	25 Ω	11.45 %	2.903
1x4	75x300	50 Ω	21.14 %	3.617

Characterization Structures

Simulated Characterization Options



Future Work

- Wilkinson power dividers at millimeter wave frequencies
- Variable Attenuators using MEMS
- Low noise amplifiers using resistors to increase stability

Characterization Measurements

