Multiband Integrated RF/Wireless Functions For 3-D System-On-Package Technology

> J. Papapolymerou, M.M.Tentzeris S.Bhattacharya and D. Anagnostou

> > <u>RF Alliance PRC,</u> School of ECE, Georgia Institute of Technology Atlanta, GA 30332, U.S.A.

[papapol@ece.gatech.edu]



Motivation: Emerging Applications

- RFIDs (13.56 MHz, 915 MHz)
- UWB systems (3-10GHz)
- Remote Sensing (14/35 GHz)
- 27.5-31.3 GHz LMDS
- 38 GHz unlicensed -----
- 59-66 GHz unlicensed
- 77 GHz collision avoidance and parking assistance
- 94 GHz military 🛶

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Enabling Technologies in the future



Ultra-compact Module Technologies for RF wireless systems



I. High-read Range High-efficiency Read/Write UHF RFID Antennas and Chips Embedded in/on Flexible LCP Substrate

Motivation:

- How to build improved performance RFID tags embedded in/on various substrates?
 - 1) Optimized matching networks
 - 2) Directivity/Gain enhancement (Dual radiating bodies)
 - 3) Single and Dual polarized antennas









Dual radiating Body (W=43mm, L=60.8mm)



Antennas fabricated on 12 in x 12 in LCP Film (Single and Dual Polarized W,L=76.2 mm)





II. UWB Antennas on Flexible Substrates



II. UWB Antennas on Flexible Substrates (Results)



III. RF MEMS Switch on LCP



The springs anchor the membrane to the finite ground coplanar waveguide's (FGC's) ground planes [not shown]. A special process was developed to fabricate the MEMS switches on and LCP substrate.

Dark brown – electroplated gold Yellow – evaporated gold



Packaged Cavity over Air-Bridge MEMS Switches

Stack package and MEMS substrates over alignment pins



2 mil deep lasermicromachined cavities on the underside of the packaging layer are aligned over an LCP substrate with MEMS switches. Measurements are made through the feedthrough holes.



MEMS Switch in "UP" State



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 S_{21} should be as close to 0 dB as possible (full signal transmission) – Less than 0.5 dB up to 35 GHz

S₁₁ should be as low as possible (minimal reflection) – Less than -10 dB up to 35 GHz

The switch performs nearly identically with an without the LCP package layer!

MEMS Switch in "DOWN" State



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 S_{11} should be as close to 0 dB as possible (perfect reflection)

S₂₁ should be as low as possible (minimal transmission) – 50 dB @ 27 GHz, 20 dB @ 35 GHz

The switch performs nearly identically with an without the LCP package layer!

Fabricated 4-bit Phase Shifter



Capable of phase shifts from 0° to 337.5° in 22.5° increments Georgia Institute of Technology

Packaged 4-bit Phase Shifter



14/35 GHz Dual-Pol Antenna Arrays

- 14 and 35 GHz are frequencies identified by NASA for rain and snow sensing from space
- The multilayer LCP capability allows both arrays to be contained in a common substrate
- LCP has the unique property of being flexible which could allow rollable antenna arrays that are rolled into tubes and deployed once in space

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Conformal arrays

14

14/35 GHz Antenna Arrays





14.5

Frequency [GHz]

15

13.5

14

16

15.5

LCP Micromachining for Embedding RF Actives



Resistors on LCP for Broadband Applications



Measurements of 4 square long resistor using 25 Ω /sq foil (DC value 3.2 Ω)



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RF Termination and Termination Model



Measurements of 1 square long resistor using 25 Ω /sq foil (DC value 12.5 Ω)

Sample resistance vs Frequency, NiCrAlSi resistors

S. Horst, S. Bhattacharya, J. Papapolymerou, M. Tentzeris, ECTC 2006

Termination Structures for Integrated Couplers

• Three design steps to incorporate embedded terminations



1. Characterize Resistors

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(4 port coupler shown)