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March 9, 2009
Session# 7.08 Miniaturization and Advanced Electronics Packaging for Spacecraft
Pres #: 7.0801
Paper ID: 1077
Rm: Jefferson
Time: 8:50pm

Electrical Characterization of a Novel Coaxial Die-to-Die Interconnect

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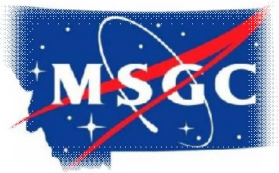
Department of Electrical and Computer Engineering



Motivation

High Density, High Performance Packaging

- Miniaturization & reliability in aerospace packaging is paramount
- Stacked Die and System-in-Package are emerging
- These systems have significant upside performance potential

Emerging Technologies in Aerospace

1) Stacked Die
   - *Vertical integration saves footprint impact*

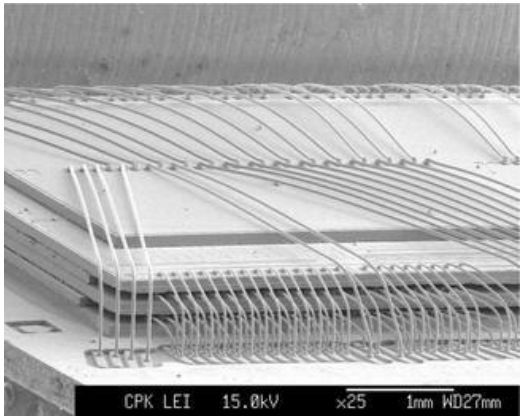
2) System in Package
   - *Multiple components in one package reduces board-level interconnect*

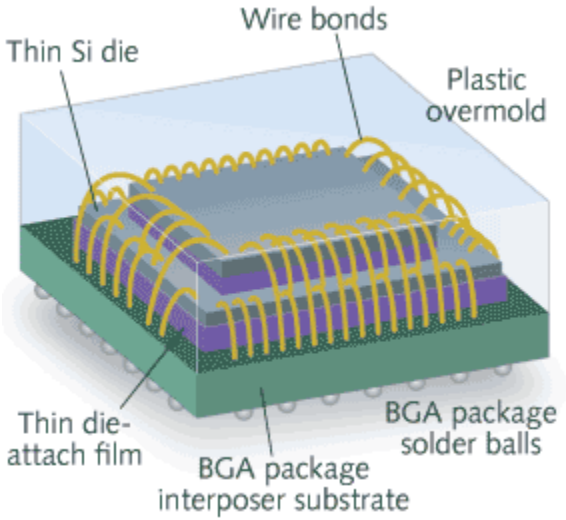
Motivation

Drawback of Advanced Packaging

Unshielded interconnect leads to electrical noise:

1) impedance discontinuities
2) cross-talk
3) ground bounce

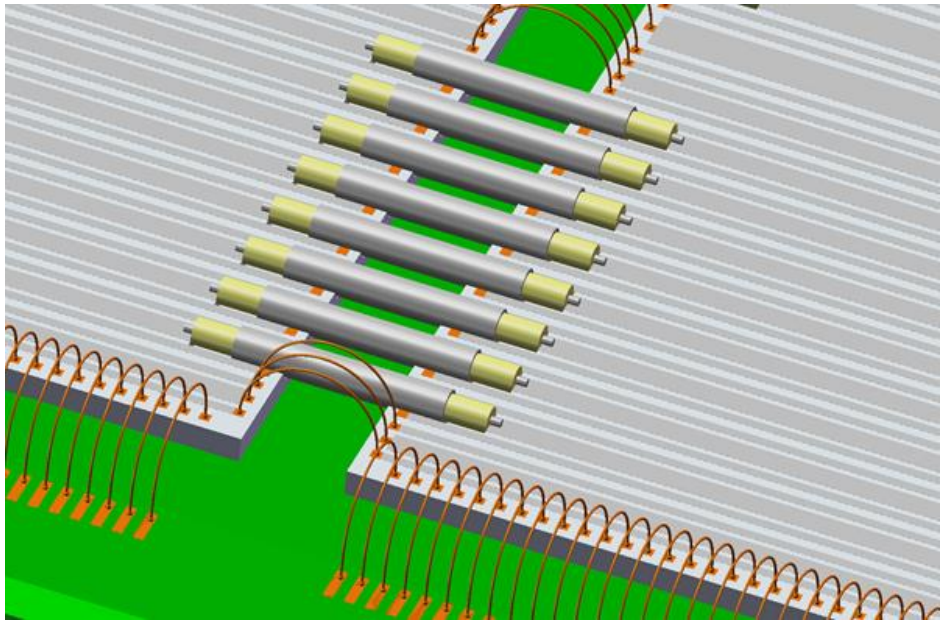




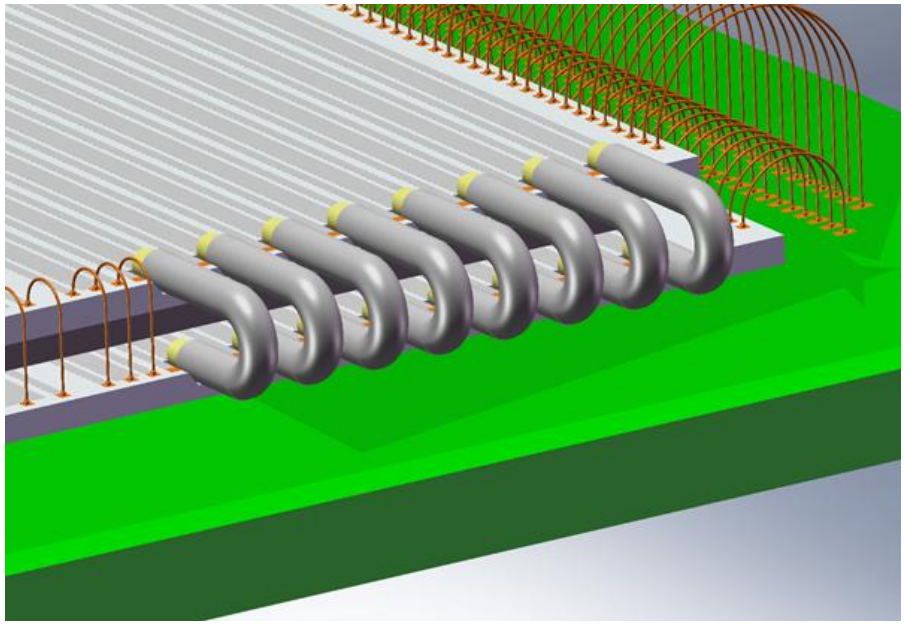
Our Approach

A New Die-to-Die Coaxial Interconnect System

- Ideal for multiple dies within one package
- Selectively added to high speed nets



Adjacent Dies



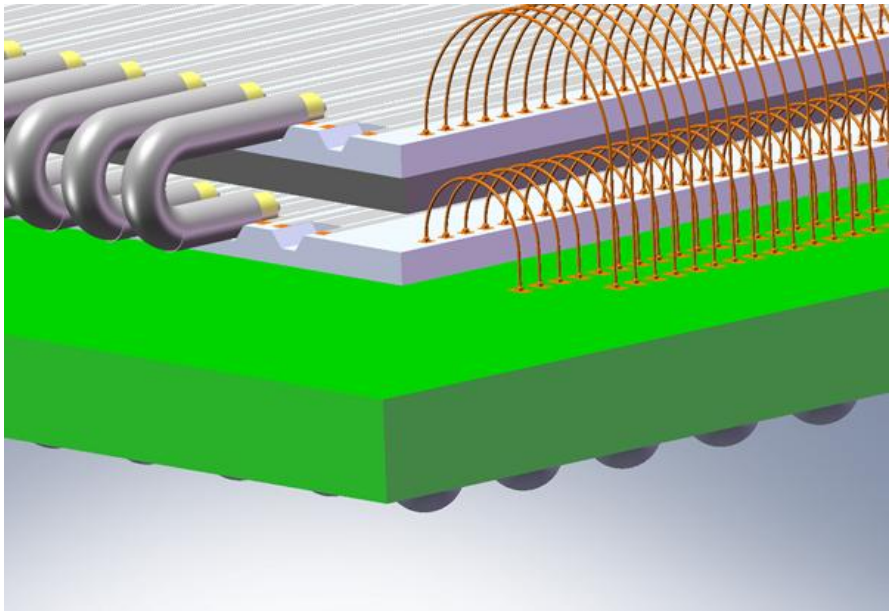
Stacked Dies

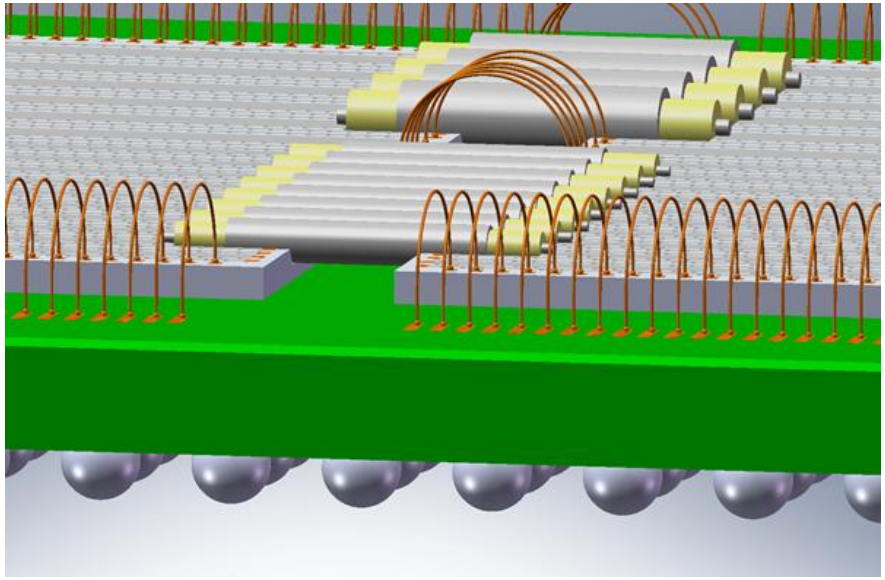
Our Approach

Electrical Advantages

Shielded Interconnect leads to:

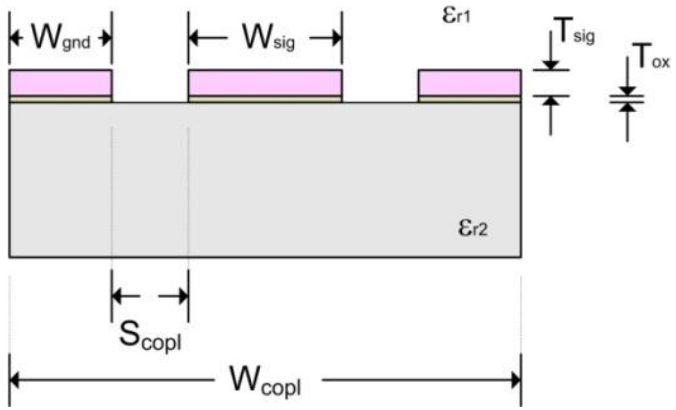
1) Controlled Impedance
2) Cross-talk Avoidance
3) Ground Bounce Reduction



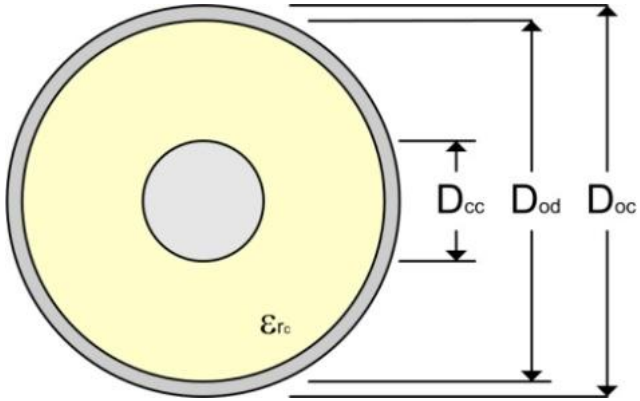


System Design

On and Off Chip Controlled Impedance



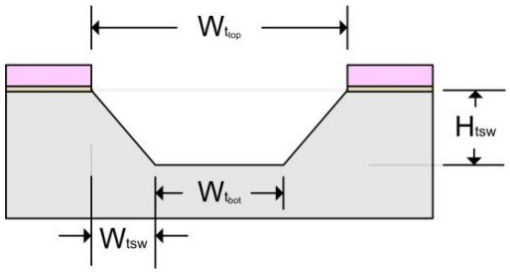
On-Chip Coplanar Transmission Lines

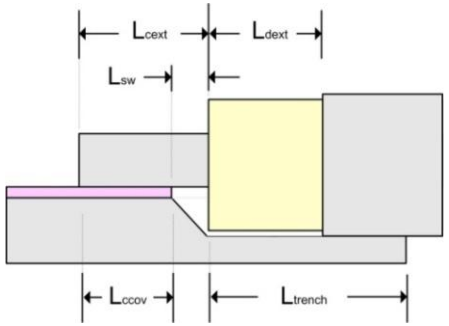


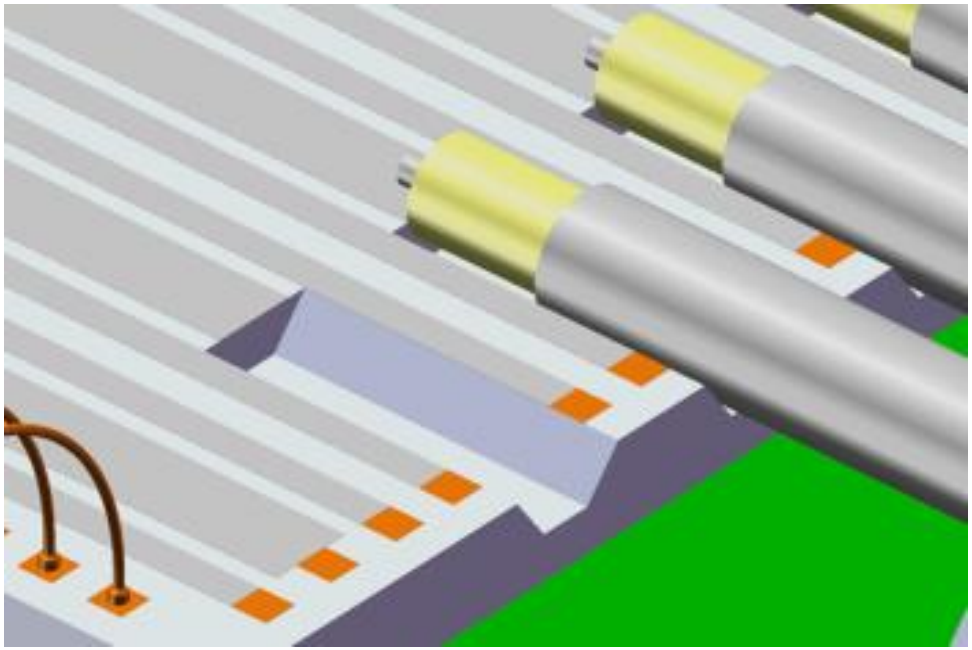
Off-Chip Miniature Coaxial Cables

System Design

Etched Trench Allows Interface Between On and Off Chip Interconnect





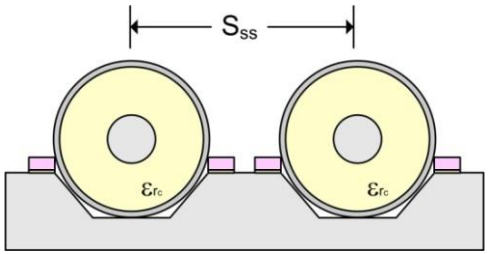


System Design

Critical Dimensions

Coax Cable Diameter

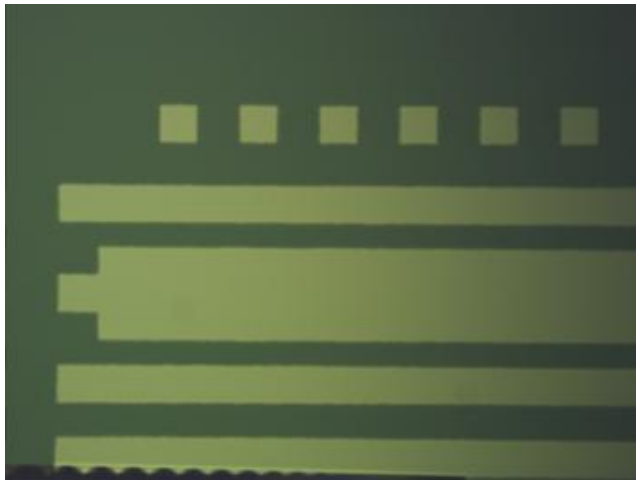
UT-013 = 330um
UT-013 = 584um

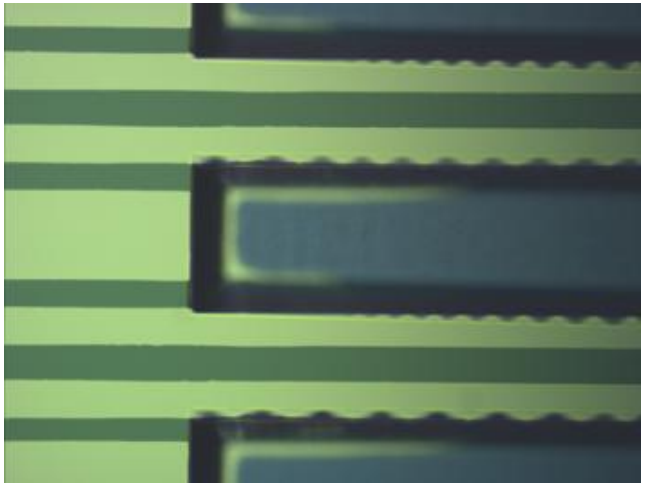


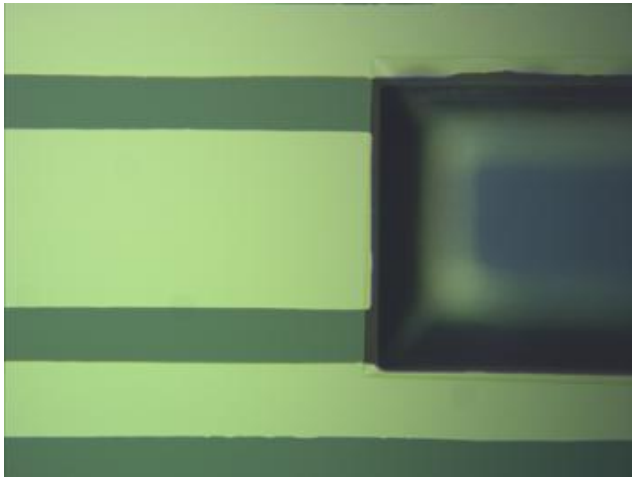
Region	Parameter	Units	Coaxial Line	
			UT-013	UT-020
Coaxial (ε_{rc}=2.1)	D_{oc}	µm	330	584
	D_{od}	µm	254	419
	D_{cc}	µm	79	127
Coplanar (ε_{r1}=1) (ε_{r2}=11.7)	T_{sig}	µm	1	1
	T_{ox}	µm	1	1
	W_{sig}	µm	190	400
	W_{gnd}	µm	100	100
	S_{copl}	µm	65	85
	W_{copl}	µm	520	770
	S_{ss}	µm	620	870
Trench	W_{ttop}	µm	320	570
	W_{tbot}	µm	300	530
	W_{tsw}	µm	10	20
	H_{tsw}	µm	123.5	226.5
Transition	L_{trench}	µm	900	900
	L_{dext}	µm	400	400
	L_{sw}	µm	10	20
	L_{cext}	µm	100	100
	L_{ccov}	µm	90	80

Fabrication

- Dies created at the *Montana Microfabrication Facility*

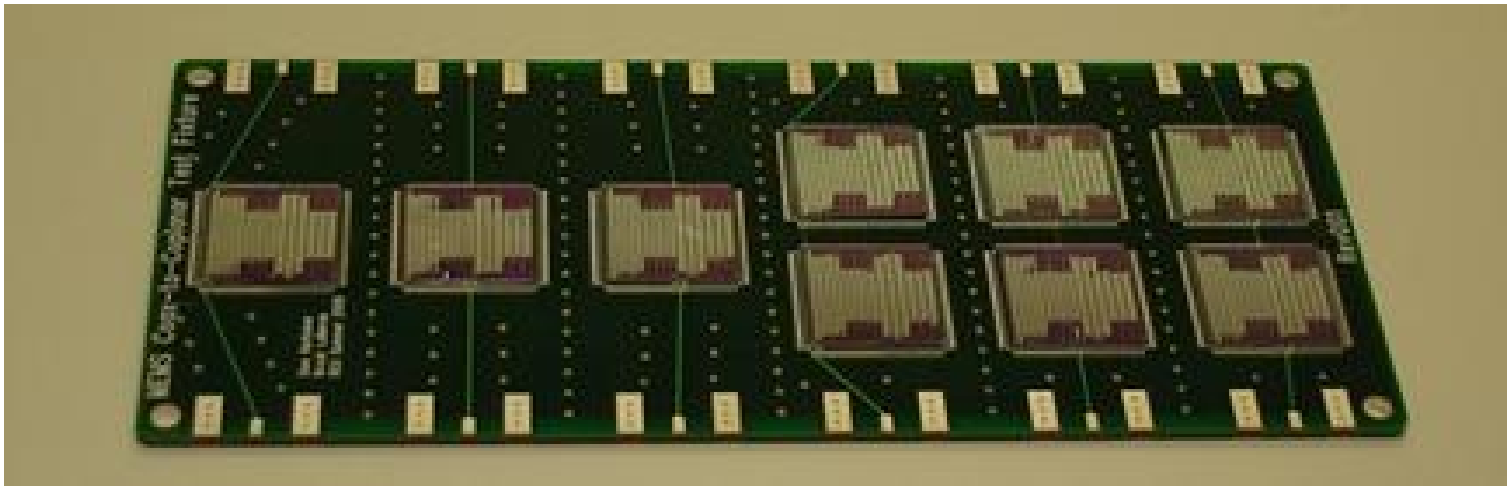


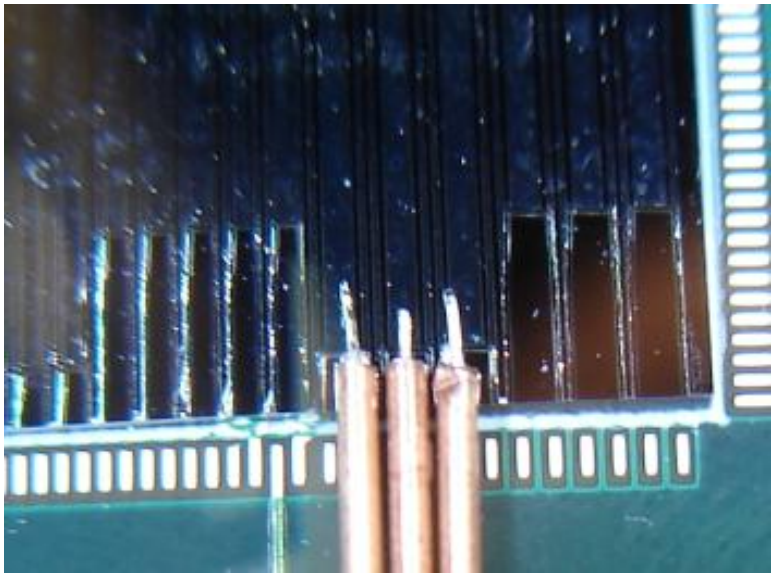


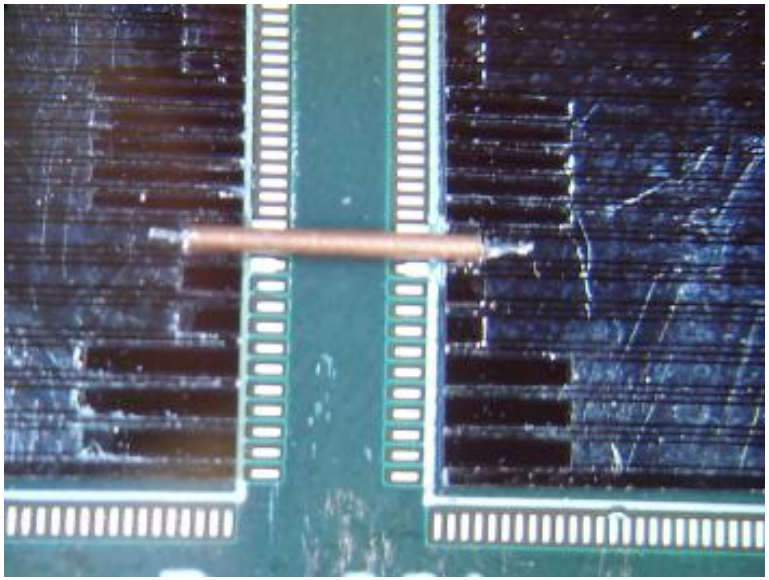


Fabrication

- A test board was created to test Board-to-Die and Die-to-Die Performance

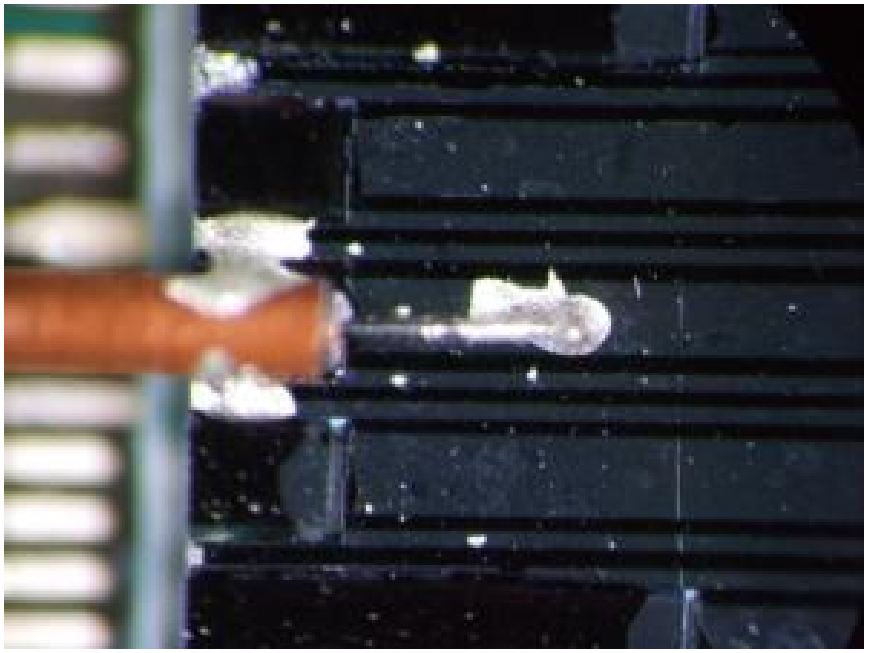


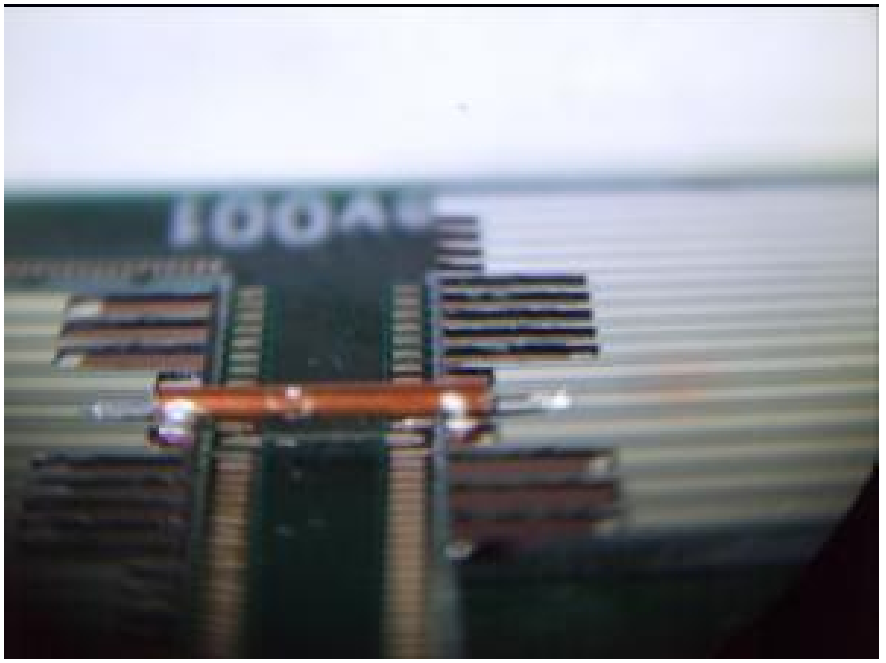




Fabrication

- Assembly of coaxial system accomplished with conductive silver epoxy

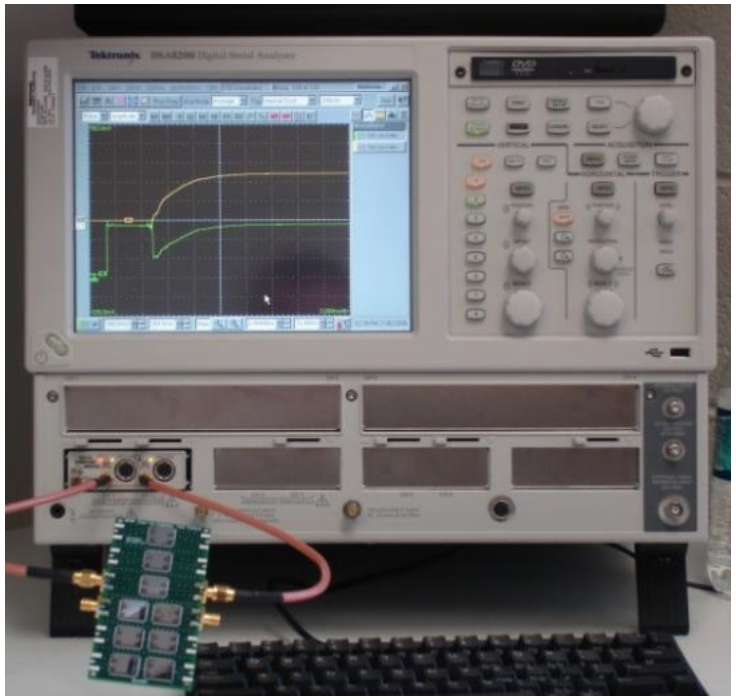




(*EPO-TEK® H2OE)*

Test Setup

- Time Domain Reflectrometry (TDR) and Transmission (TDT) was used to measure the performance of a wire bonded and coaxial system

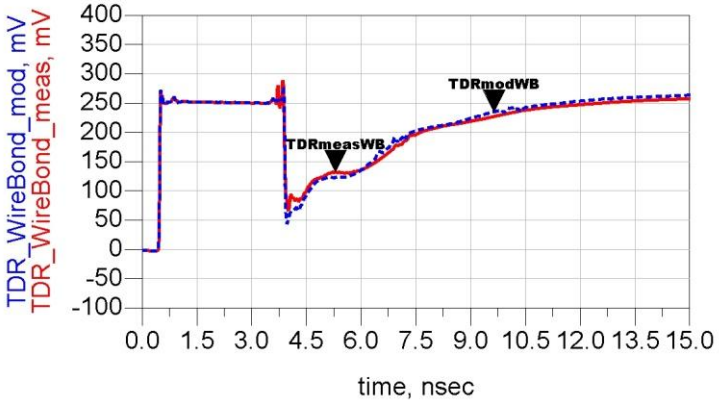


Equivalent Modeling

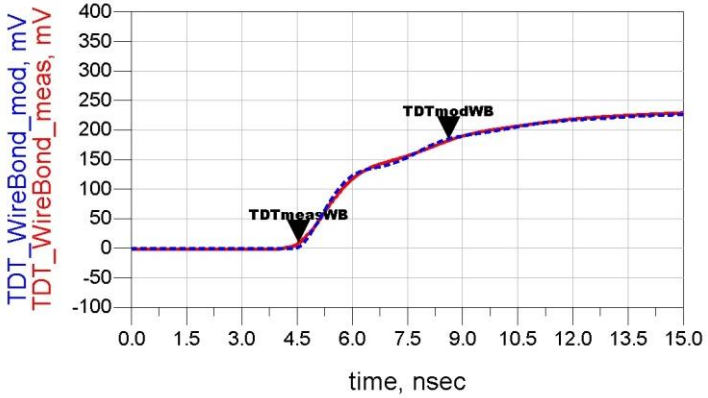
- Equivalent SPICE Models were created to match measured results

Wire bonded System

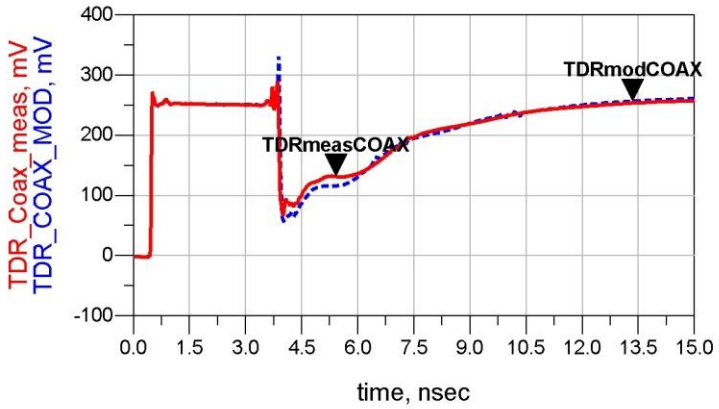
TDR

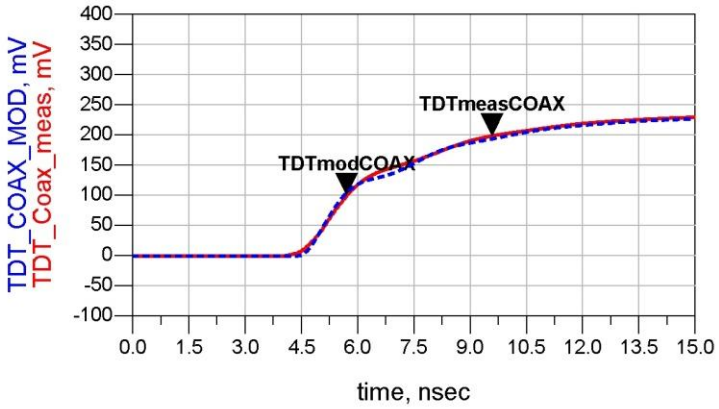


TDT



Coaxial System

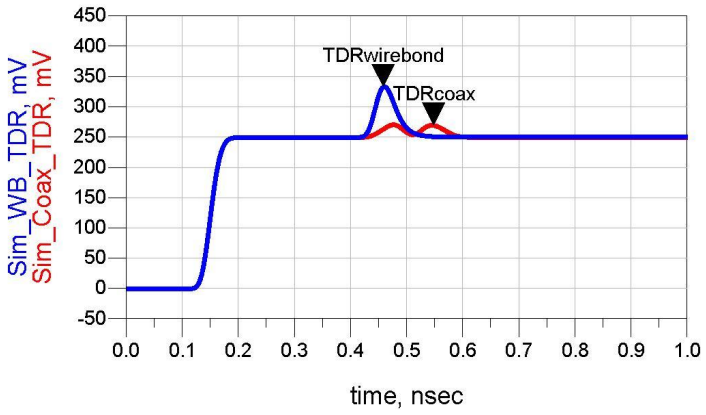


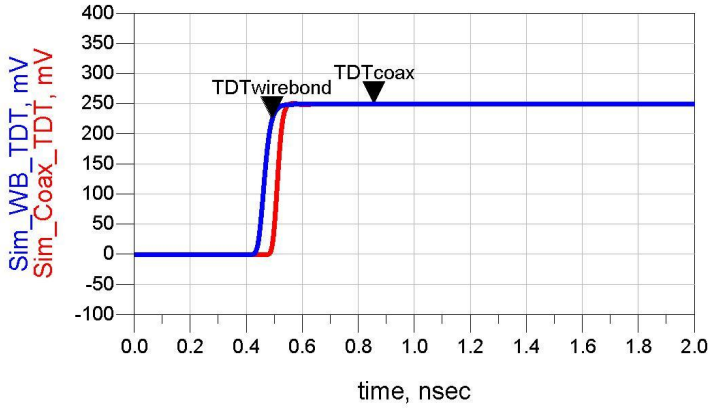


Model De-Embedding

- The model of just the interconnect system was de-embedded (deleting the effect of the test setup and long coplanar lines)

- A 35ps step response simulation was performed on the new model to understand the performance of the coaxial system vs. a wire bonded approach





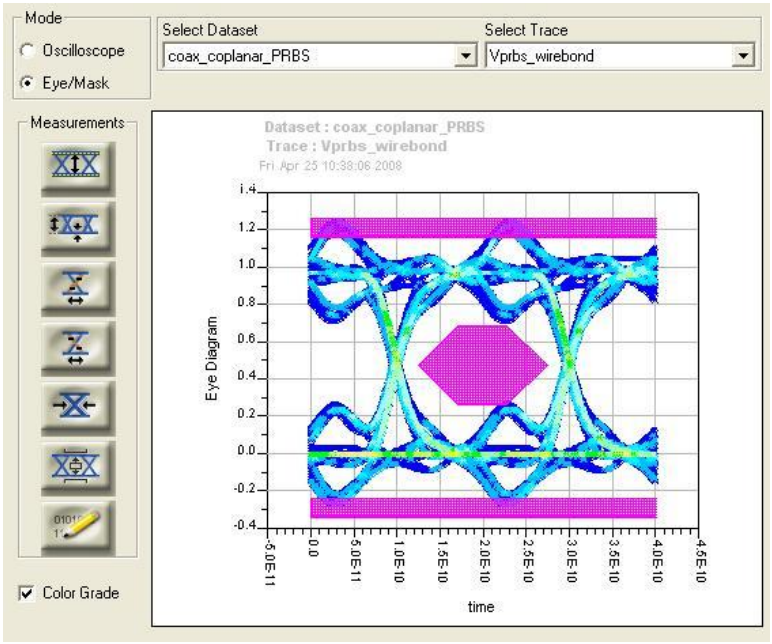
Reflections reduced from **33% (wb) to 8% (coax)**

Rise time Improved to **38ps (coax) from (48ps)**

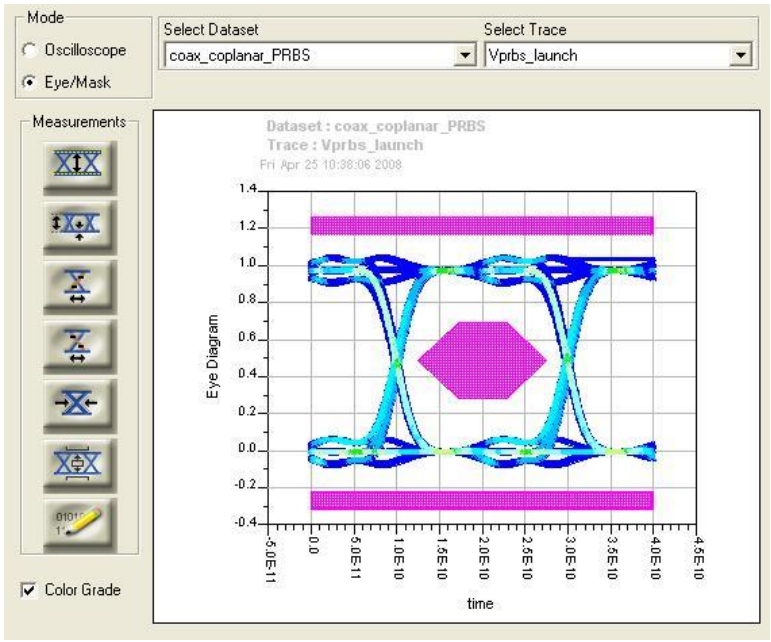
Data Rate Simulation

- An PRBS pattern was used to stimulate the interconnect system to evaluate the data rate.

"Eye Diagrams for the two systems at 5Gb/s (35ps rise times)"



Wire Bond System

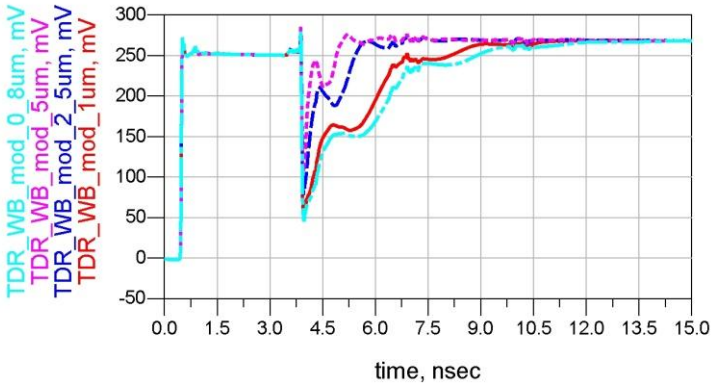


Coaxial System

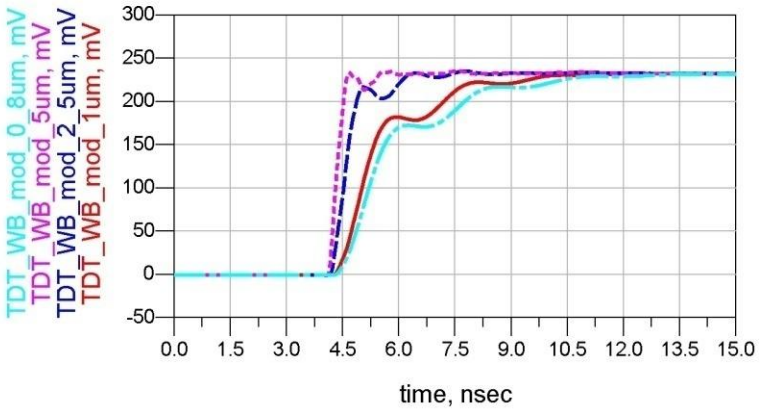
Ongoing Work

- Evaluation of Coplanar Fabrication using Back-End Process
- The height of the coplanar traces above the Semiconductor substrate is the largest source of loss in the on-chip coplanar transmission lines

"Effect of Height Above Si Substrate on Electrical Performance of Coplanar Lines"



TDR



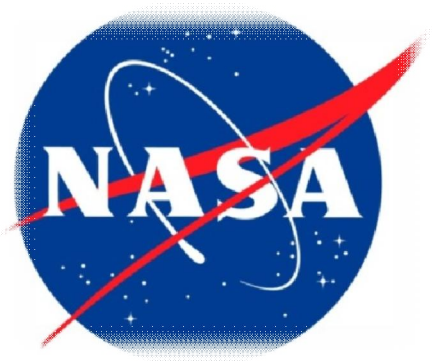
TDT

- Thicknesses desired (~5um) requires different process rather than thermal oxide growth

Ongoing Work

Acknowledgements

- thank you to NASA and the Montana Space Grant Consortium for support of this work



Questions