

Silicon Interposers Enable High Performance Capacitors

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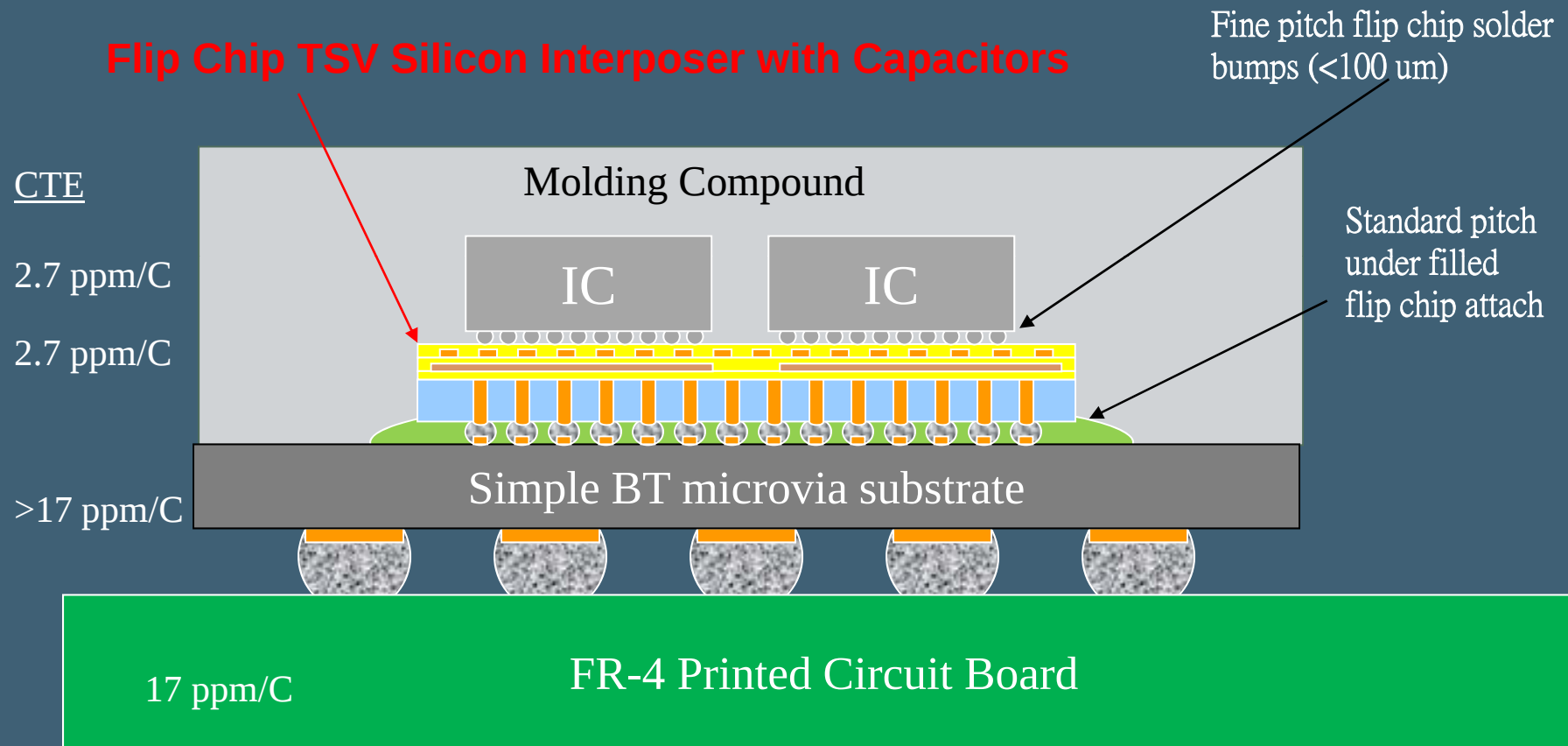
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About ALLVIA, Inc.

- ALLVIA provides Through Silicon Via and Silicon Interposer Foundry Services for the semiconductor industry.
- The Company was formed in 2004. ALLVIA is the former Tru-Si, Inc. creator of the Atmosphere Plasma Etching System for wafer thinning.
- ALLVIA offers:
 - TSV prototyping and low volume production
 - Silicon Interposers with Capacitors
 - Visit www.allvia.com for more information

As 3D Packaging becomes commonplace – adding passives is logical



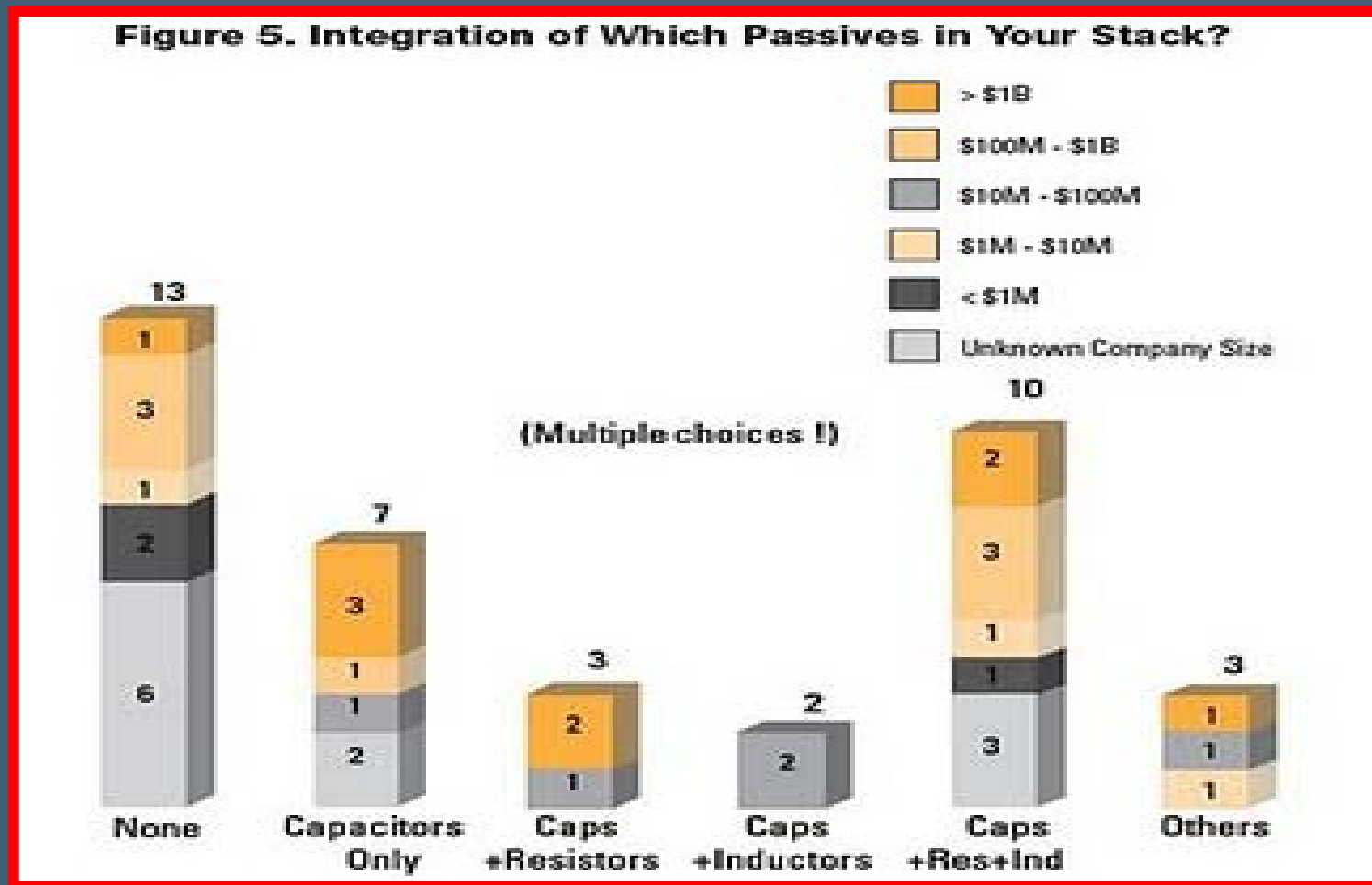
Flip Chips on a Si interposer with TSVs, routing layers (RDL) and decoupling capacitors

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Companies want passives on interposers

From the GSA EDA Interest group Survey on 3D



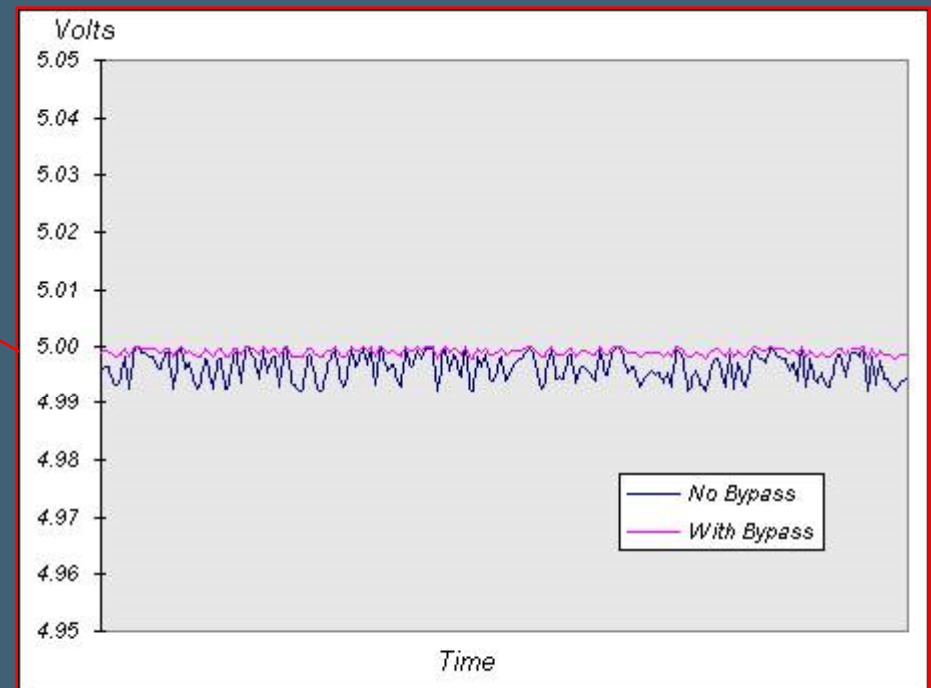
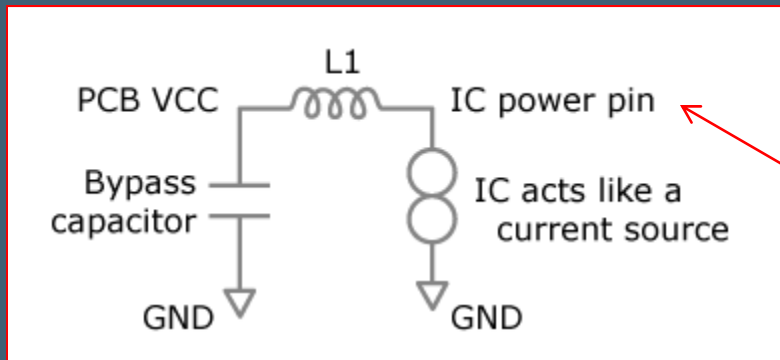
Source: http://www.electroiq.com/index/packaging/packaging-blogs/ap-blog-display/_archives/201008/blogs/ap-blog.html

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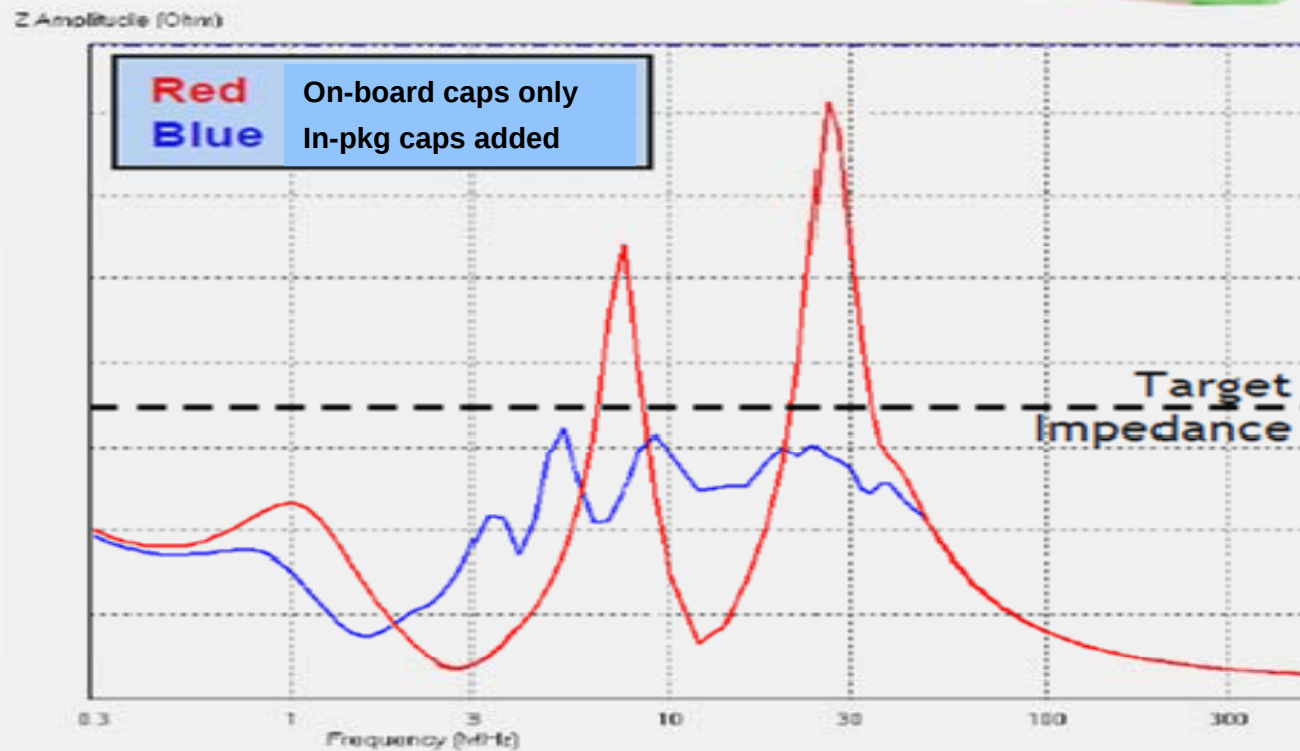
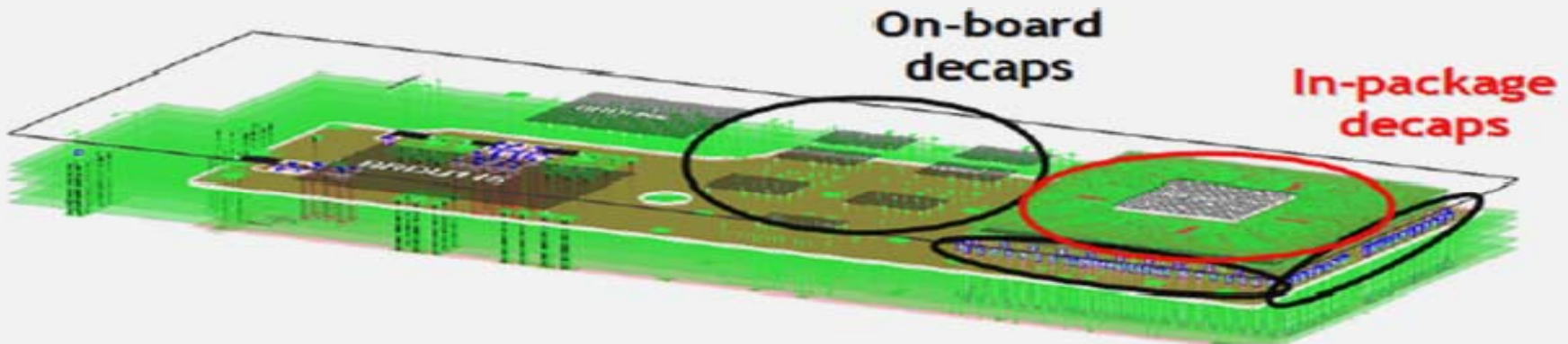
Capacitors on an Interposer can reduce voltage jitter and improve performance

“A decoupling capacitor is a capacitor used to decouple one part of an electrical network (circuit) from another.

Noise caused by other circuit elements is shunted through the capacitor, reducing the effect they have on the rest of the circuit.” (From Wikipedia)



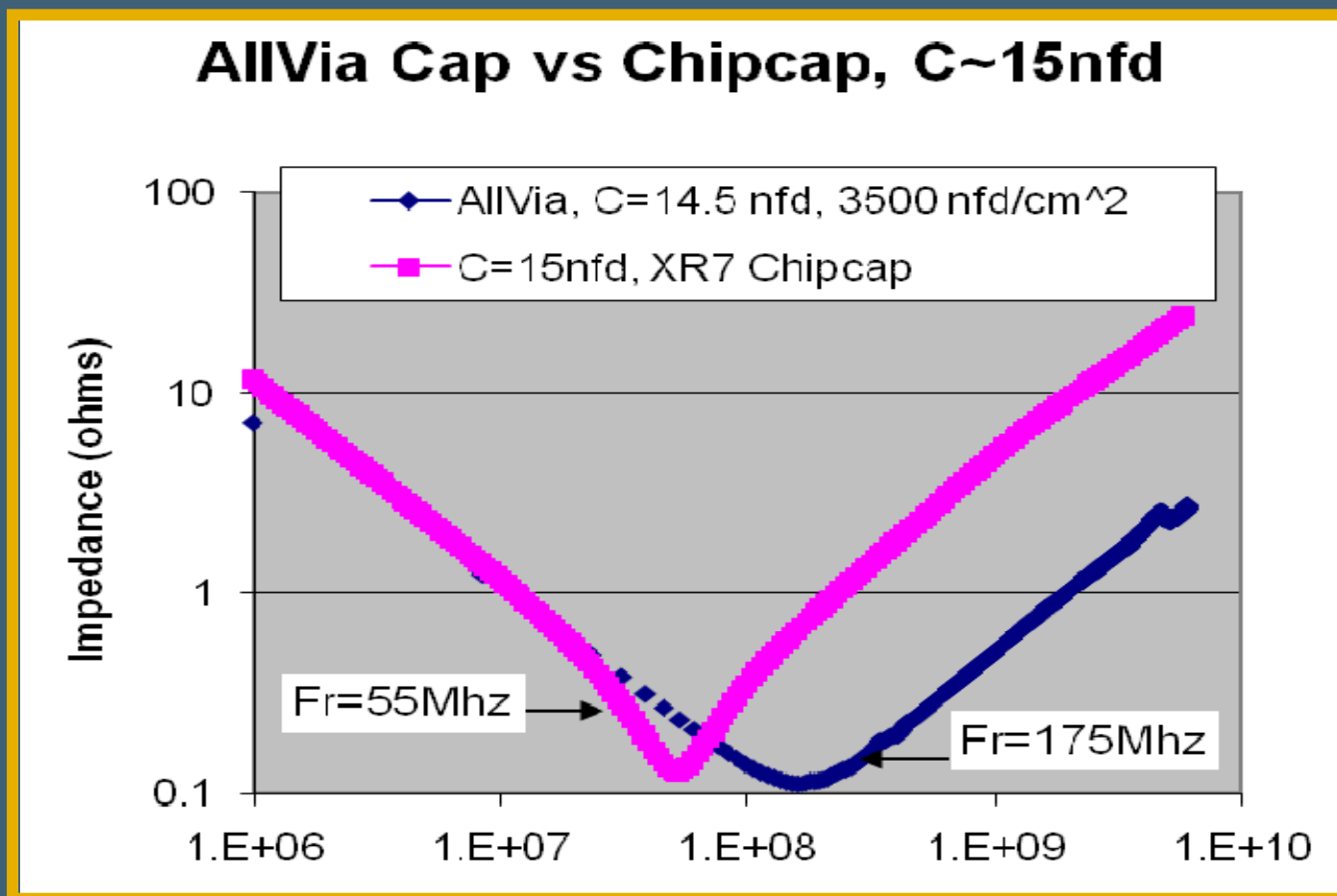
Capacitor Position is Critical



Source:



Capacitor Position is Critical



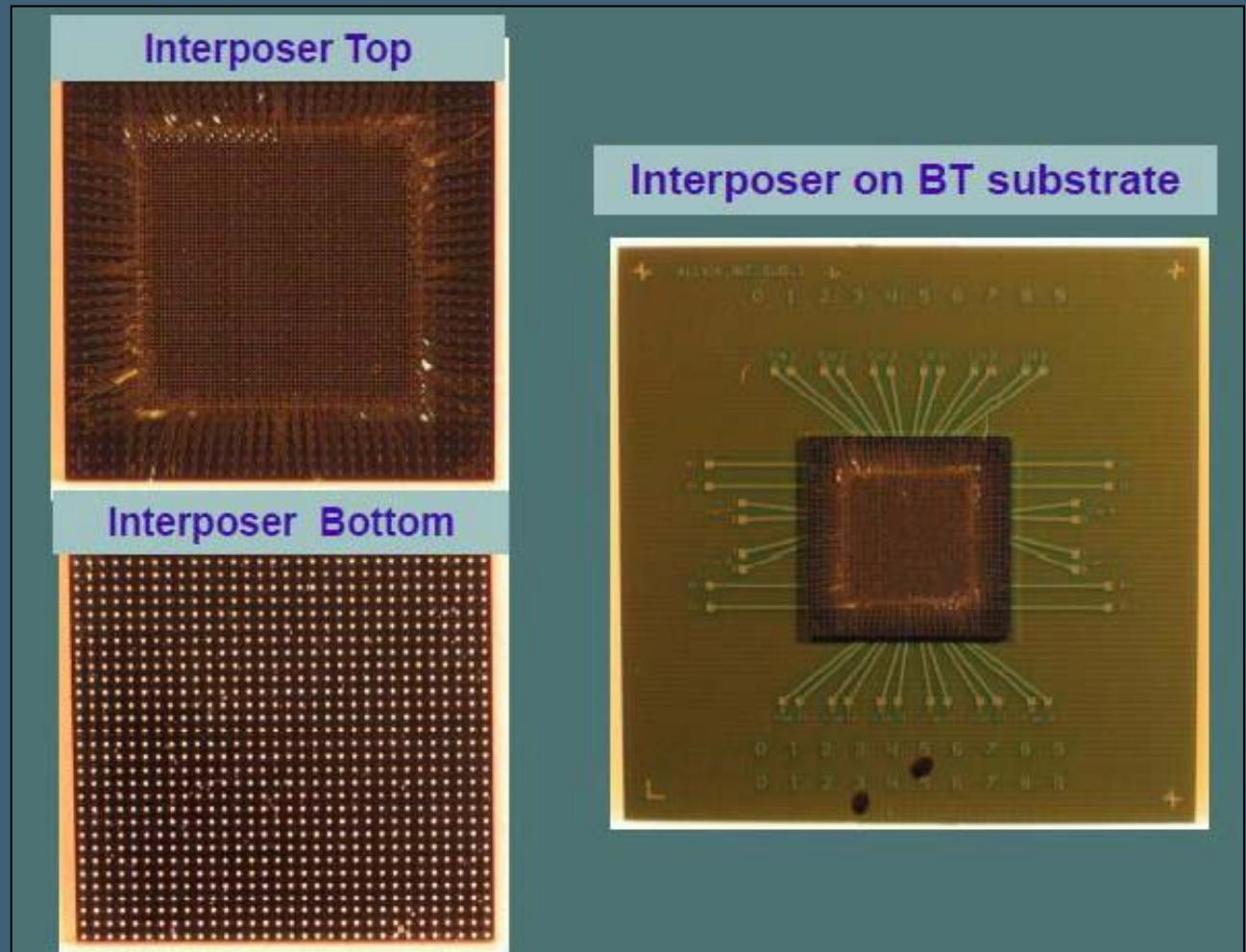
Part #	C (nfd)	L (ph)	R (mOhms)	Resonant Freq (Mhz)
Thin Film w TSV	14.8	66	104	175
X7R	15.0	710	128	55

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Silicon Interposers

Simply stated:

A means to get a denser, higher performance pcb inside an IC package

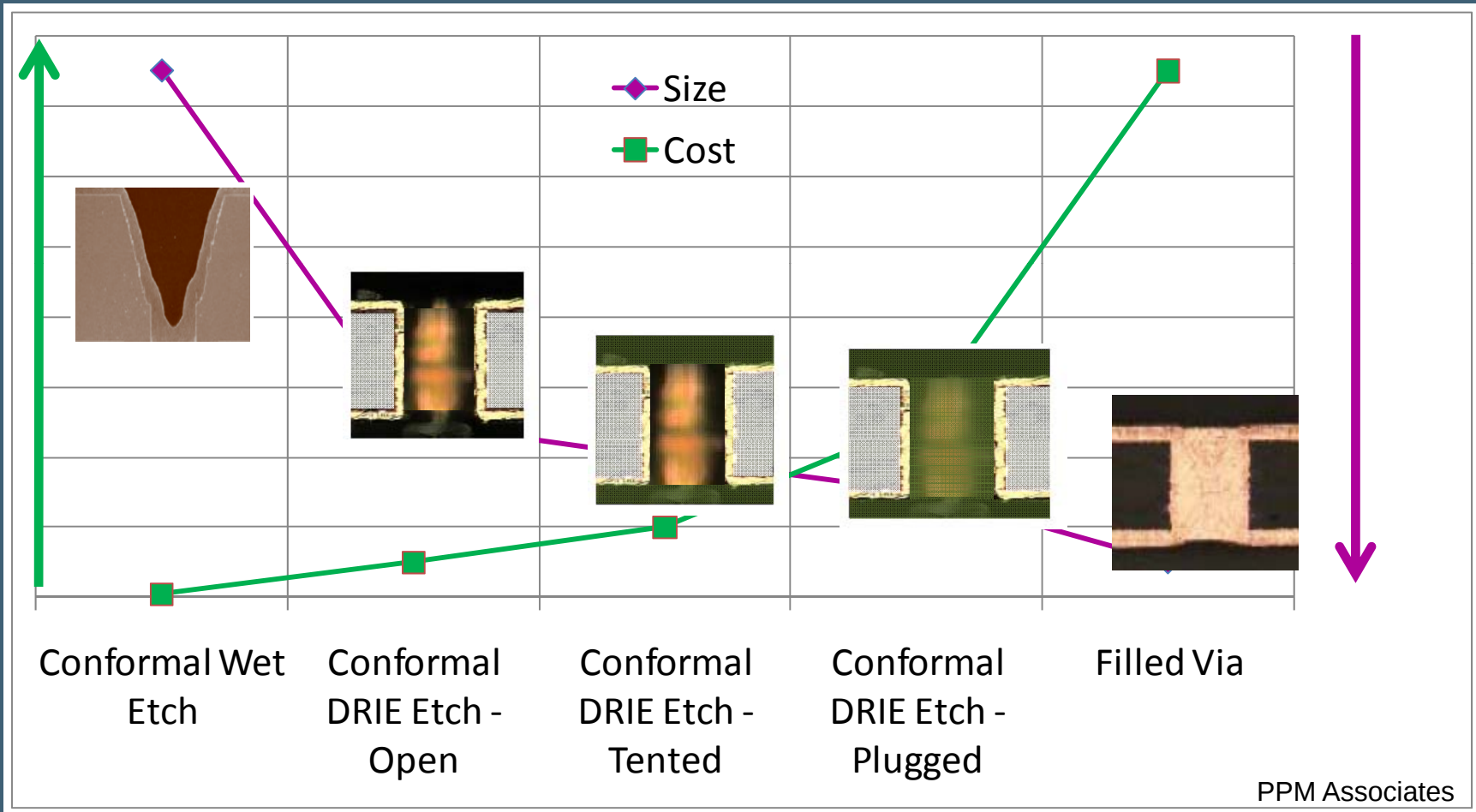


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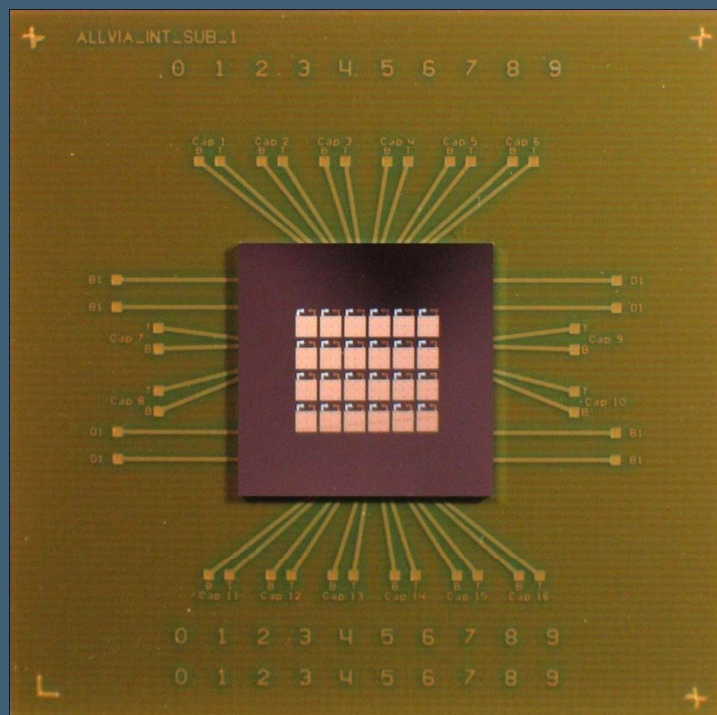
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VIA Types – in Silicon Interposers

Surprise! – There's more than you think.



Capacitor on Interposer Test Device



Approx. Static	
Material	Dielectric Constant
SiO_2	3.9
Al_2O_3	9.1
ZrO_2	25
HfO_2	14
ZrSiO_4	15
HfSiO_4	15-18

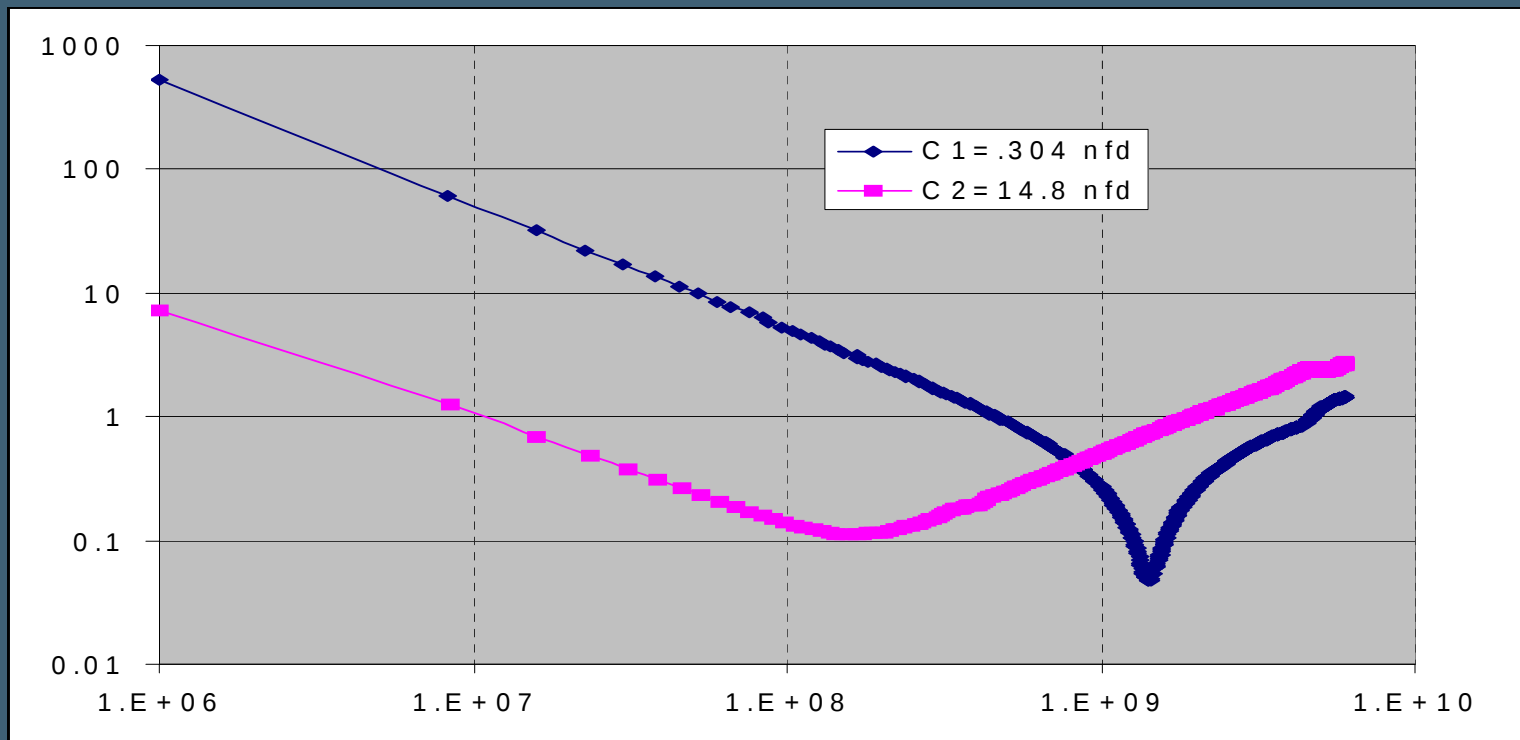
ALLVIA's current capability is up to 1500 nFd/cm²
 With 3000 nFd/cm² in development

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Thick Film Vs. Thin Film Capacitors

Results of 0.3 nFd and 14.8 nfd capacitors tested over a range of 1 MHz to 6 GHz.
The SR point is approximately 1.4 GHz and 175 Mhz respectively.

- Measurements done from 1Mhz to 6 Ghz at the wafer level
- Both thick dielectric and high capacitance capacitors measured.
- Thick film capacitor: C1 = 0.3 nfd, L=39 pfd, R= 44 mOhms, Fr = 1.4Ghz
- Thin film capacitor: C2= 14.8 nfd, L=66 pfd, R= 104 mOhms, Fr= 175 Mhz.



Backside TSV Wafer Level Reliability Test

80um via diameter 200um deep

Long daisy chain vias plus interconnects

Wafer ID	0 cycles		500 cycles		1000 cycles		Failures %
	R avg mOhms	Std Dev mOhms	R avg mOhms	Std Dev mOhms	R avg mOhms	Std Dev mOhms	
J12-SWB5	26.5	13	21.5	6.5	23	6	0
J12-SWF3	31.5	7	25.5	3.5	22	5.5	0

Capacitor Wafer Level Reliability Test

Two types of capacitors measured; standard and high capacitance

51 devices for each type of capacitor

20 devices assigned for Breakdown Voltage

	0 cycles	250 cycles	500 cycles	1000 cycles
Standard Caps (1Mhz)	457 nfd/cm ²	466 nfd/cm ²	457 nfd/cm ²	446 nfd/cm ²
Breakdown Voltage (avg)	8.9 v			8.7 v
High Capacitance Caps (1Mhz)	2506 nfd/cm ²	2281 nfd/cm ²	2217 nfd/cm ²	2130 nfd/cm ²
Breakdown Voltage (avg)	7.7 v			8.7 v

TSV Package Reliability Test

Daisy chain filled Cu TSVs, bumps, and organic substrate with underfill.

Resistance includes routing on interposer, chain of 8 TSVs, lead-free solder bumps, and routing on BT substrate.

Failure criteria: change from starting resistance > 3 sigma

Number of Cycles	0 cycles		250 cycles		500 cycles		750 cycles		1000 cycles	
	Avg. R (Ohms)	Std Dev (Ohms)	Avg. R (Ohms)	Avg % change (Ohms)	Avg. R (Ohms)	Avg % change (Ohms)	Avg. R (Ohms)	Avg % change (Ohms)	Avg. R (Ohms)	Avg % change (Ohms)
Resistance	5.72	0.21	5.70	-0.41%	5.76	0.68%	5.79	1.22%	5.81	1.57%
# of new failures	2/120 (Time Zero)		0/118		0/118		0/118		0/118	

Conclusion

High-K Dielectric thin films create excellent small capacitors

When added to Si Interposers they can be placed closer to where they are needed.

Using well understood IC dielectrics high value capacitors can be formed in small areas.