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Impacts of Solder Reflow on High Bandwidth RF Connectors

Michael Griesi and Chris Shelly

Everything's Great Until You Apply Solder!

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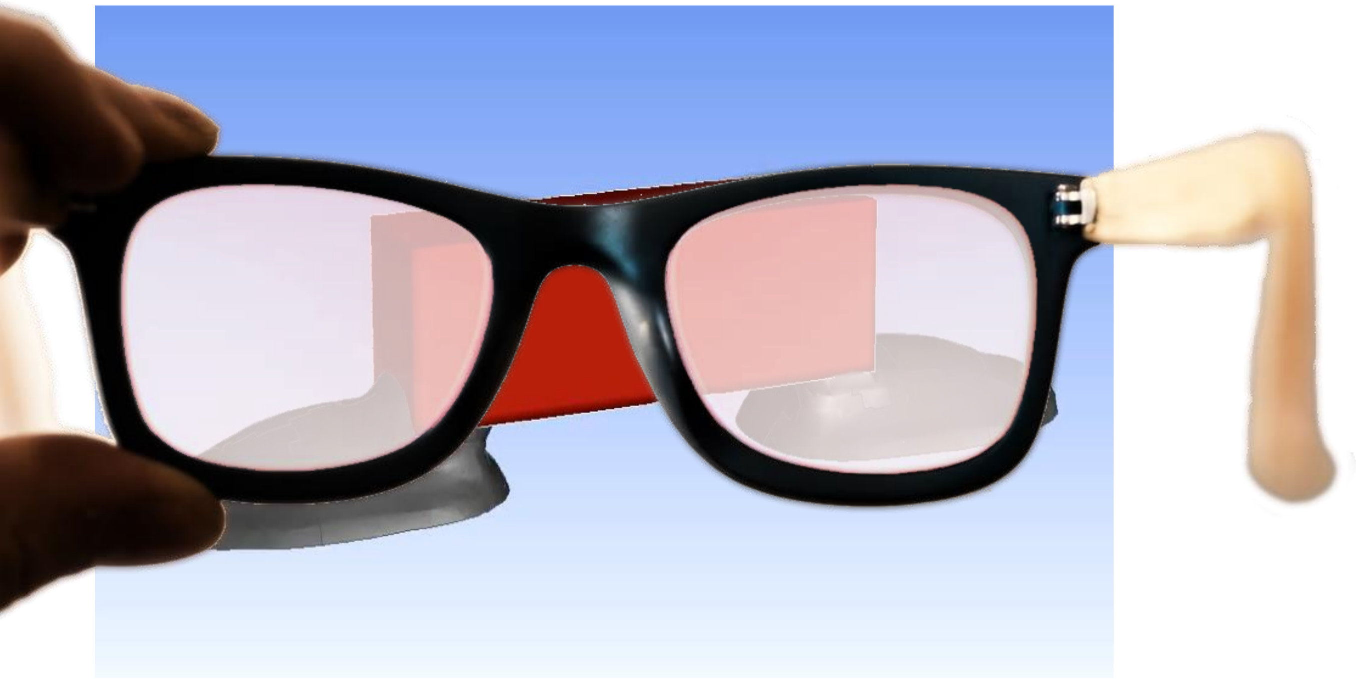

IDEAL

REAL

Everything's Great Until You Apply Solder!

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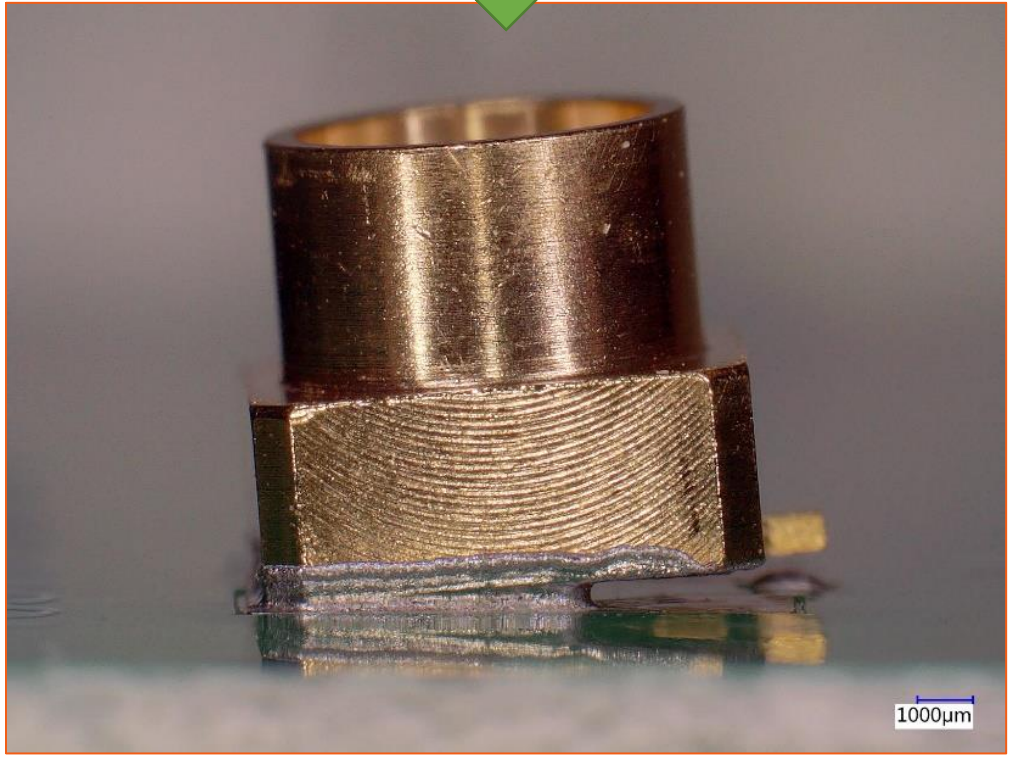
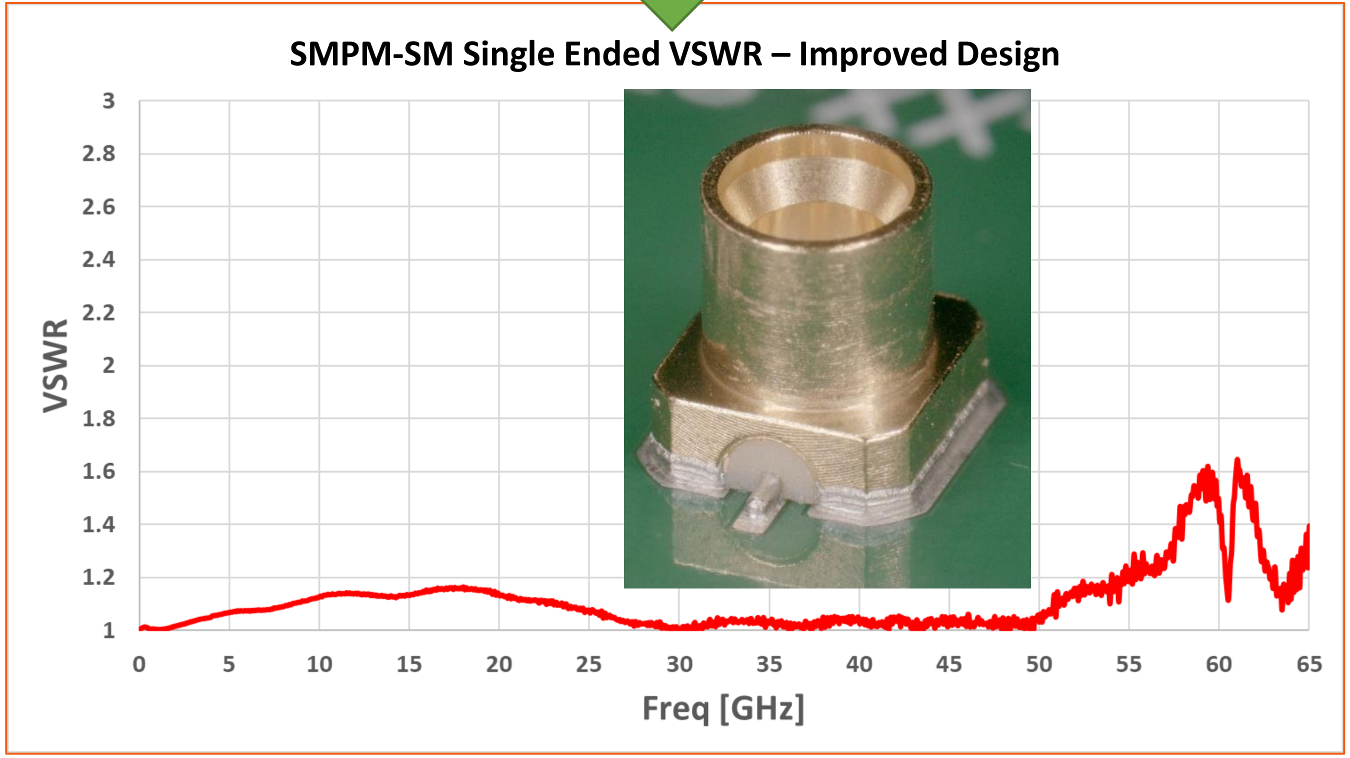
Getting from this

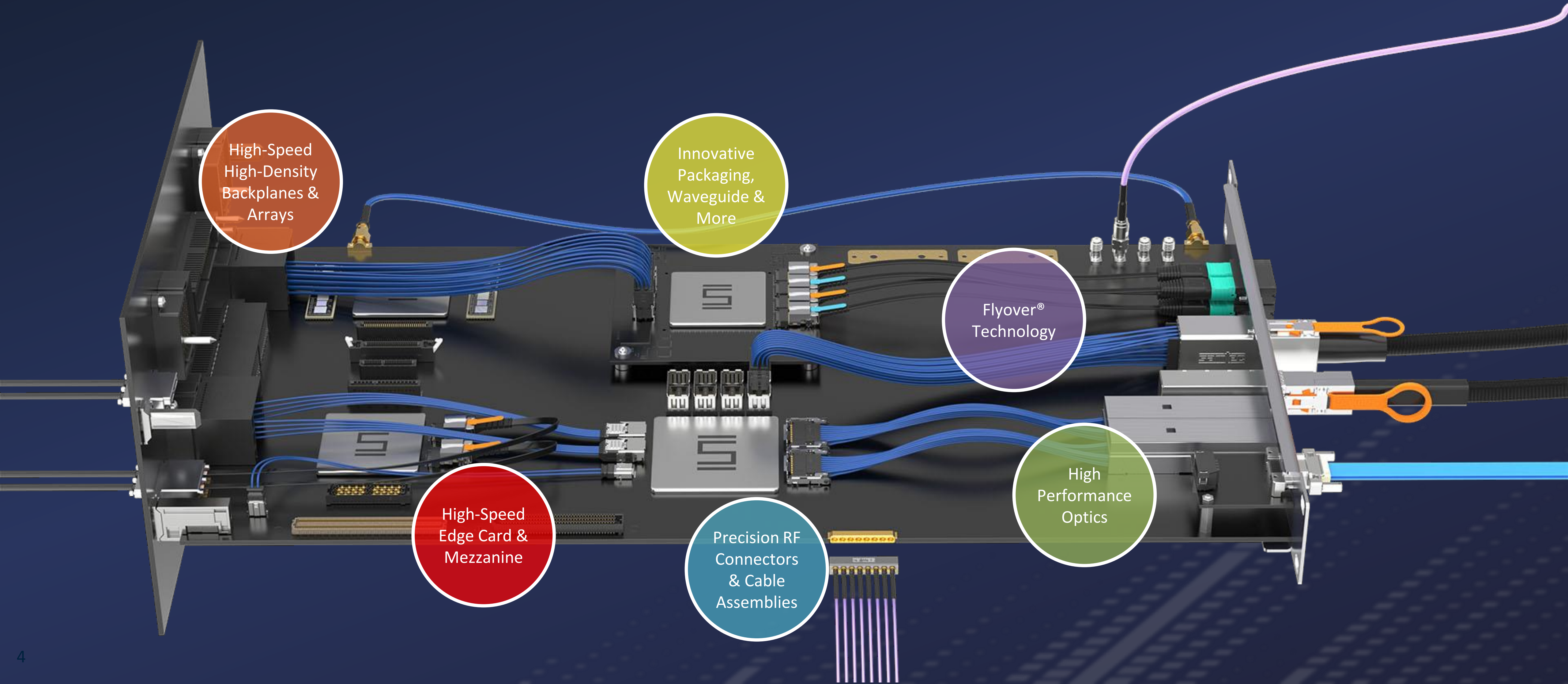


To this



CURRENT & NEXT GEN CONNECTIVITY

BOARD-TO-BOARD I SILICON-TO-SILICON



PRECISION RF | Push-on Connectors

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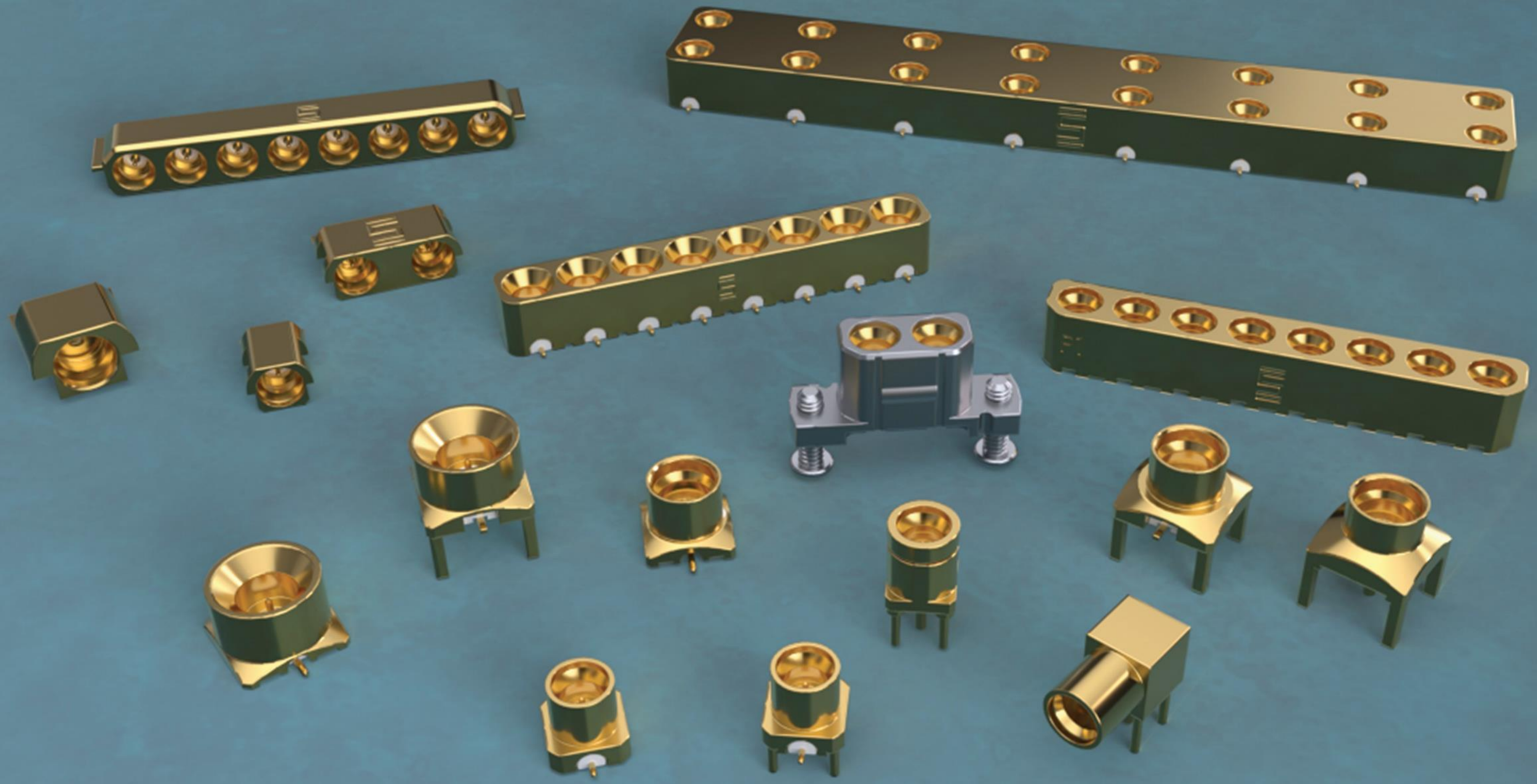
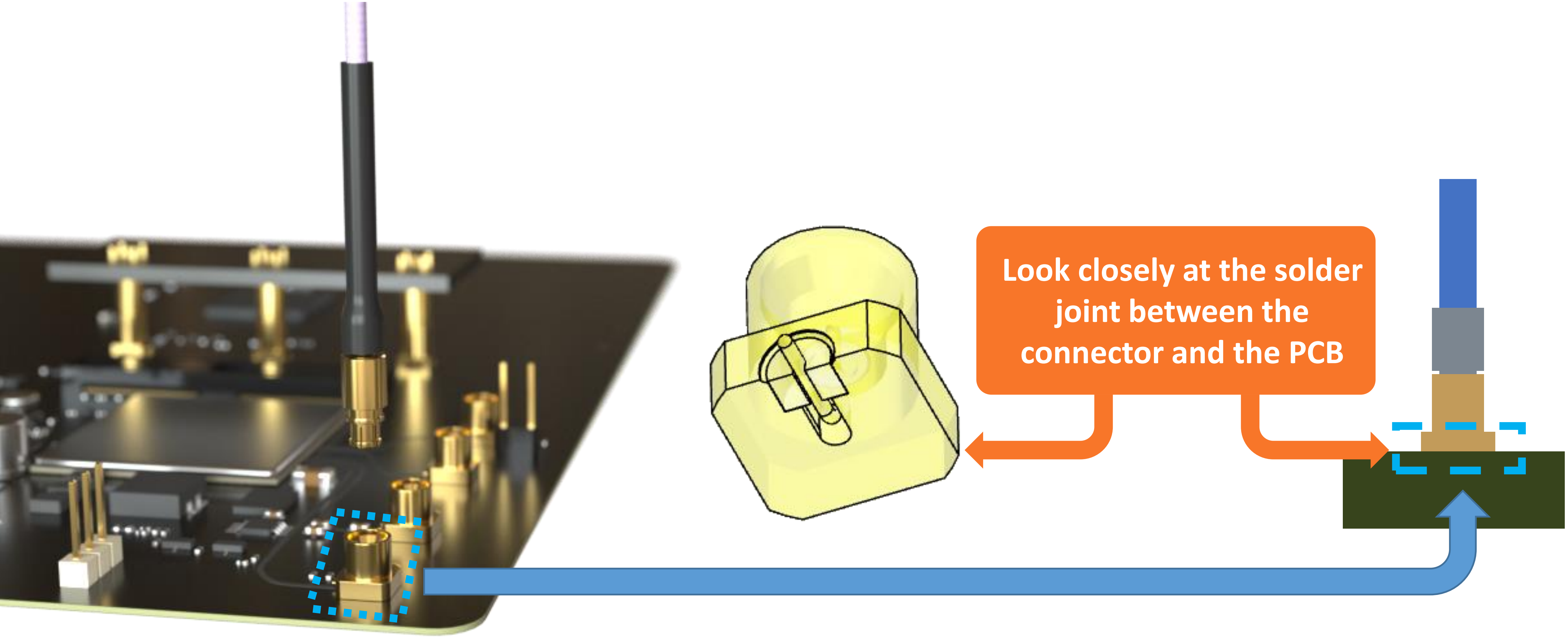


For more information visit www.samtec.com/precisionrf

Focus on SMPM Surface Mount



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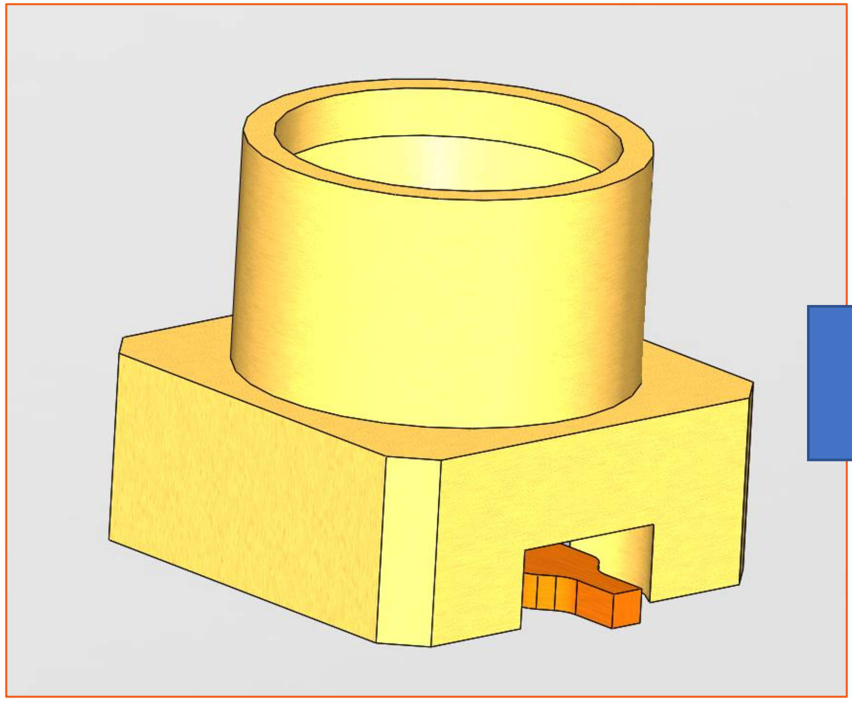
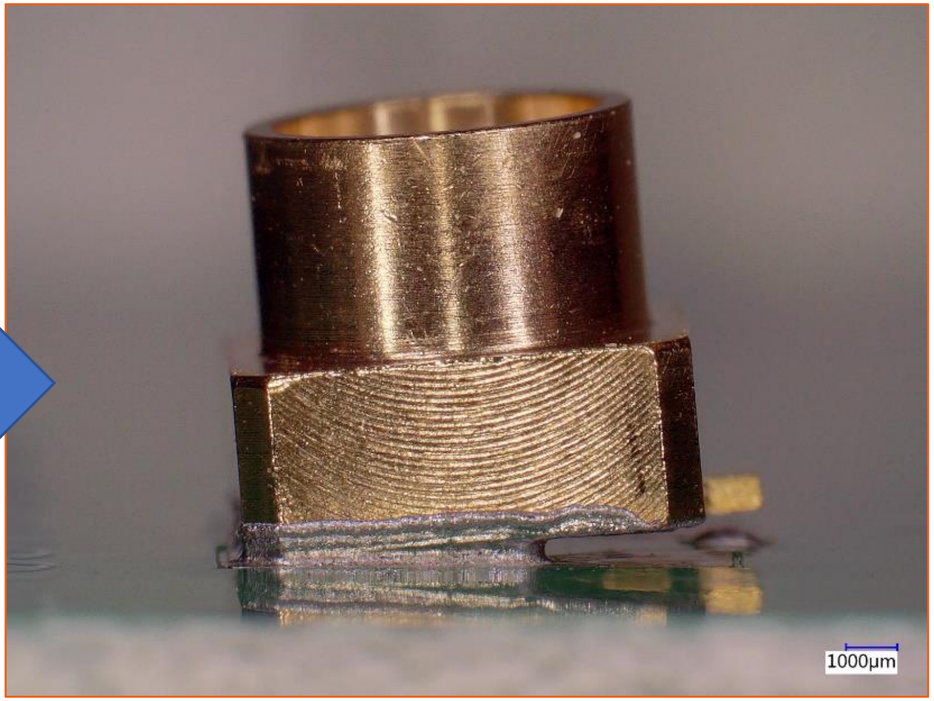
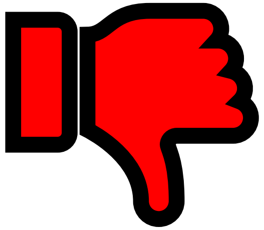
SMPM-SM INITIAL DESIGN

Initial Trials



Initial Design





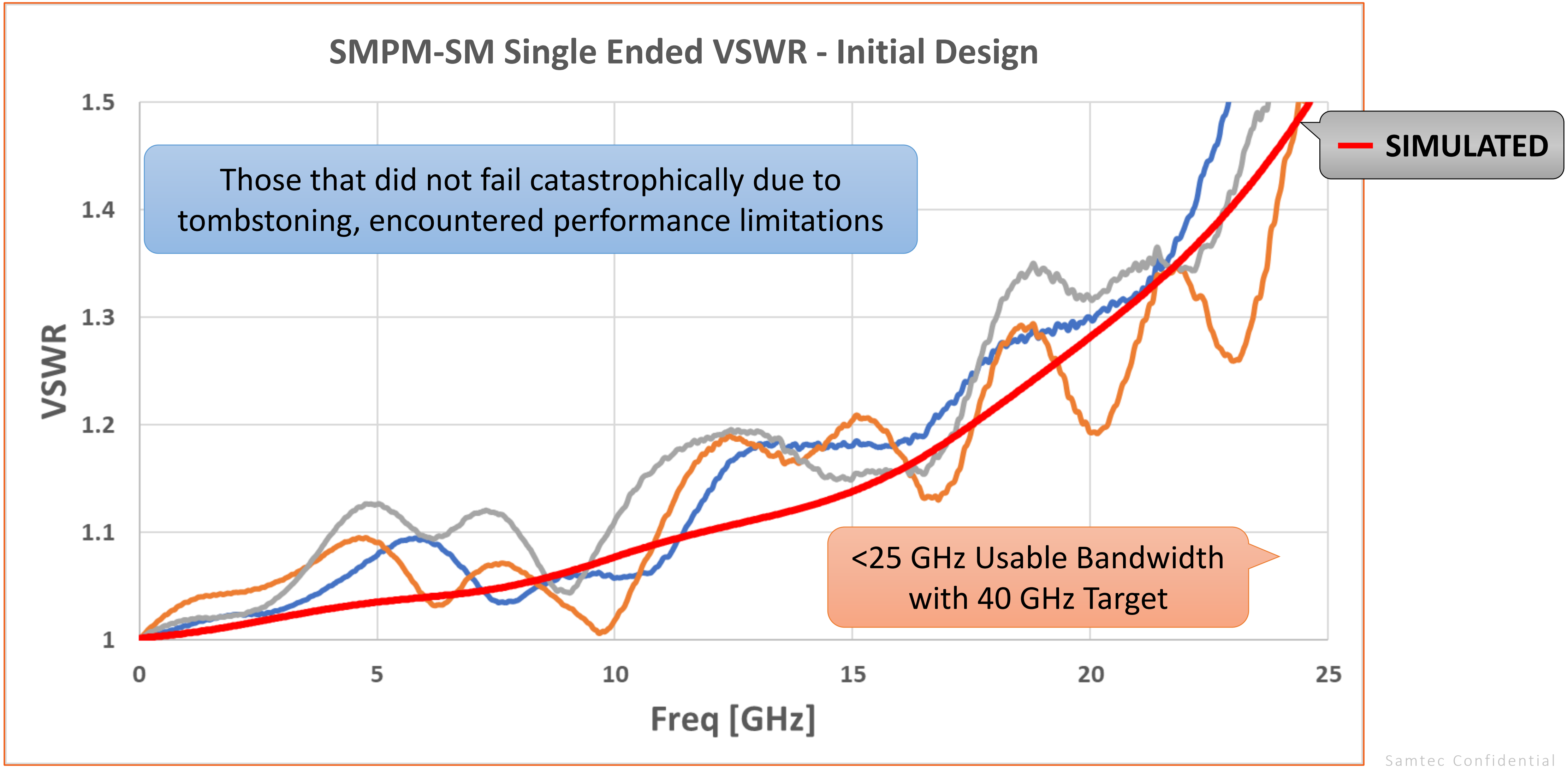
Initial Design

Design Targets:
- Desired 40 GHz Bandwidth
- Simulation showed <25 GHz

"Tombstoning"

Probable Causes:
- Thick Gold Plating
- Insulator TCE (Thermal Expansion)
- Center contact barb mechanical stress

Initial Trials



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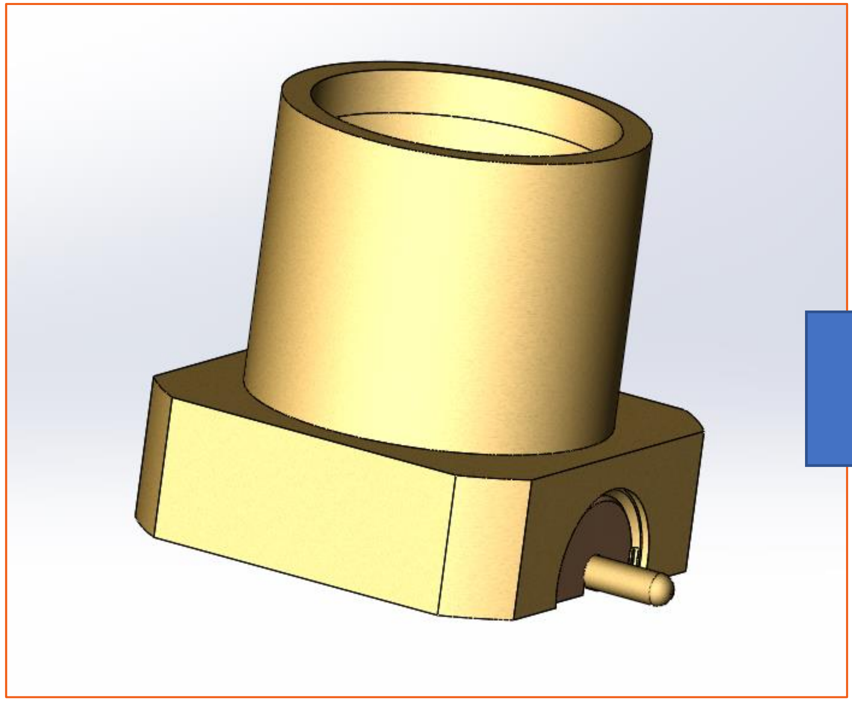
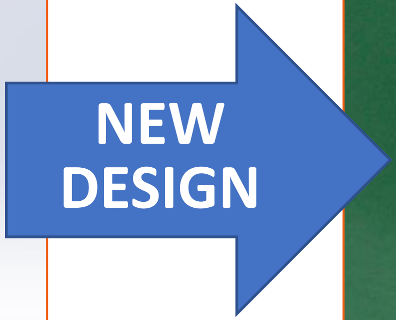
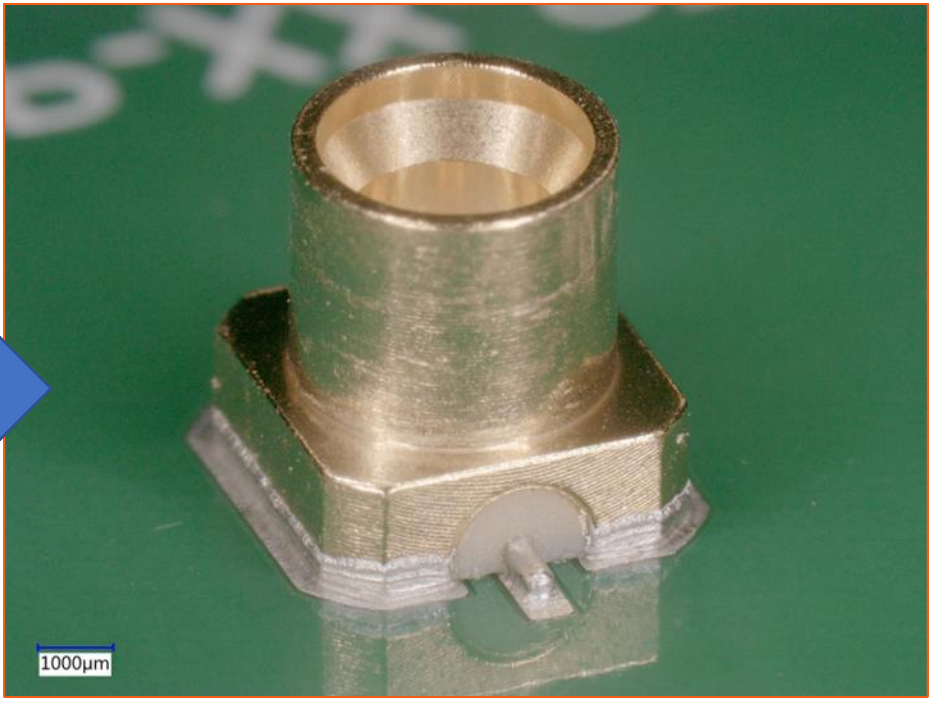
SMPM-SM-1 NEW DESIGN

New Design Looked Much Better Visually







New Design

Notable Changes:

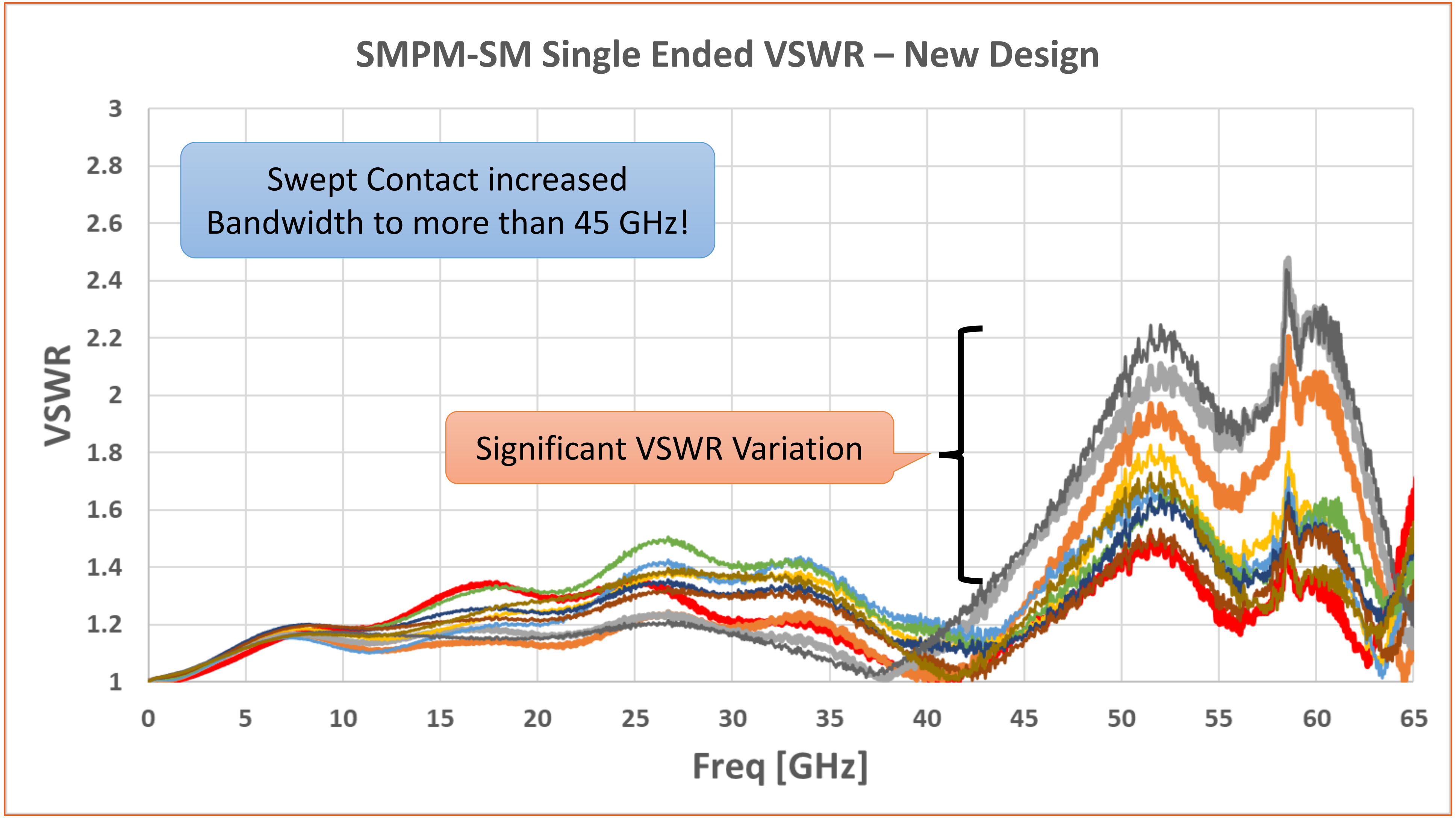
- Thinner gold plating
- Higher Temp Insulators
- Swept Contact

No More "Tombstoning"

Notable Improvements:

- Solder "**Looks**" Good

New Design VSWR Showed Variation



New Design VSWR Showed Potential

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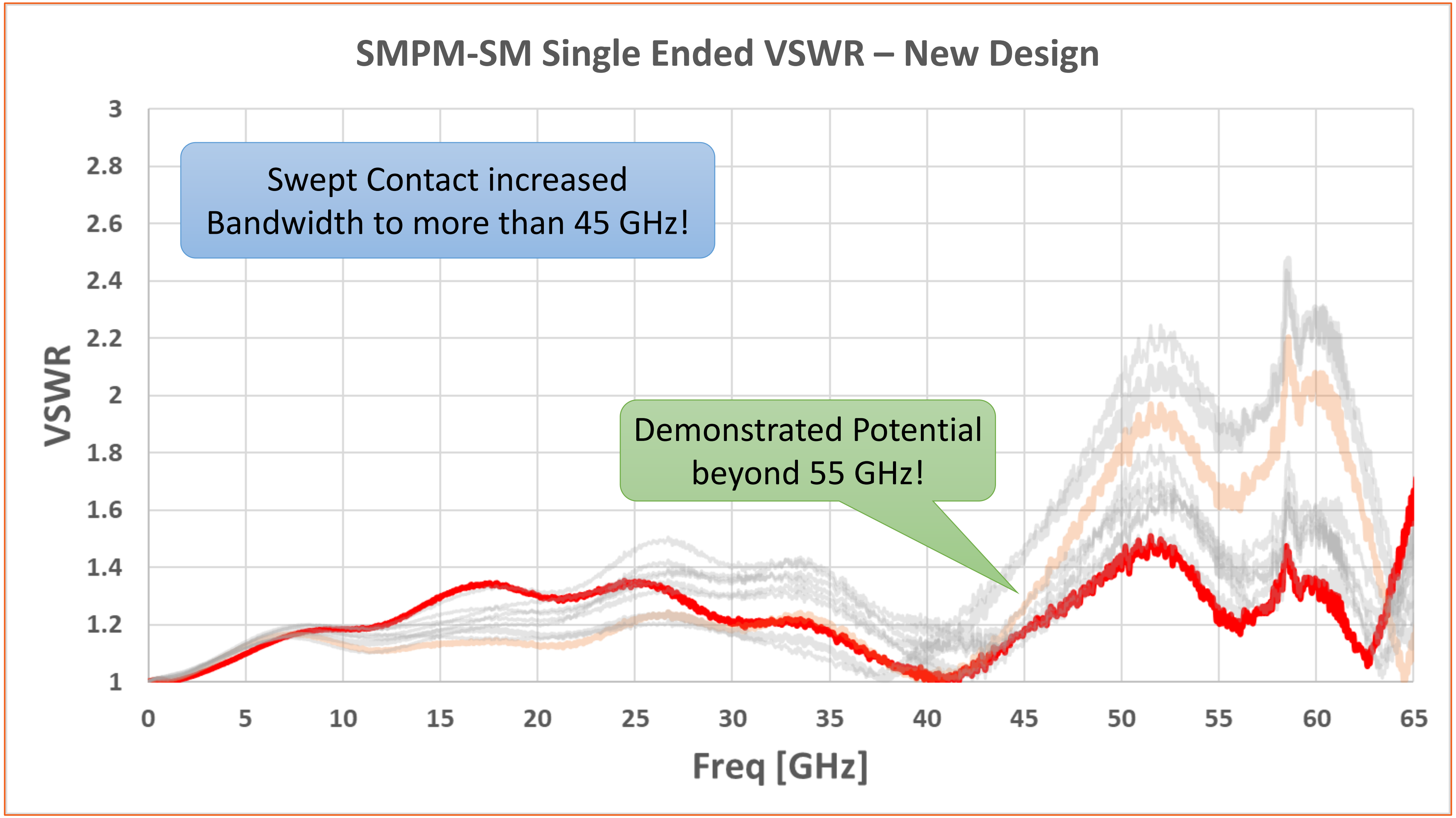
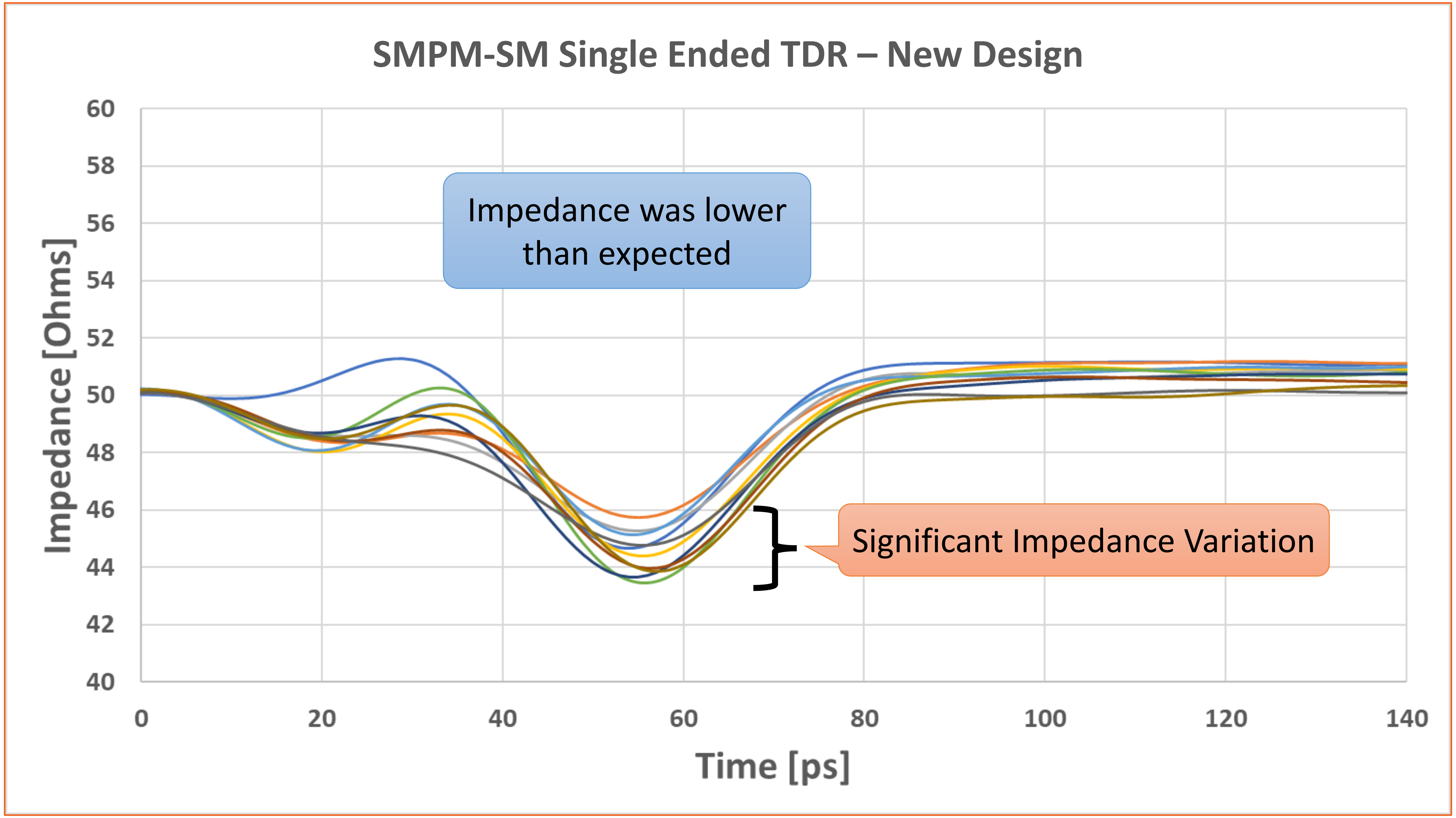


Variation with Impedance



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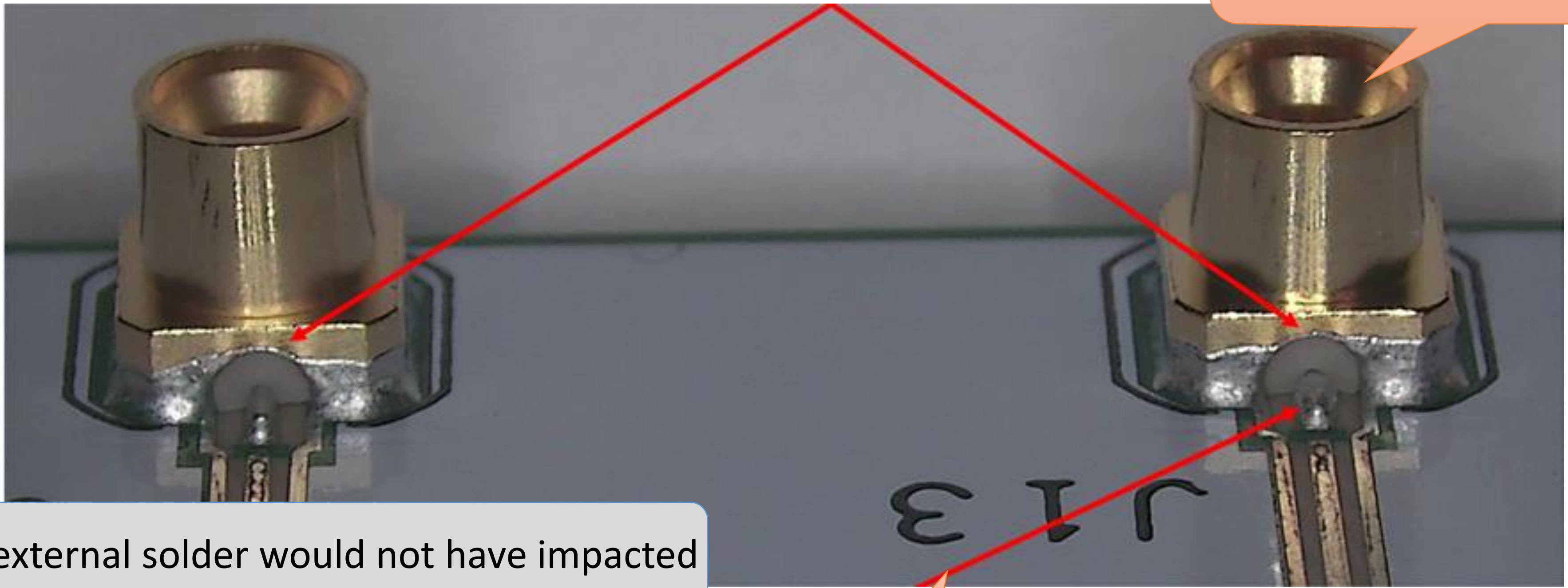
THE HUNT FOR VARIATION

Visible External Solder Wicking

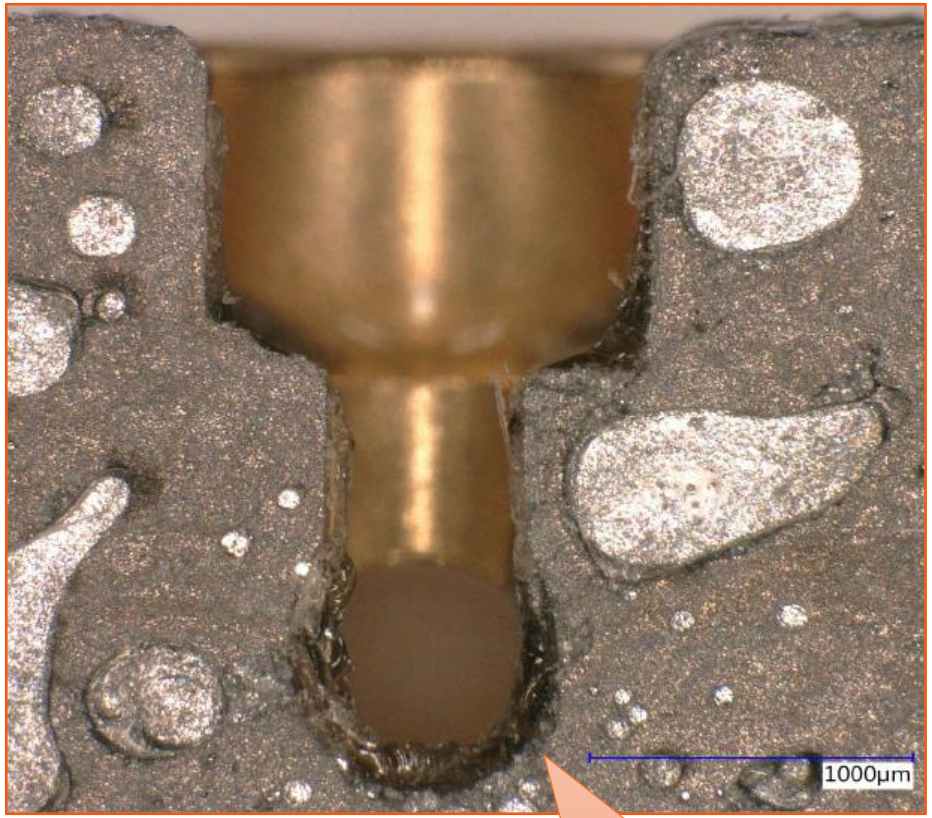
Some of the samples had significant wicking up the body and around the dielectric



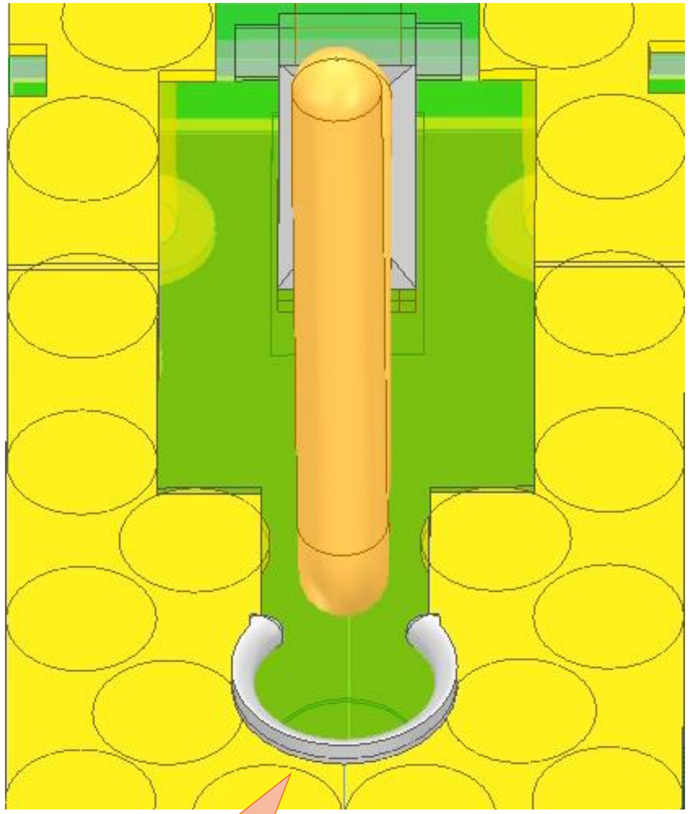
While the external solder would not have impacted the internal impedance… Wicking was significant enough to suggest solder might also be wicking under the connector which would not be visible

There was also excessive solder on the connector pin

Hidden Solder Pooling Under the Connector

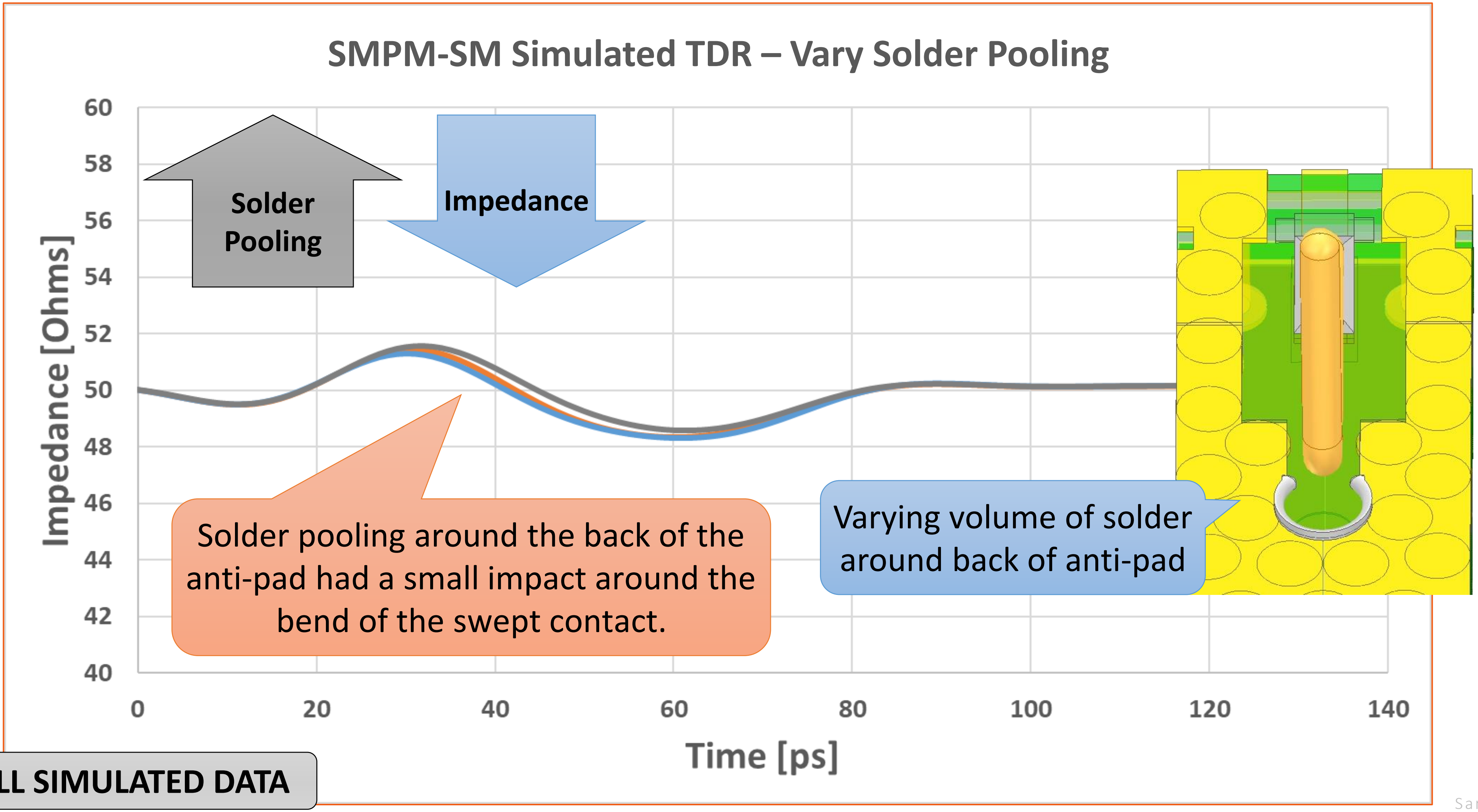


Sure enough, solder was found pooling along the inner edge of the connector at the pad



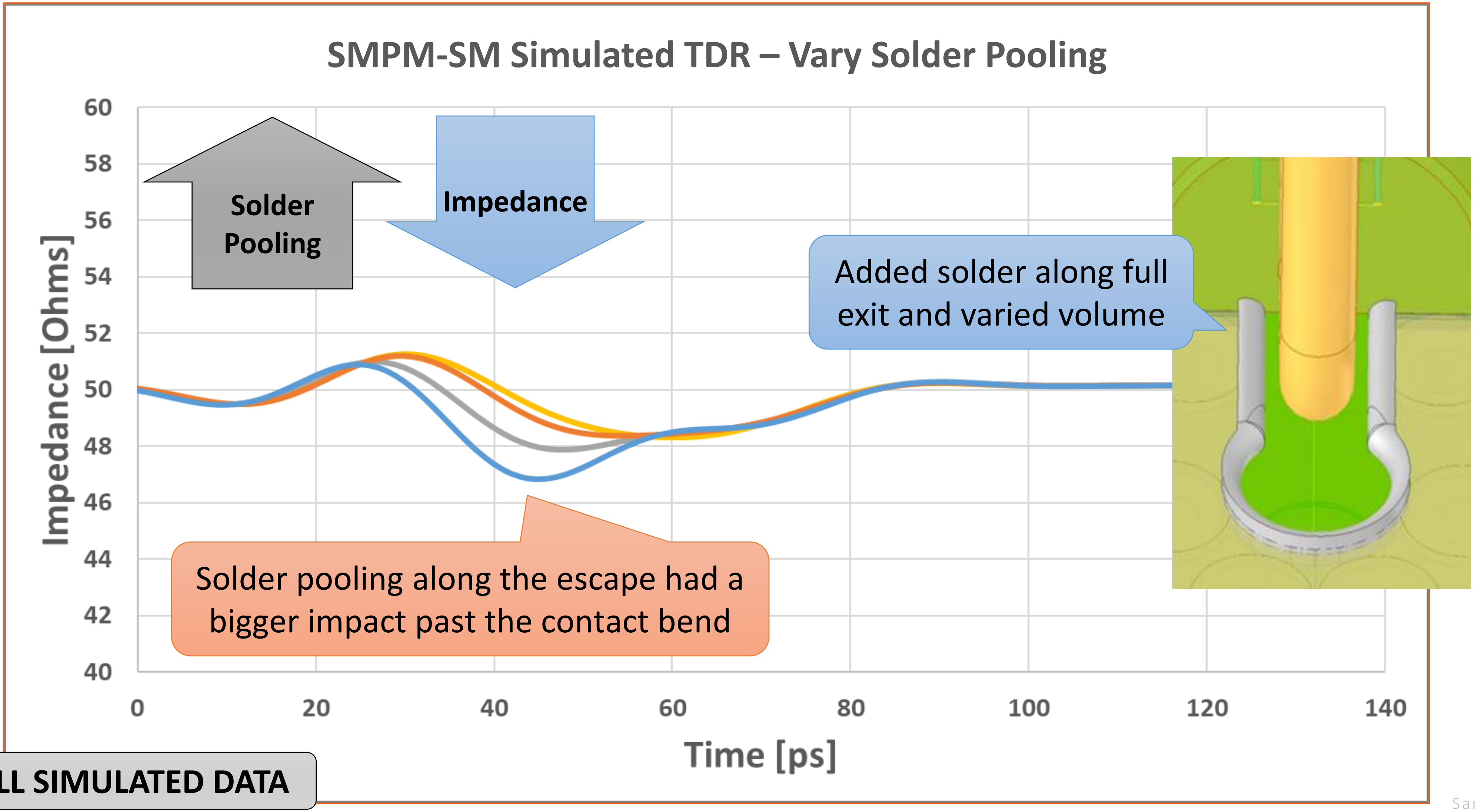
A solder pool was added to the simulation model to assess the potential impact

Impedance Variation from Solder Pooling



ALL SIMULATED DATA

Impedance Variation from Solder Pooling

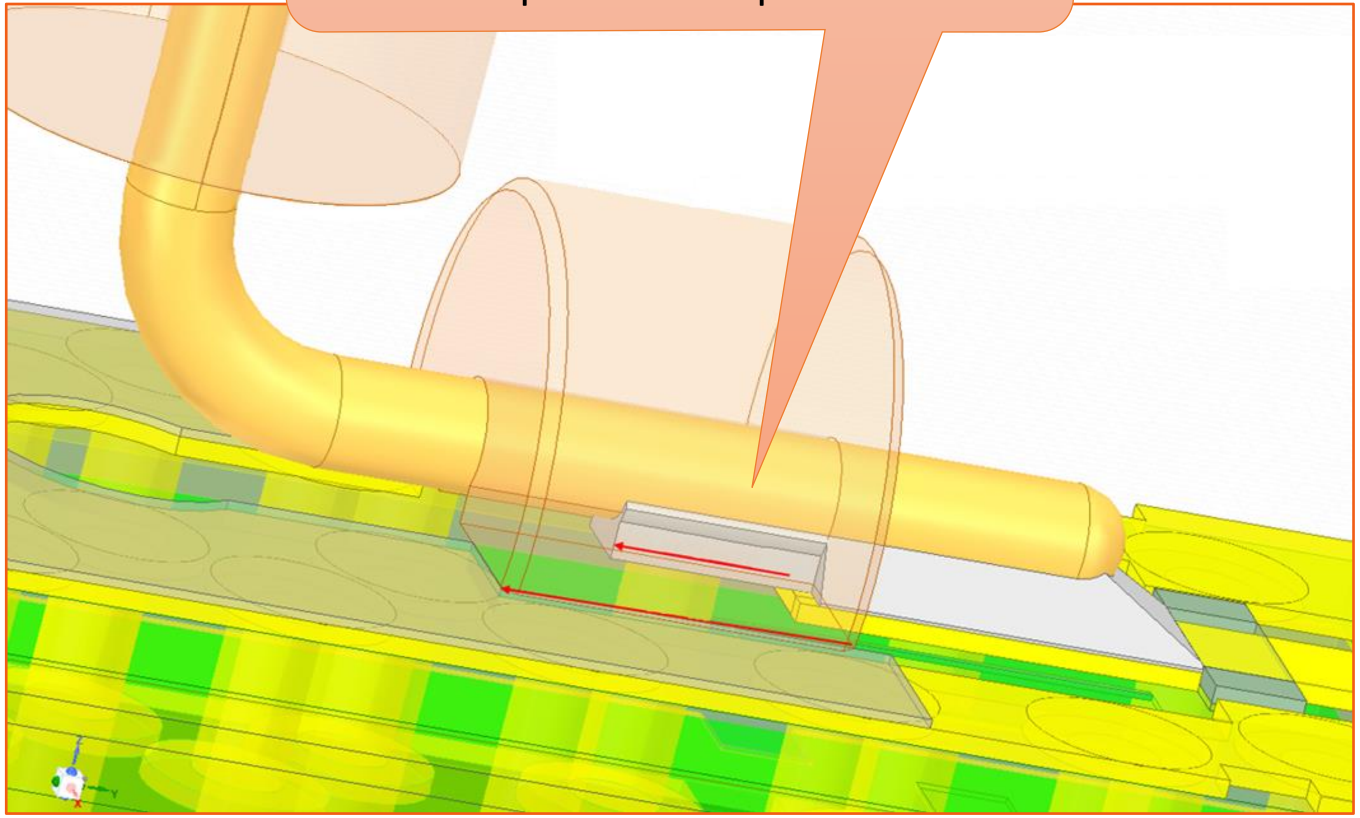


ALL SIMULATED DATA

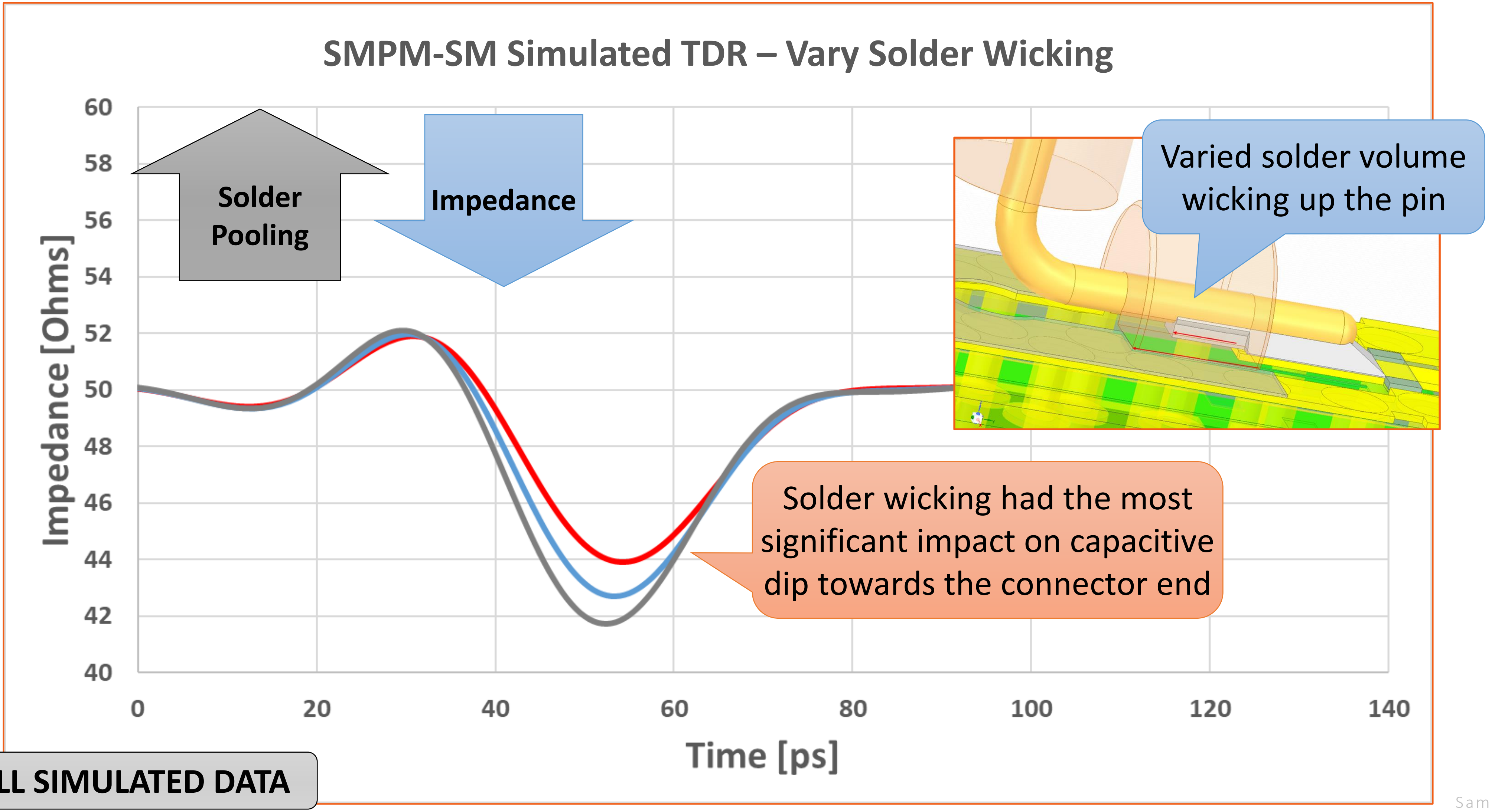
Hidden Solder Wicking Up the Connector Pin

Solder was found wicking up the contact, under the insulator, with significant variation across samples

Solder wicking added to the simulation model and varied to assess the potential impact

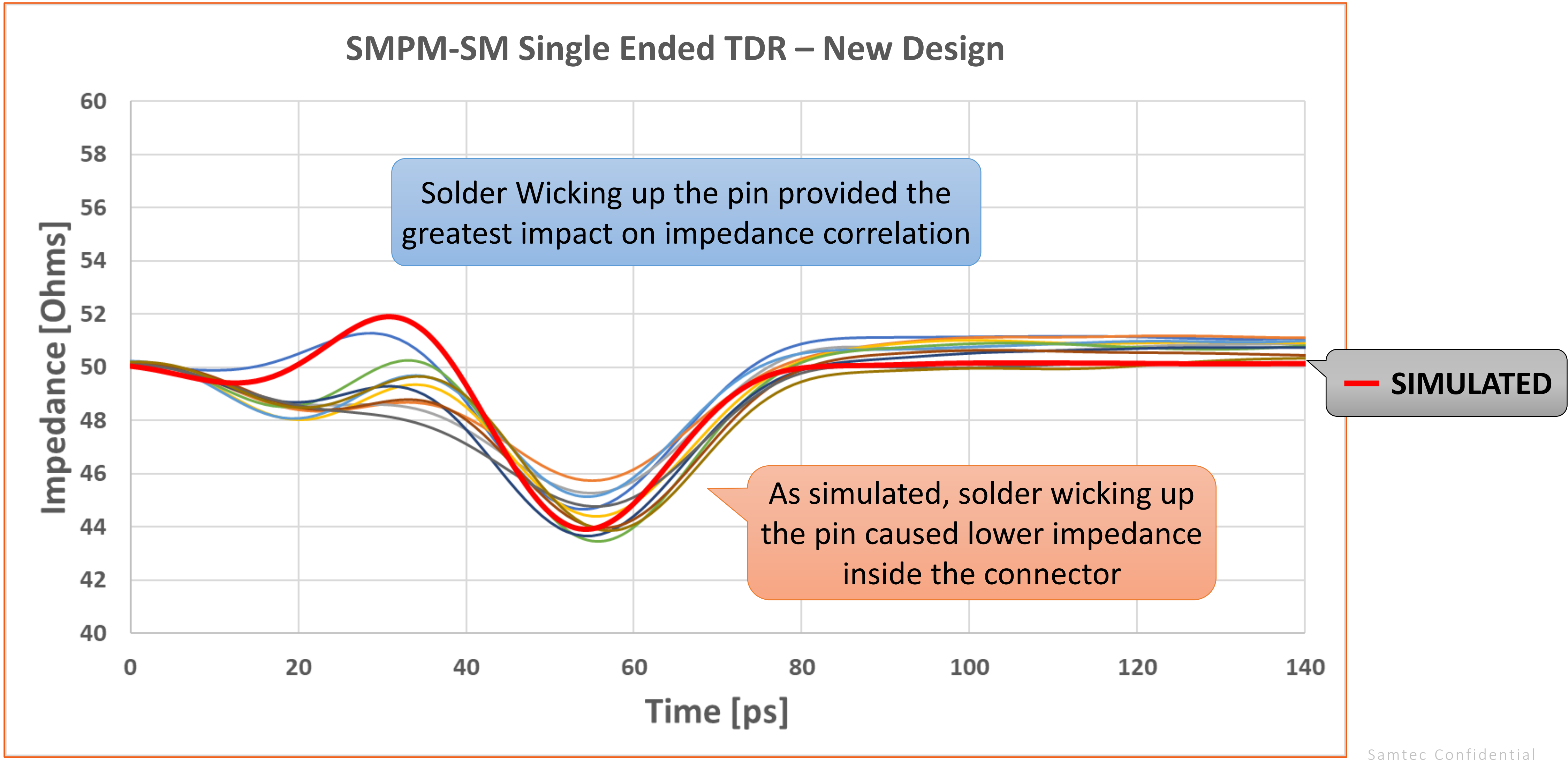


Impedance Variation from Solder Wicking

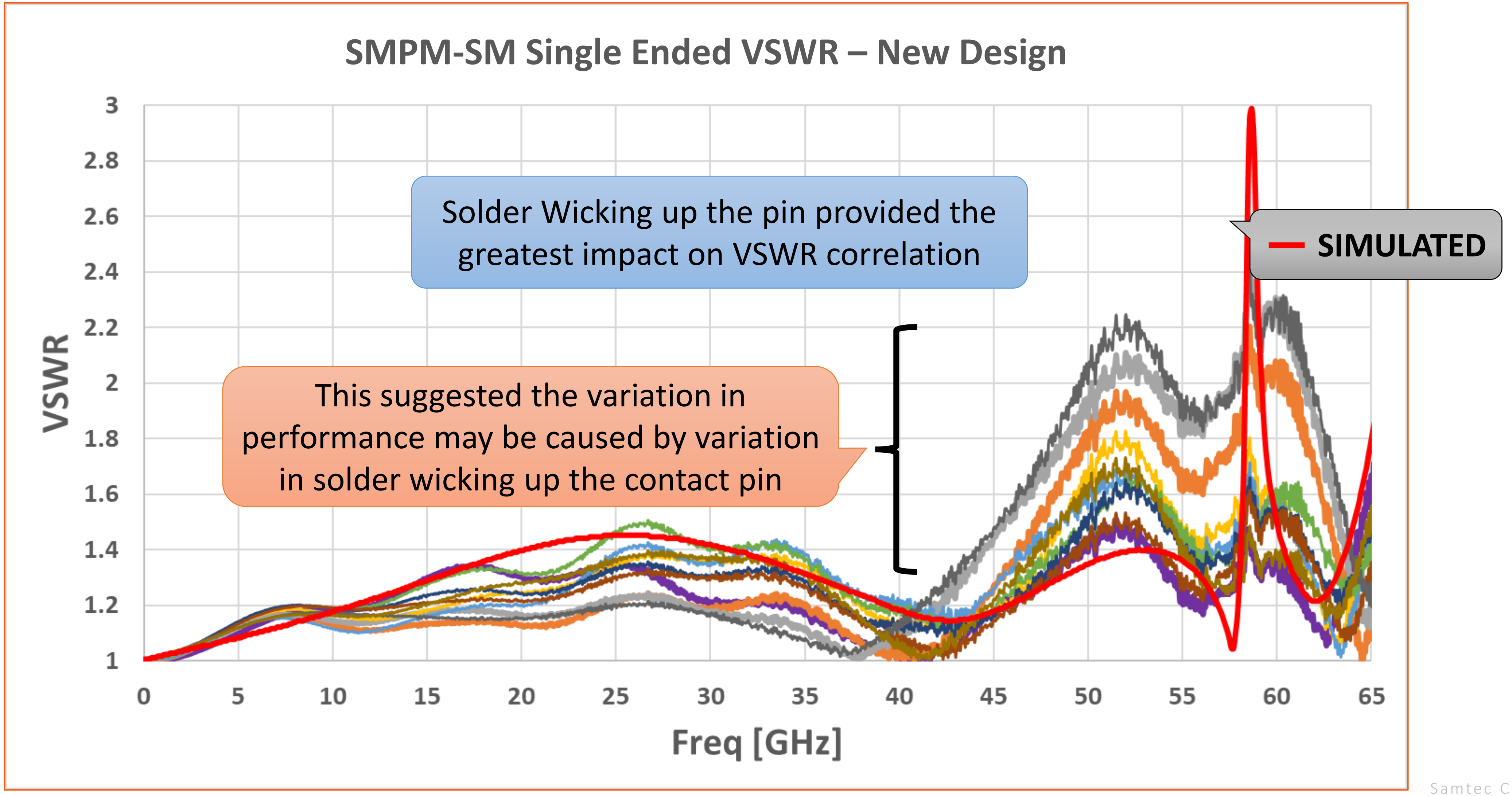


ALL SIMULATED DATA

Simulation Model Correlation



New Design VSWR Showed Variation



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MINIMIZING VARIATION

Mitigating Solder Pooling

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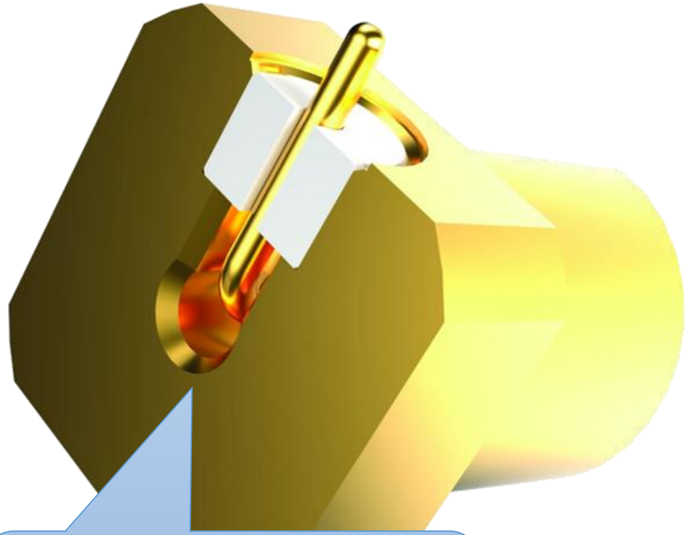
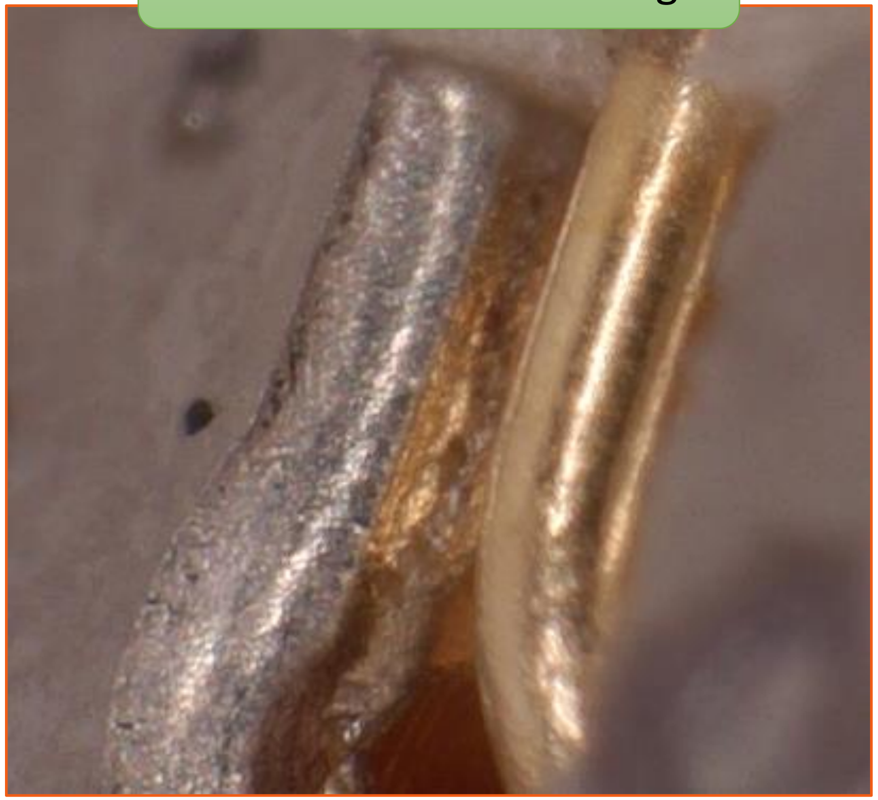


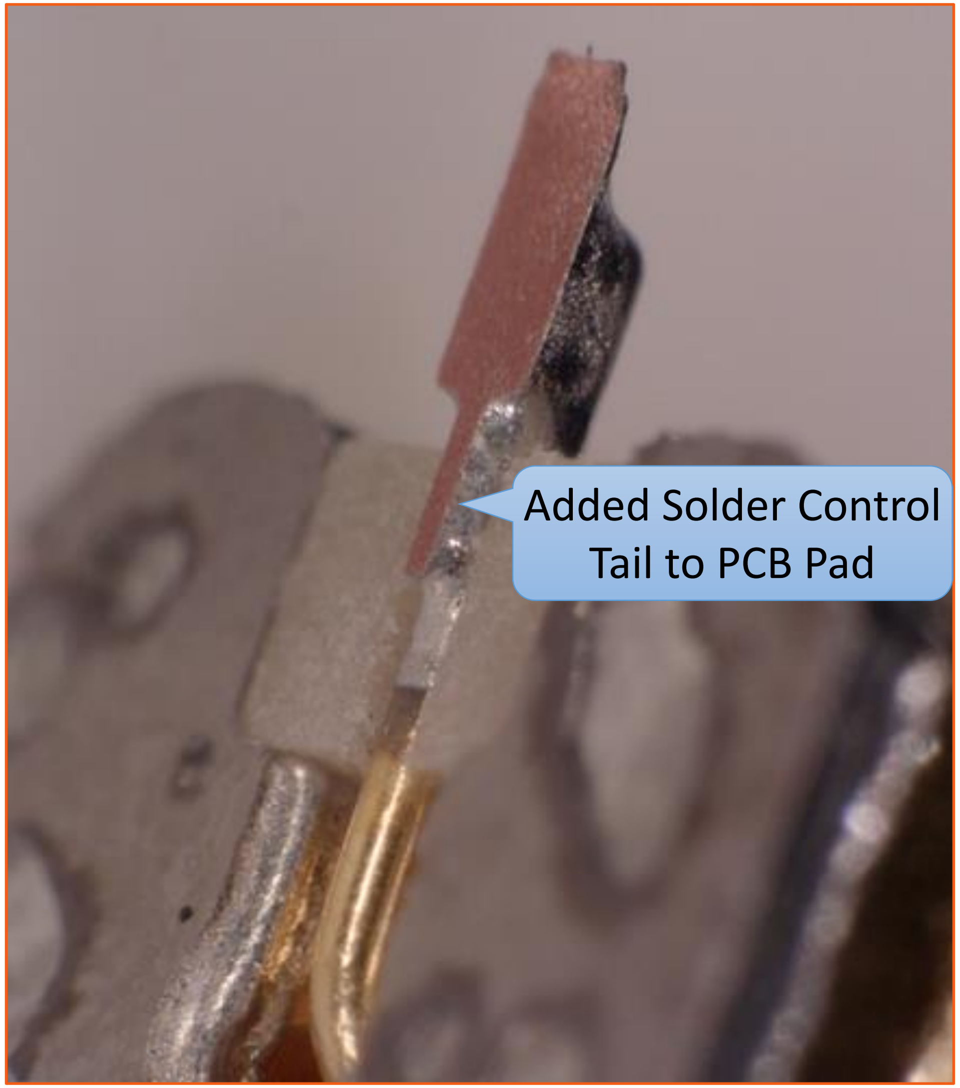
Added Chamfer to Connector Edge to Minimize Solder Pooling

Connector Chamfer Minimized Solder Pooling!



Chamfer provided a space for the solder without impacting SI

Controlling Solder Wicking



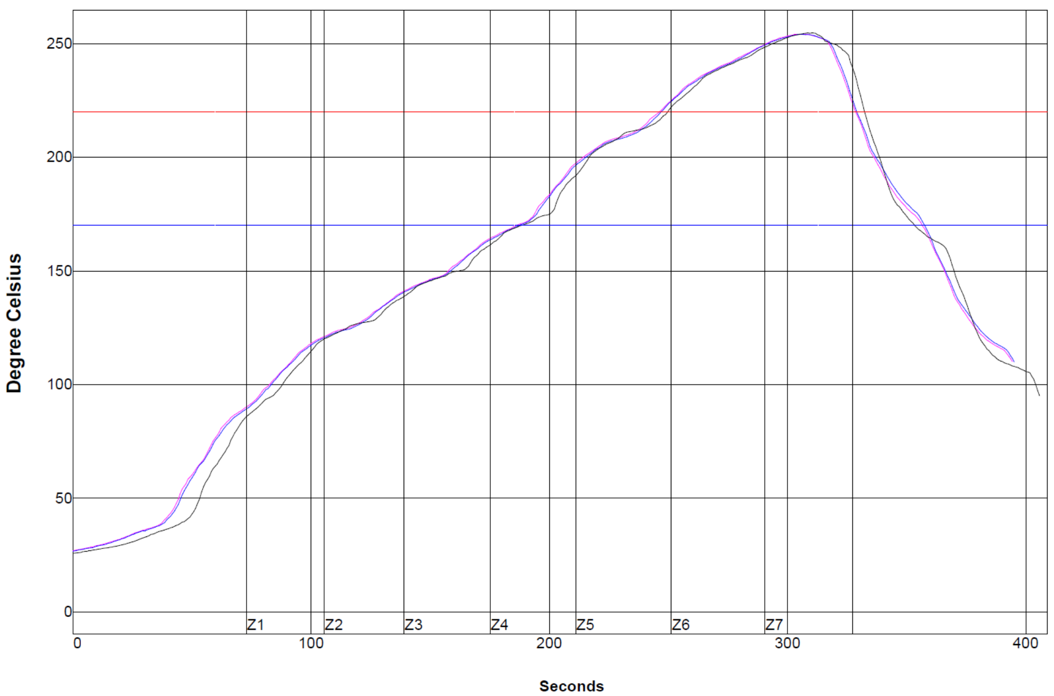
Reflow Thermal Profile

AGGRESSIVE THERMAL PROFILE

Setpoints (Degree Celsius)

Zone	1	2	3	4	5	6	7
Top	120	140	160	185	235	260	275
Bottom	120	140	160	185	235	260	275

Conveyor Speed (inch/min): 20.0



PWI= 73%	Max Rising Slope		Soak Time 170-220°C		Reflow Time /220°C		Peak Temp	
Connector	1.76	1%	60.03	0%	82.29	72%	254.17	53%
Connector	1.75	1%	59.78	-1%	82.09	71%	254.12	53%
PCB	1.95	27%	61.36	9%	82.67	73%	254.73	58%
Delta	0.20		1.58		0.58		0.61	

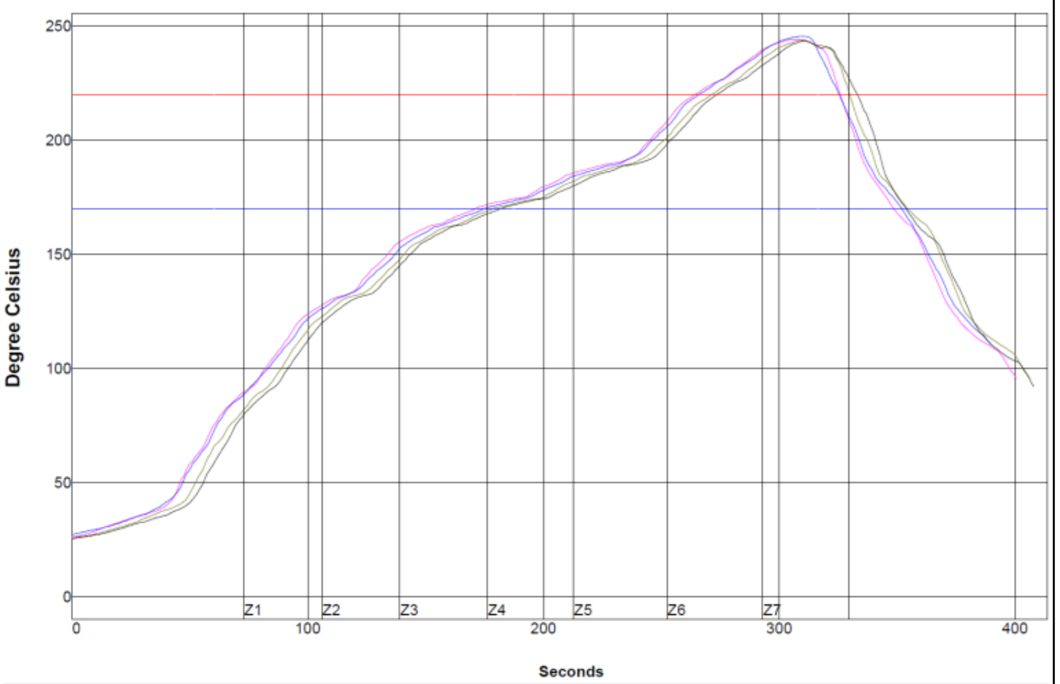
Peak Connector Temperature: **254°C** I Reflow Time: **82s**

MODERATE THERMAL PROFILE

Setpoints (Degree Celsius)

Zone	1	2	3	4	5	6	7
Top	120	150	180	180	195	245	265
Bottom	120	150	180	180	195	245	265

Conveyor Speed (inch/min): 20.0

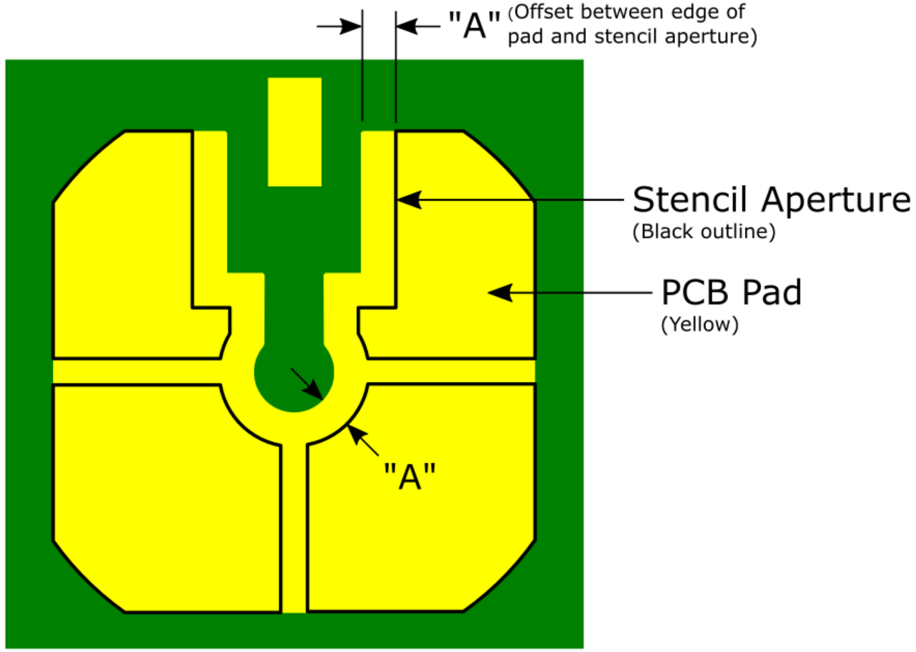


PWI= 220%	Max Rising Slope		Soak Time 170-220°C		Reflow Time /220°C		Peak Temp	
Connector	1.80	7%	93.06	220%	61.72	-3%	244.12	35%
PCB	1.73	-2%	91.28	209%	59.59	-11%	245.62	51%
PCB	1.70	-7%	92.87	219%	58.65	-14%	244.01	33%
PCB	1.74	-2%	91.57	210%	59.75	-10%	243.56	28%
Delta	0.10		1.78		3.07		2.06	

Peak Connector Temperature: **244°C** I Reflow Time: **62s**

Reflow Process Adjustments

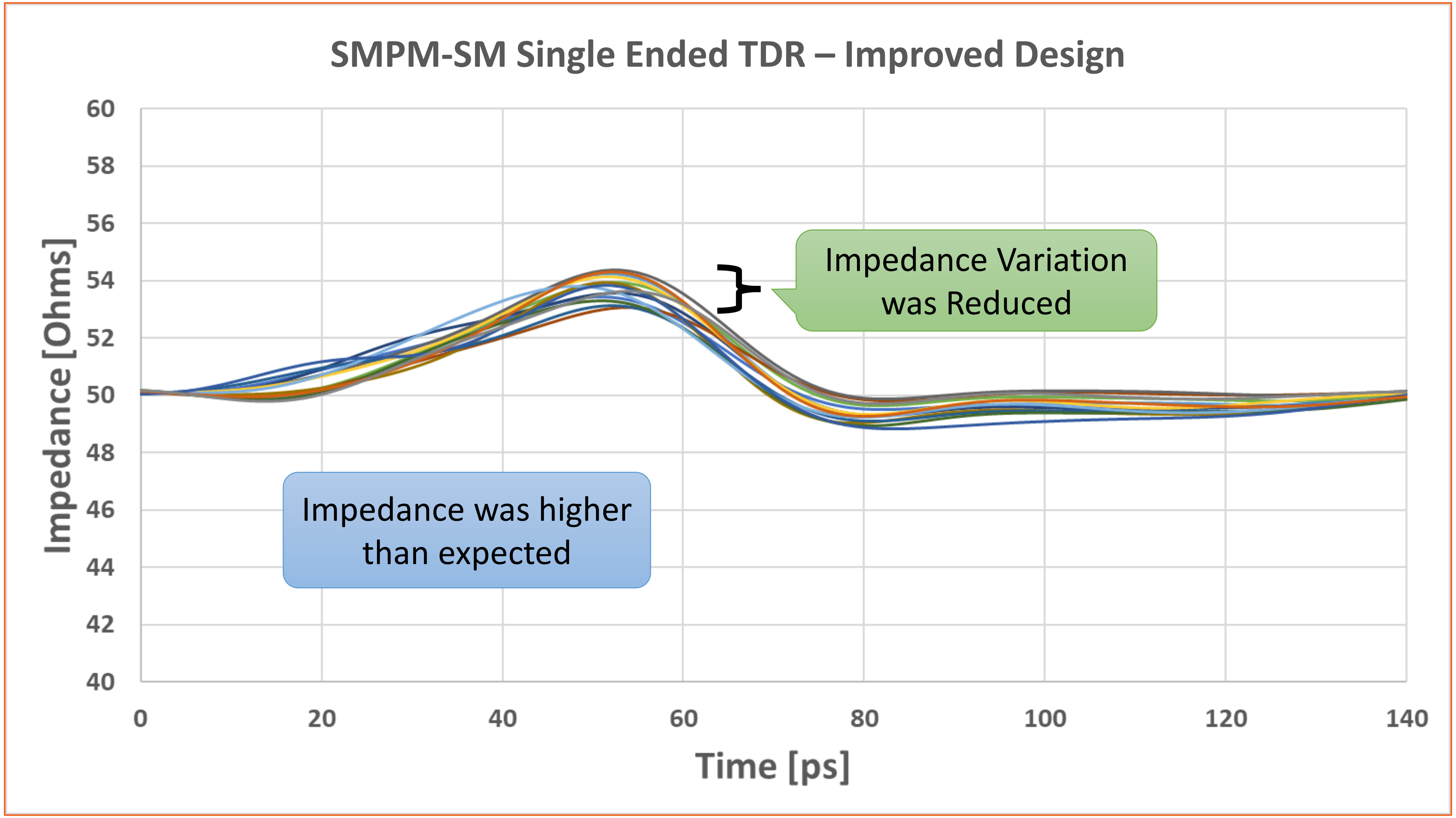
Process Parameter Adjustments			
Solder Paste:	Water-Soluble	→	No-Clean
Reflow Environment:	Nitrogen	→	Air
Stencil Thickness:	.005”	→	.004”
Reflow Profile:	Aggressive	→	Moderate



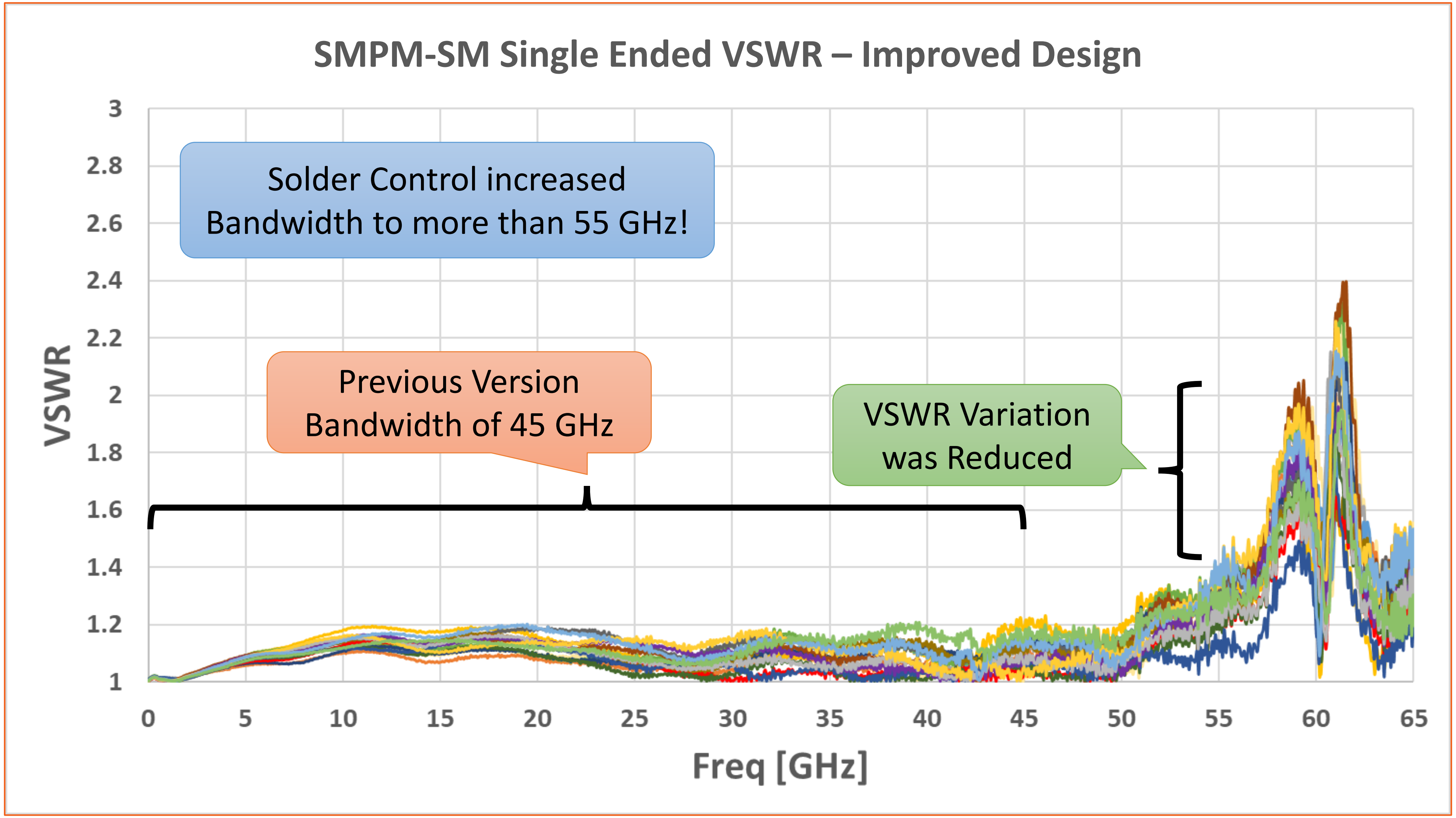
Stencil Aperture Modifications:

“A” dimension (offset between edge of pad and stencil aperture) was increased in iterations to prevent solder from wicking/migrating into critical regions for SI.

Improved Design & Process Reduced Zo Variation



Improved Design & Process Reduced VSWR Variation



Improved Design & Process Increased BW Potential

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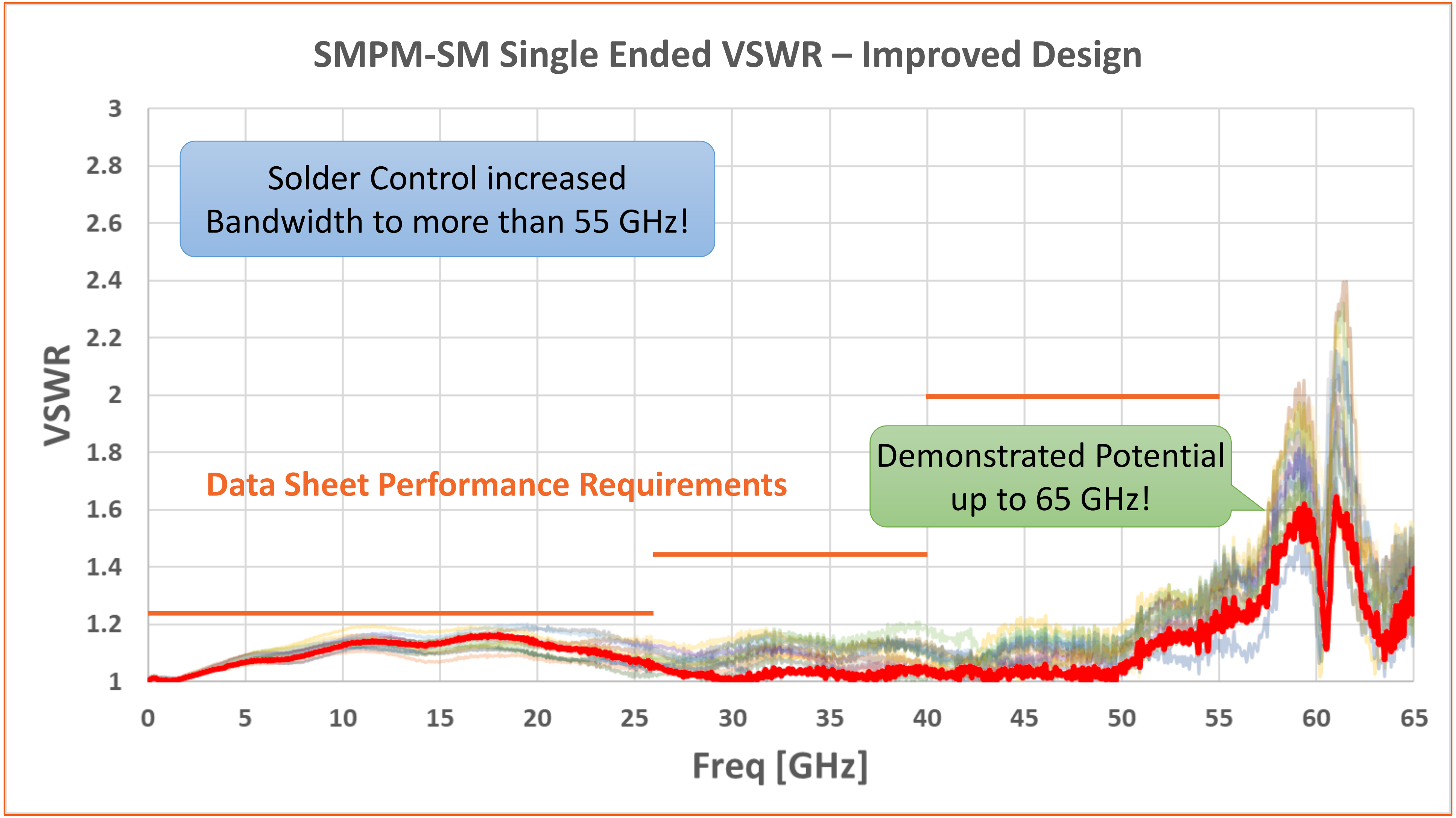
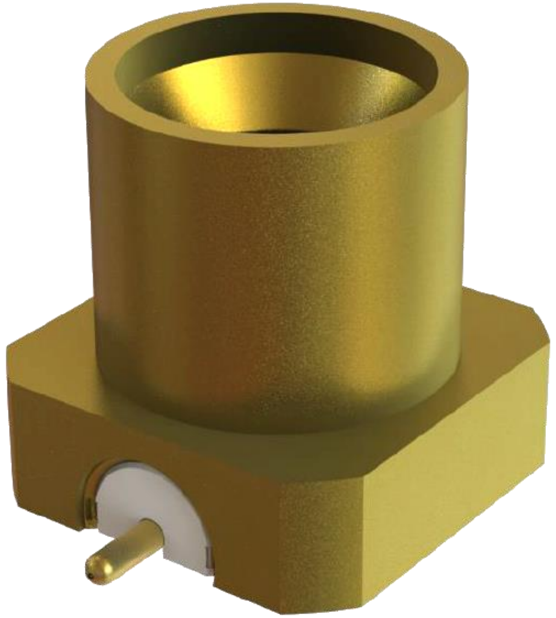


SMPM-SM-1



SMPM-XX-P-XX-ST-SM-1

GENDER
-PF: PLUG FULL DETENT
-PS: PLUG SMOOTH BORE

TYPE
-P: PCB

FINISH
-EG: 50µ" HEAVY GOLD CENTER CONTACT, 10µ" GOLD OUTER BODY

ORIENTATION
-ST: STRAIGHT

TERMINATION
-SM: SURFACE MOUNT

OPTION
-01

ELECTRICAL DATA

www.samtec.com/products/smpm-sm

Impedance	50 Ohm
Frequency Range	DC to 55 GHz
VSWR[1]	DC to 26.5 GHz: 1.25:1 Max 26.5 GHz to 40 GHz: 1.45:1 Max 40 GHz to 55 GHz: 2:1 Max
Insertion Loss[2]	$0.04\sqrt{F\ (GHz)}$ dB Max
Insulation Resistance	5000 MOhm Min
Voltage Rating (Sea Level)[3]	170 Vrms Max
DWV[3]	325 Vrms Min (sea level)

[1]VSWR per connector when tested on Samtec multi-layer test PCB
[2]Single connector insertion loss only
[3]May be further limited by PCB design

PCB Reference Design

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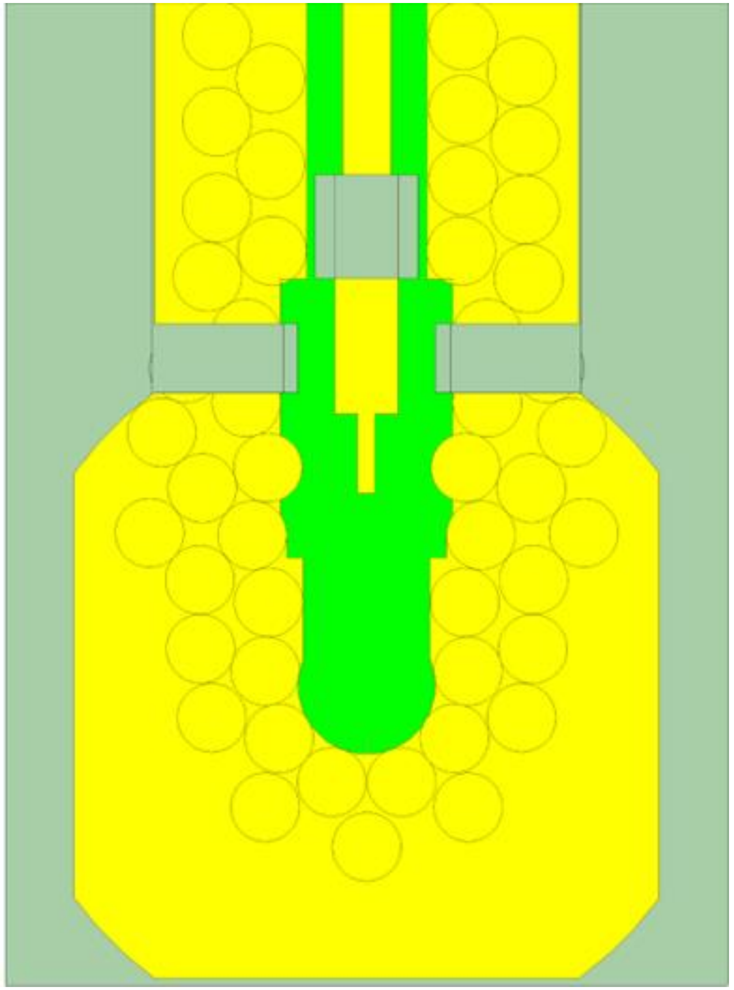
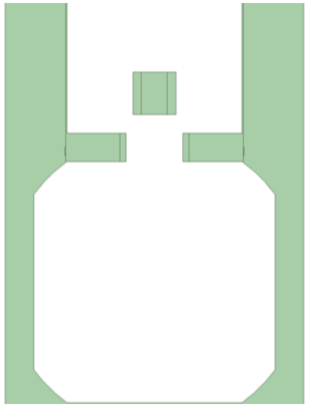
FOOTPRINT IMAGE



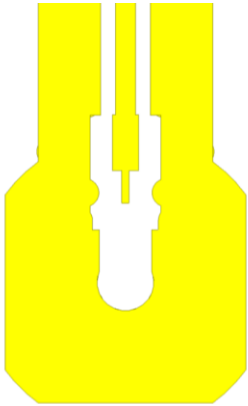
PCB STACK UP

Layer Number	LayerName	Material	Thickness mils	Thickness mm
	TOP_SM	PSR-4000-BN	0.71	0.018
1	TOP	PLATED COPPER (0_5oz)	2.09	0.053
	CORE01	I-TERA MT40 (2x1086) (67%) C	7.01	0.178
2	P02	COPPER (0_5oz) VLP2	0.59	0.015
	DIEL02	I-TERA MT40 (1x1080) (70%) PP	3.43	0.087
	DIEL03	I-TERA MT40 (1x1080) (70%) PP	3.43	0.087
	CORE04	I-TERA MT40 (2x1086) (67%) C	7.01	0.178
	DIEL05	I-TERA MT40 (1x1080) (70%) PP	3.43	0.087
	DIEL06	I-TERA MT40 (1x1080) (70%) PP	3.43	0.087
3	P03	COPPER (0_5oz) VLP2	0.59	0.015
	CORE07	I-TERA MT40 (2x1086) (67%) C	7.01	0.178
4	BOTTOM	PLATED COPPER (0_5oz)	2.09	0.053
	BOTTOM_SM	PSR-4000-BN	0.71	0.018
		Total thickness over solder mask and plated copper	41.53	1.054

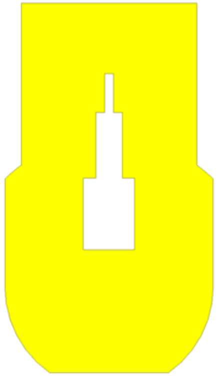
SOLDERMASK



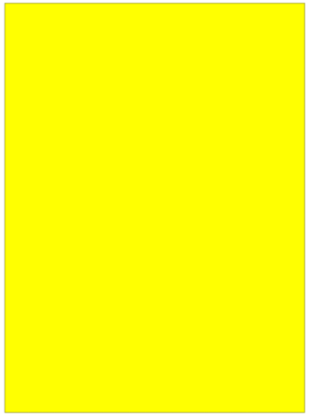
LAYER 1



LAYER 2



LAYER 3



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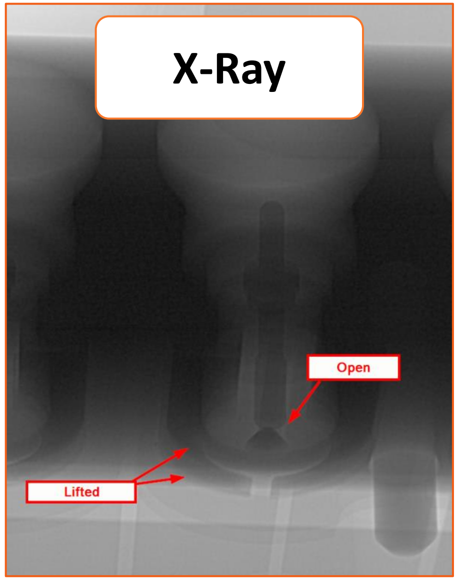
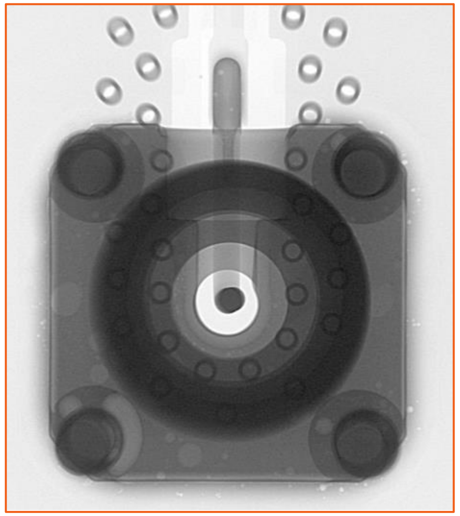
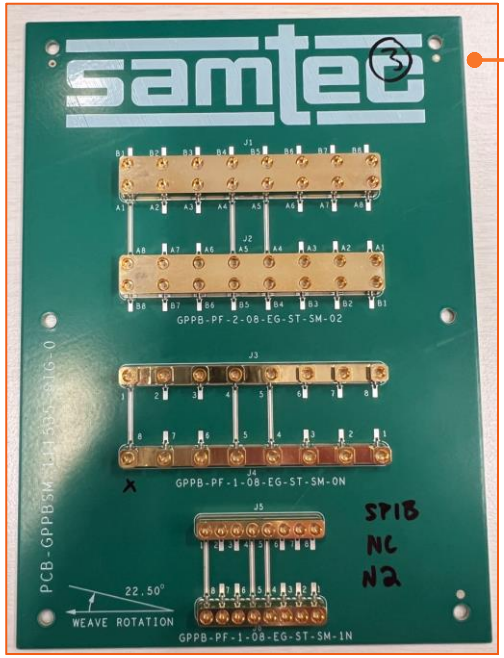
RELATED WORK

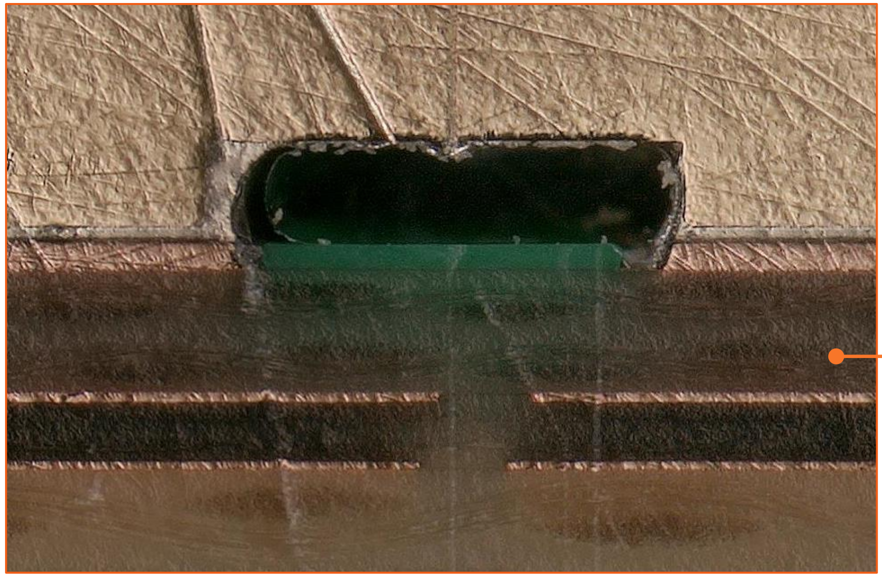
Tools & Techniques







SI Test Boards



Mechanical Cross Section

Mechanical Removal: Solder Test Boards

Modeling Solder Reflow

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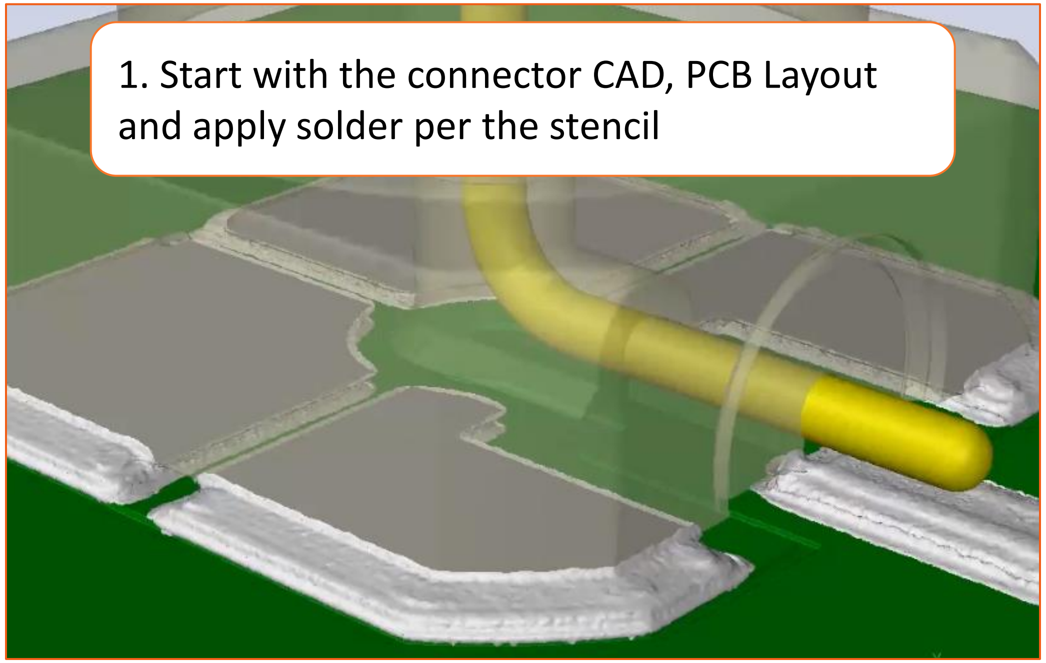
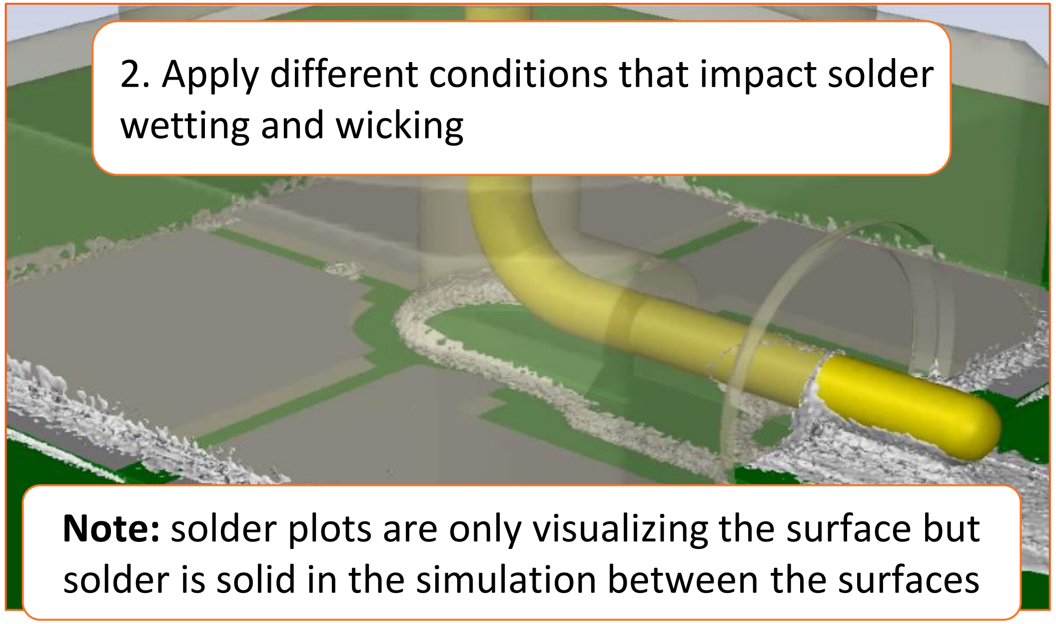
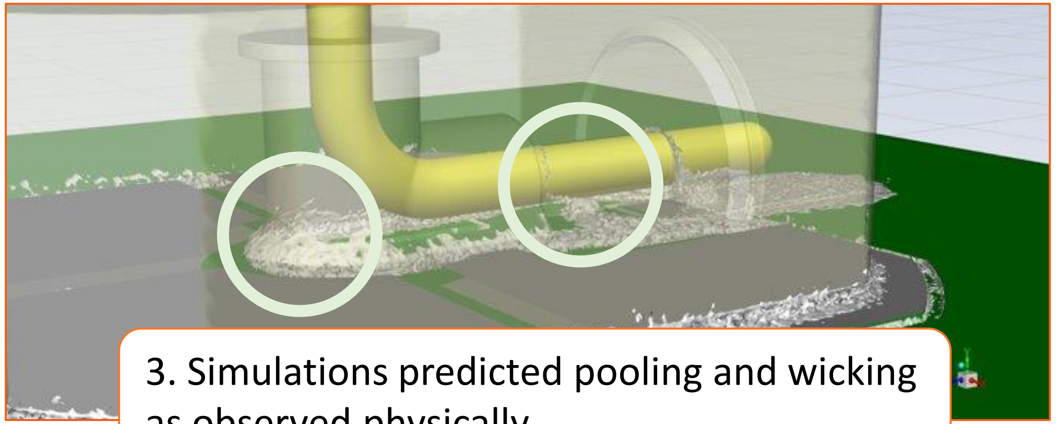
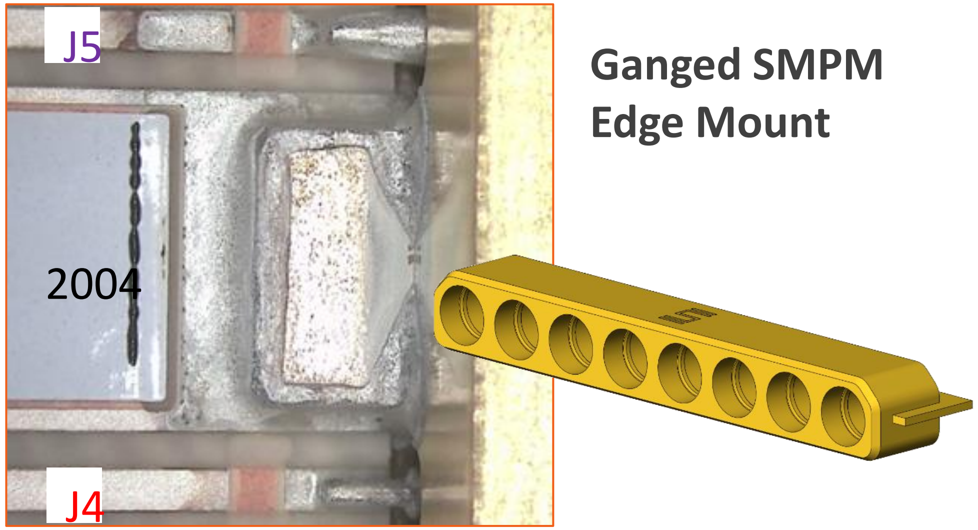




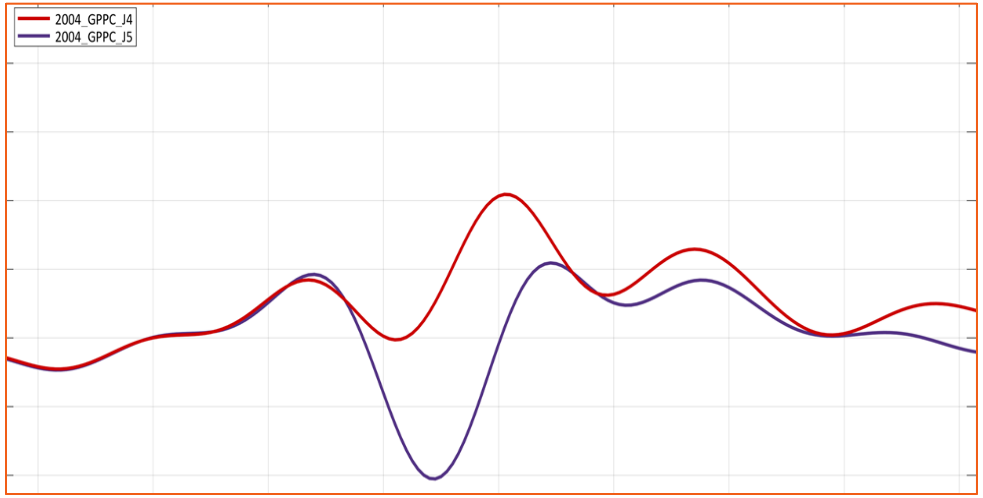


We are actively exploring workflows, developing modeling capabilities and refining material characteristics in order to develop improved methods of predicting solder reflow to minimize design iterations.

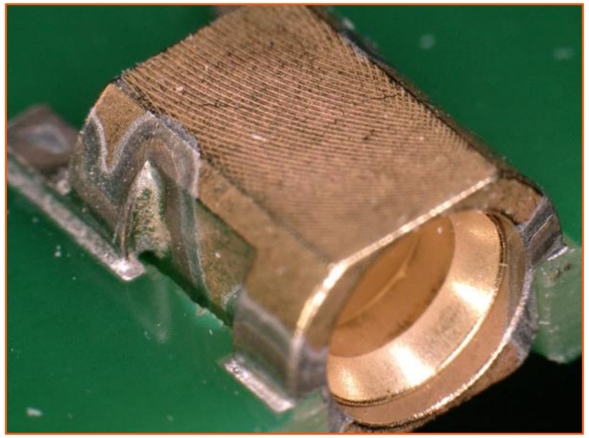
Other Connectors

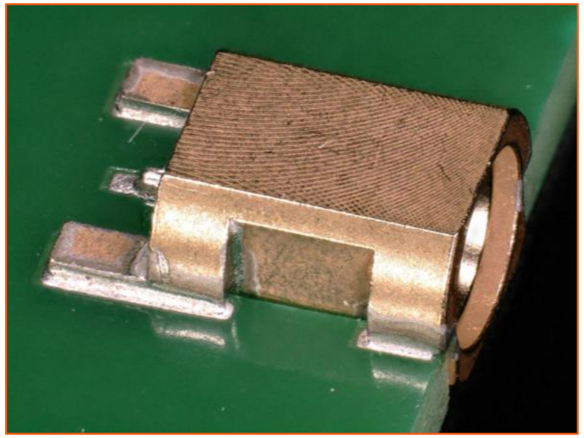


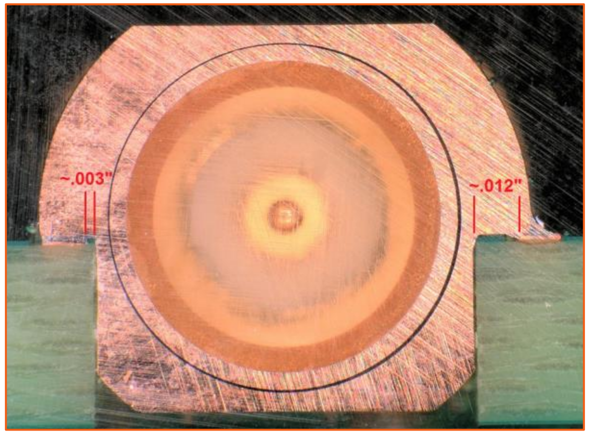
Ganged SMPM Edge Mount

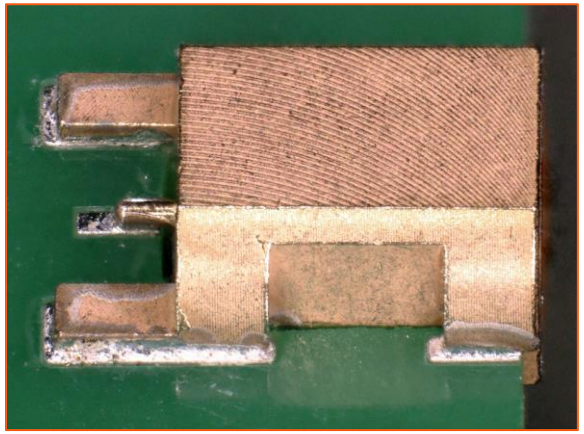


SMPM Edge Mount

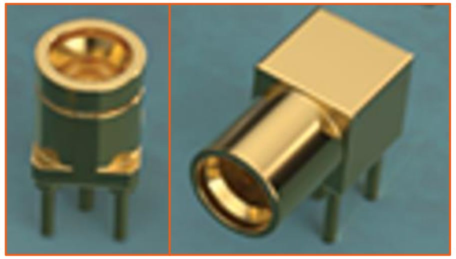




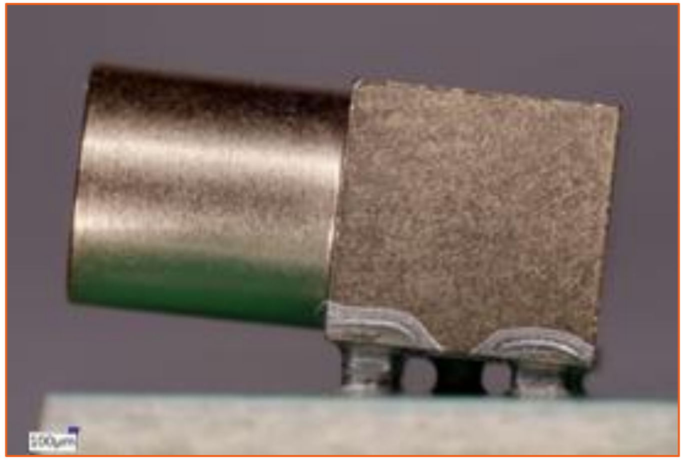


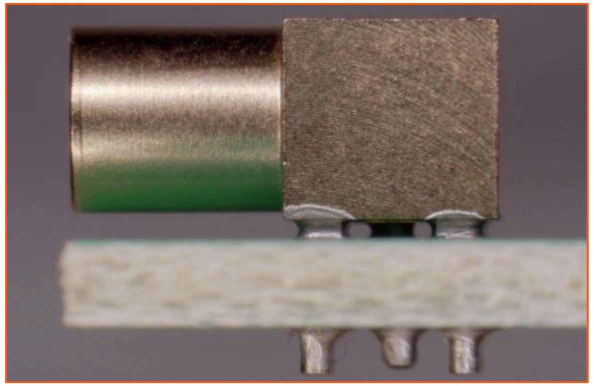


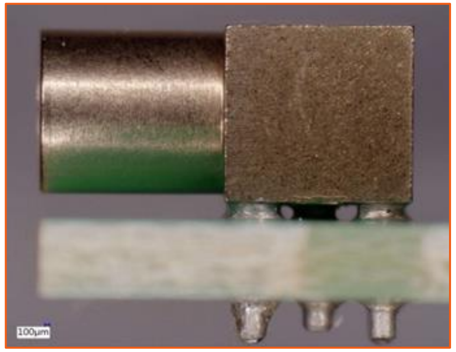
Other Connectors

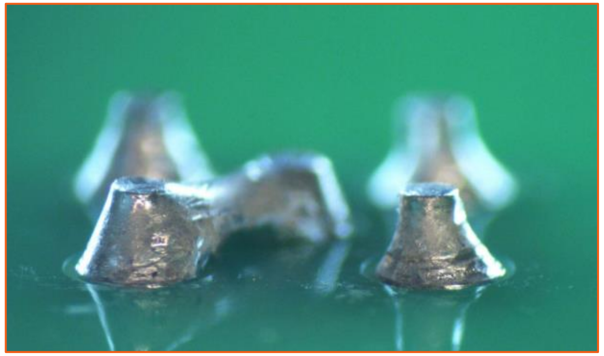


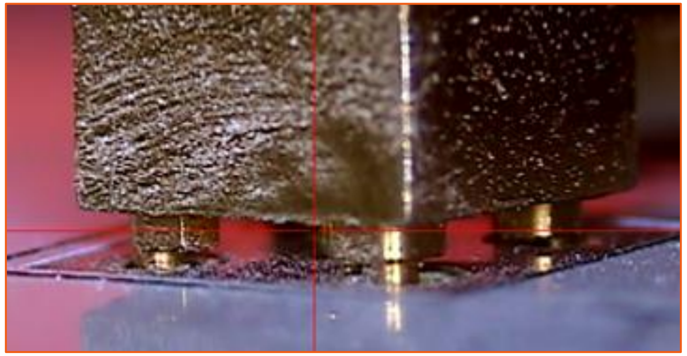
SMPM Through-hole











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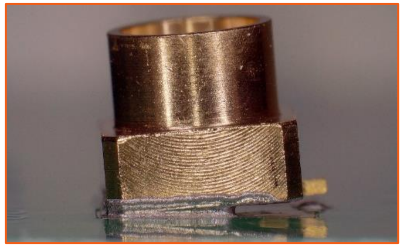
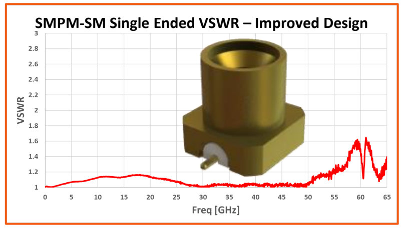
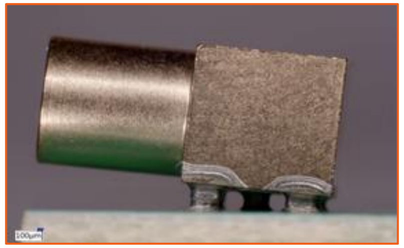


1) Solder reflow plays an important role in the success and performance of high bandwidth RF connectors

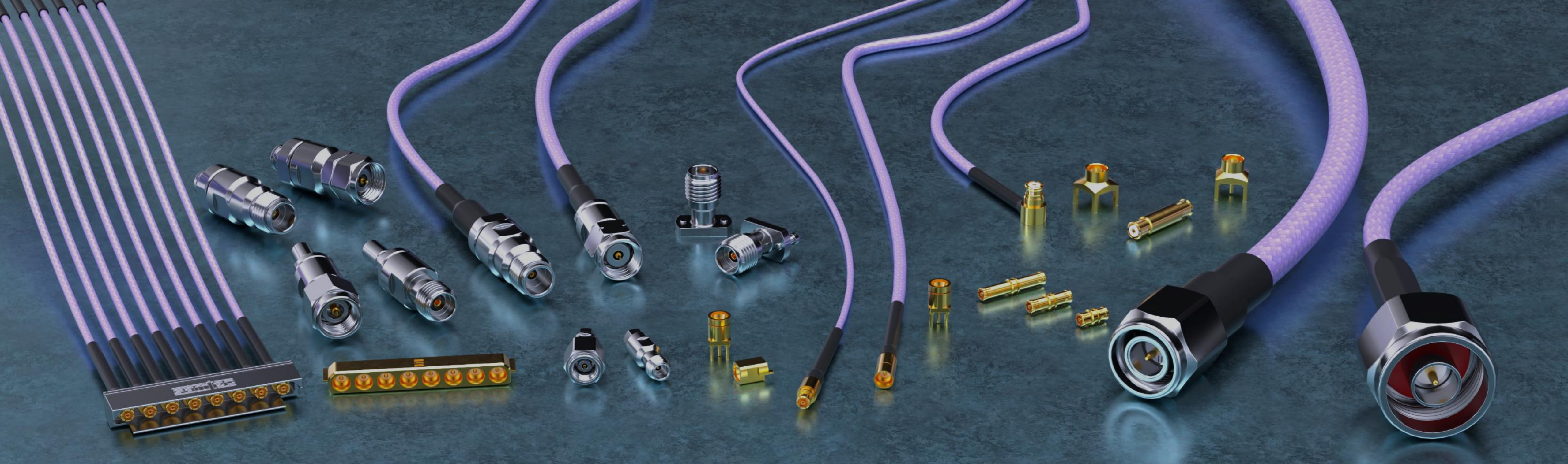
2) To better control solder reflow, changes can be made to the connector, the PCB, and the process



3) The connector, PCB, and process were all improved to develop Samtec's high performance **SMPM-XX-P-XX-ST-SM-1**



4) The challenges of solder reflow and the impact it has on performance extends to all high bandwidth RF connectors



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