



**PRECISION CIRCUIT TECHNOLOGIES**  
Every micron matters.

Ultra-high-performance Printed Circuits and Electrical Interconnects, enabling next-generation design & fabrication capabilities for leading semiconductor and electronics manufacturers.

*“Nearly every Cell Phone, Laptop, Computer, Data Center, Vehicle, Aircraft, TV, or Game Console has a chip inside that was tested during silicon development using technology now owned by PCT”*



Jim Rathbun  
Founder, President

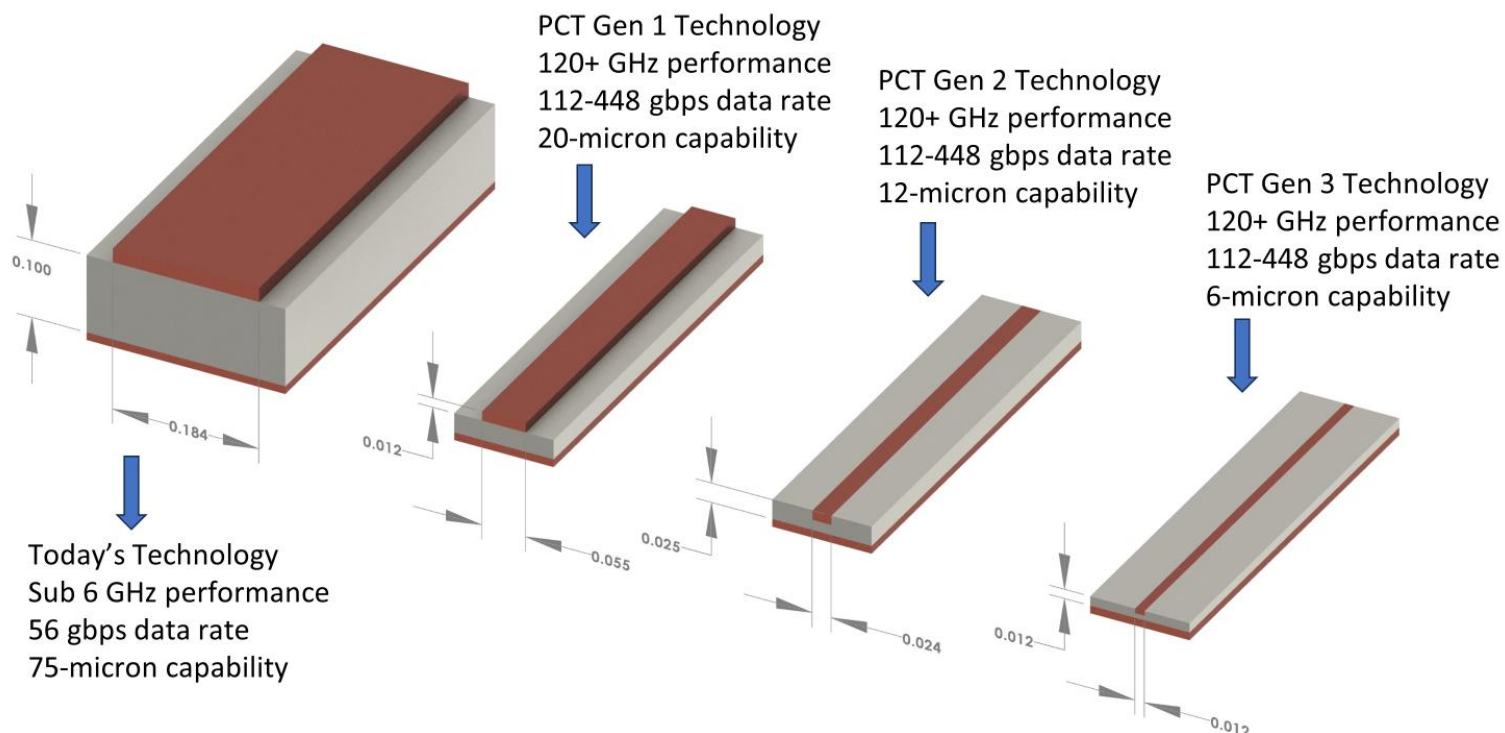
**PRECISION CIRCUIT TECHNOLOGIES | PCT**  
Every micron matters™

## Technology Advantage and Customer Benefit

The proposed Technology Portfolio provides Customers in the broad Electronics Industry the opportunity to reduce the physical size of the circuits and assemblies in their end products, while increasing performance.

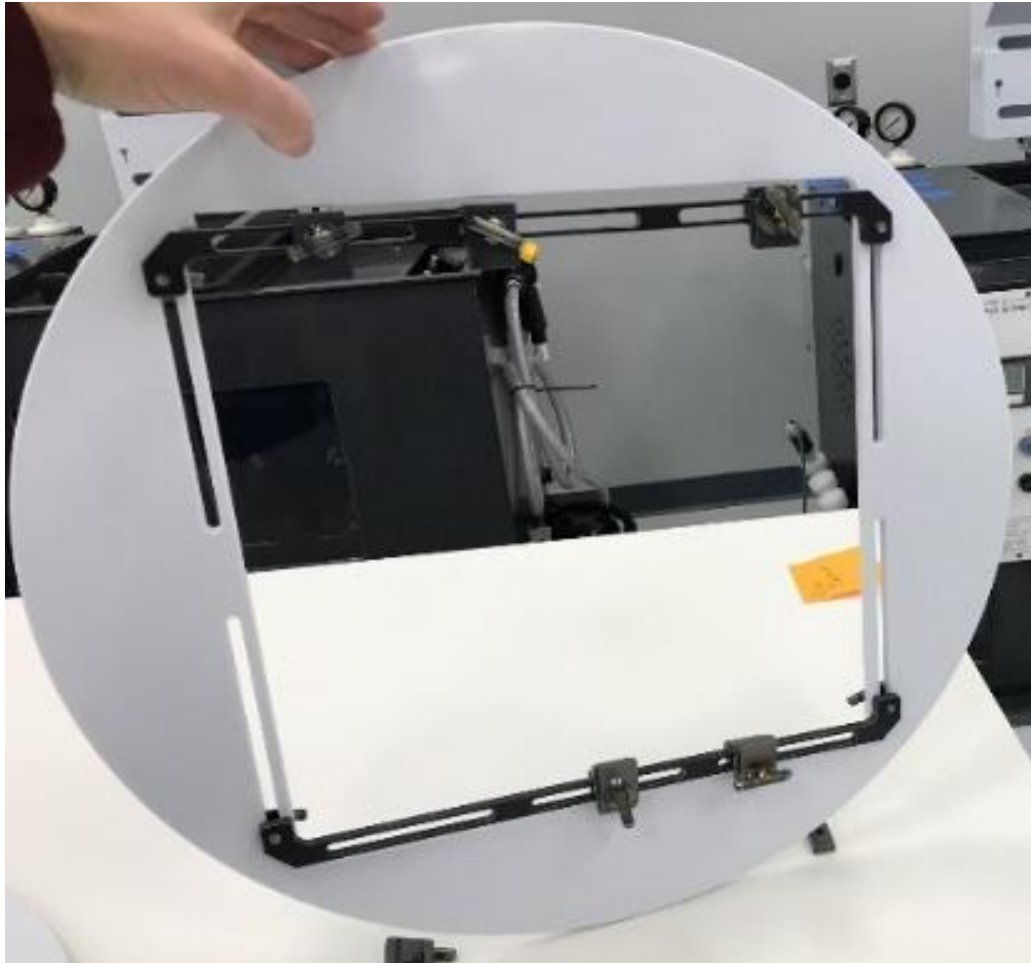
ALL Market segments need finer geometries, high layer count, and high frequency. LCP is ideal material to establish very high density and very high speed, rigid-substrates-flex and rigid flex.

## Circuit Size and Performance Comparison



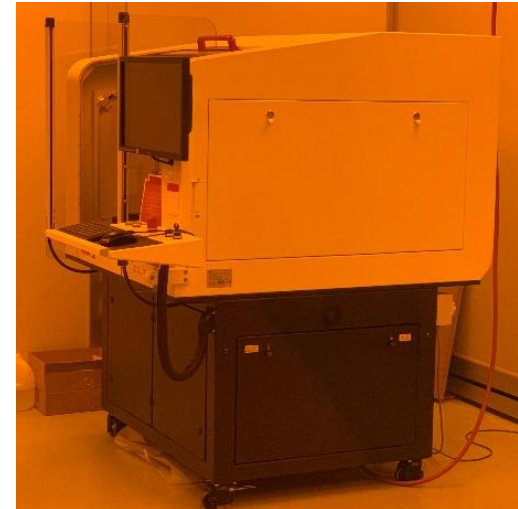
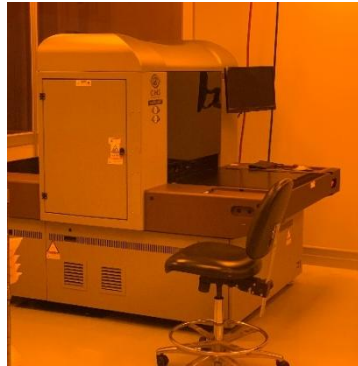
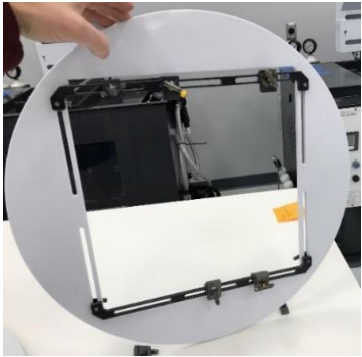
## LCP Circuit Platform – Basic Building Block – Vertical Processing

- Below 25 micron Line and Space – Vertical wet processing is key
- Fluid dynamics from topside to bottom side matters



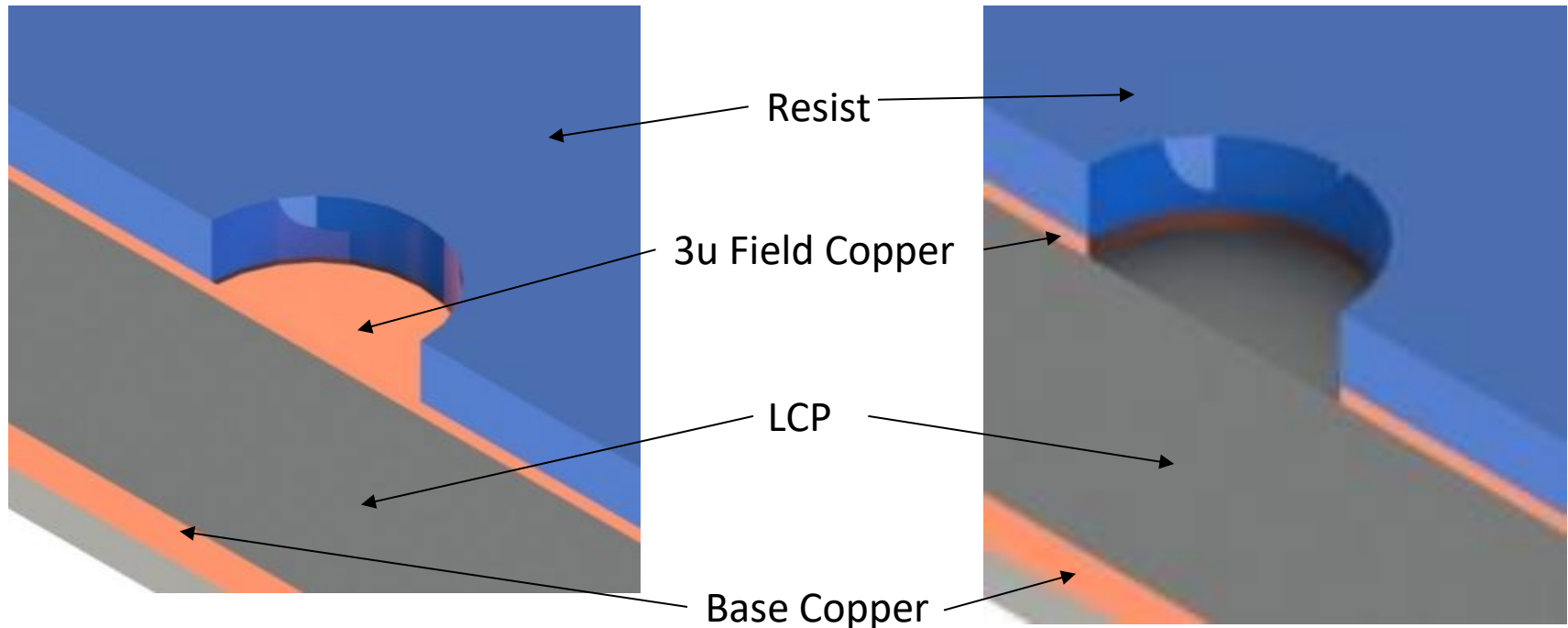
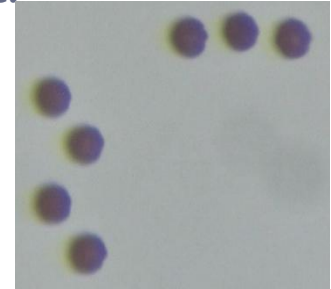
Advanced Technology Development Center Brooklyn Park MN Jul 2025  
Line and Space shrink is not the only measure of capability. Impedance matching, low loss  
and precision control of circuits and stack are critical to performance.

ABF, Glass, and Polyimide have limitations that LCP technology overcomes



## LCP Circuit Platform – Basic Building Block – Via Formation Prep

- Below are basic platform fabrication steps
- Base LCP prepared with Cu one or two sides coated with resist.
  - -Option 1 with 3 u field copper– etch target
  - -Etch field copper at via target
  - Laser Drill via through LCP down to base copper layer
  - 50 micron vias shown right photo

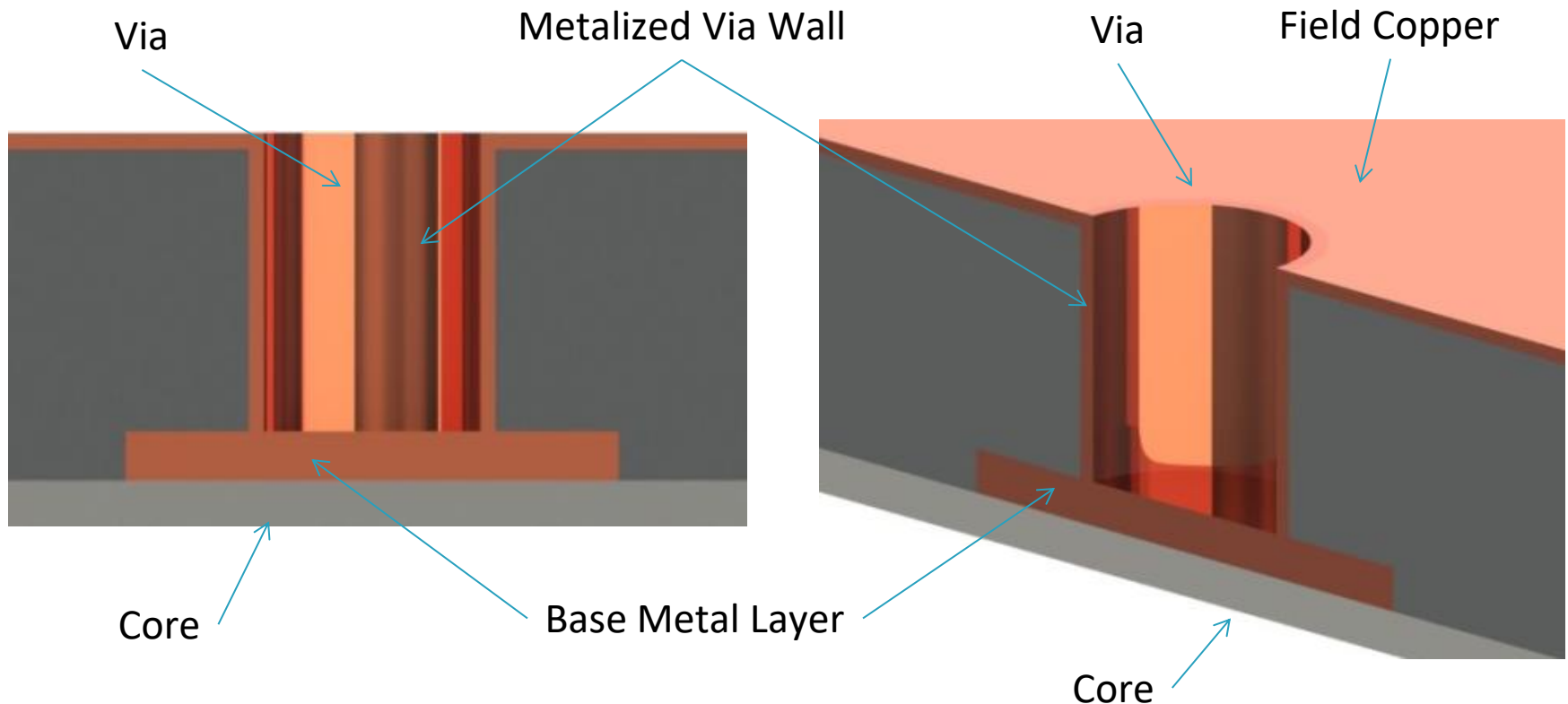


## LCP Circuit Platform – Option 1 – Blind Via Multi-Layer

LCP Surface and Via walls metalized

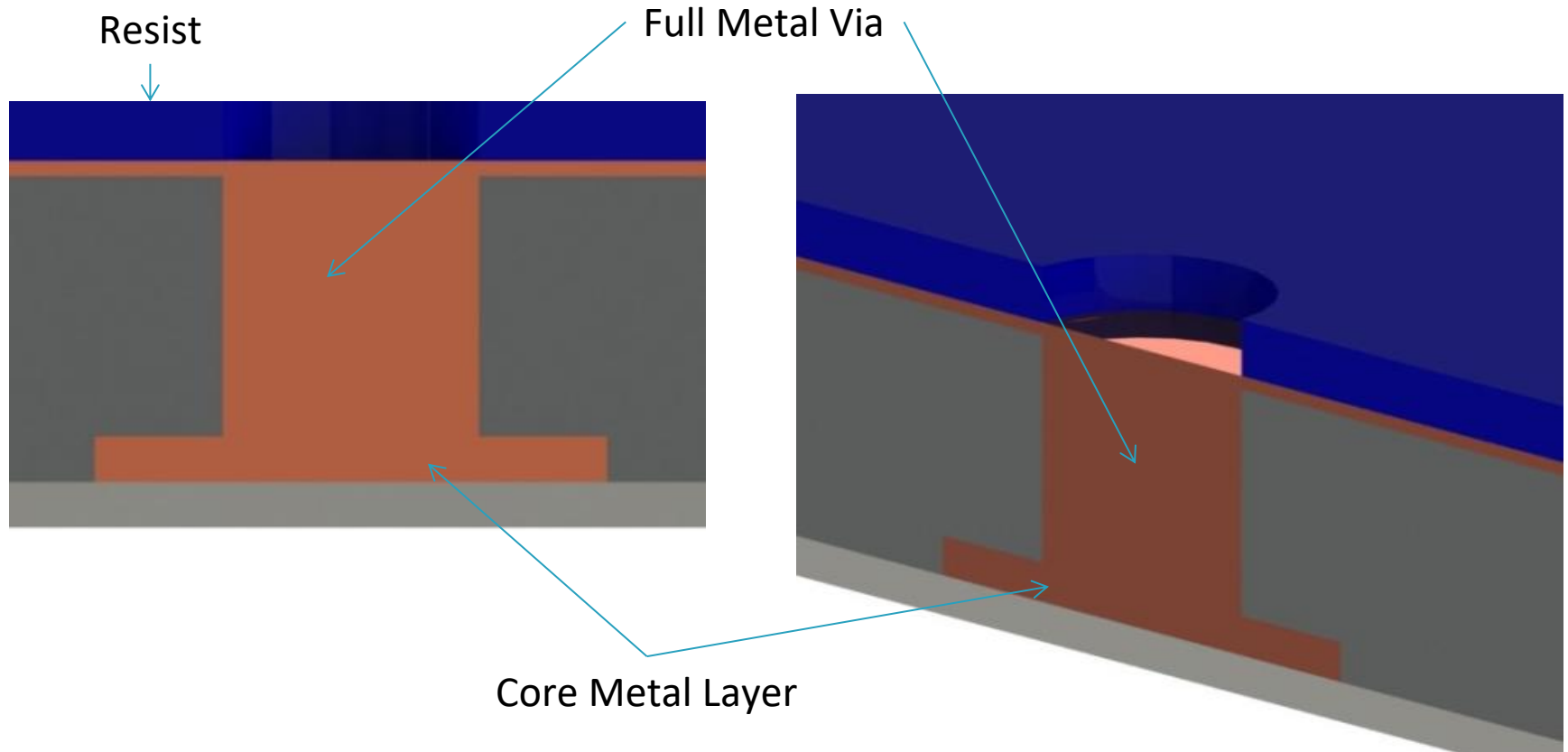
Electroless Copper or Pd based metallization as needed

Via walls electrically connected to base metal layer



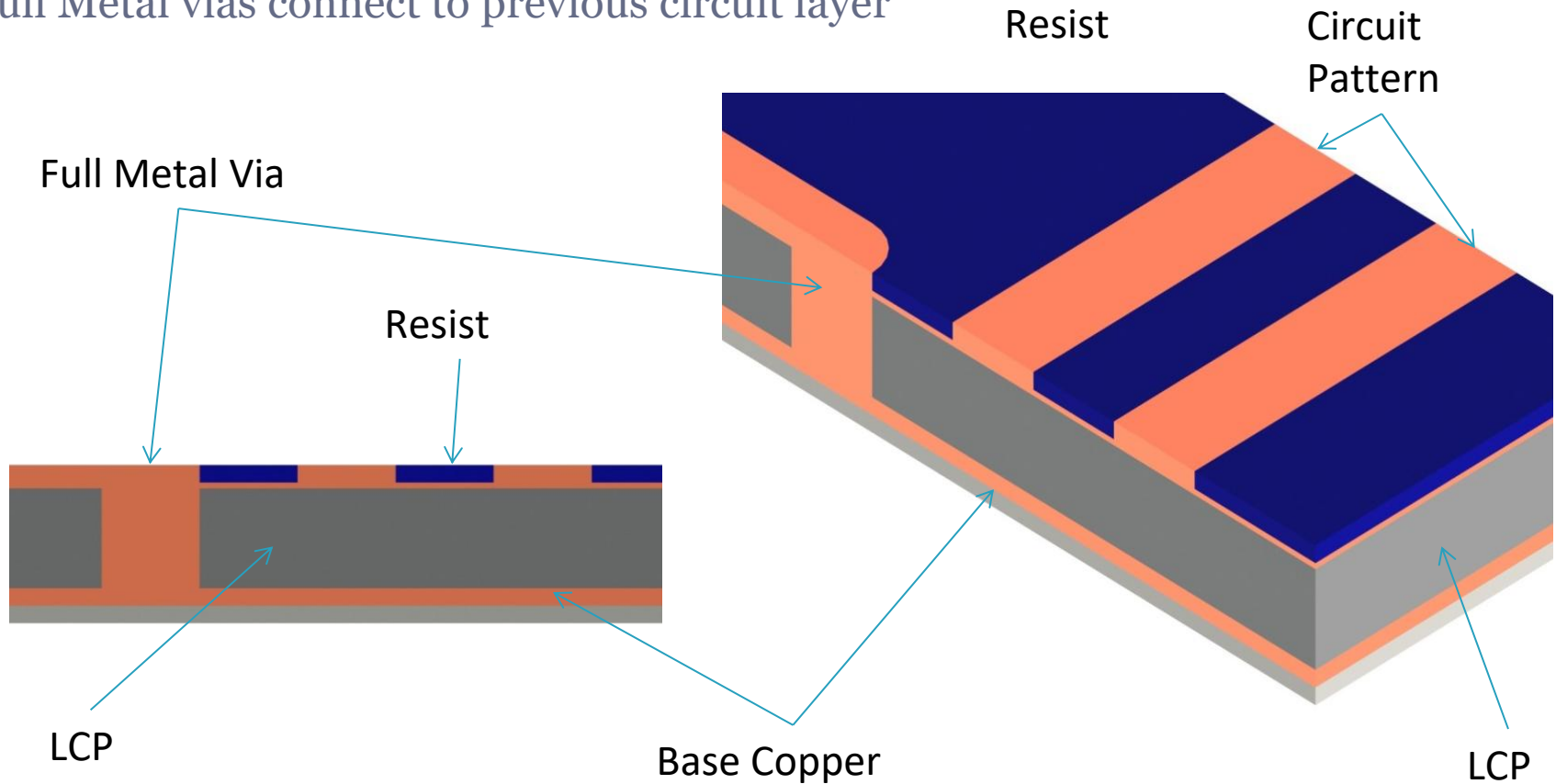
## LCP Circuit Platform – Option 1 – Blind Via Multi-Layer

“Defect Fill” style plating method creates Full Metal Via  
Vias are plated to resist level to create field copper for next layer processing



## LCP Circuit Platform

- Electrolytic plating bus connected to field copper
- Circuits pattern plated to top of resist
- Full Metal vias connect to previous circuit layer



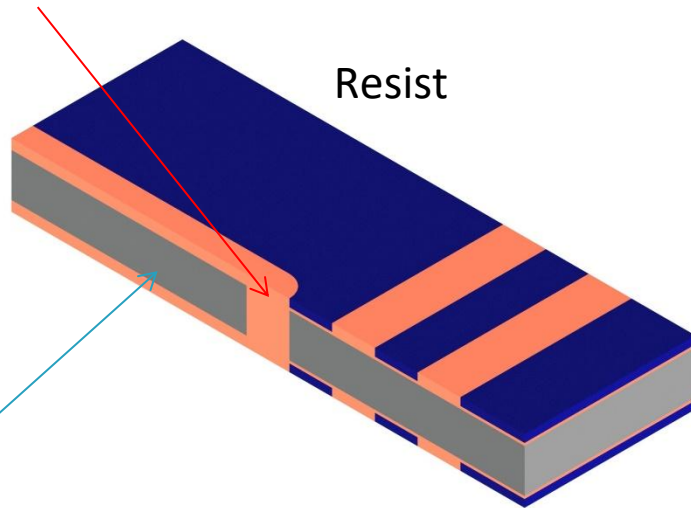
## LCP Circuit Platform – Pattern Plate both sides with Full Metal Via

- Electrolytic plating bus connected to field copper
- Circuits pattern plated to top of resist
- Full Metal vias connect between circuit layers

Full Metal Via

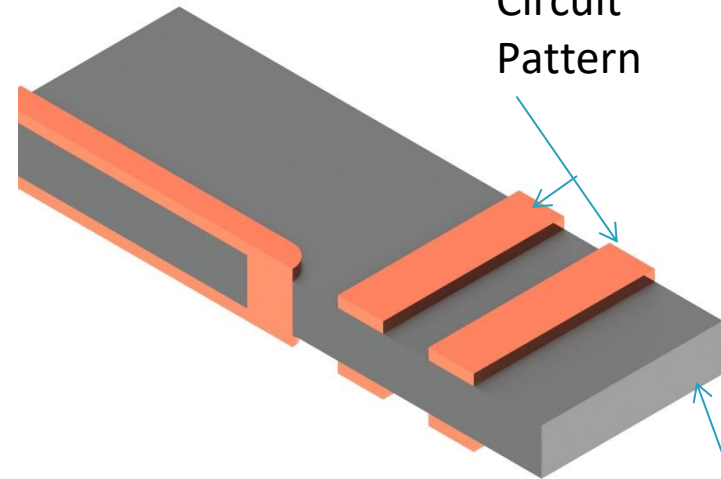
Resist

LCP



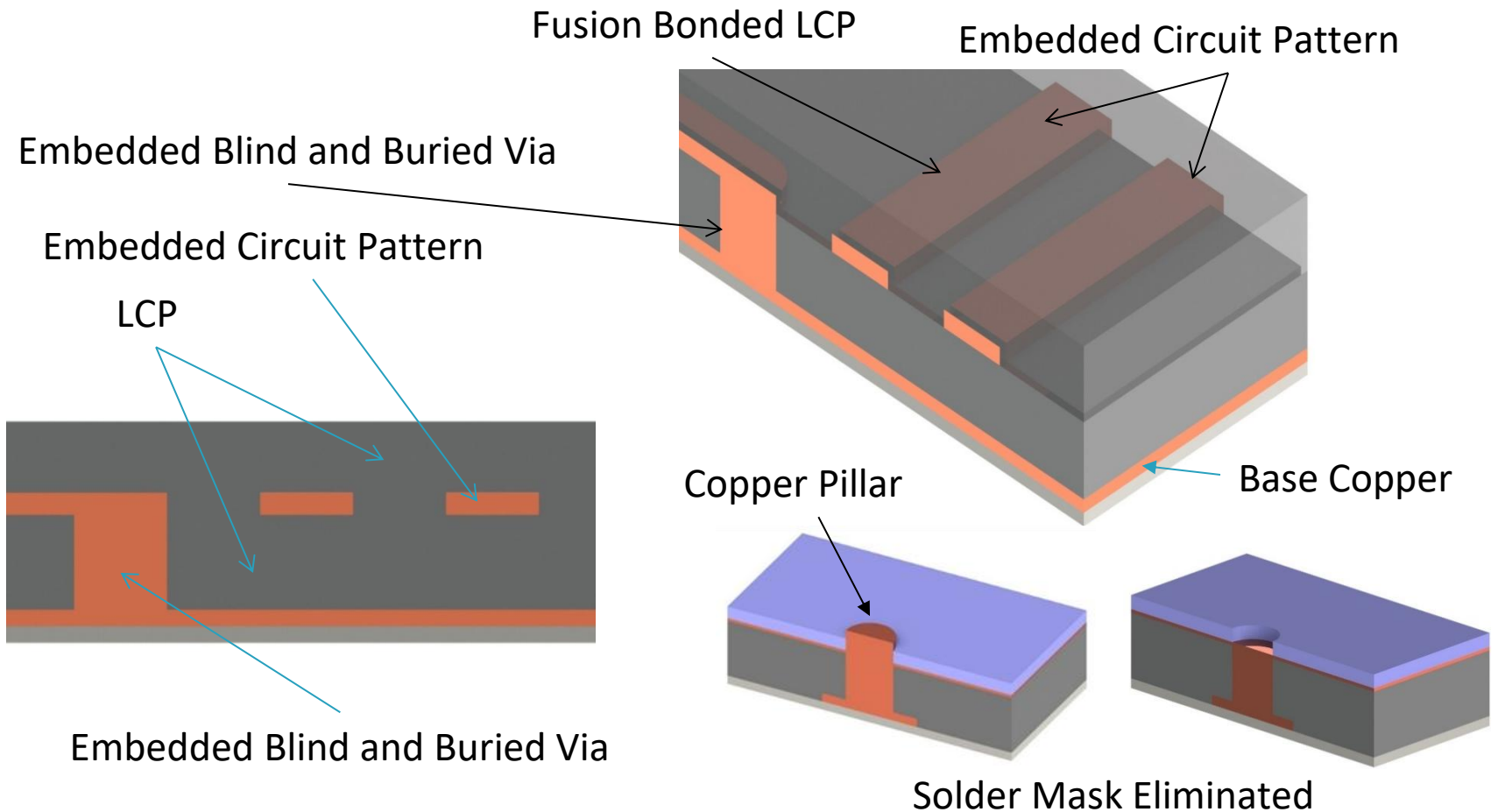
Circuit Pattern

LCP



## LCP Circuit Platform

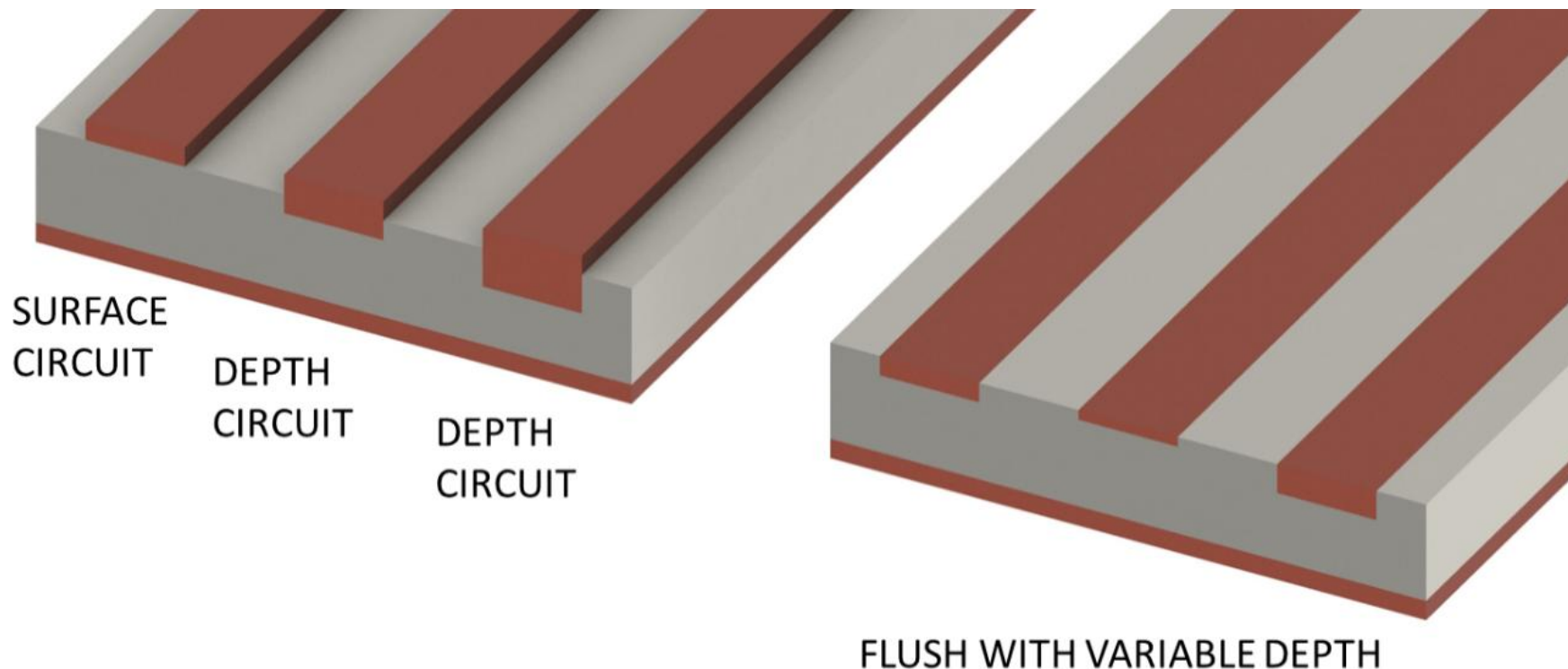
- Next Dielectric Layer is Fusion Bonded – LCP to LCP
- Vias and Circuit Patterns are embedded with common dielectric surrounding



## Technology Advantage and Customer Benefit

The PCT approach reduces Circuit Size and Increases Circuit Density. It also adds variable circuit size and thickness on the same metal layer, providing customers with extreme design freedom with high-speed and power management applications.

Liquid Crystal Polymer enables extreme circuit size reduction with precision impedance tuning.



## Extraordinary Technology – Global Liquid Crystal Polymer Leadership

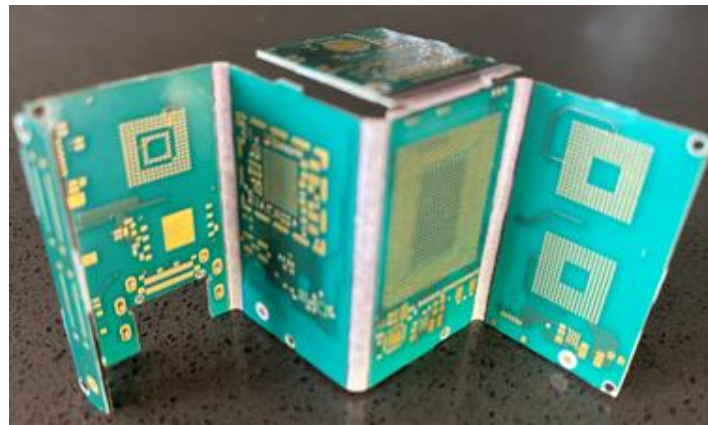
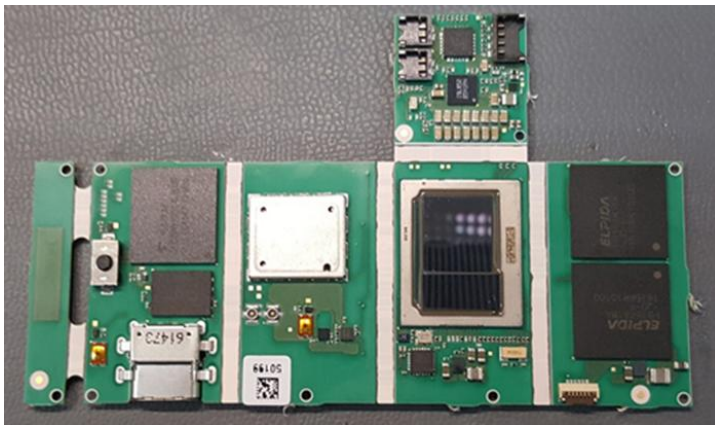
The Technology focus is Advanced Printed Circuitry Fabrication with Microelectronics Assembly and making very small, fast electrical connections. A focus is Liquid Crystal Polymer (LCP) materials.

- LCP is very thin and has excellent electrical performance – 120 GHz – 112-224 gbps
- The manufacturing process is very accurate and provides precision tuning of the circuits.
- Technology provides extreme impedance control from 50 micron lines to 6-9 micron.

### Example:

Foldable LCP Laptop Motherboard – Size of a credit card – 12 circuit layers – conforms to desired shape

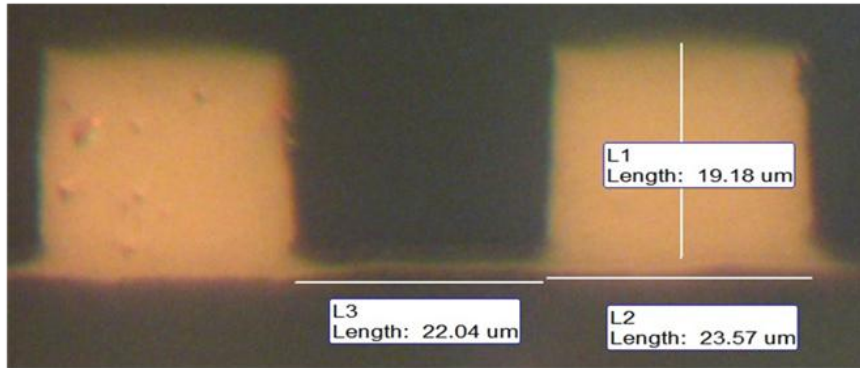
Equipment set, Process recipes, Design Rules all defined – backed up with patents and trade secrets



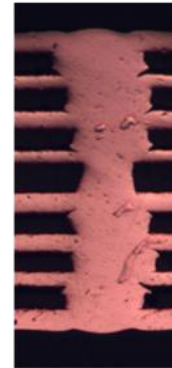
## Core Technology Focus – Precision Circuit Fabrication – Every Micron Matters

Precision control of circuit geometry on each layer–Layer to Layer connections and lamination are critical

Precision Control of the Circuits within 1 micron



Many Layers

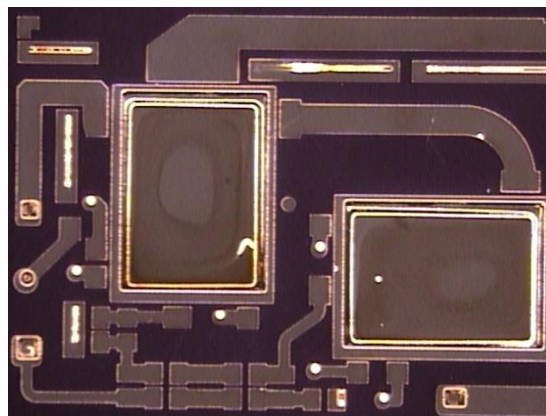
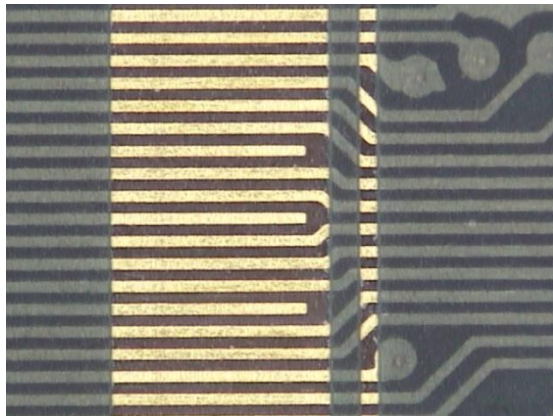


Chips Closer Together  
Chips Embedded in LCP



Precision control of trace geometries and via structures – 25-50 micron is good enough for today's applications with path to 6-9 micron.

Embedded Thermal Management

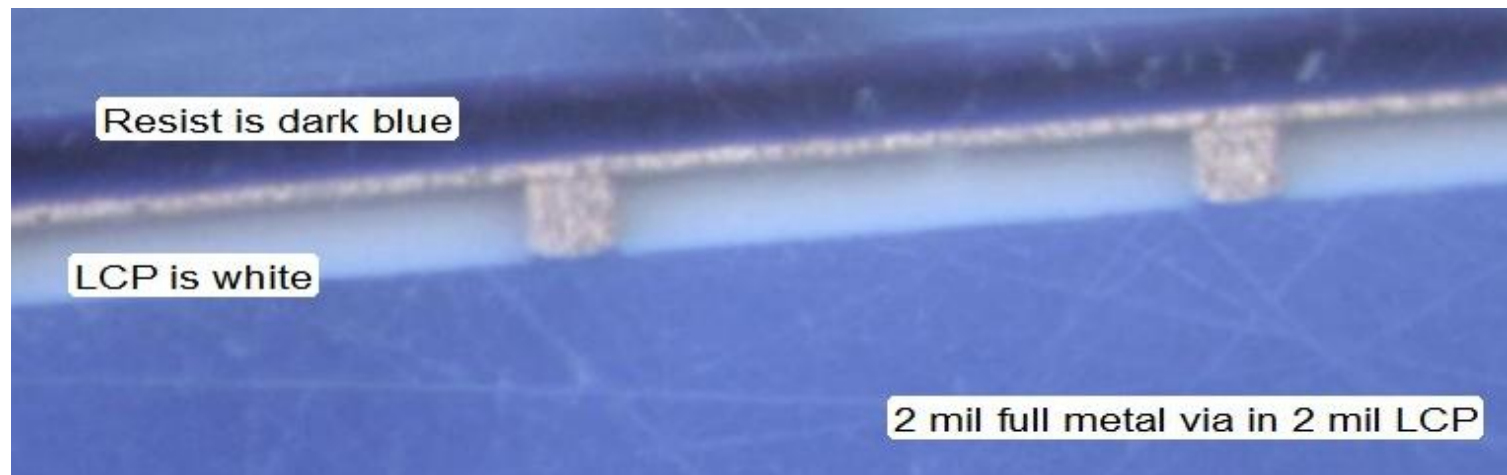
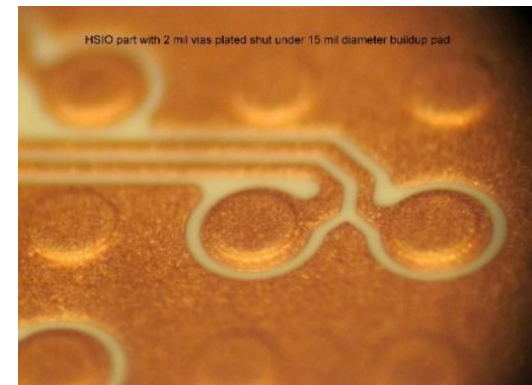
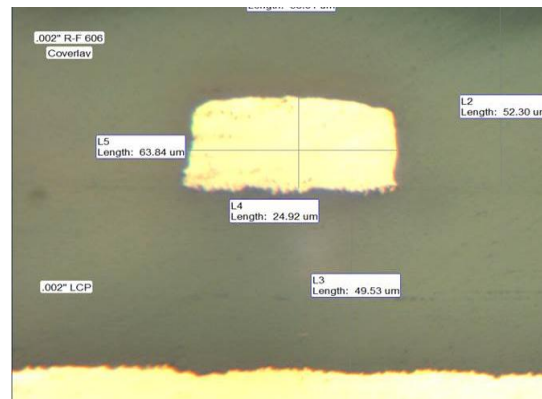
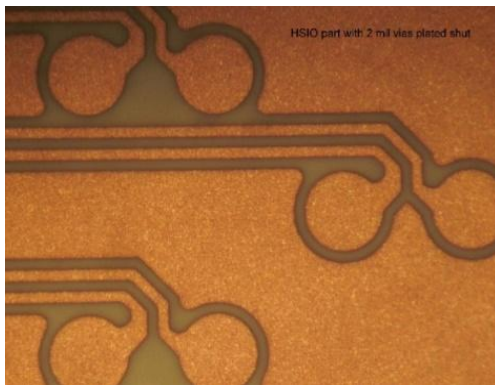


Embedded Die



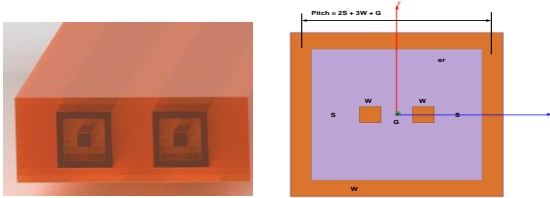
## Core Technology Focus – Precision Circuit Fabrication – Every Micron Matters

Precision control of circuit geometry on each layer–Layer to Layer connections and lamination are critical  
 -1 micron change in trace width, trace height, and dielectric separation is 1 ohm change in impedance  
 -Vertical side walls of vias and trace sections are critical to performance and impedance match



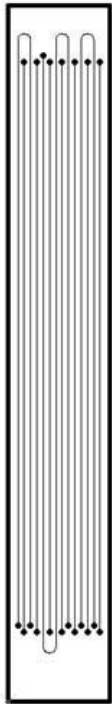
## Embedded Coax Validation Sample – Progression to 9 micron lines

Target impedance of 50 ohms – 10 different signal lines measured – Nominal to be adjusted by 2 ohms



Initial test results from Coupon 9B (300x100 coax with 60 micron center conductor):

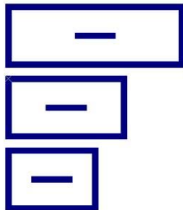
Name	Result	Avg	S/N	Job #	LYR	Time/Date	Min Z	Max Z	Std Dev	Oper
Embedded coax 4.5 inch	Pass	52.23	9B-1			1 5/16/2017 14:33	50.98	53.2	0.72	
Embedded coax 4.5 inch	Pass	51.9	9B-2			1 5/16/2017 14:33	50.8	52.86	0.64	
Embedded coax 4.5 inch	Pass	52.59	9B-3			1 5/16/2017 14:33	51.86	53.44	0.56	
Embedded coax 4.5 inch	Pass	52.19	9B-4			1 5/16/2017 14:34	51.63	53.02	0.5	
Embedded coax 4.5 inch	Pass	52.35	9B-5			1 5/16/2017 14:34	50.64	53.83	1.02	
Embedded coax 4.5 inch	Pass	52.47	9B-6			1 5/16/2017 14:34	50.89	53.98	1.08	
Embedded coax 4.5 inch	Pass	52.42	9B-7			1 5/16/2017 14:34	50.97	53.77	0.9	
Embedded coax 4.5 inch	Pass	52.58	9B-8			1 5/16/2017 14:34	51.14	53.71	0.85	
Embedded coax 4.5 inch	Pass	52.76	9B-9			1 5/16/2017 14:35	51.25	54.01	0.93	
Embedded coax 4.5 inch	Pass	51.67	9B-10			1 5/16/2017 14:35	50.1	53.04	0.94	



Transmission line test coupon with 10 test lines:  
 7 test traces at 4.5" long.  
 2 test traces at 9.4" long.  
 1 test trace at 14.3" long.



Center conductor routing shown.



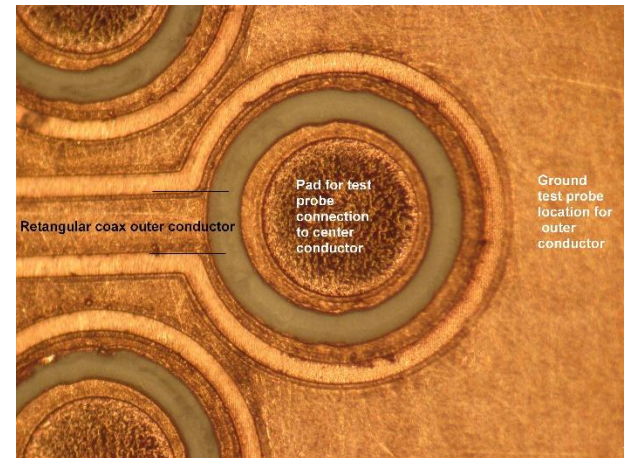
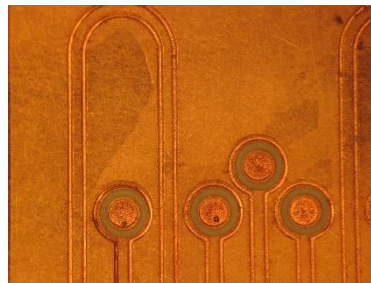
Cross sectional view:

300x100 micron rectangular coax (Coupons 7A-9B)

200x100 micron rectangular coax (Coupons 4A-6B)

150x100 micron rectangular coax (Coupons 1A-3B)

Center conductor widths of 20, 35, and 60 microns (shown at 60 microns).



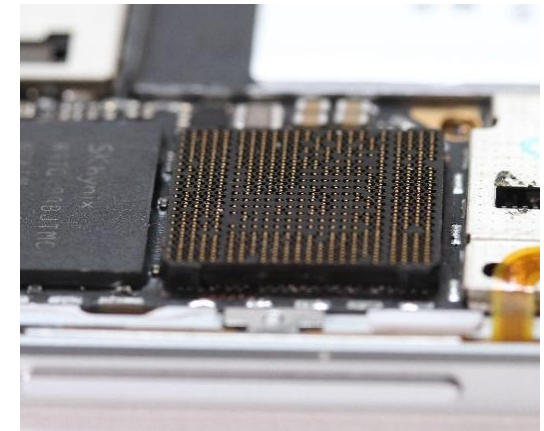
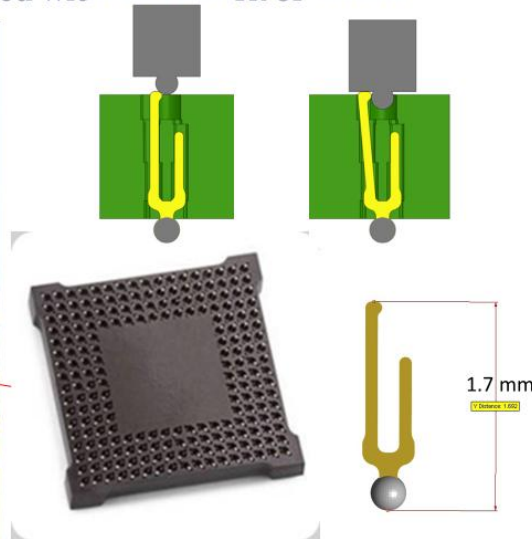
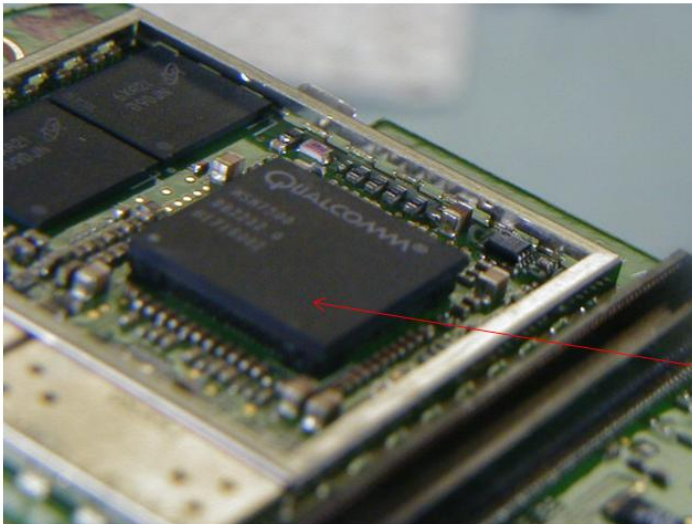
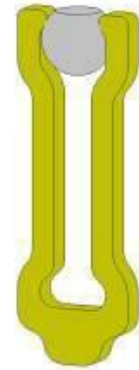
## High Speed Connector Applications – Socketing BGA Devices Directly without solder reflow

- Socket is soldered to the system pcb using same profile as BGA device
- BGA is plugged into socket, contact holds solder balls, unplug and replace

### Grypper Product Lines – G40, G80

Unique Device Size socket product that solders to the target circuit board in place of the BGA device. No fasteners or pcb through holes needed.

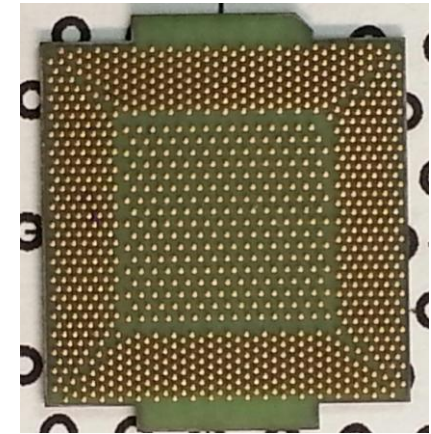
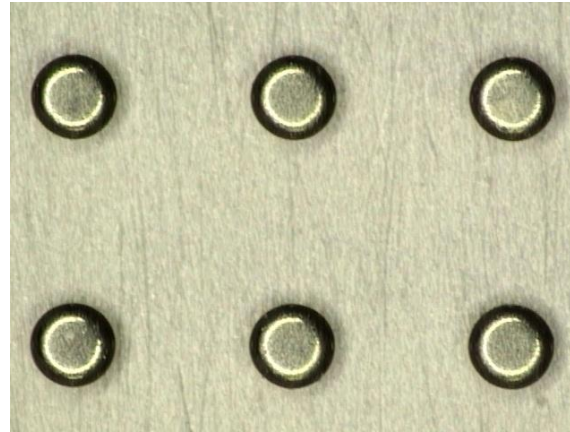
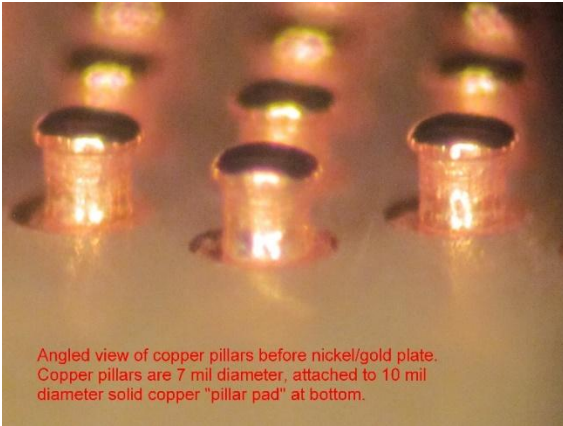
Devices are inserted into the socket and contacts engage with solder ball to retain the device and allows devices to be swapped without rework or reflow



900+ pin connector  
 400 micron pitch  
 Cell Phone Processor

## Core Technology Building Block – Contact Terminal Deposition

-Contact member terminals are deposited directly onto Flexible Circuit or Rigid Substrate, creating a low profile and high-speed interface.



## Solution High Reliability – Gold to Gold Connection

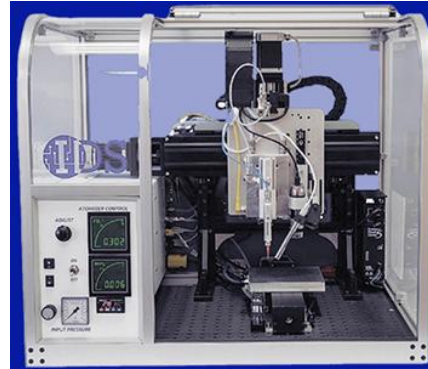
- Copper Pillar Substrate
- Electroplated or Stitched Pin



Development program with Micron, Dell, and Lenovo to create alternatives to M.2 SSD edge card connectors, high-speed flex cables + connectors, and battery connector replacement. The program ended with COVID.



## Advanced Materials Development – Particle-Based Inks are a Problem



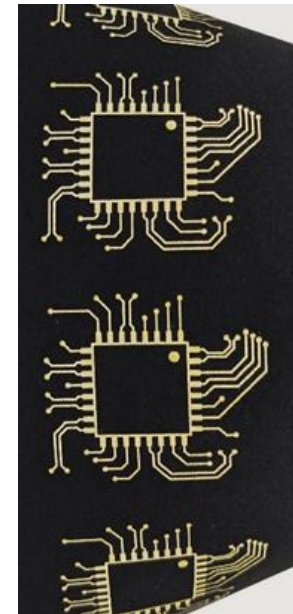
### Process Advantages –

Particle-free metal inks – Au, Ag, Pd, Pt, Cu, Ni

- Replace Electroless and potentially Electrolytic plating
- Potentially all material sets – LCP, ABF, PI, FR4, Megtron etc.
- Surface coating, Line and Space Printing, Via metallization
- 25 micron inkjet, surface inkjet, 10 micron aerosol jet
- No wet chemistry – No waste treatment – No waste

Low Loss Dielectric – PLLD printed onto LCP or other core

- Direct Write - Replace film, lamination, imaging, laser
- Hybrid – Surface coat with laser vias and image assist
- 25 micron inkjet, surface inkjet, 10 micron aerosol jet
- Thin or Thick, Planar or Topography



# Manufacturing

## 3D Printed Circuits – Additive Manufactured Electronics (AME)

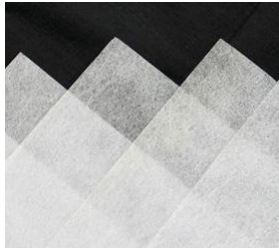
### PCT's 3D Circuit Printing - focused on Advanced Materials – Low Loss Dielectrics and Particle Free Metal Inks

Revolutionary Low Loss Dielectric: PFAS Free and 0.0004 df Loss factor  
 Proprietary formulations provide Direct Print, Coated Surface, and Reinforced options.

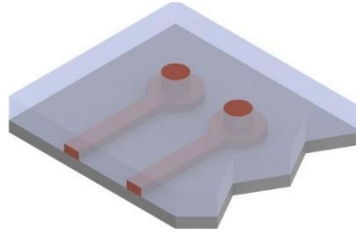
Vectran Reinforced



PET Reinforced



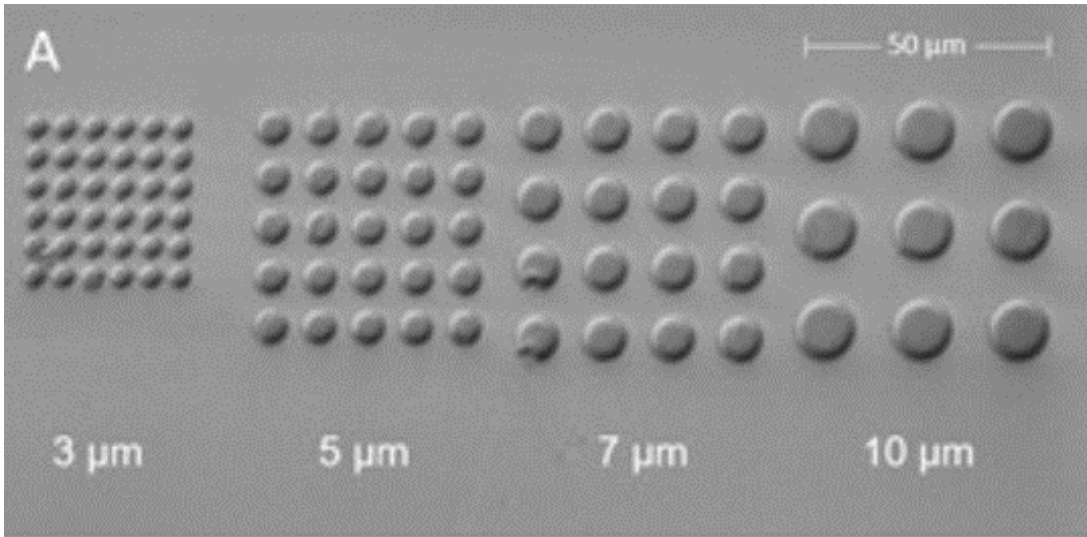
LCP-Ceramic Powder



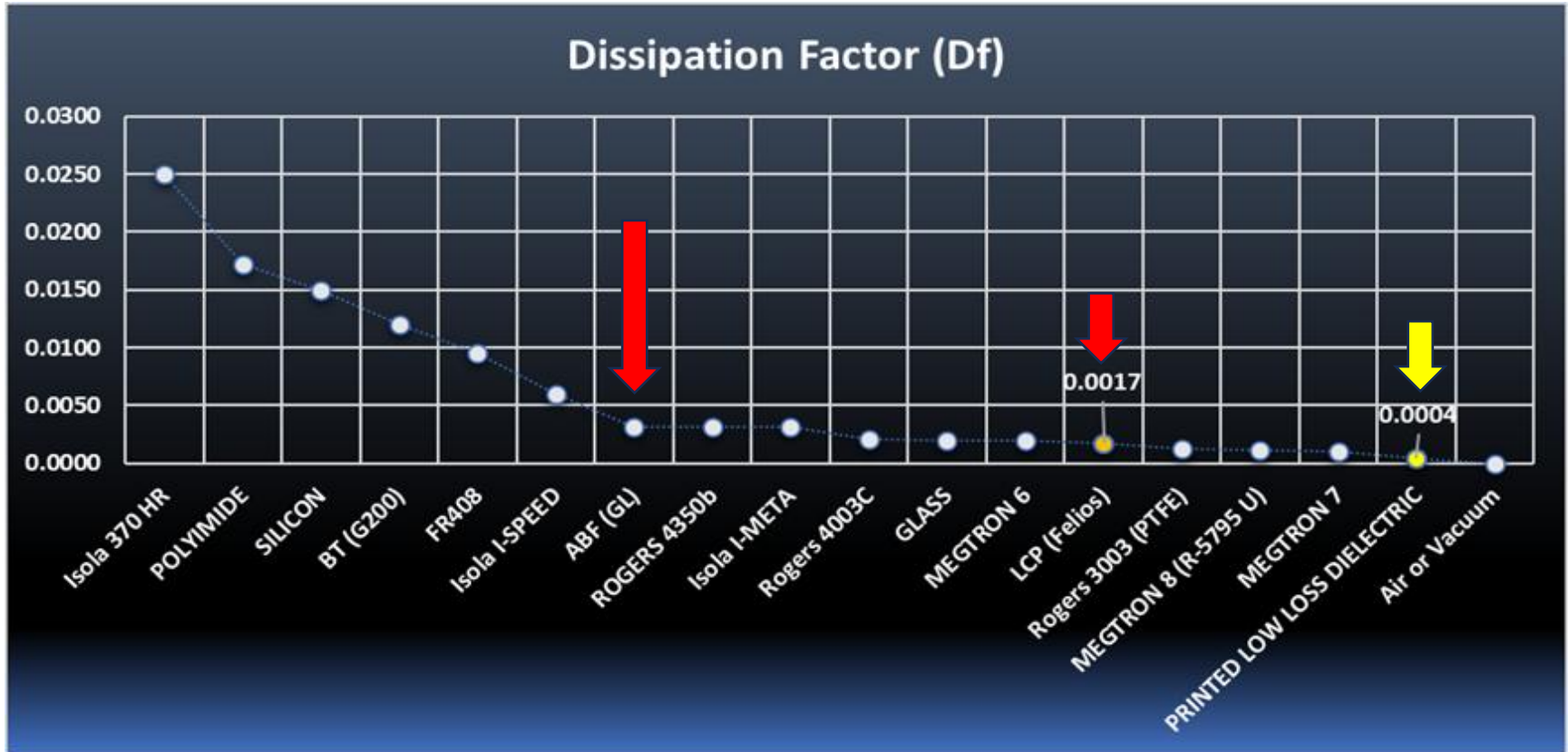
Revolutionary Particle Free Metal Inks  
 Molecular suspension of Metals deposit pure metal plating with thermally induced chemical reaction.



Photo-Imageable – 3 micron



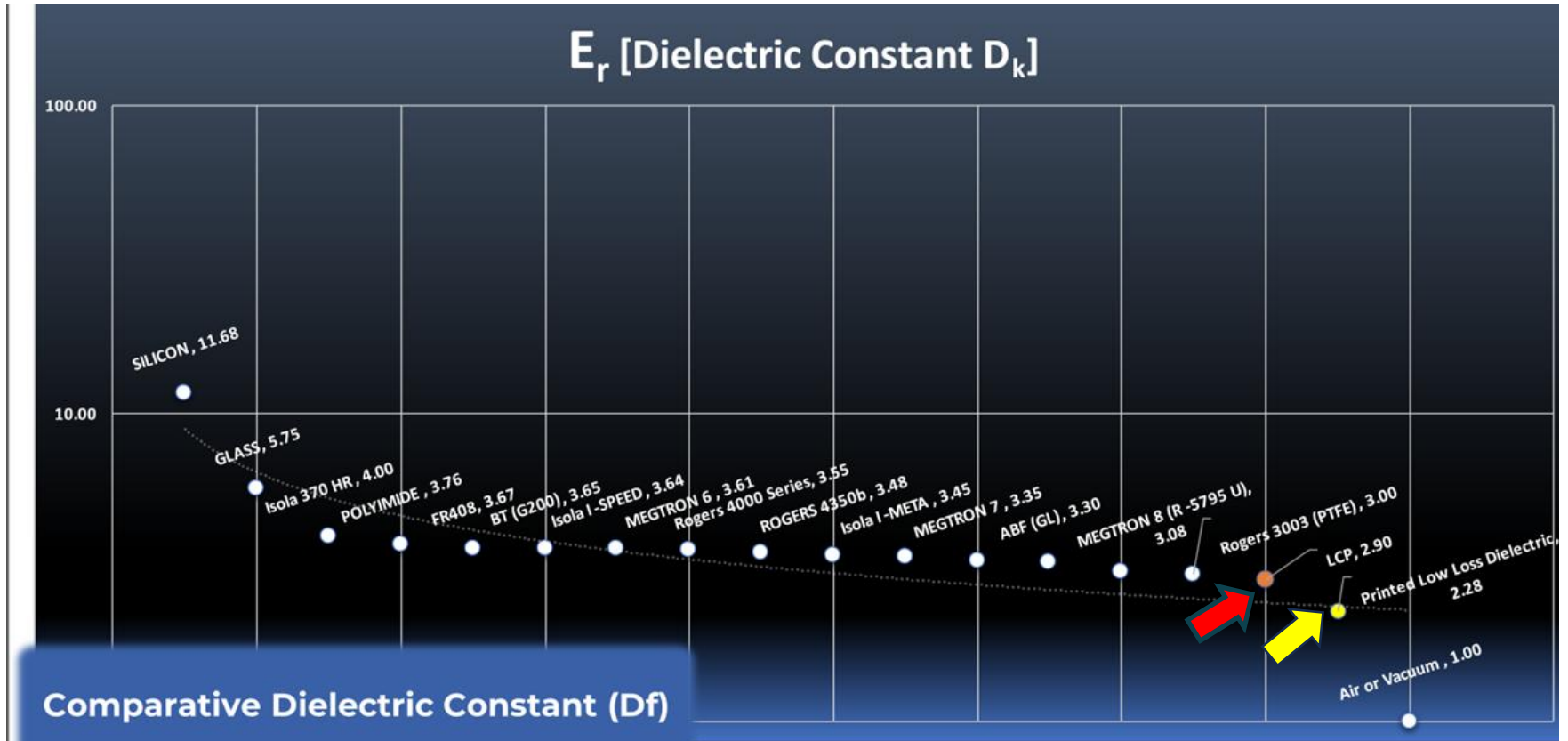
## Technology Advantage and Customer Benefit – Ultra Low Loss Dielectrics



LCP has df of 0.0017

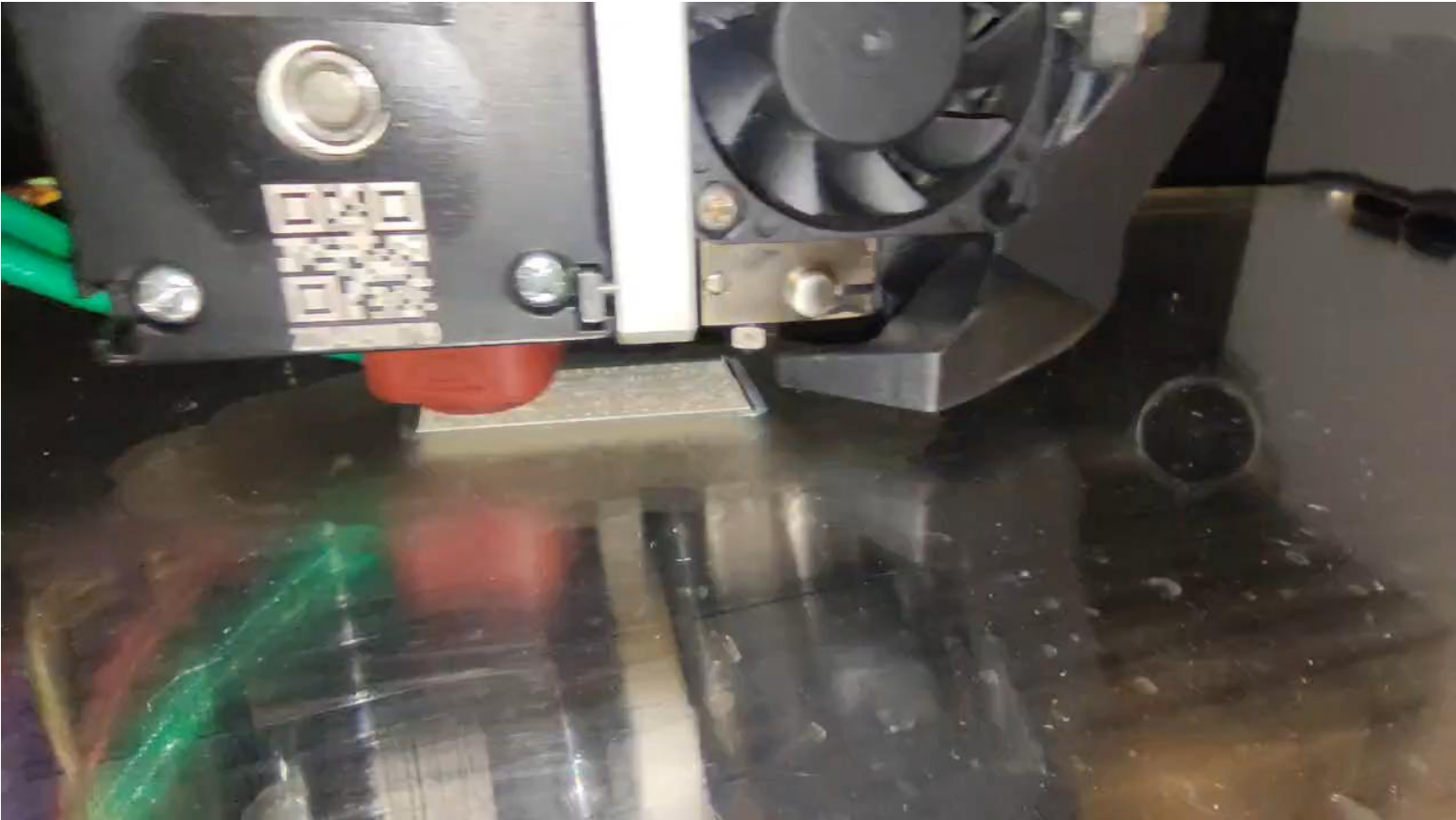
PCT Low Loss Dielectric range 0.004 to 0.0004

## Technology Advantage and Customer Benefit – Dk-Df adjustment



**Beyond Electrical Performance – PCT expertise and patents fabricating with LCP**  
**Thinner alternative to PTFE based products and much easier to manufacture**

## Technology Advantage and Customer Benefit – Why LCP?



**-World's first 3D Direct Print LCP Printer from Pellet Derived Filament**

-Prints LCP Film in Minutes – Prototype Injection Molded Parts in hours

## Sneak Peak of the Future – Direct Metallization of Dielectric

