

ElectroJet™

Printed Electronic Materials

COMPLETE TURNKEY SYSTEMS FOR NEXT
LEVEL ADDITIVE MANUFACTURING



ChemCubed ~833.243.6333 ~ info@chemcubed.com

ChemCubed

Multi-Layer
Multi-Material
Digital Printing
Solutions for
Tomorrow's Electronics

Who We Are

- Research, development and manufacturing company of specialty materials for Additive Manufacturing (3D Printing)
- Technical and business professionals with over 25 years experience in the printing industry
- Focused on end-use applications for the material properties and the final product specifications



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Key Market Segments

Advanced
Manufacturing

Aerospace

Automotive

Electronics

Medical/Dental

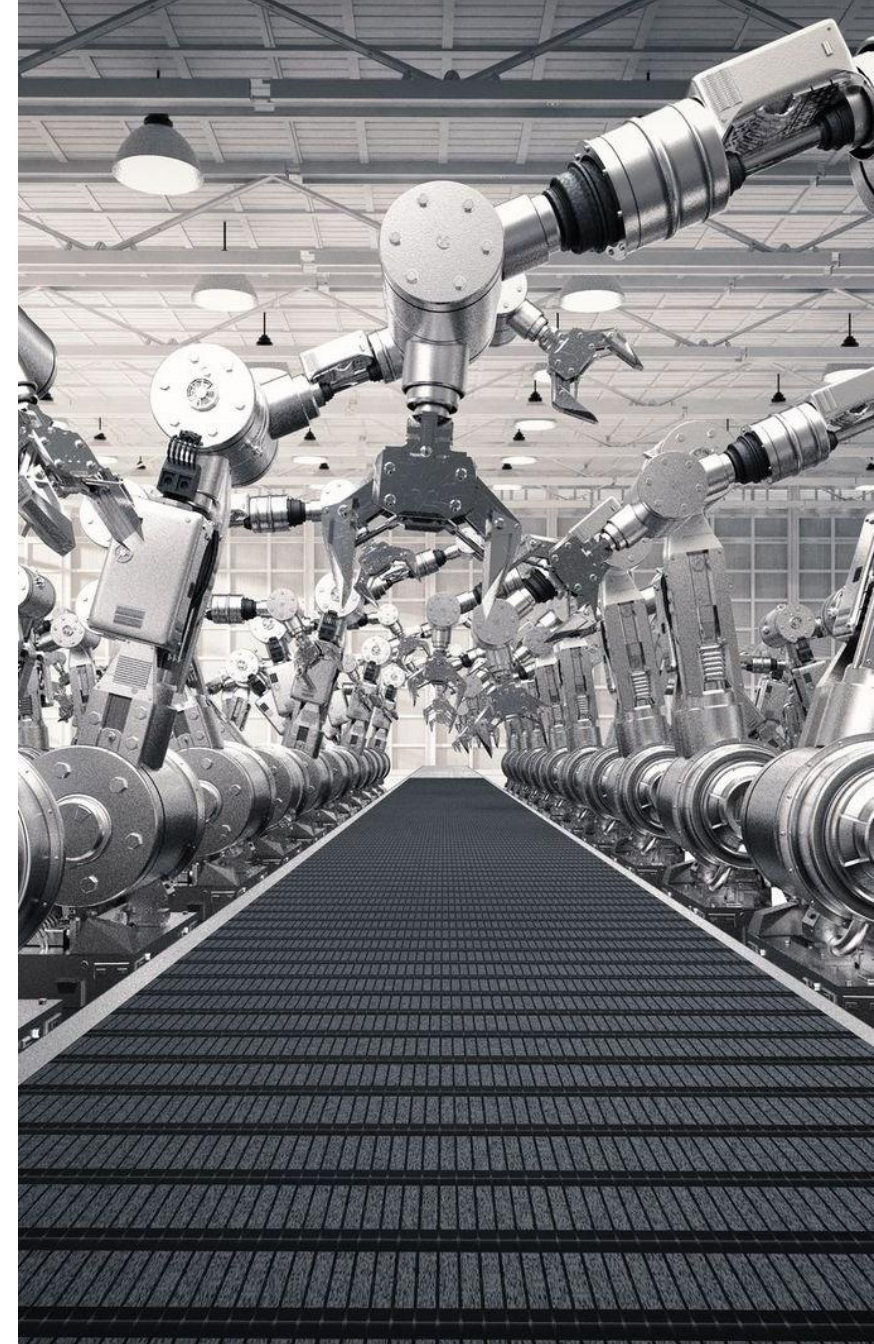
Military/Defense

Optics

Security



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Engineered for Performance ChemCubed Brand Solutions



NANOCOMPOSITE PHOTOPOLYMERS FOR EXPONENTIAL PERFORMANCE

- RIGID AND FLEXIBLE MATERIALS
- OPTICAL MATERIALS



MULTI-LAYER, MULTI MATERIAL DIGITAL PRINT SOLUTIONS FOR ELECTRONICS

- NANOPARTICLE-FREE SILVER
CONDUCTIVE INKS AND DIELECTRICS
- UV 3DPRINTING TECHNOLOGY

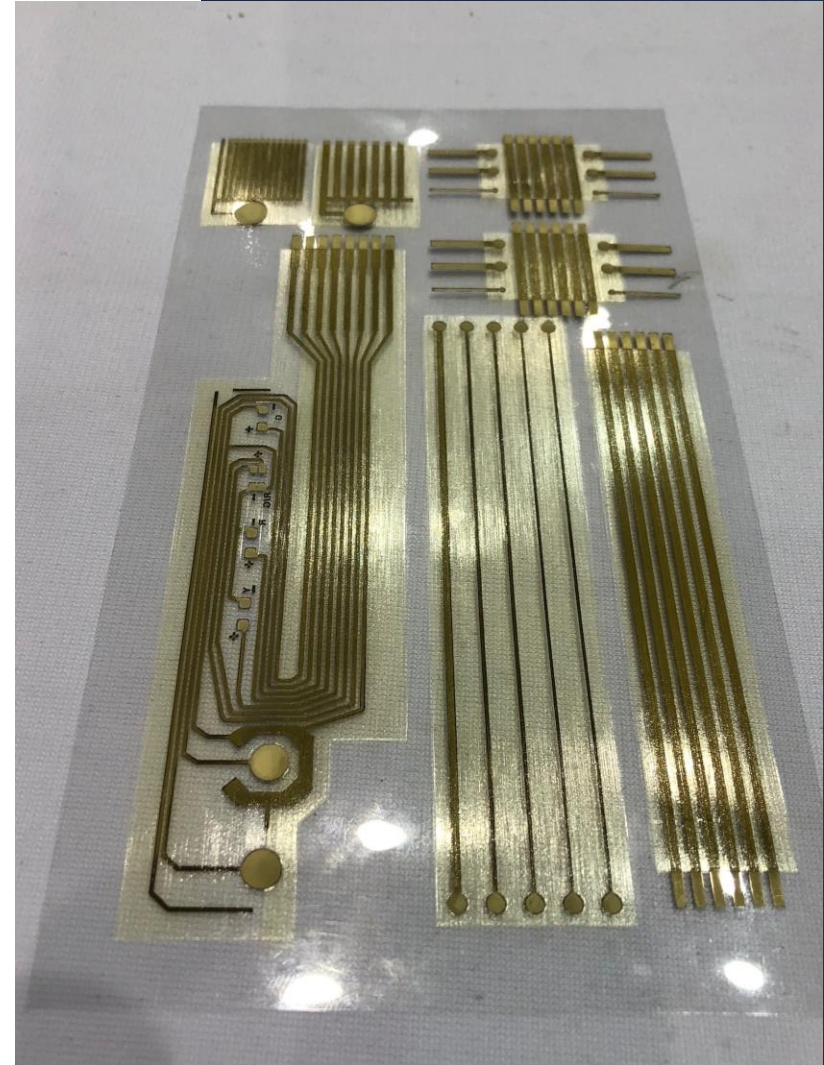


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Printed Electronics Defined

Printed electronics is an all-encompassing term for the printing method used to create electronic devices by printing on a variety of substrates

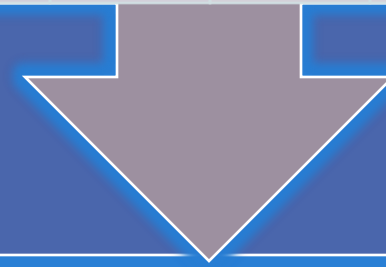
- Originally related to organic or plastic electronics that use inks made of carbon-based compounds
- Demand for wearable devices, thinner electronics, higher performing applications are driving material and printer developments
- Evolving over time toward print technologies capable of speed and cost efficiencies
- Printed materials are becoming thin, light and flexible enough to be integrated into existing production lines



Printed Electronics Methods

Multiple Methods of deposition technology but not all are equal

Silk Screen	Syringe	Aerosol Jet	Inkjet	Direct Write	Thermal Transfer	Flexographic	Spray Coating	Spin Coating	Direct metal / other emerging tech
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Many considerations when reviewing deposition technology for an application

Digital printing (variable vs. fixed)	Multi-material / Multi-layer requirements	Specialty vs. Commodity output (resolution, speed, size dimension)	Planar vs. 3-axis / 5-axis	Compatible materials (Inks)
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Benefits of printed electronics



Sustainable Impact (additive vs. subtractive)

Fewer input materials
Less energy



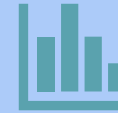
Design, Development and Rapid Prototyping

Hours vs. weeks /
Immediate design
testing feedback
Speed of modification /
Speed to market
In-house vs. outsourcing
potential (IP security)



Custom fabrication / retrofits

Mitigate fleet electronics
obsolescence
Reduced technical
constraints typically
associated with mass
producing electronics



Component miniaturization / weight reduction



Functional optimization - multi-layering / embedding / protective encapsulation

Additive vs. Subtractive

Traditional etch process

- Mask resist to determine copper trace
- Etch away unmasked copper
- Fixed subtractive process
- Changes require new mask/etch

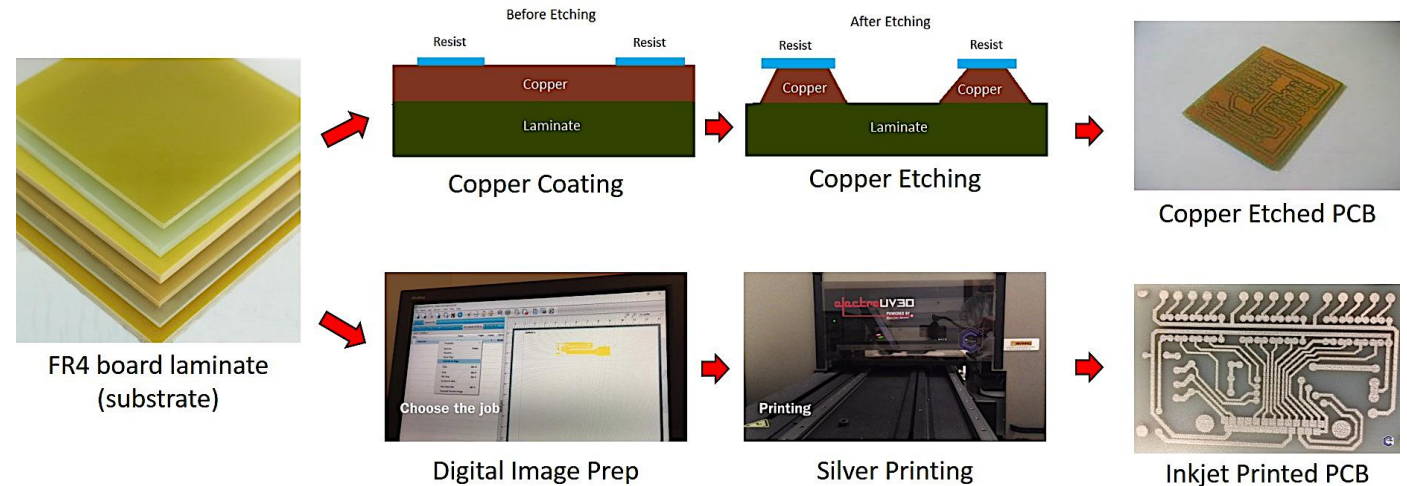
Digital print process

- Computerized image for copper trace
- Print directly on substrate
- Variable additive process
- Changes by file and reprint

Multi-layer process

- Traditional by repeat etch, lamination, drilling
- Inkjet by sequence of file print / materials

Digitally printed circuits vs. traditional copper etching (additive vs. subtractive mfg)



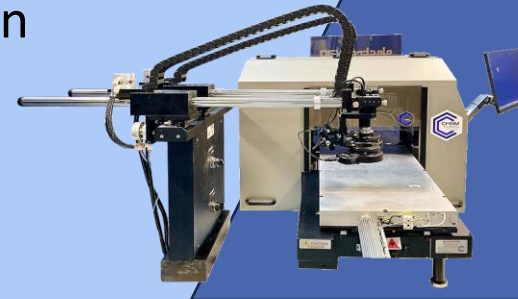
The **ElectroJet™** System Additive Printed Electronics

THE ELECTROJET™ BRAND IS A CULMINATION OF HIGH-PERFORMANCE MATERIALS, INKJET PRINTING TECHNOLOGY, AND PROCESS CAPABILITIES

- **Materials** are commercially available for a wide variety of applications
- Our eight-channel **printers** provide multi-layer, multi-material electronics with unparalleled performance
- Our **process** support gets your team trained within hours; our dielectric templating supports printing accuracy < 10 microns.



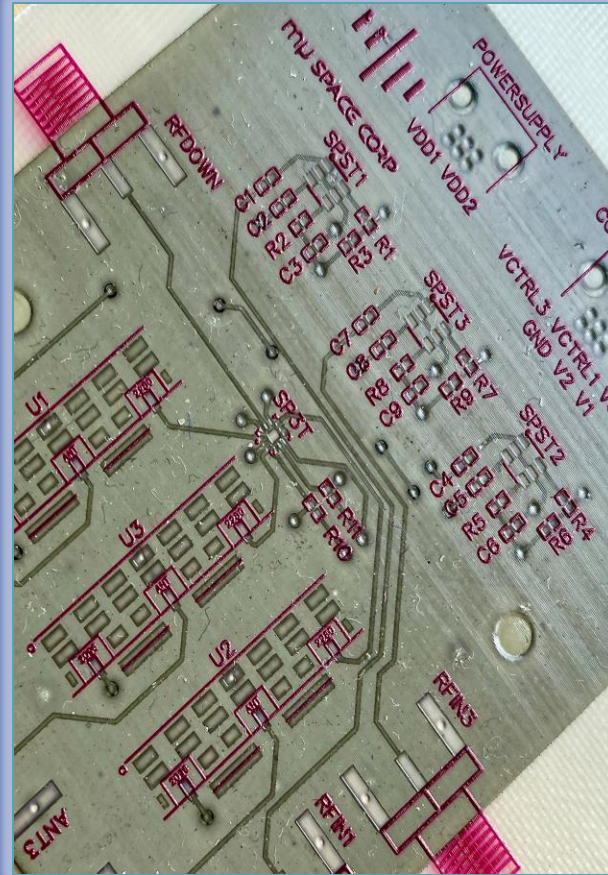
The trio provide a full synergistic solution for our end-user



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Nanoparticle-free Silver CONDUCTIVE Ink

- Best-in-Class Conductive Performance
 - near bulk conductivity of silver
 - bulk resistivity in the range of 10^{-8} ohm-m
 - Unmatched Sintering Efficiency
 - as low 80°C in 5 minutes
 - as fast as seconds >100 °C
 - Superior printability and reliability with repeatability to within 1%
 - Excellent Adhesion to multiple substrates
- C3-Ag-1037-2: Standard for electroUV3D printer
- C3-Ag-1037-2h: Viscosity tuned for brand inkjet heads



UV Curable DIELECTRIC Insulating Ink

- Superior Insulating performance between conductive layers
- Adhesion promoter to high surface energy substrates
- Encapsulation to protect from moisture, chemicals and physical abrasion of the external environment
- Multiple formulations optimized to end-use applications

C3-DI-7: Standard workhorse formula

C3-OPT-7: Optically clear high-pot insulating

C3-DI-8: Optically clear flexible layers

ElectroJet™ Materials

It is more about the ink than you think



ElectroJet™ Materials

The difference is clear

Nano-particle Silver Inks



- Opaque in color
- 15 - 40% silver particle loading
- Contains other fillers/resins
- Particles settle and require recirculation prior/during use

ElectroJet™ Particle-Free Silver Ink

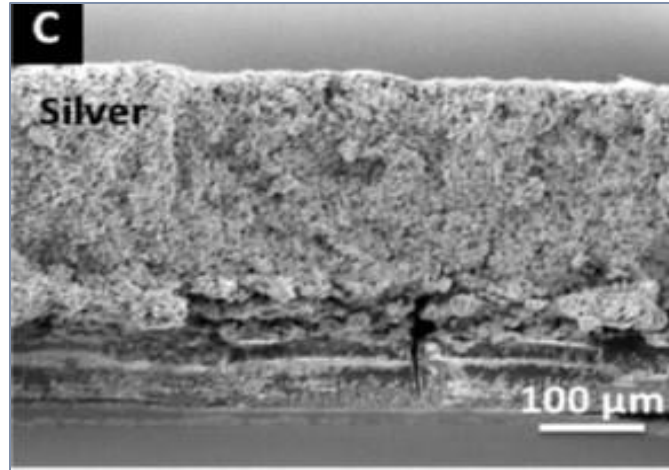


- Transparent in color
- Particle-free
- Contains NO fillers or resins
- Simply filter prior to use and ink remains stable without recirculation

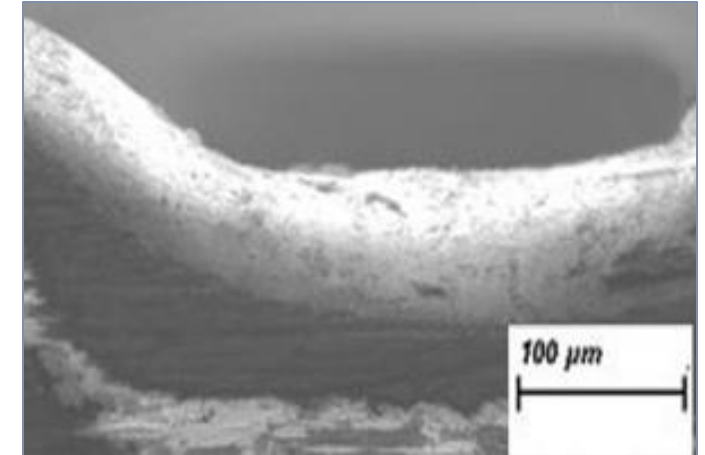


Materials

Clearly, there is a difference



- Particles can clog inkjet heads
- Sintering temp 130c / 30 min
- Sintered silver and fillers (40 – 60%)
- Filler and/or voids are non-conductive



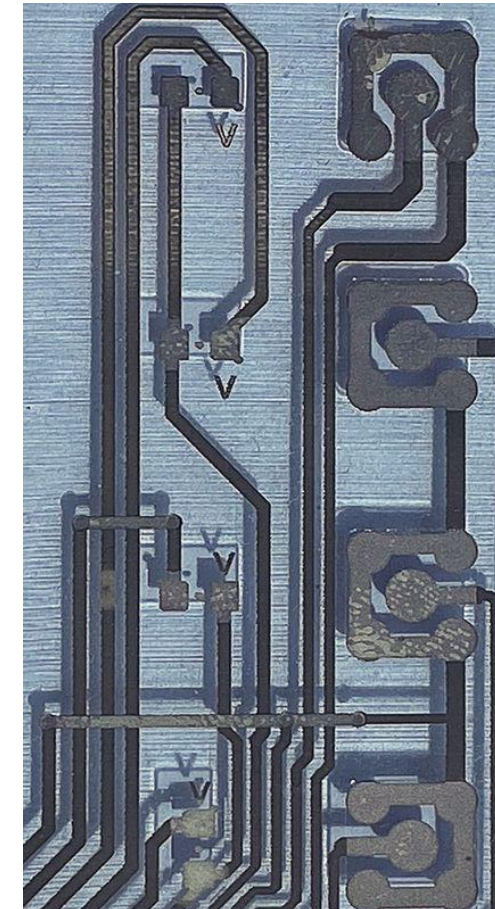
- Jettable reliability
- Sintering temp 80c / 5 min
- Sintered silver only (99%)
- Void-free silver is fully conductive

High Performance Dielectric – our newest ink

Our most recent formulation is a revolutionary nanocomposite dielectric material that:

- insulates layers between the circuits,
- masks material for soldering, and
- supports at connection points; thereby allowing it to replace F board for two-sided boards

	DI-7	HPD-3D
Coefficient of Thermal Expansion ($10^{-6}/K$)	177	25
T_g ($^{\circ}C$)	70	133
Young's Modulus (MPa)	400	1150
Tensile Strength (MPa)	21.1	66
Elongation (%)	25	15

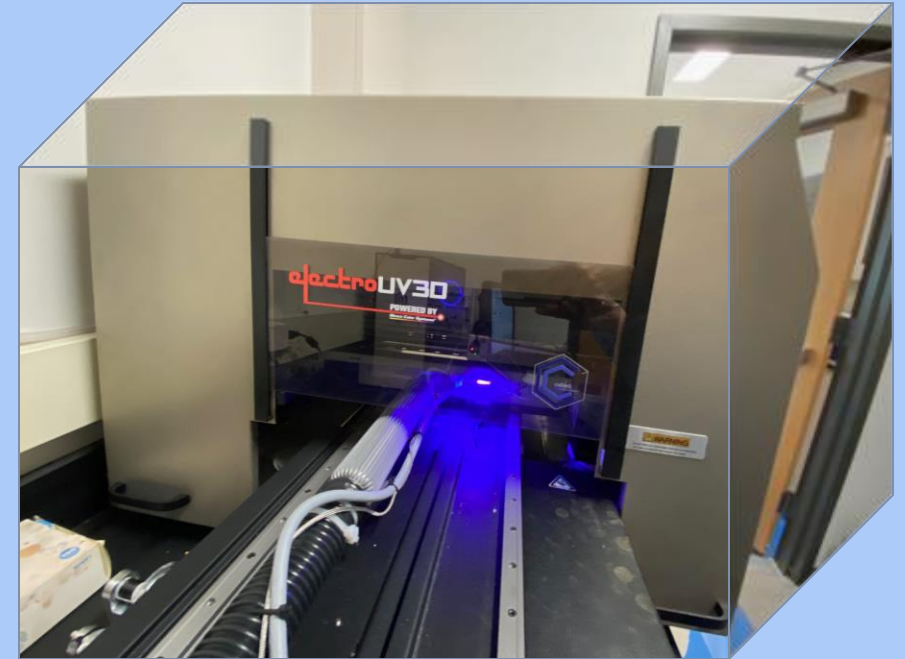


Printing Technology

There is not only a need for higher performing materials,
but also, the combined solution of a ready-to-use and fully capable printing
technology

Needs of a Commercial Printing Tool Solution:

- Inkjet process to replace multiple steps and hands-on techniques
- Unprecedented low cost and efficient production
- Flexibility to design/develop/prototype *and finally PRODUCE* for the majority of digitally printed electronic applications
- Multi-material layering of functional coatings and laminations



ElectroUV3D Printers

Multi-material Capabilities

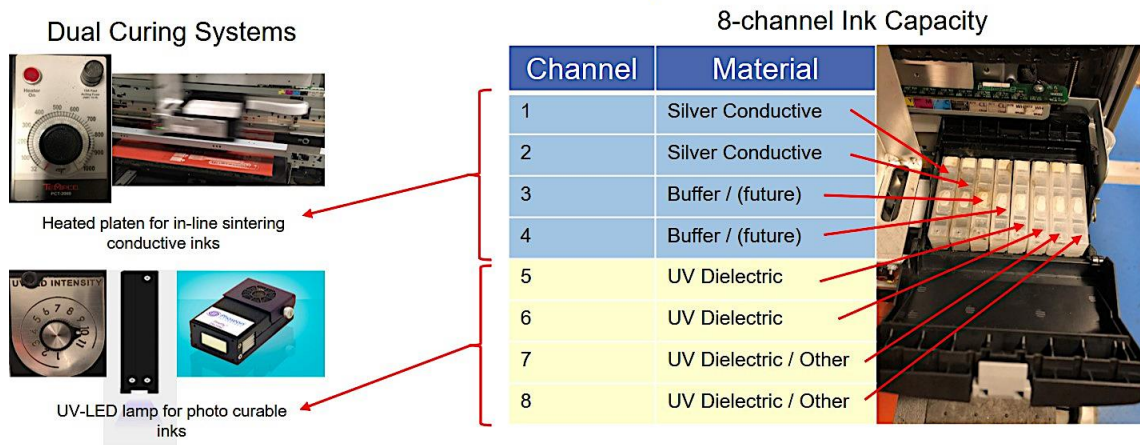
Dual Curing Systems

Heated platen for in-line sintering conductive inks

UV-LED lamp for photo curable inks

8-channel Ink Capacity

Channel	Material
1	Silver Conductive
2	Silver Conductive
3	Buffer / (future)
4	Buffer / (future)
5	UV Dielectric
6	UV Dielectric
7	UV Dielectric / Other
8	UV Dielectric / Other



- Digitally prints both silver conductive inks and UV curable dielectric insulating / building inks
- Inline Heat Sintering of **silver conductive inks**
- Inline LED UV curing of **dielectric insulating inks**
- 12" x 24" printing bed w/ silicone tacky mat standard, larger sizes available
- 1.5 pl to 21 pl drop size
- 2880 x 1440 dpi resolution 8-channel inkjet head enables simultaneous multi-material, multi-layer printing of electronic circuits and components

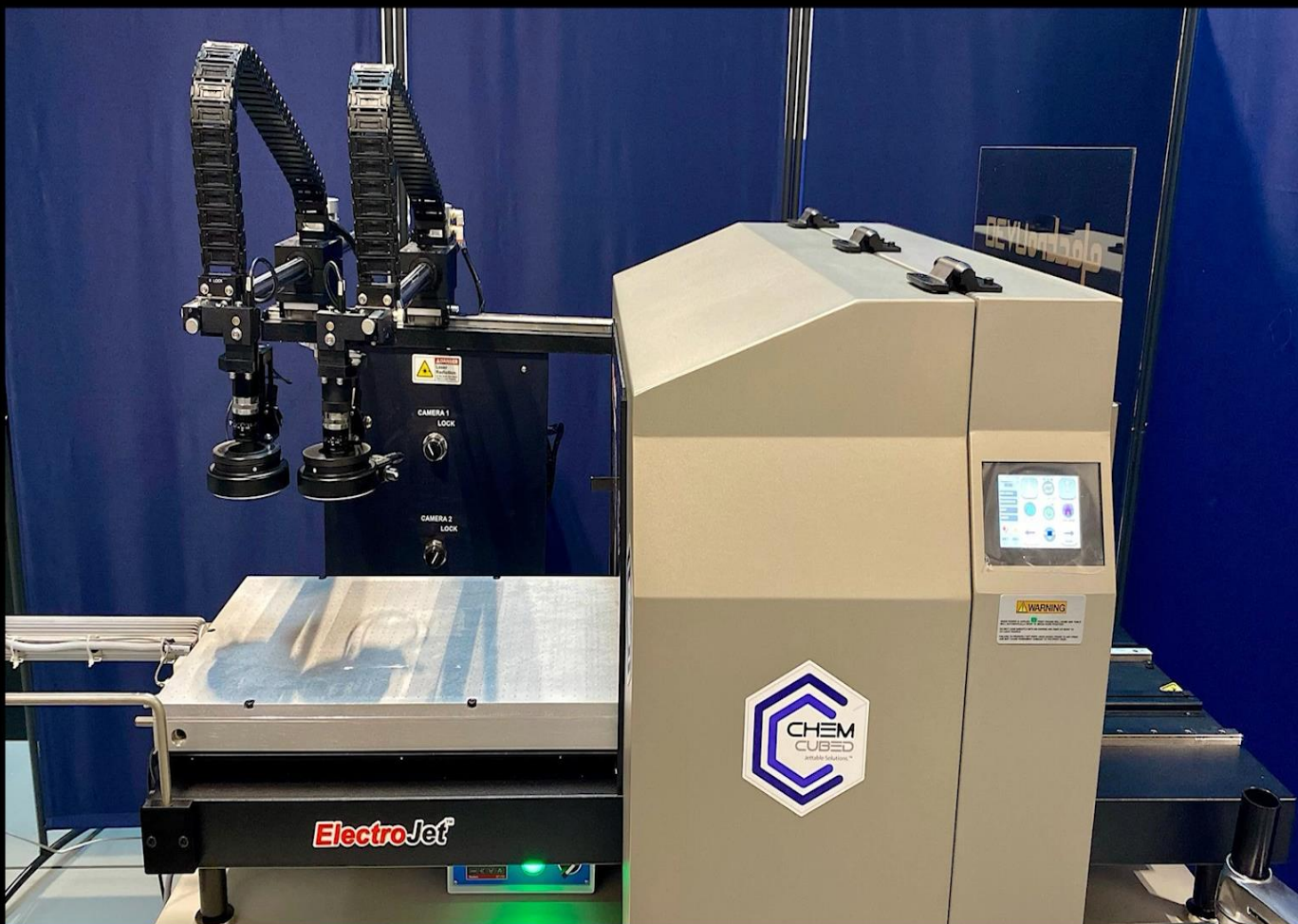


The Original ElectroUV3D Printer

Turnkey Packages Include:

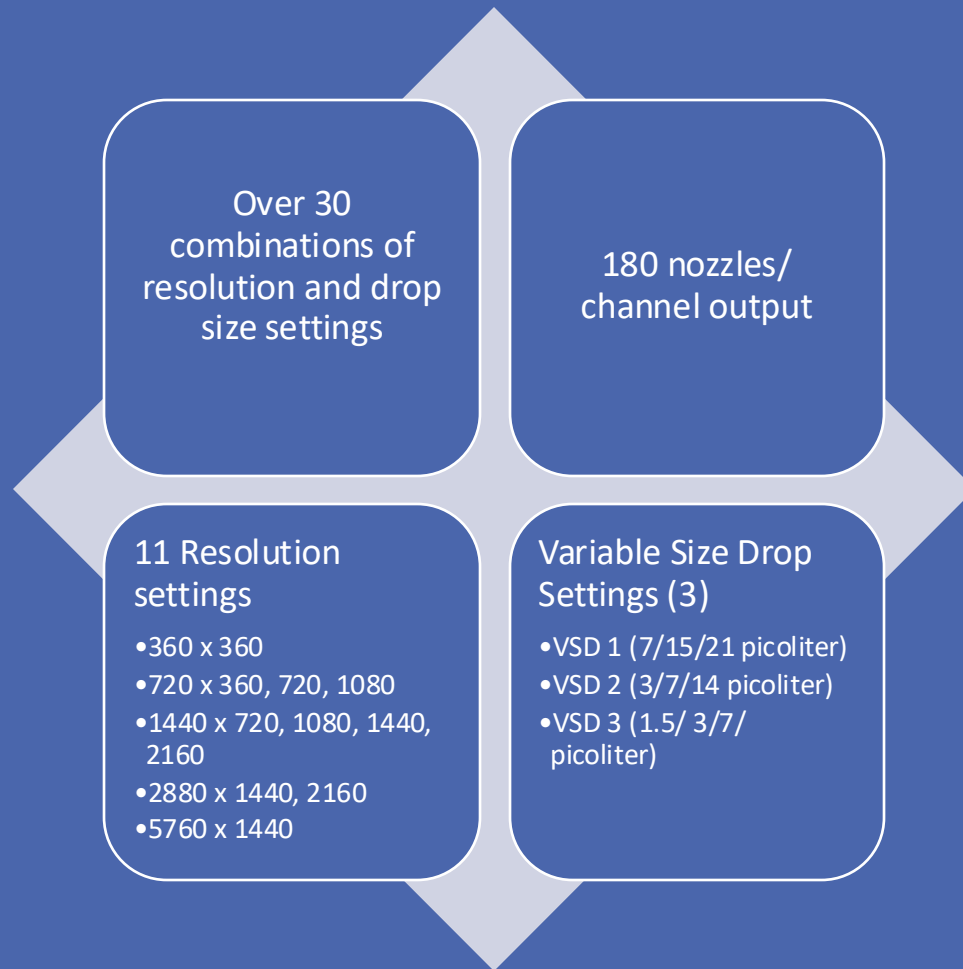
- A multi-function, multi-material inkjet UV3D printer (standard size of 12'x24' with larger sizes available)
- Software
- Accessories
- Maintenance Supplies
- Starter Inks
- Easy Installation and Set-up
- Professional Training

All you need is a computer,
we provide the rest



**ElectroJet™ Multi-layer/Multi-material Printing
for Additive Manufacturing of Electronics**

Print Quality and Capabilities



Print Quality Features

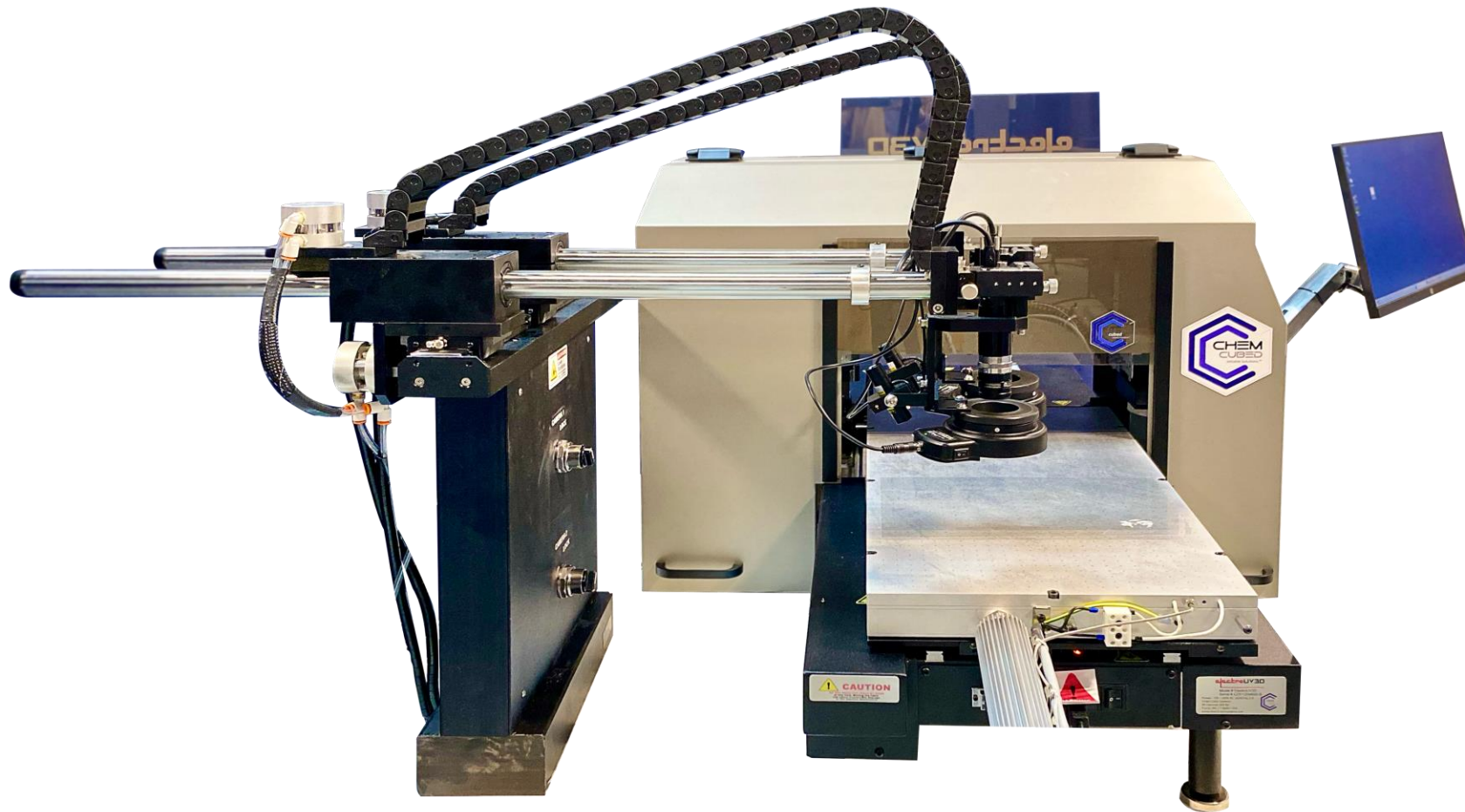
- Conductive trace features down to:
 - 100 um trace widths
 - 200 um trace gaps
 - Stand alone trace widths to 50 um w/ templating
- Y-Axis position accuracy/repeatability +/- 0.038 mm (0.0015")
- Other Features
 - Uni- and Bi-Directional Printing
 - Draft of Production Mode Printing
 - Up to 6" z-directions height
 - Full turn-key package with 1-year limited warranty



Enhanced Optical System

This system provides increased printing accuracy with alignment capabilities to 10 microns and measure capabilities as small as microns.

This vision system provides the software, tooling, magnification, lighting, and circuit pattern recognition marks to support every manufacturing need.



ElectroUV3D-3200

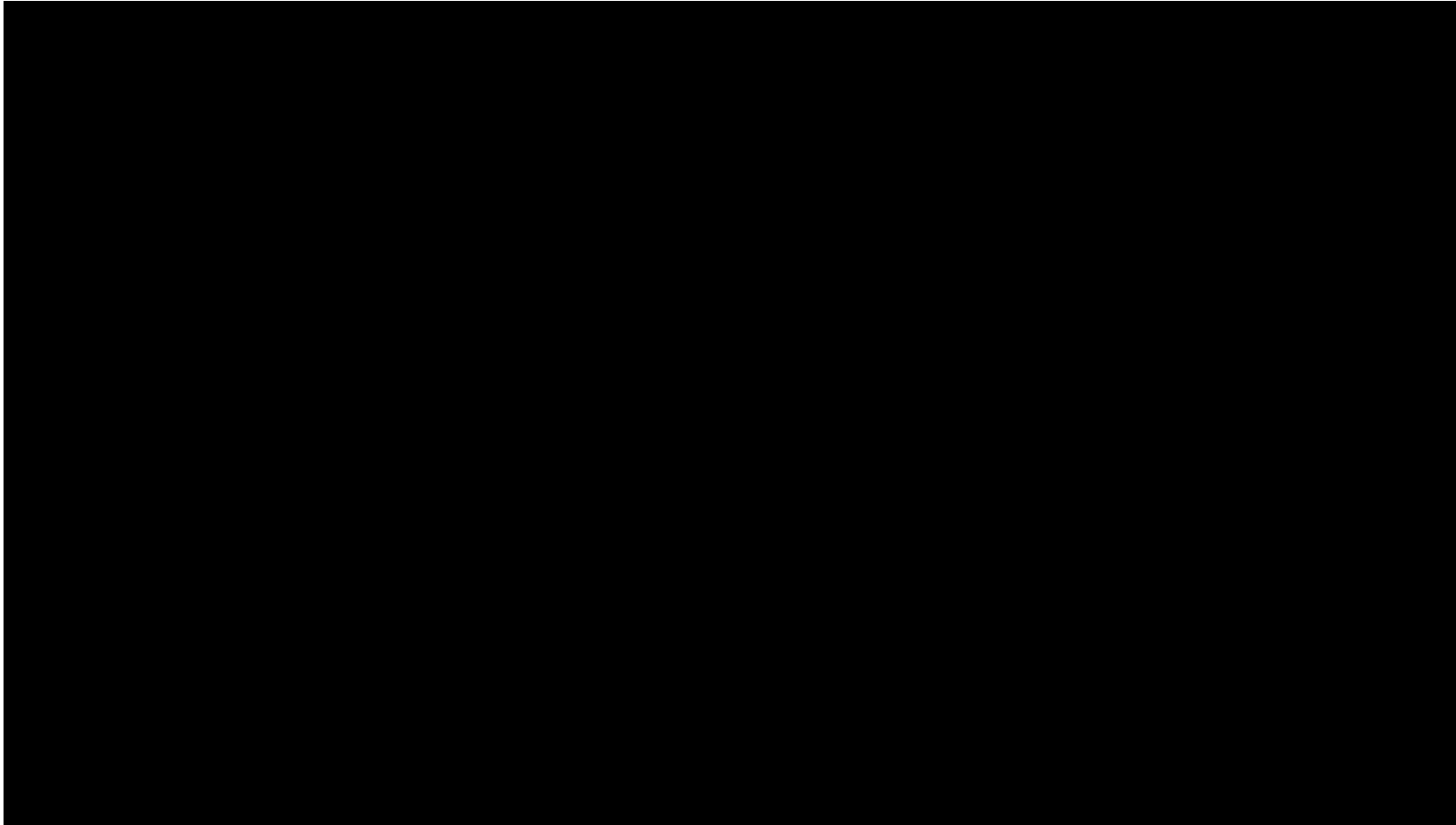
Our Newest Printer

True Manufacturing of Printed Electronics

- 24" x 36" Printing Bed
- UV Curing System
- Vacuum Suction Platform
- Automatic Printing Height Adjustment with Direct Measurement



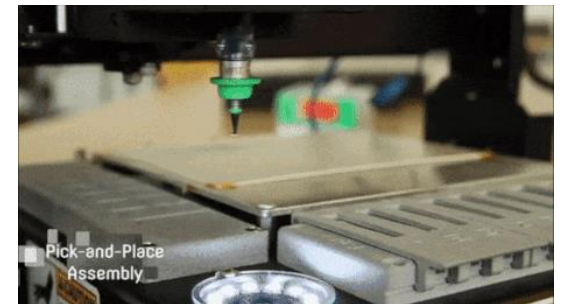
High Speed, High Performance



ElectroJet™ Inks also support

BotFactory BFSV2 System

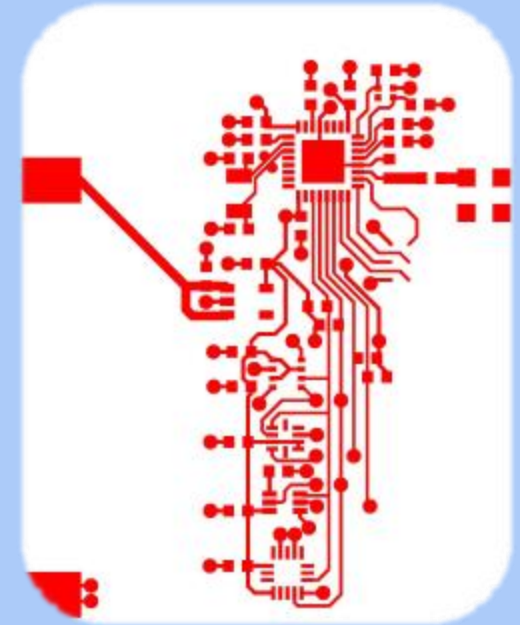
- Thermal Inkjet Technology
- Line width and spacing as low as 8mil
- Up to 6 layers
- Dispense paste and glues in the same system
- Pick and Place technology



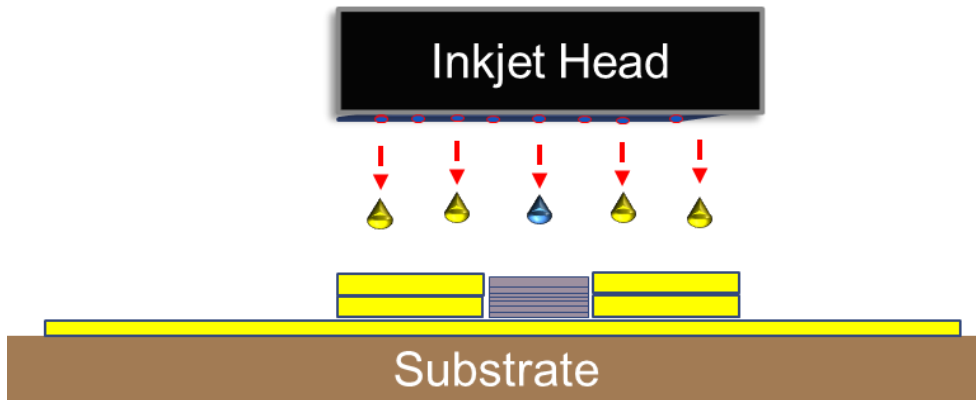
Training

We provide a full session of installation and training for everything you'll need to know about setup, maintenance and operation of the printer. We also train on the common processes, as well as specific techniques for your needs

ChemCubed's Professional Training covers everything you'll need to start printing immediately:	File Import and Conversion
	File layer ordering/selection
	Printer settings
	Print initiation process
	All related processes/methods/best practices
	Documents provided with user manuals



Dielectric Templating

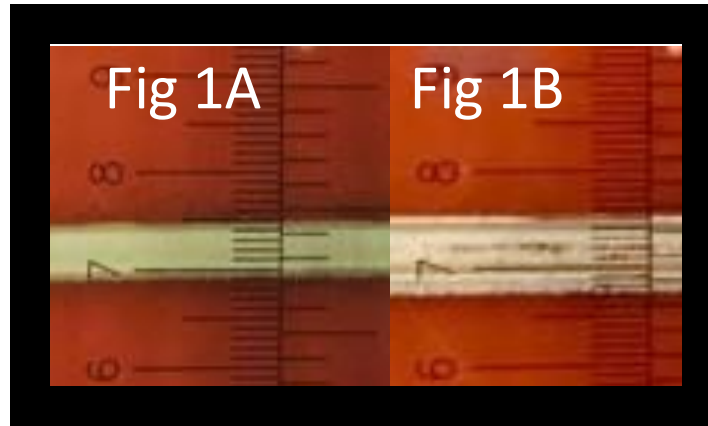


- Controlled Trace Widths
- Increased Trace Heights
- Optimized Conductivity



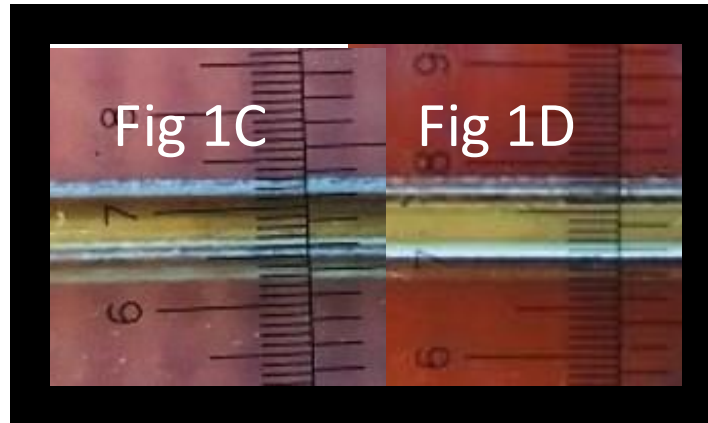
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Silver trace layering effect



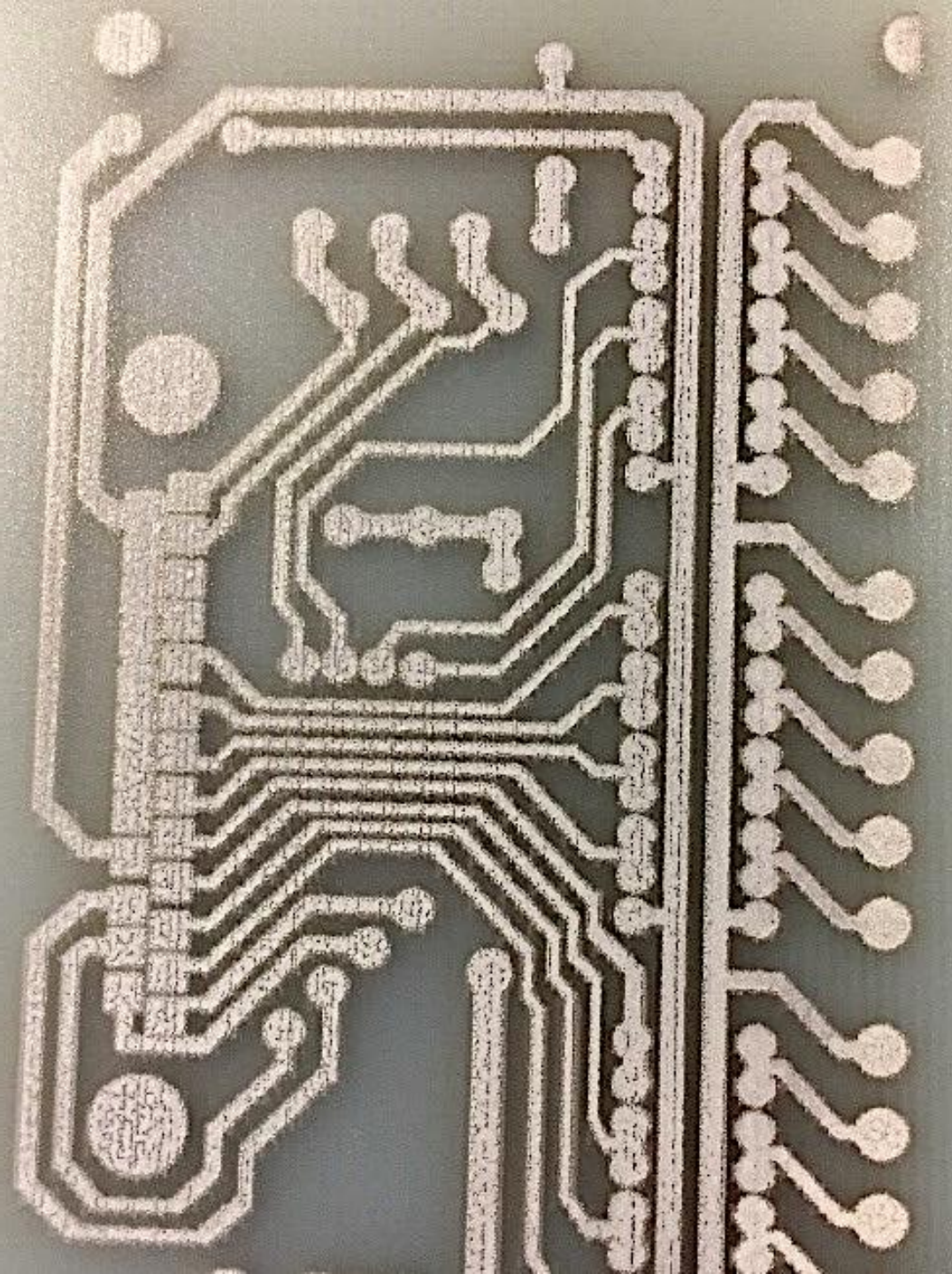
Without dielectric templating:

- Fig1A – 3 passes of silver ink
- Fig1B – 18 passes of silver ink
- Trace height fails to build in z-direction effectively (\sim max 5 μ m)
- Trace width continues to spread (0.55mm to 0.80mm)



With dielectric templating:

- Fig1C – 3 passes of silver ink
- Fig1D – 18 passes of silver ink
- Trace height builds effectively in z-direction (\sim 24 μ m)
- Trace width is maintained (0.40mm)



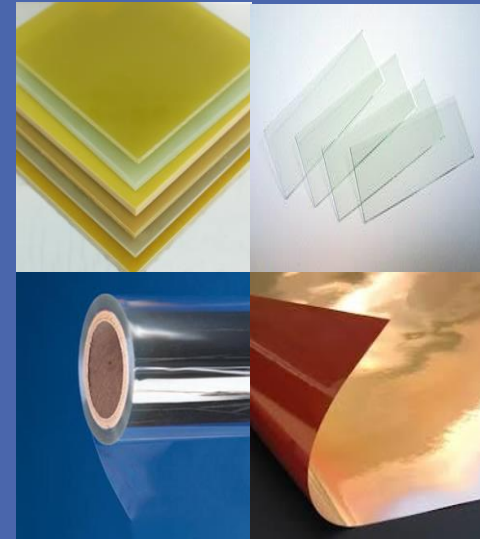
Post Print Process

- Solder Mask Procedure
 - Protects a printed circuit against oxidations/prevents solder bridges between solder pads
 - Widely used in reflow soldering
 - Printed by ElectroUV3D printer, same process as dielectric ink

Substrates

Rigid, Flexible and Rigid/Flex* planar materials

- FR4 board
- Liquid Crystal Polymer (LCP)
- Polyester (PET)
- Polycarbonate
- Polyimide Film (Kapton)
- Glass
- ITO coated glass
- Ceramic
- Foil / Metal
- Paper / Coated Paper
- Label stock

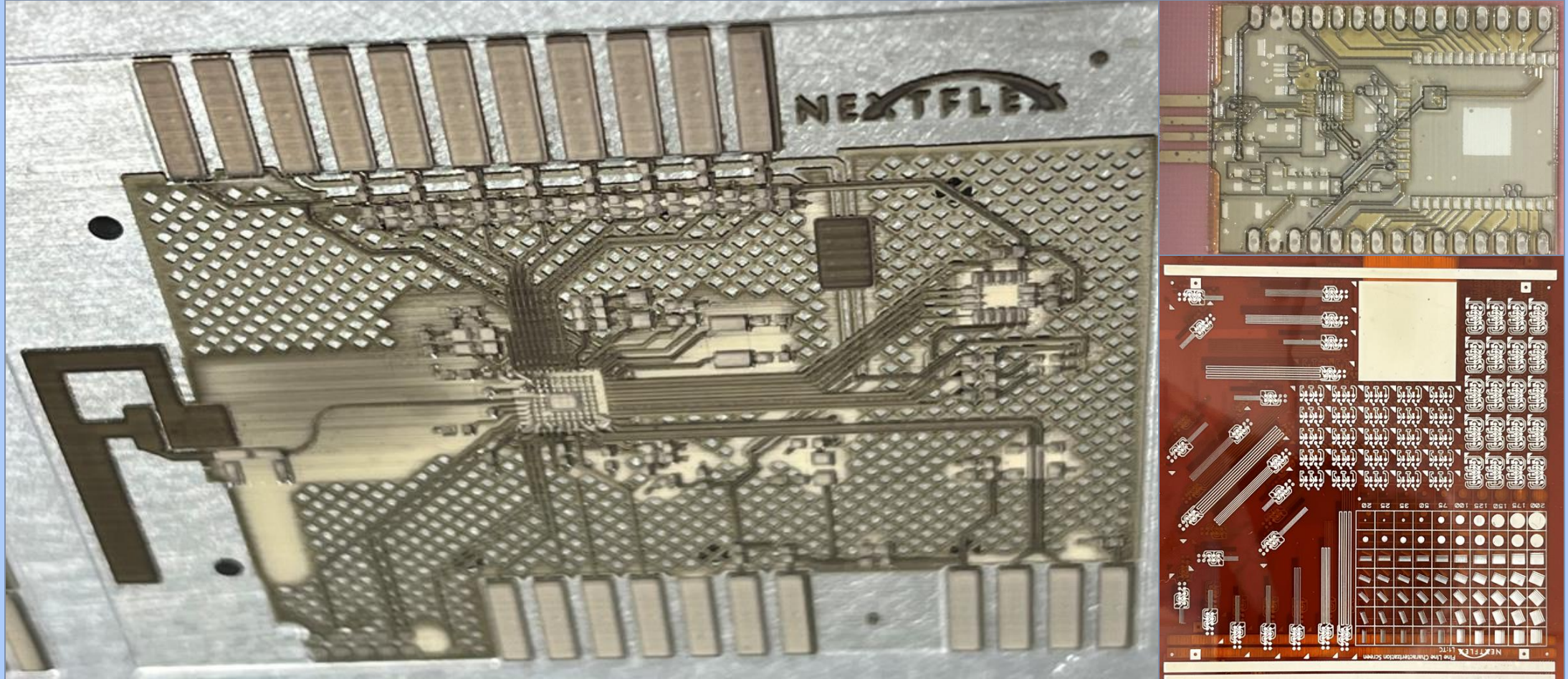


*Rigid material may be printed on flexible substrates



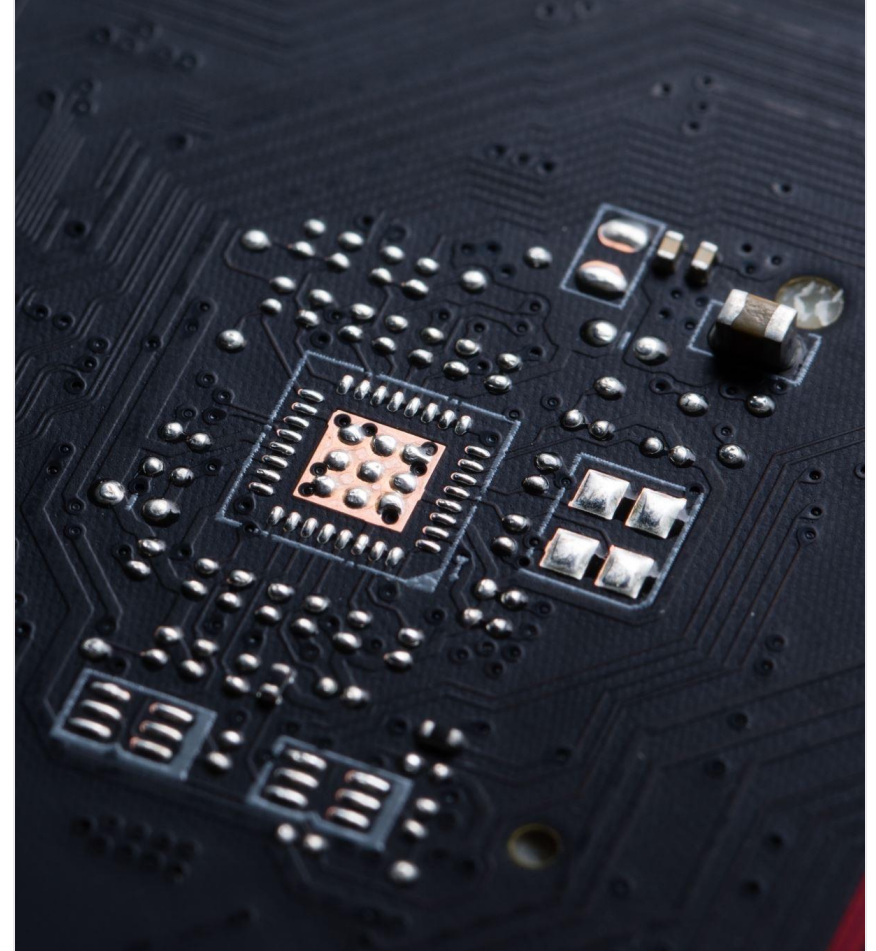
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Multi-layer Processes



Applications

- Printed circuitry/circuit boards/electronics packaging
- Displays
- Flexible hybrid electronics, wiring harnesses
- Passive components (resistors, capacitors, inductors)
- RFID, sensors, shielding and antennae applications
- Semiconductor manufacturing
- Photovoltaics
- Wearables



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