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Semiconductor Capital Equipment
in Europe

IVAM Mid Week-Coffee July 2021

Photonic Curing – A versatile Application from Curing to Lift-Off

Uwe Kriebisch

Outline

- Merconics Market
- Photonic Curing Principles
- Photonic Soldering
- Photonic Lift-Off
- Photonic Printing
- Questions

Merconics Market & Partners

BRUKER

NEXTIN Solutions

Semiconductor Inspection Systems

attolight™

INSPECTROLOGY

OPTOMEC®

Production Grade 3D Printers... with a Material Difference

ceradrop

A MGI GROUP COMPANY

NOVACENTRIX®

Hugle

Veeco

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Photonic Applications

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PulseForge® Applications and Processes

- Photonic Soldering
- PulseForge® Lift-Off™
- PulseForge® Printing
- R2R inkjet integration
- Thin film bolometer
- Textiles and wearables
- Lab services
- Ultra fine line printing
- Thermoforming
- Photonic curing of polymeric films
- Dispensing & 3D printing
- Electroplating on seed layers
- Photonic curing of ceramics and semiconductors
- TCO processing and alternatives
- High speed drying on the PulseForge®
- Cost estimation

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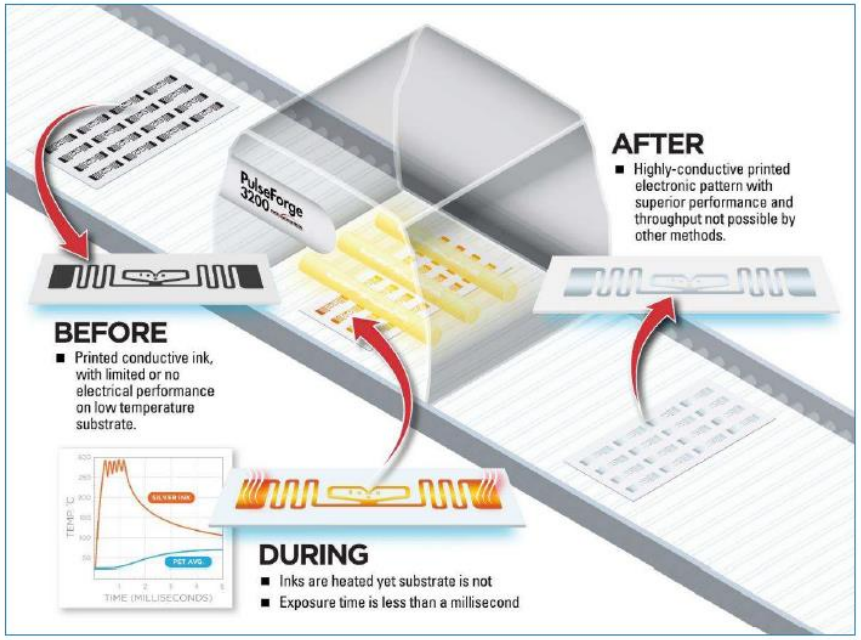
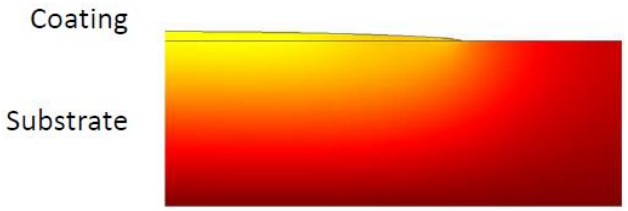
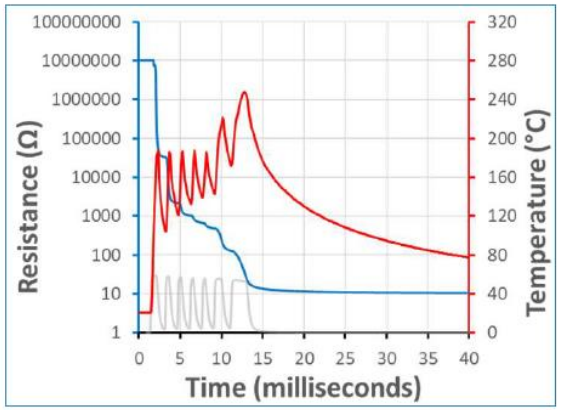
Photonic Principle

What is Photonic Curing?







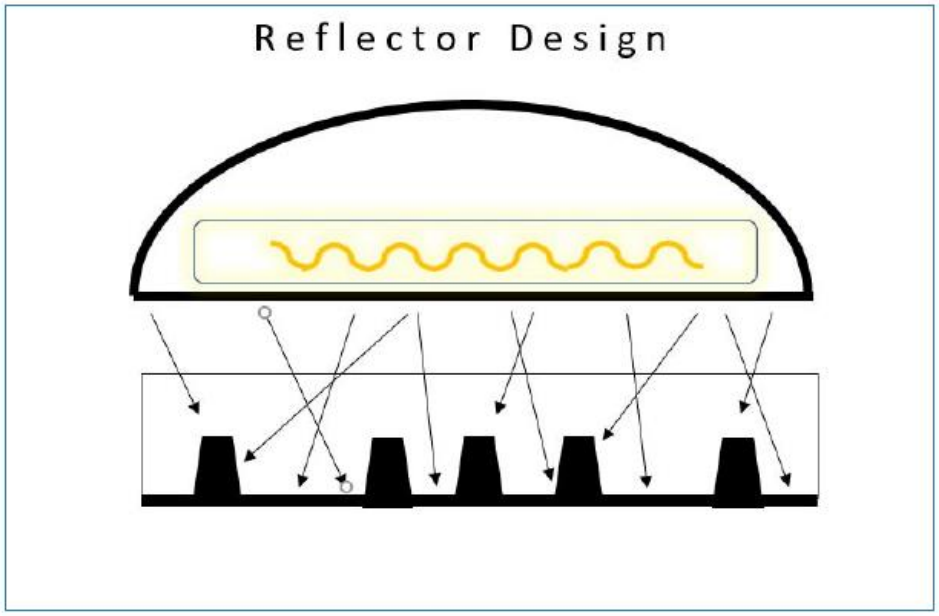
Photonic Principle

NOVACENTRIX

Solutions Engineered for Process Control

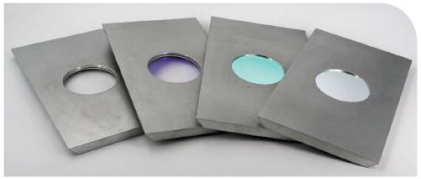
Our photonic curing tools have been designed, developed and tested for what's important to you:

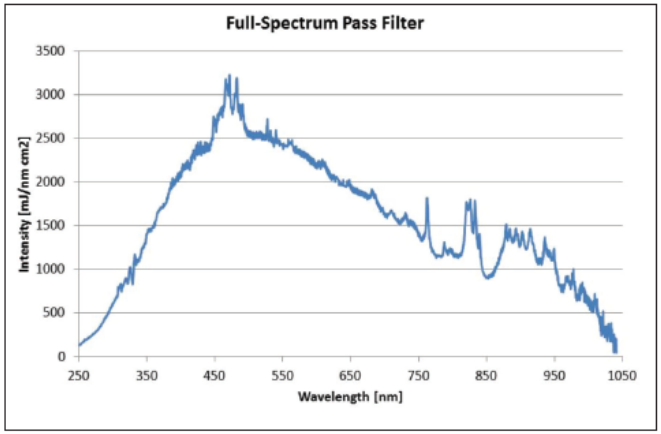
- 2-3% wide area uniformities
- High power densities (up to 48 kW/cm^2)
- High energy densities (up to 100 J/cm^2)
- Tunable pulse lengths from µsec to msec
- Uncollimated light beam
- Cures 2.5D objects
- Short process times (ms vs minutes)
- Selective material processing
- Minimal heating of non-target materials
- Economical production scale >1M^2/sec

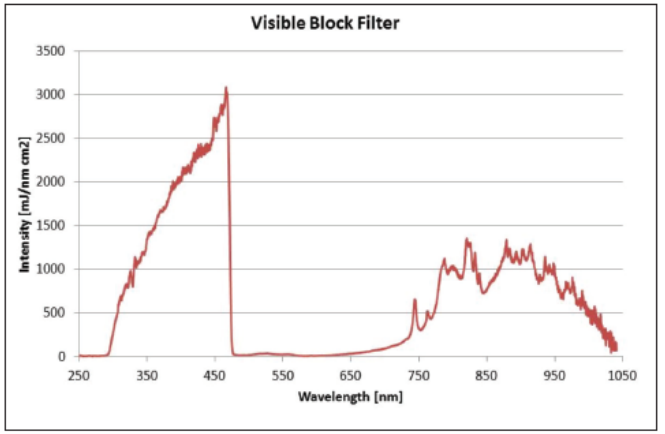


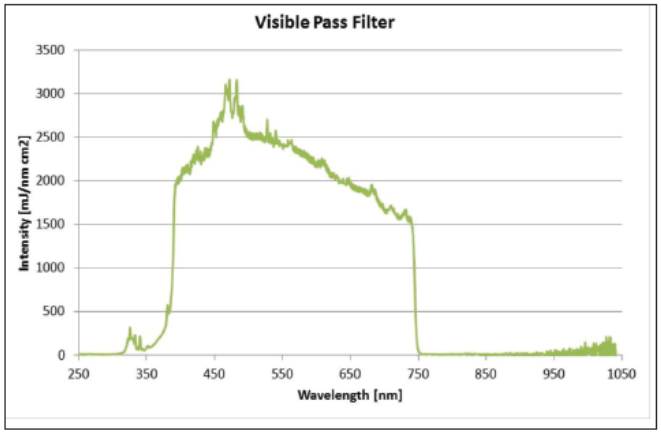
Filter Options

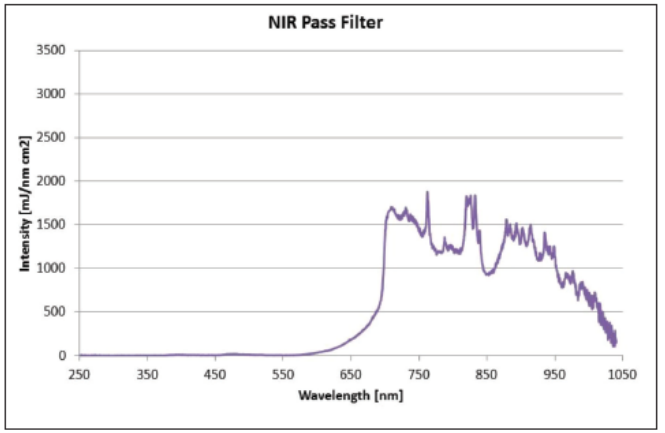
Photonic Curing Filter Set
for PulseForge® R&D Tools











Measured transmission versus wavelength for each filter for an identical PulseForge pulse condition

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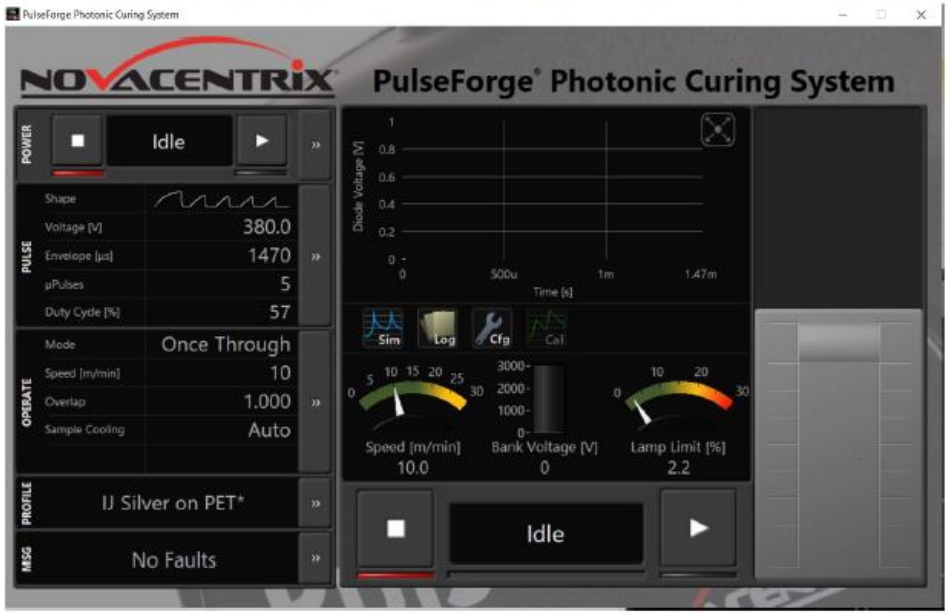
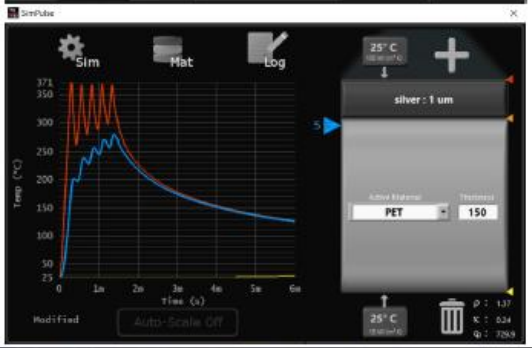
Photonic Principle

SimPulse® is Photonic Curing Simulation



PulseForge® Operations Interface

Shaped Pulse Conditions w/ Pulse Editor



Thin Film Thermal Optimization

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Photonic Principle

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Solutions Engineered for Process Control

Pulse Shaping: Multi-Function Curing

Able to dry and sinter using two temperature zones

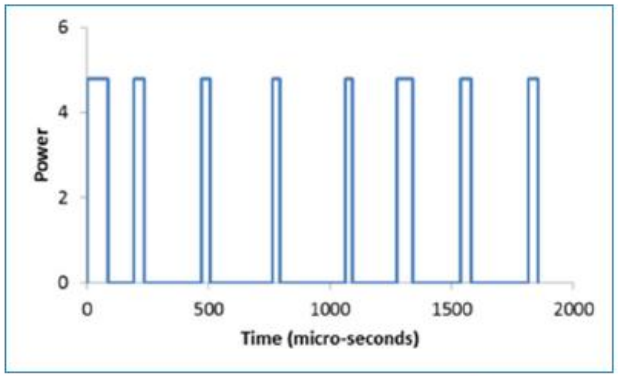
Pulse lengths from 25 to 10,000 microseconds

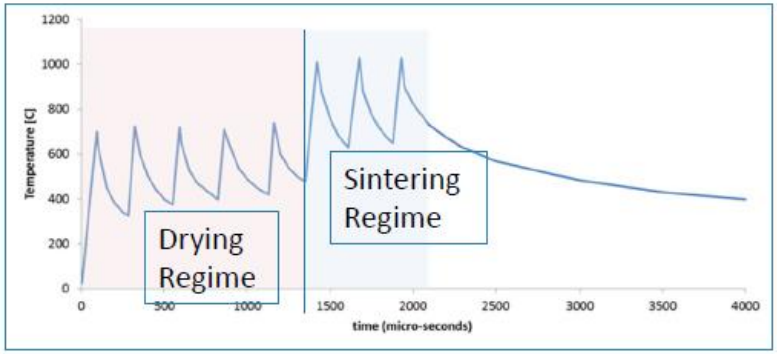
Minimum pulse length increments: 1 microsecond

Minimum space between pulses: 25 microseconds, with 1 microsecond increments

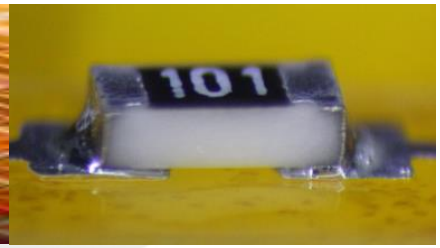
Thermal non-equilibrium process

High temperature material processing capability on low temperature substrates





Photonics Soldering



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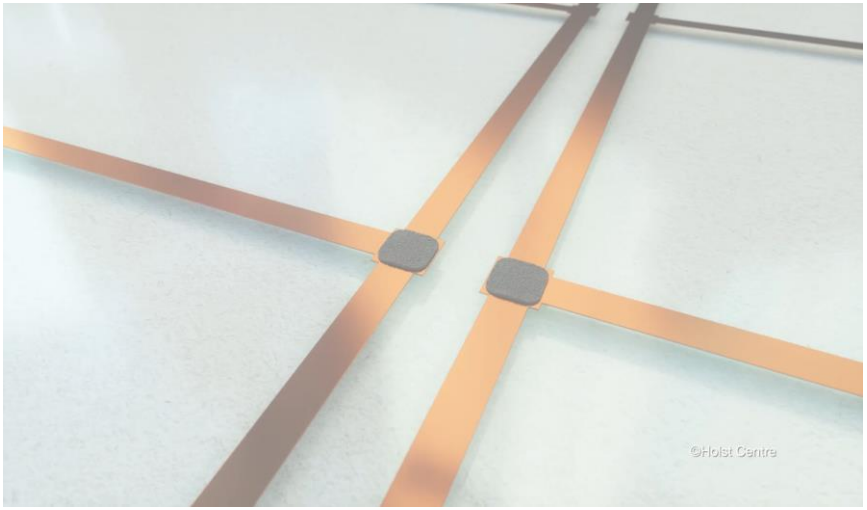
PULSEFORGE – Enabling Flexible Hybrid Electronics

Standard electronics packages – Conventional Solder – Economical, Flexible Substrates



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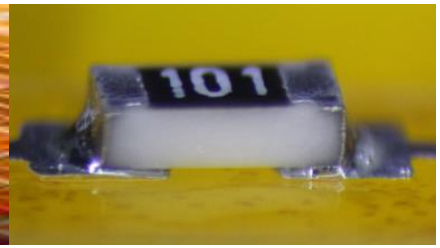
Photonic Soldering



PulseForge Soldering - Differentiators

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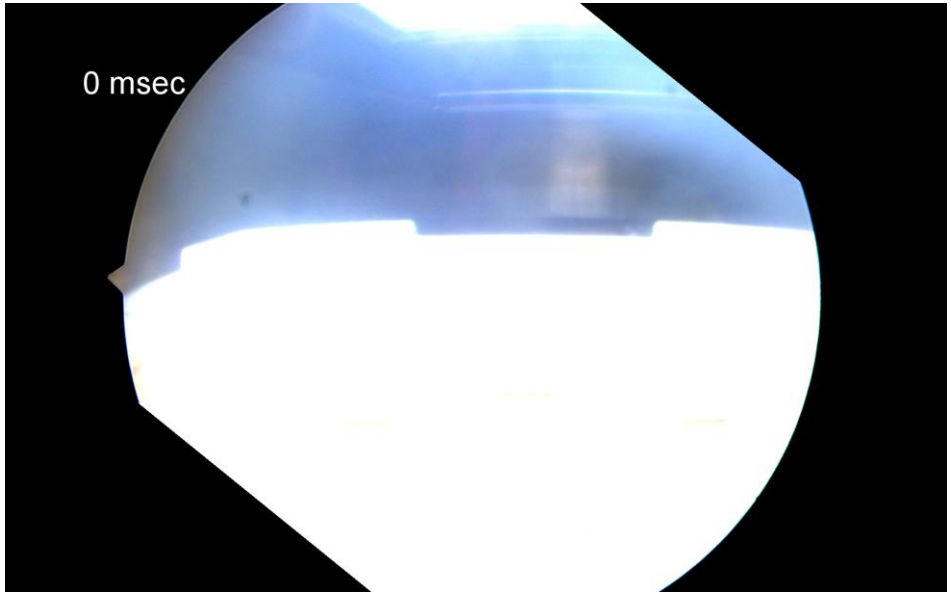
Looking forward – differentiating our technology

Spatial selectivity
- Thermally sensitive substrate
- Thermally sensitive component
- Thermally sensitive regions

Very high throughput



Solder used – Indium SAC305 -8.9HF

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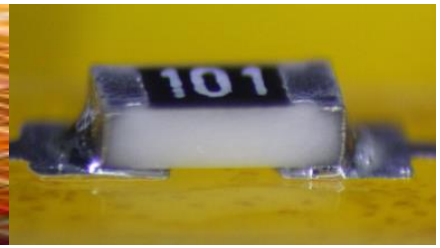
Temperatur Profil

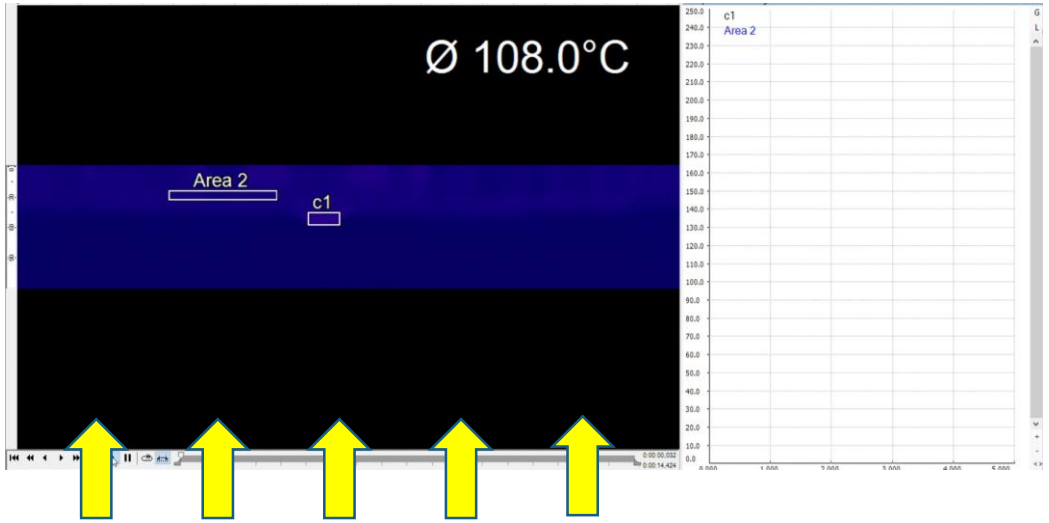


PulseForge Soldering - Differentiators

NOVACENTRIX

Looking forward – differentiating our technology

Spatial selectivity
- Thermally sensitive substrate (LED arrays on PET)
- Thermally sensitive component (Sensors, batteries)
- Thermally sensitive regions (interconnects)



Direction of light

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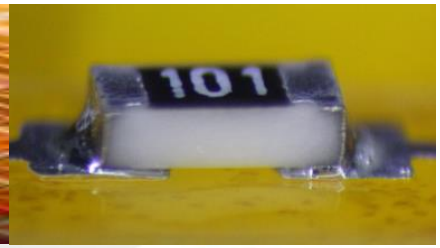
Other Materials



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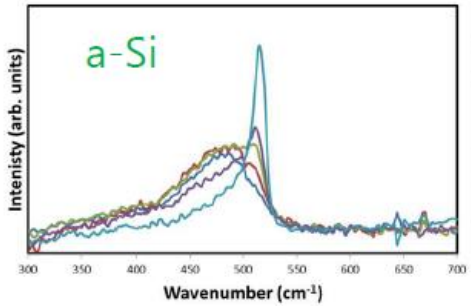
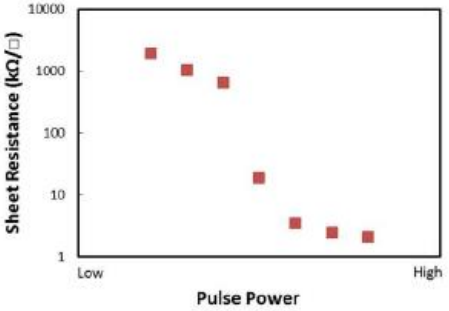
Photonic Curing of Ceramics and Semiconductors

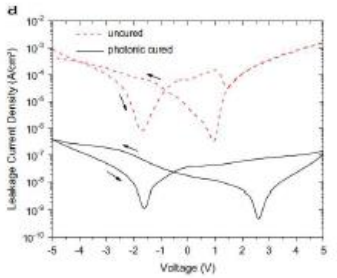
Various materials processed on the PulseForge system:

- a-Si films
- Semiconductors for PV applications (CdTe, CIGS, perovskites, etc.),
- IGZO for displays
- PZT ceramics
- ITO processing

Key consideration is compositional control to eliminate unwanted dopants and achieved crystallinity.







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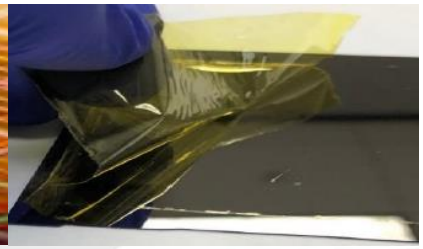
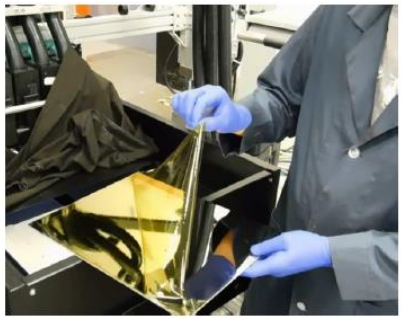
PulseForge Lift-Off



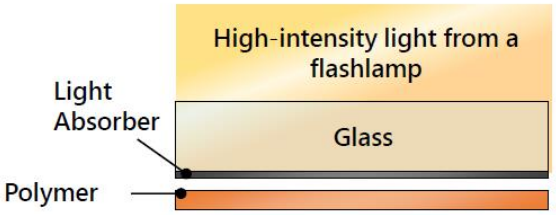
PulseForge® Lift-Off

Developed as laser lift-off (LLO) alternative, its characteristics include:

- ❑ High-intensity light-emitting flashlamps
- ❑ Large-area illumination per flash
- ❑ Faster than LLO
- ❑ Light absorbing layer is crucial for this process
- ❑ Suitable for both wafer-level and panel-level packaging applications



Polymer (≈10 µm) lift-off
(360 mm x 465mm – Gen 2)



150 mm wafer (60 µm thick) debonded
in less than a second

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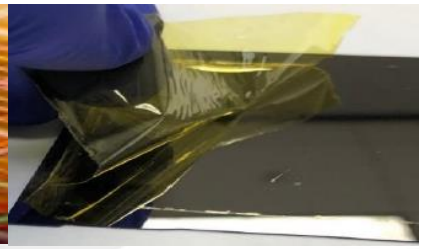
Applications

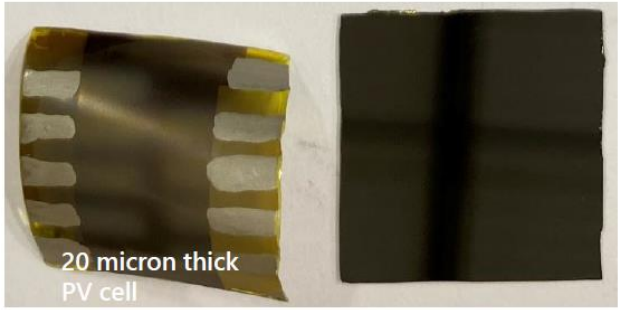


Targeted Applications

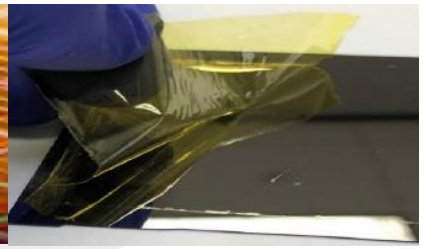
Flexible display manufacturing

Advanced wafer level packaging-thinned wafer debonding

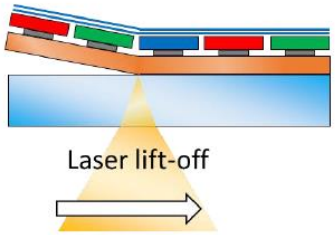
Other ultra-thin electronic devices



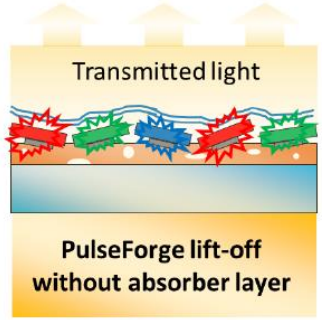
Process



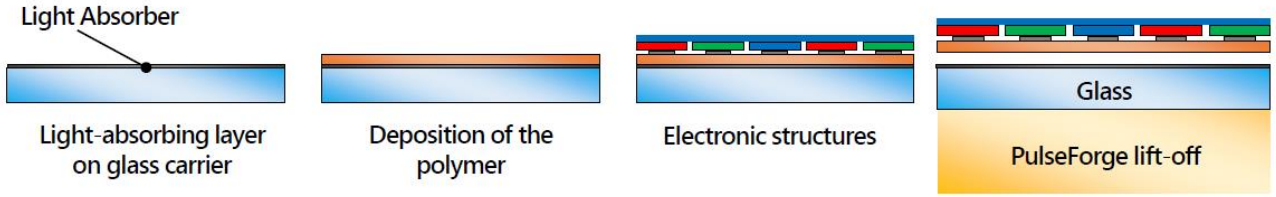
Light Absorber Layer in PulseForge® Lift-Off



- Laser lift-off uses excimer lasers
- Most polymers absorb almost 100% of excimer laser beam

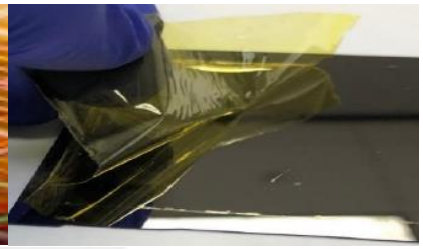


- PulseForge® lift-off uses broadband light spectrum (200 – 1500 nm) from flashlamp
- Nearly 80% of the light is transmitted through the polymer impacting the device stack



- To prevent the transmission, a thin layer of light absorbing layer is sputter-coated on the glass
- The absorber layer has 0% transmission and absorbs nearly 60% of the incident light
- The absorber layer coated glass substrate can be reused

Comparison



Laser Lift-Off Versus PulseForge® Lift-Off

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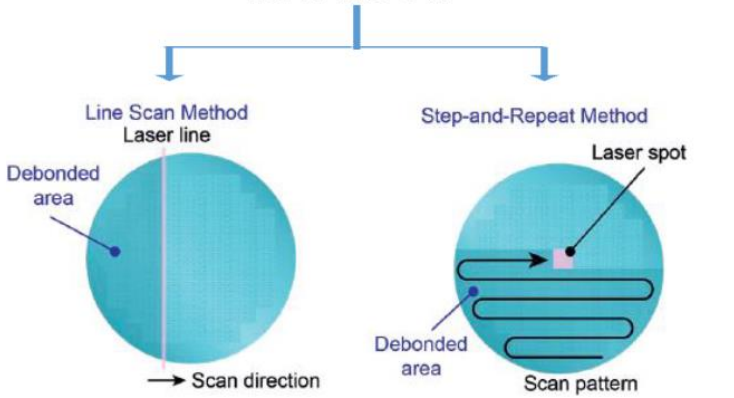
Processing Strategy

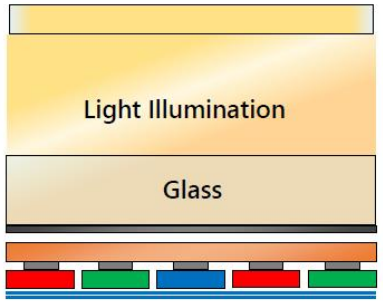
Laser Lift-Off



*DOI: 10.1016/j.phpro.2013.03.075

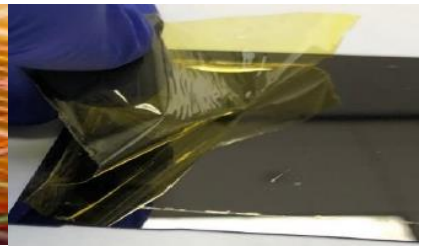
Requires 1000 laser pulses to cover 300 mm wafer*

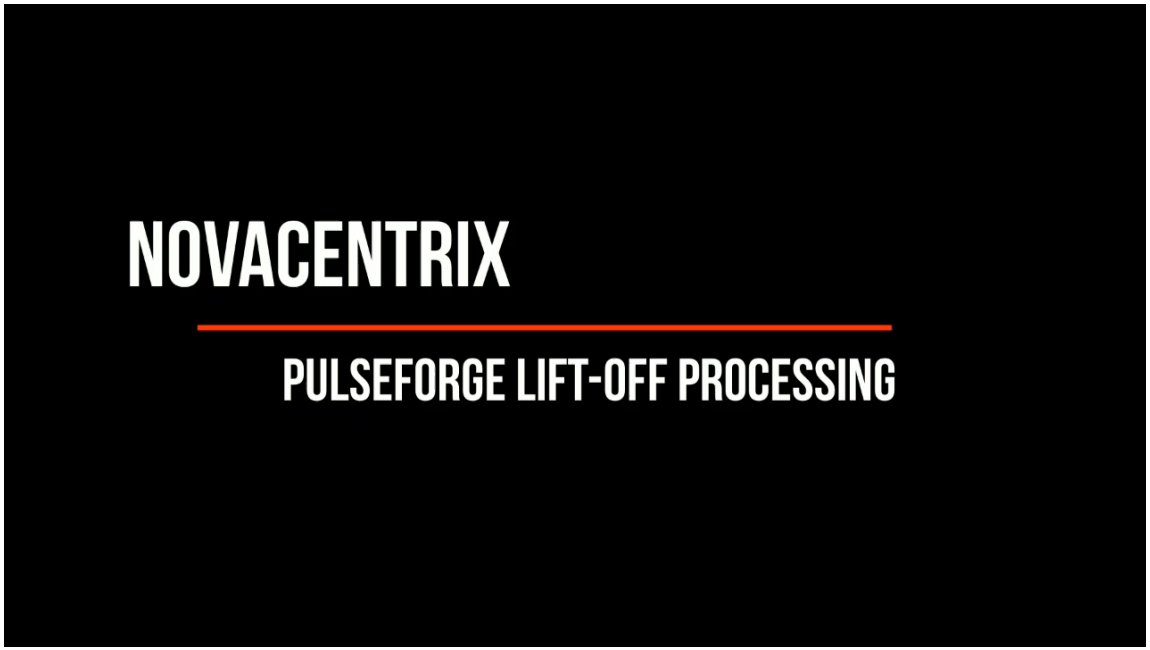
PulseForge® Lift-Off



One-flash strategy - requires as low as one pulse to process 150 mm wafer

Lift-Off - Demonstration

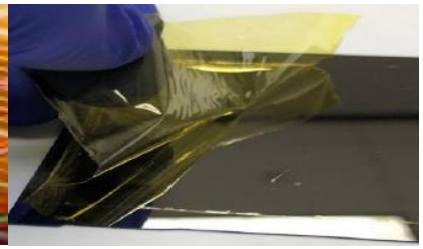




- Faster than laser – release polymer films in seconds
- Transiency of the process keeps the top of the film cool (less than 80 °C)
- Higher tolerance to defects because no light is exposed on the polymeric substrate
- Self-limiting process

Watch this video at https://www.youtube.com/watch?v=74Y3aCFQy1E

Used Cases



Polymer-agnostic Process

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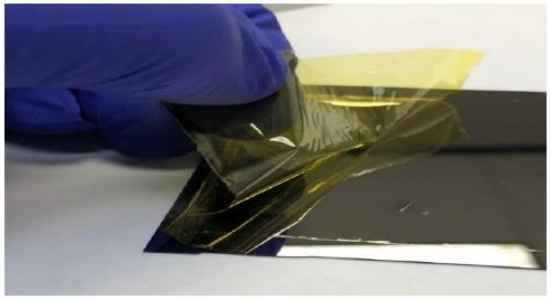
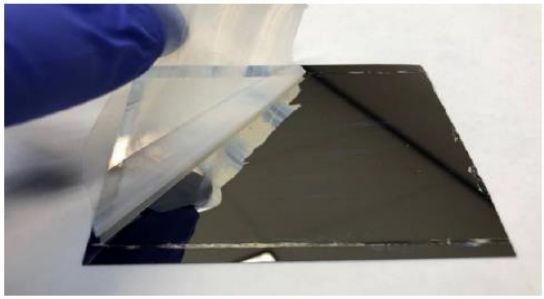
A wide variety of both thermoset and thermoplastic solution cast polymers have been released using PFLO.

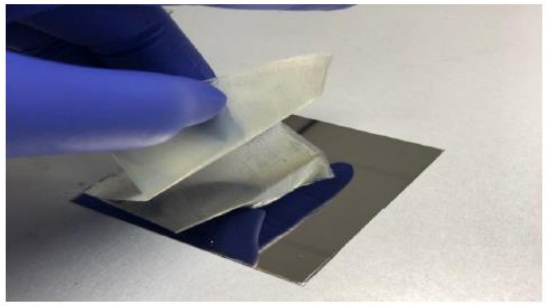


Standard polyimide

Clear polyimide

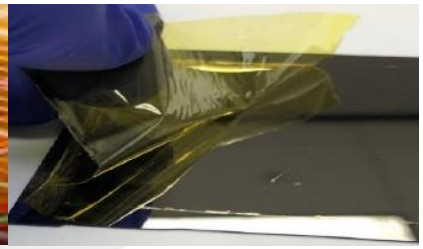


Polyurethane



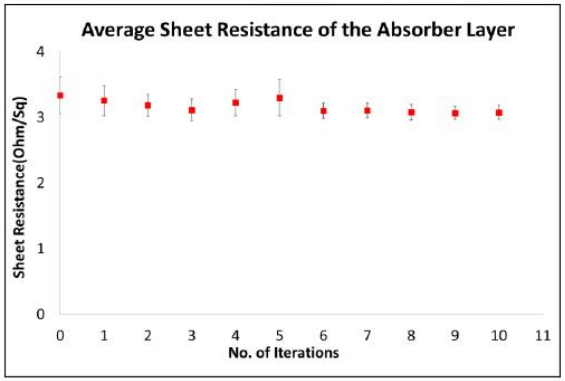
Polyester

Carrier Reusability

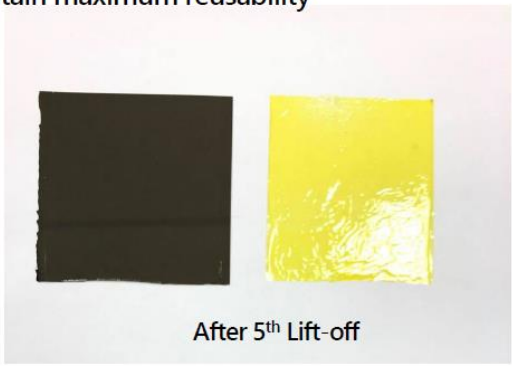


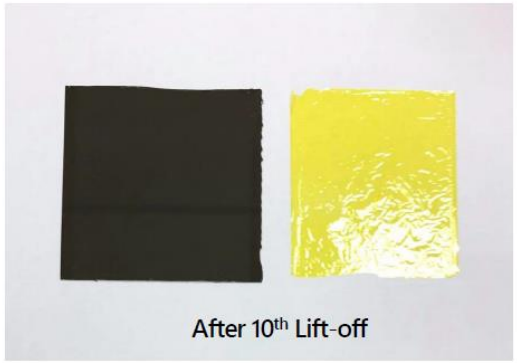
Reusability of the Carrier

- Up to 10 lift-off iterations have been tested to study the reusability of the substrate. No visible damage observed
- 10 -12 µm thick polyimide coating was used for the study
- Average sheet resistance of the absorber layer coating remained consistent even after 10 iterations
- Reusability of the substrate is dependent upon the type of the polymer used as different polymers have dissimilar decomposition temperatures and other thermal properties
- Process conditions can be tuned to obtain maximum reusability




After 1st Lift-off


After 5th Lift-off


After 10th Lift-off

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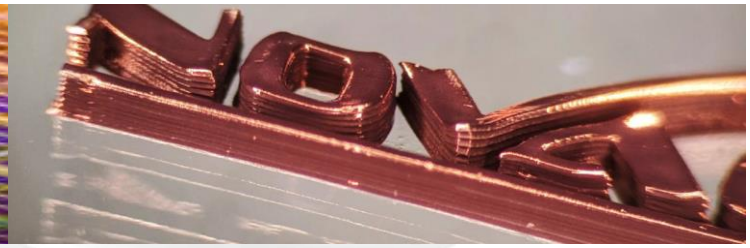
Photonic - Printing



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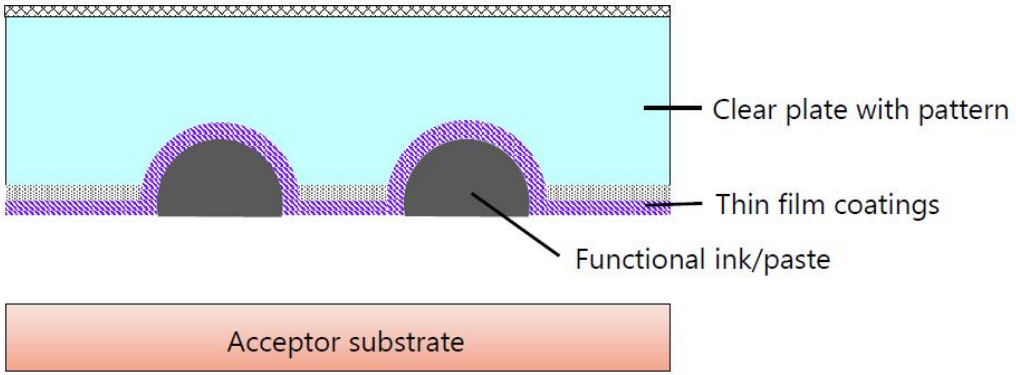
PulseForge Printing – Mechanism

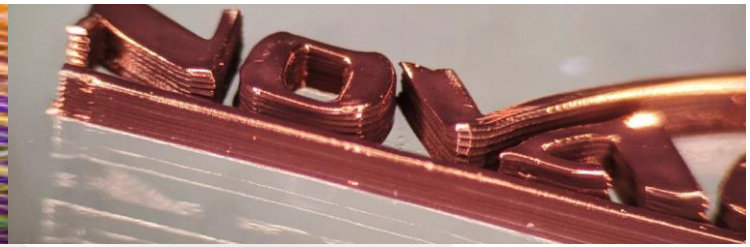
It is an emerging application from NovaCentrix for patterning high aspect ratio prints of a wide variety of functional inks or other materials and components in a rapid and non-contact technique.

The printing is achieved using high power pulsed light and a patterned print plate.

The animation at right shows a metal nanoparticle ink pattern being printed.



Photonic - Printing



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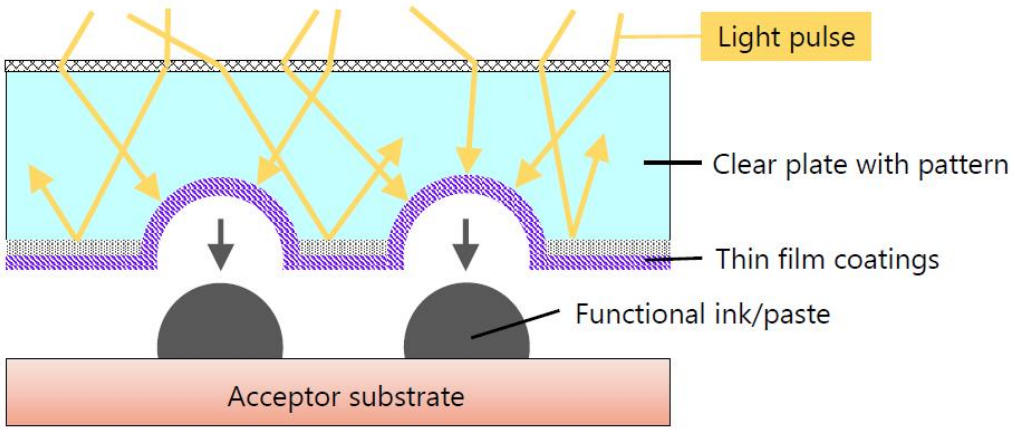
PulseForge Printing – Mechanism

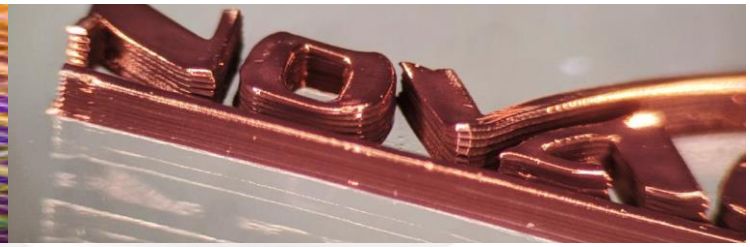
It is an emerging application from NovaCentrix for patterning high aspect ratio prints of a wide variety of functional inks or other materials and components in a rapid and non-contact technique.

The printing is achieved using high power pulsed light and a patterned print plate.

The animation at right shows a metal nanoparticle ink pattern being printed.



Photonic - Printing



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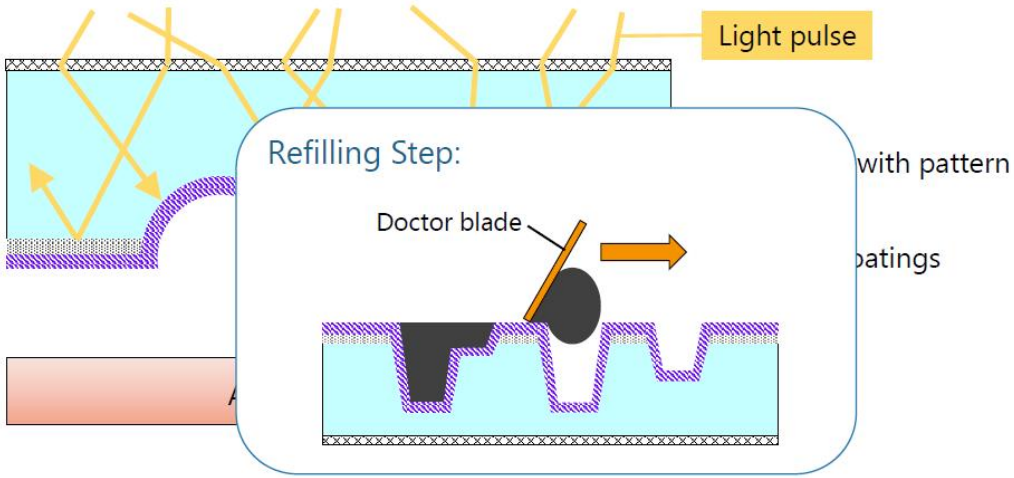
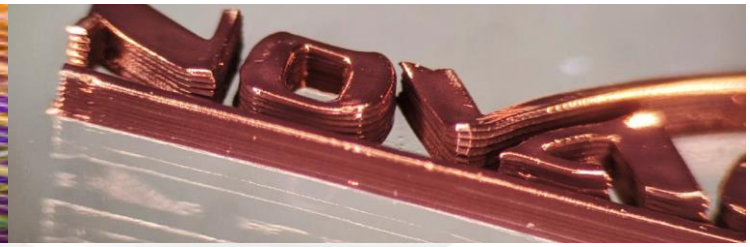
Note that between prints, the ink is refilled into the plate with a dispense and doctor blade step.



Photonic - Printing

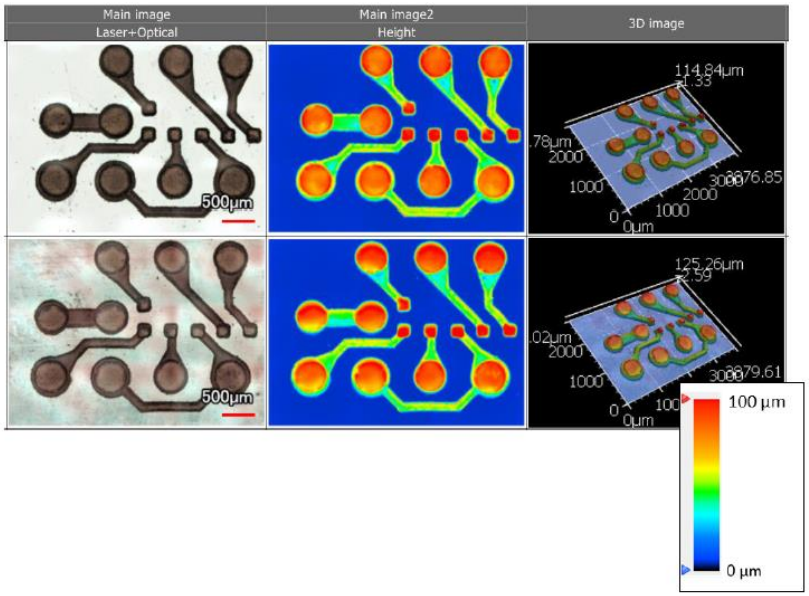


NOVACENTRIX

PulseForge Printing – Variable Print Thickness

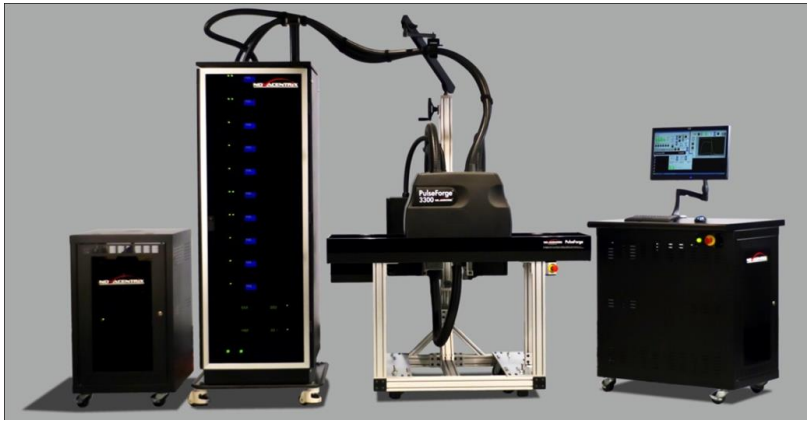
Variable print thickness can be achieved and the redistribution layer pattern shown demonstrates our copper ink as-printed and after curing. High viscosity inks tend to give better pattern quality and printing performance.

This can be considered at **2.5D printing technology**.



Novacentrix - Systems

Inline Manufacturing System



Integration System

Roll-to-Roll System

R&D System

merconics

Thank You

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