Neotech AMT

Advanced Manufacturing Technologies for 3D Printed Electronics

Scalable 3D Printed Electronics – "Fully Additive" To High Volume Manufacture

Dr. Martin Hedges – Managing Director

4.6.2020

Agenda

1. Company Overview

2. Designing a 3D Printed Electronics Process

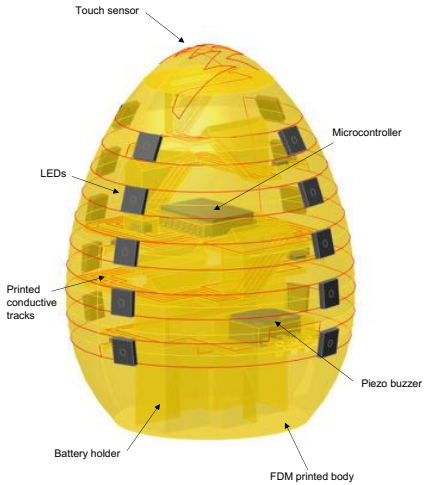
3. Application Examples

4. Beyond Simple Circuits

5. 3D Print Systems

Neotech AMT GmbH

- Neotech manufactures system for 3D Printed Electronics.
- Pioneering 3D PE development since 2009.
- First 3D capable system installed in 2010.
- Patented mass-production capable system of type 45X built 2012.
- 1st commercial sale & install of mass production system in Q3 2013.
- 1st commercial mass production started on Neotech systems in Q3 2015.
- Winner of the 2019 TüV Süd – Innovation prize with FAPS

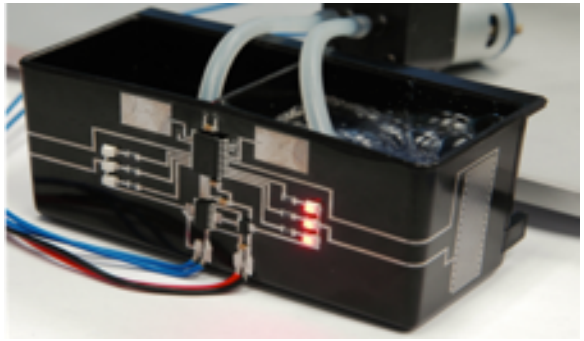


"Fully Additve Electronics"
(FAPS-Neotech)<

Market Need for 3D Printed Electronics

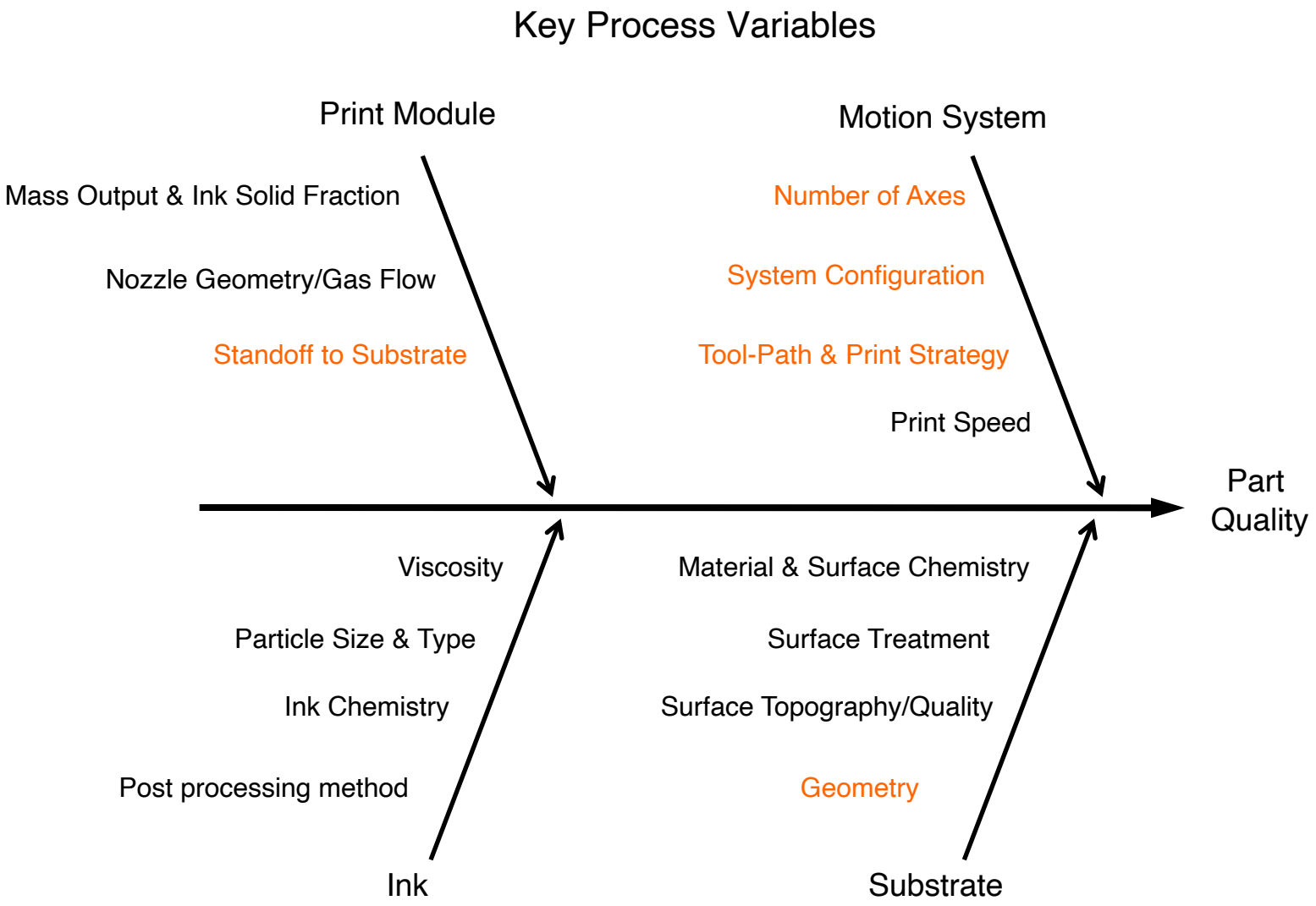
Design Flexibility	Economics	Environmental
Integration of Mechanics-Electronics-Optics	Reduced Part Count	Reduced Materials Mix
Flexibility of Shape	Shorter Process Chains	Simplified Recycling & Disposal
Minaturisation	Reduced Materials Use	Reduced Material Quantity
New Functionality	Increased Reliability	Reduced Parts Tourism

Multi-station Printing
at LITE-ON Mobile Mechanical SBG



Tank Filling Sensor
Automotive

Enabling a 3D Printing Process

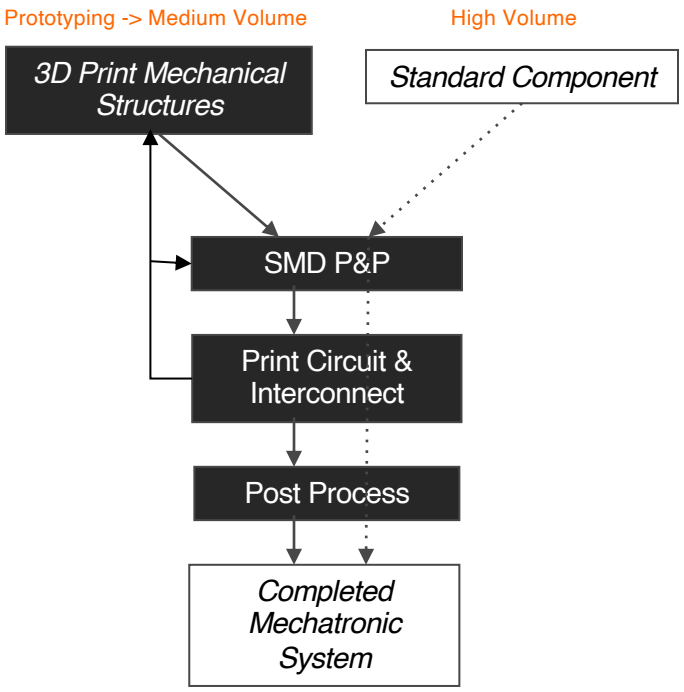


Scalable Process Chains

Two basic process chains exist for 3D Printed Electronics:

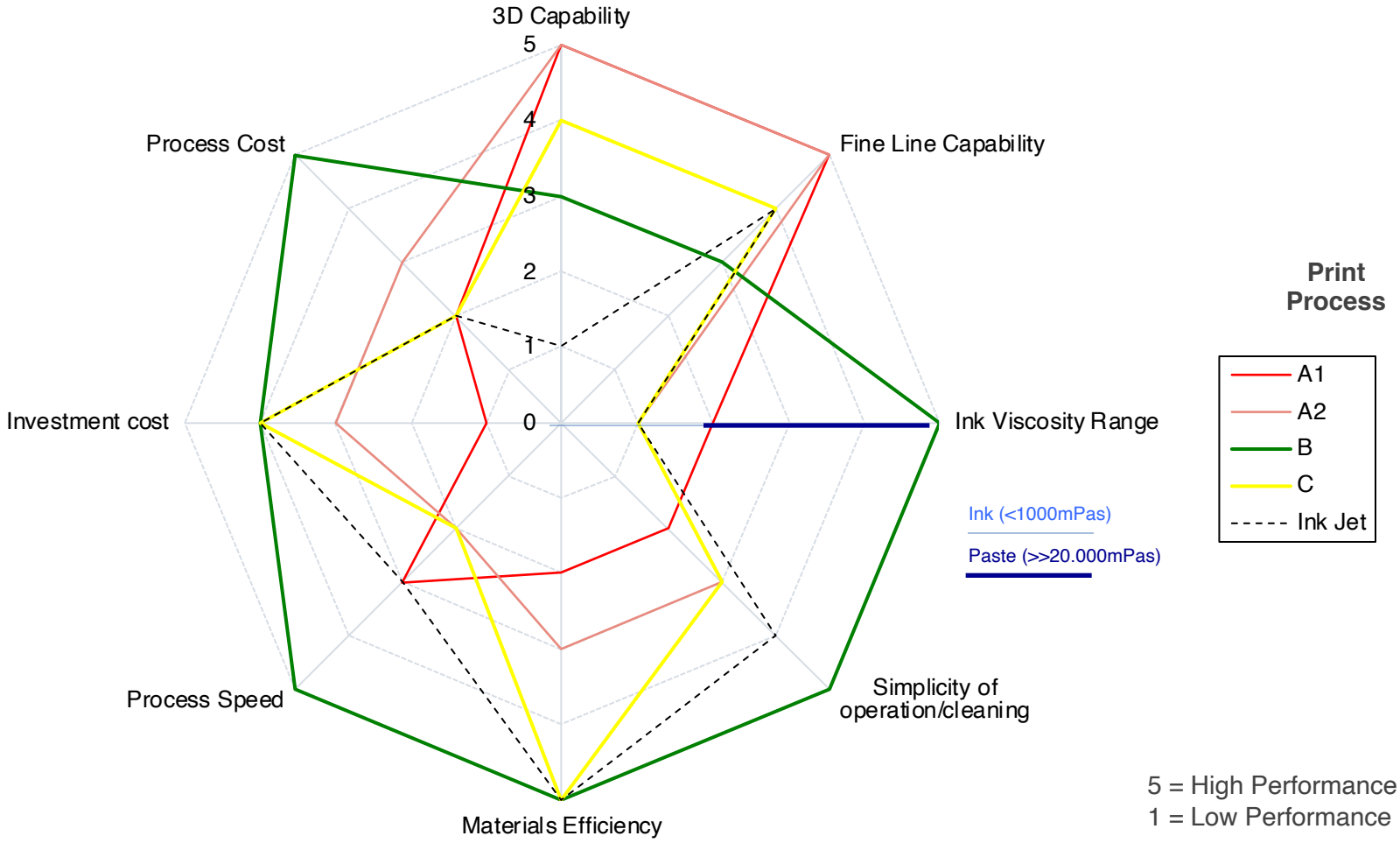
1. For high volume manufacture, electonics are intergrated onto the surface of a standard components (mouldings, composites etc.)

2. For lower volumes “Fully Additive” manufacture can be applied – classical structural AM (via FFF, SLA…) is combined in the 3D PE process.



Print Head Selection

Each print process has a unique combination of characteristics
Process selection driven by application requirements:



5 = High Performance
1 = Low Performance

A1 = Aerosol Process 1, A2 = Aerosol Process 2, B = Piezo Jetting, C = single nozzle InkJet

Dealing with complex geometries

Motion 3D CAD/CAM Tool-path Generation Software

CAD/CAM package that seamlessly interacts with the print platform to enable the printing of highly complex 3D circuits:

Simple process flow for 3+2 indexed to 5 axis simultaneous printing

Optimised cycle times via free definition of the print sequence

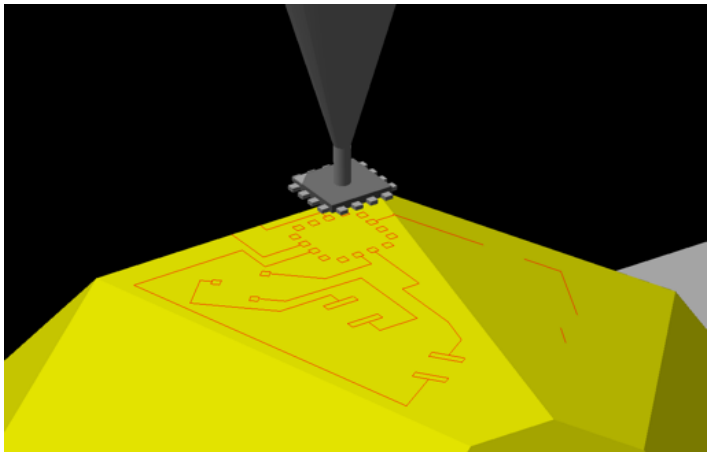
Machine motion simulation & collision detection

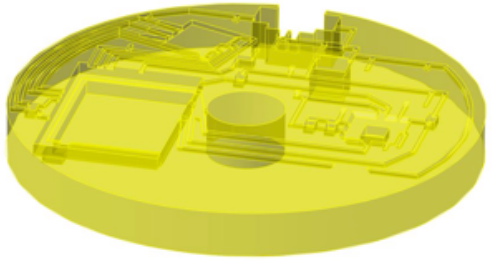
Look ahead function for accurate start/stops of the print process

CAM Check Function – check programmed tool-path vs. machine process limits (point to point time, acceleration and axis speed)

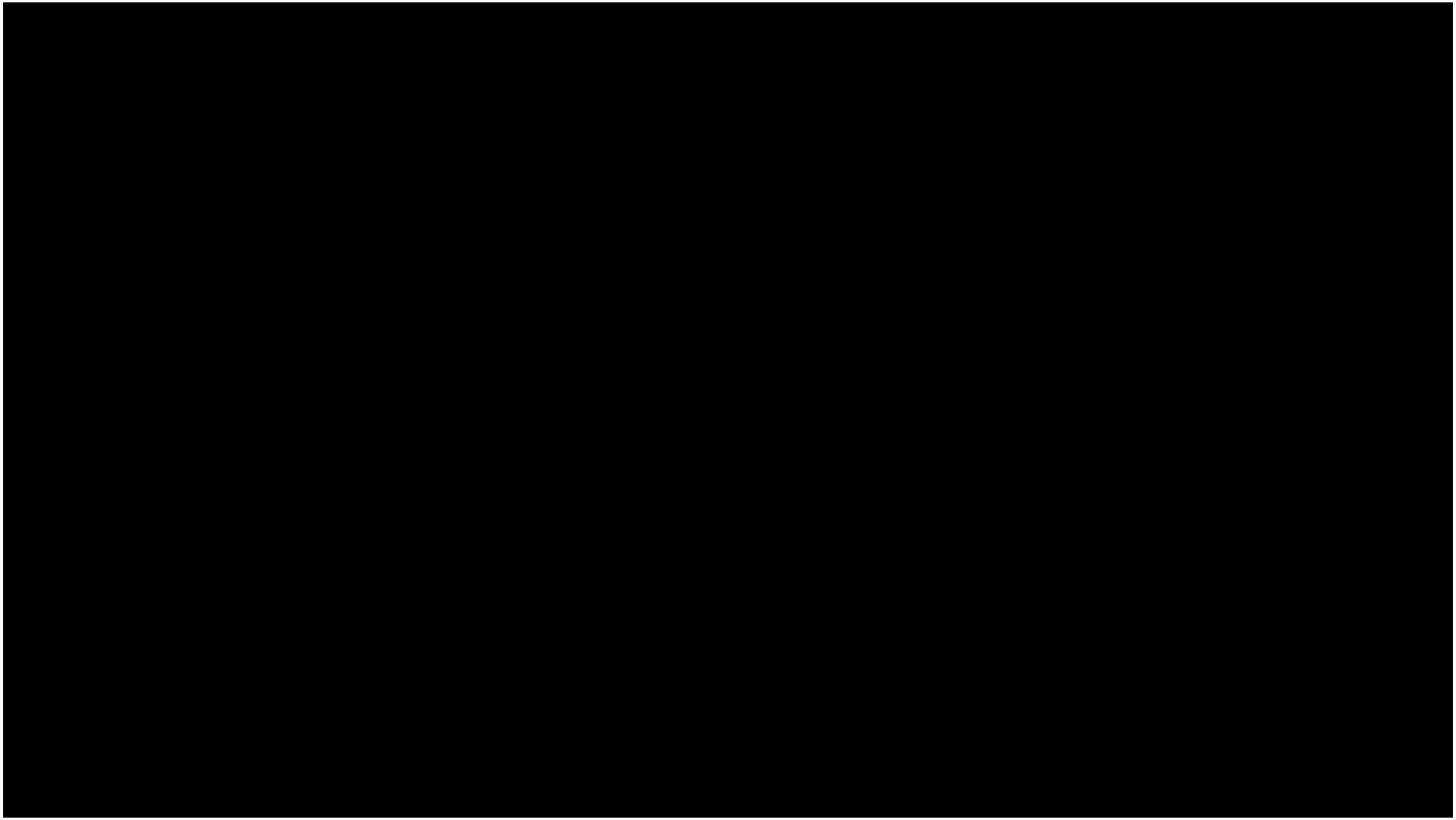
Machine specific ISO Standard G-Code post processor

All process steps (3D Print, 3D Circuit Print, SMD Pick & Place, Pre-/Post-processing) in single machine code

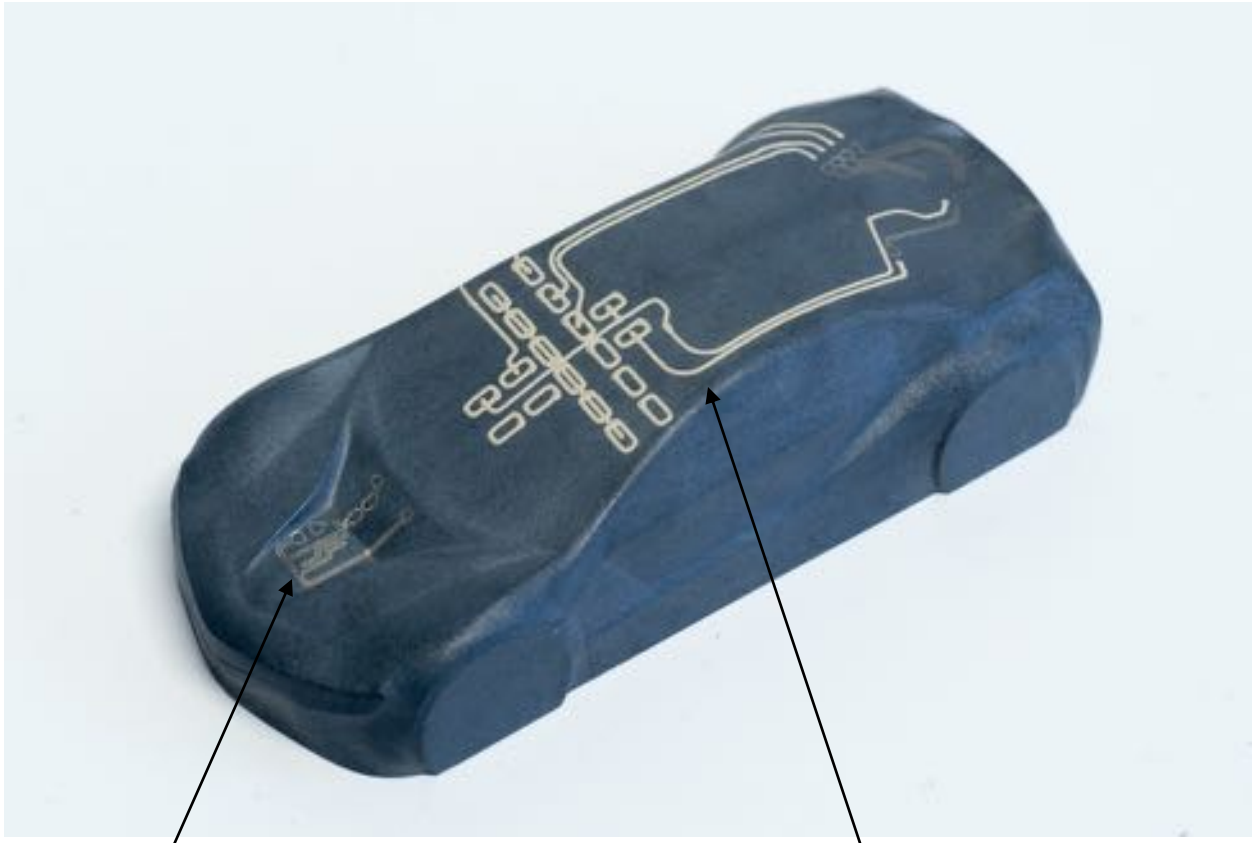




5 Axis Print Demonstration



Example of Dual Print Technolgies



NanoJet
Fine Line (ca. 60um)
Ag Nano-particle Ink
Viscosity: 20mPas

PiezoJet
Medium Line (300um)
Ag Ink with particles D90 ca. 6um
Viscosity ca. 70.000mPas

Current Applications

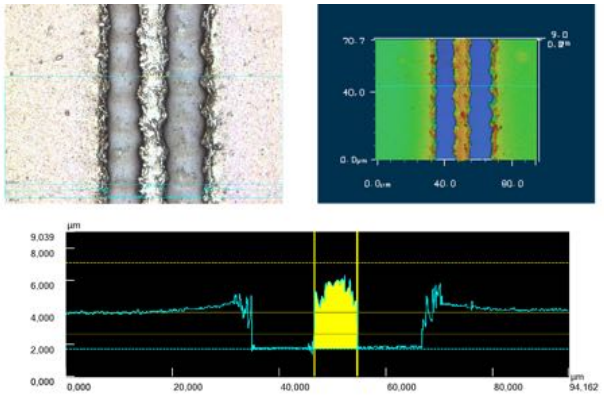
Mobile Communications – Antenna & Circuits

Ag inks & pastes on moulded resins: PA, PC/ABS…
Particle free inks in test and show some promise

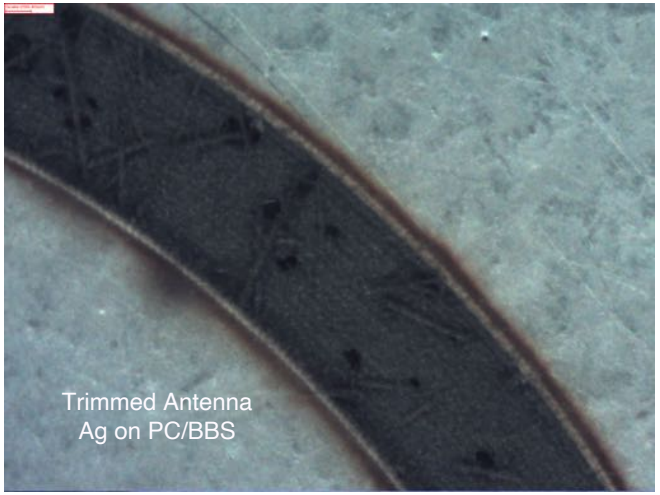
RF Performance: matches industry standard
Production Costs: specific antenna designs show cost benefit

Current development: rapid print and laser trim
Further cost reduction and improved performance
New route also enables rapid processing of fine line features down to 10um

Multi-station Printing.
Courtesy: LITE-ON Mobile Mechanical SBG

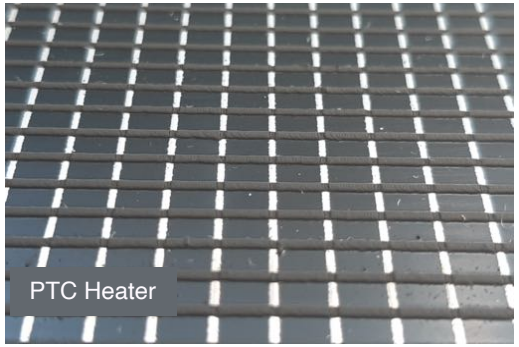


Fine Line (9 ± 1 µm)/High Aspect Ratio



Automotive Applications in Development

Functionality	Current	Planned (2021-)
Heater Patterns	Lidar/Radar	
	Rear windscreen	
	Cabin Interior (PTC)	
Lighting	Cabin Interior (LEDs) with touch sensor control	3D OLED
	Optical Waveguides	
Sensing	Temperature sensor	
	Pressure sensor	
Sustainability	Weight Reduction for Cabin Interior	Frame/Body panel
	Automated Recycling	Electronics on Sustainable Substrates



Weight Reduction & Sustainability

Mechatronic system is complex – many moulded parts, PCBs, cables, connectors…

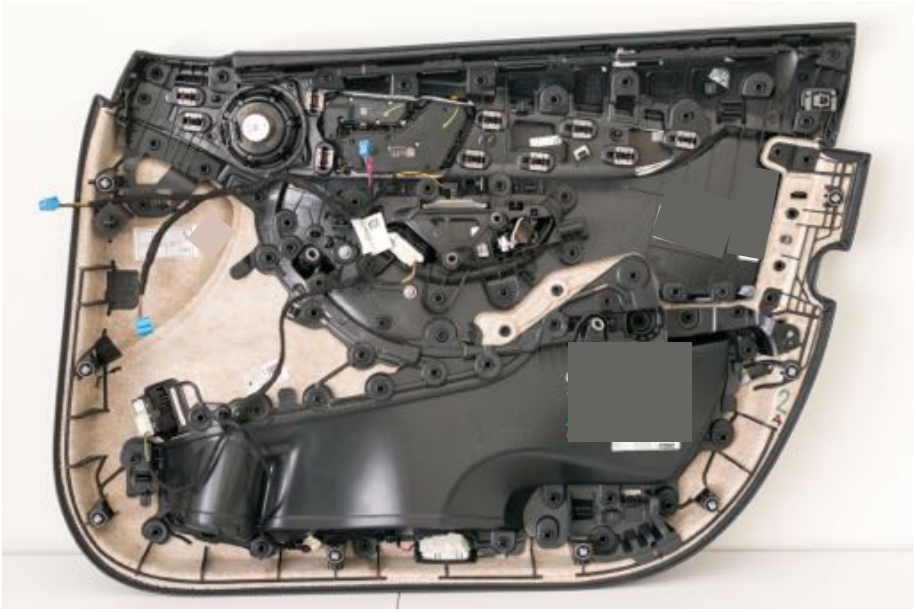
Wiring harness overweight & costly – thick cables to withstand manual assembly

3D Printed Electronics benefits:

1. Reduce weight, parts count and manual assembly steps

2. Potential to use environmentally friendly acoustic panel as main electronics substrate.

3. Automated recycling possible



Door Panel Interior

Switch Paddle Circuit

Automotive

Proof of Concept study

Target higher level of integration & cost saving

Circuit printed directly on switch paddle body – remove PCB

Next step replace connector cable with printed circuit/interconnect – cost saving

Courtesy:

MARQUARDT

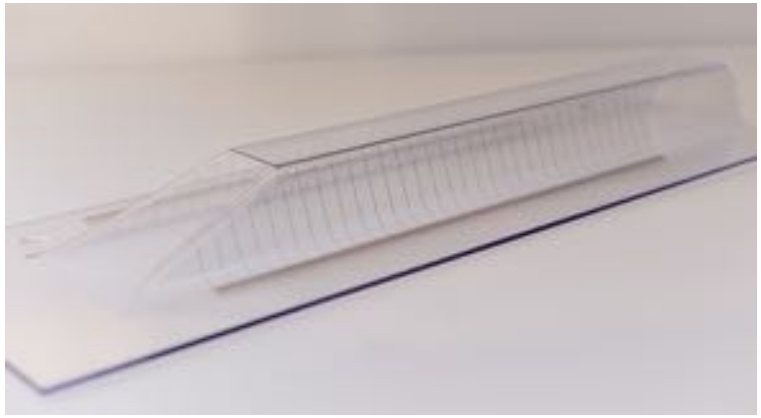
3D Heater Patterns on PC

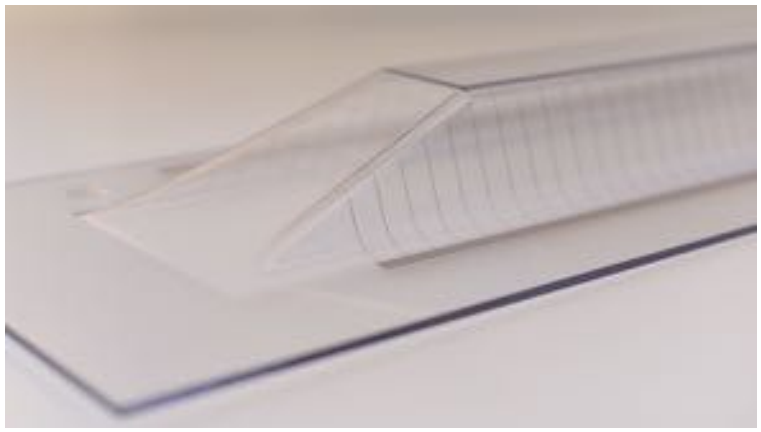
Automotive Glazing

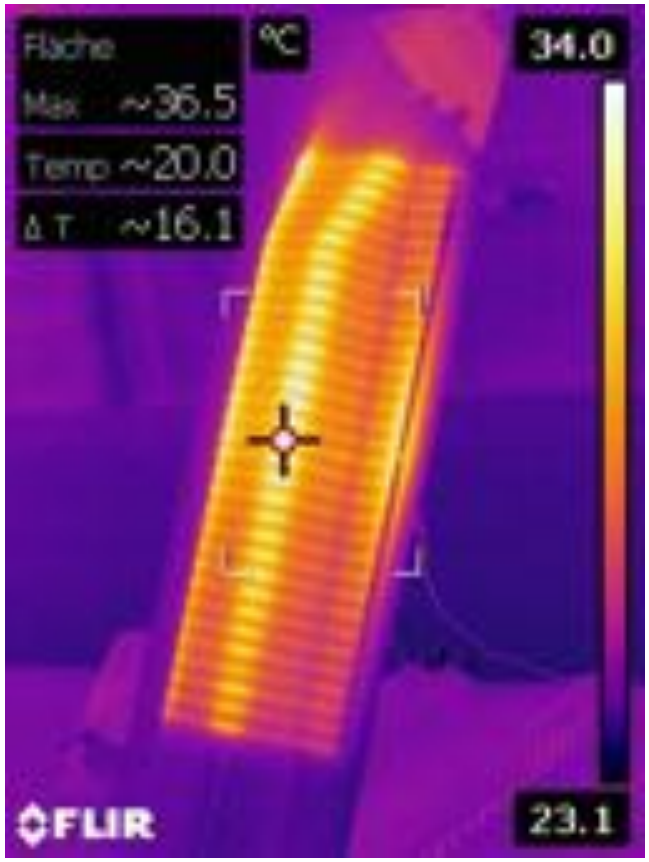
Ag heater circuits printed on large PC part: 750 x 250 x170mm (x-y-z)

Heating 18W (3A/9V) – tune print process to increase heating capacity

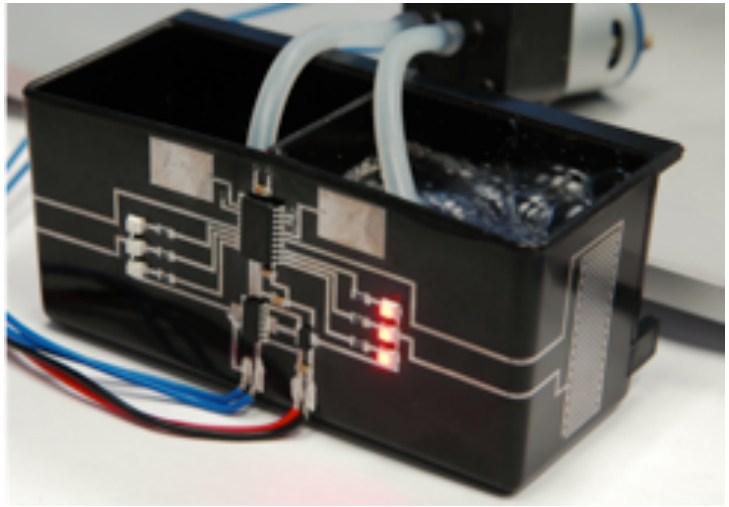
Parts to be coated with protective anti-scratch/anti-UV layer



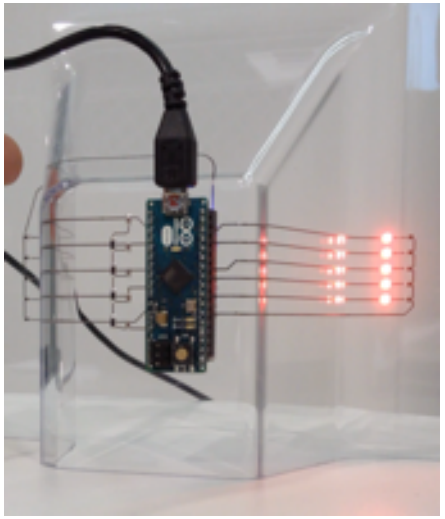




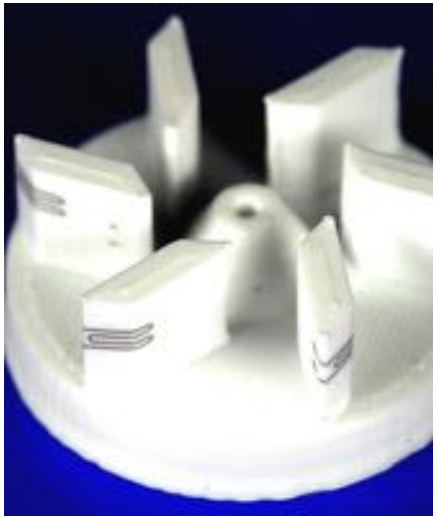
3D Printed Sensors



Tank Filling Sensor
(Capacitive)



Touch Sensor on
moulded PC
(Capacitive)



Strain Gauge on 3D
Printed PLA
(Fraunhofer IFAM)

Printed Circuits & Sensors for Healthcare

After suffering a stroke patients are often accompanied by unilateral motor dysfunction resulting in weak finger strength, grip, and poor circulation.

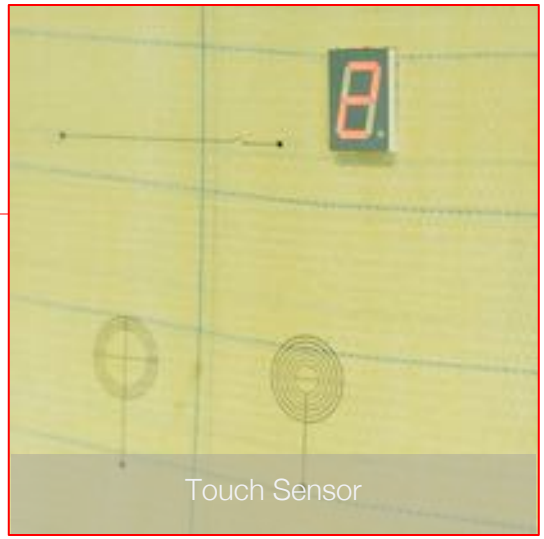
The rehabilitation ball has printed circuits and embedded electronic components on curved, flexible substrates.

It is held in the palm of the hand for close-and-open exercises and effectively increases finger strength and stroke recovery.

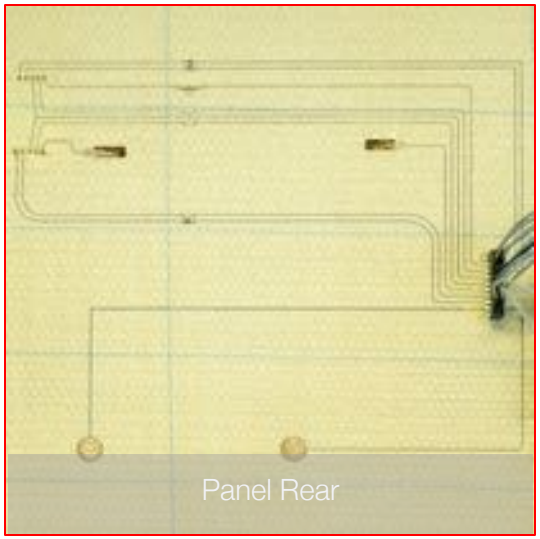
The device provides real-time feedback the patient's grip strength and monitors the training process for patients.

Device developed and manufactured by EverYoung BioDimension Corporation

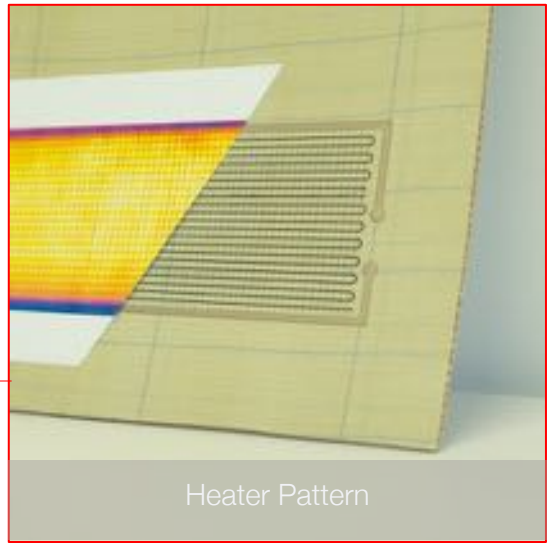
Smart Cabin Panel



Touch Sensor



Panel Rear

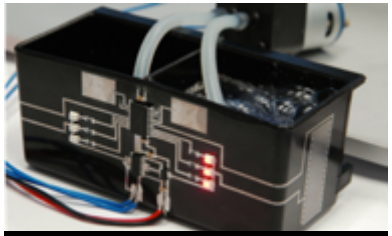


Heater Pattern

DLR FeVedis Project with Fraunhofer PYCO & FAPS

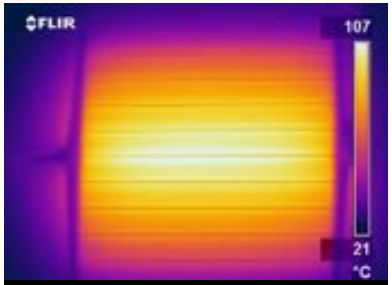
Additional Functionality for 3D Printed Electronics

3D Today



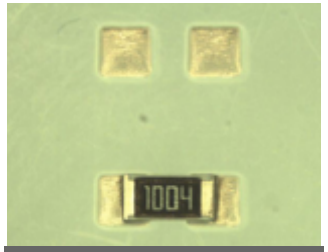
Circuits & Sensors

Antenna

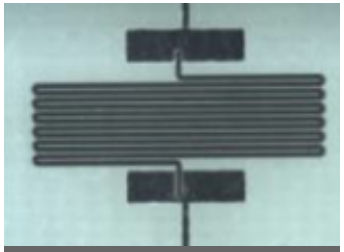


Heater Patterns

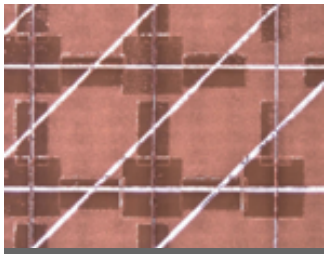
Printed in 2 to 2½D Today -> Future in 3D?



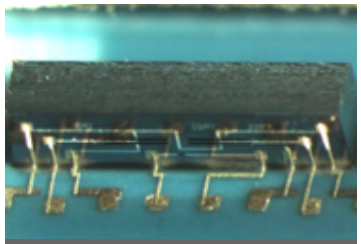
Chip Bonding[1]



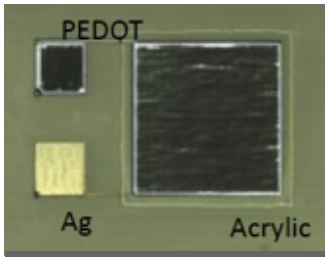
Resistors[1]



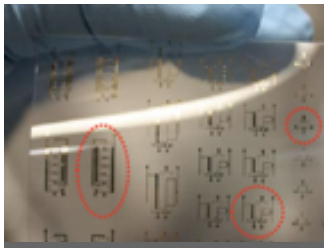
Multilayer Circuits[1]



3D Interconnects[2]



Capacitors[1]



Transistor Circuits[1]

[1] Courtesy Optomec Inc.
[2] Courtesy Fraunhofer IKTS

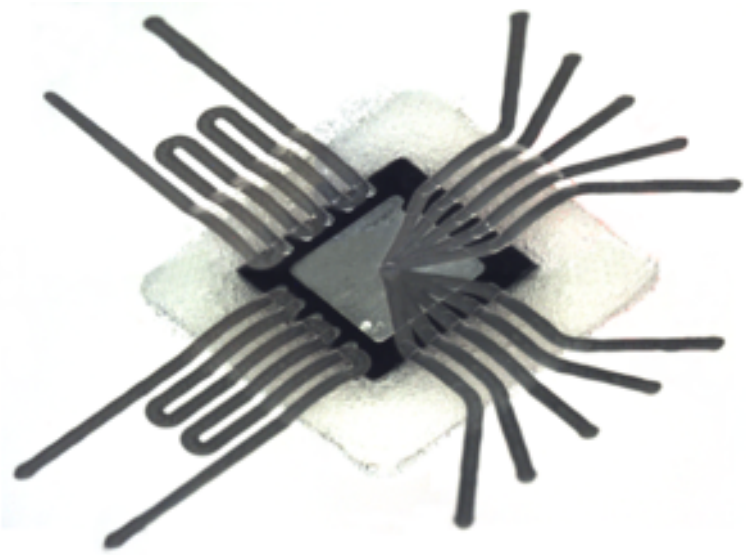
Chip Interconnection SMDs

Concept: SMD fixed with adhesive on/in part surface, then direct print of circuit and interconnect

Benefits:
- Low temperature route, no soldering
- Simplified material mix, simplified re-cycling
- Simplified processing
- Extremely robust package, especially when embedded

QFN (Quad Flat No-lead) Microcontroller

Interconnect/Circuit 230μm in Ag, Fixed with 2 Component Epoxy



Embedded in PC

Surface mounted on glass

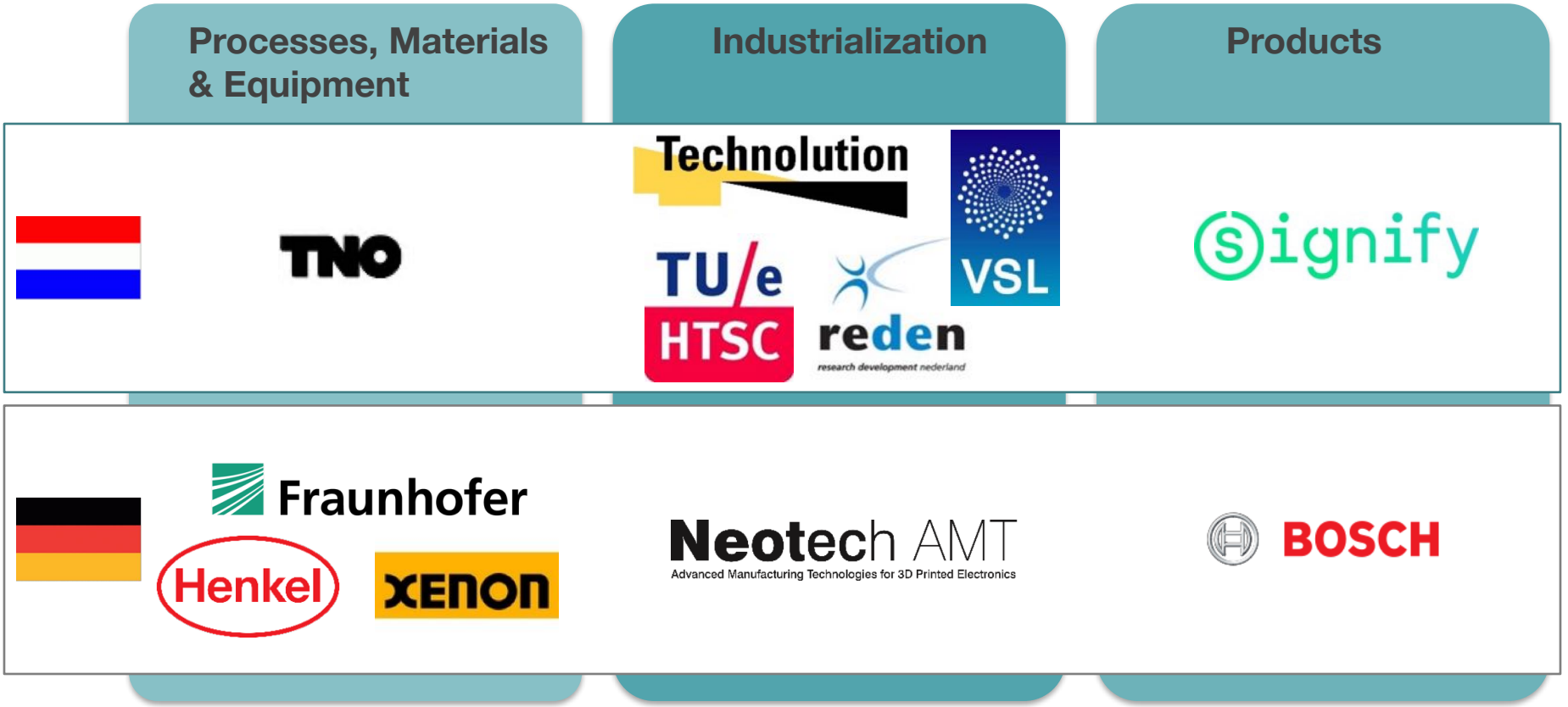
“Fully Additive” 3D Printed Electronics

(Combining classical 3D Printing with Printed Electronics)

EU PENTA Project: Hyb-Man

Hybrid 3D Manufacturing of Smart Systems

1. Develop hybrid 3D manufacturing methods to enable flexible first time right production of smart systems
2. Exploit 3D Printing of polymers in combination with 3D Printed Electronics as core production technologies
3. In-line testing and quality monitoring processes will be integrated as part of the complete process chain
4. Outcome: improved Additive Manufacturing processes, a hybrid manufacturing production cell and prototypes of integrated electri products (LED luminaires, automotive adaptive sensors)



Project Timeframe:1.4.17-31.3.21

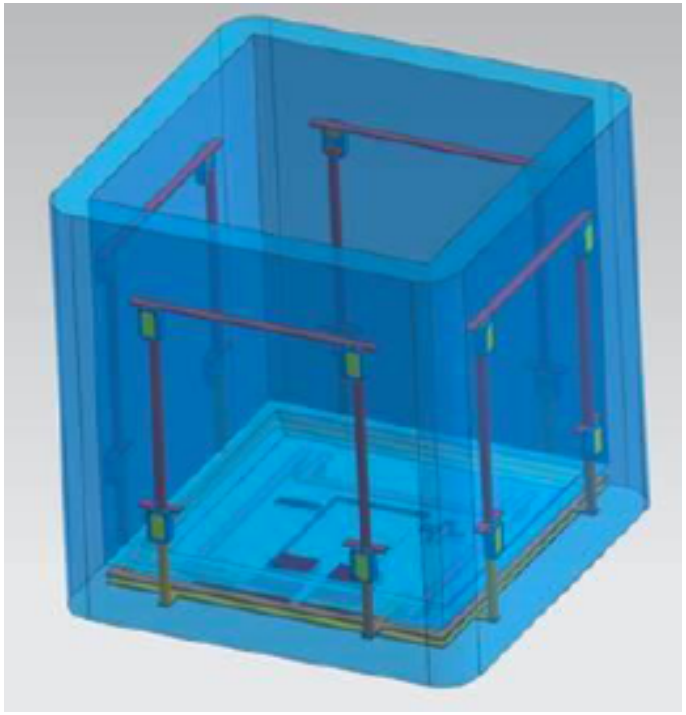
EU PENTA Project: Hyb-Man

First Product Demonstrator: LED Box

Main box body printed in PLA, next transfer to PC/ABS then PA

20 LEDs added (5 sets of 4):
4 in base added and then circuit printed to directly contact.
16 LEDs in walls mounted with conductive adhesive.

Side wall circuits use 5 axis motion



Product Demonstrator – Automotive

Production steps:

1. Printing the housing → 2. Adding/P&P of SMDs

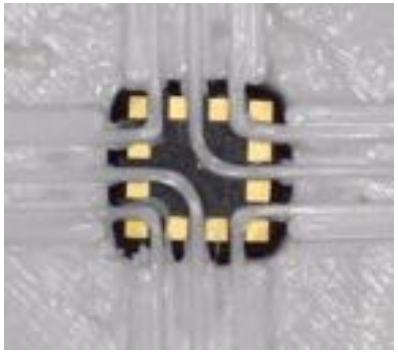
3. Print circuit and interconnect → 4. Continue FFF Structural Print

Challenge – BMA Sensor Requires fine line interconnects.

Could use fine line printing method, e.g. Aerosol, IJ,...

However cost/complexity an issue.

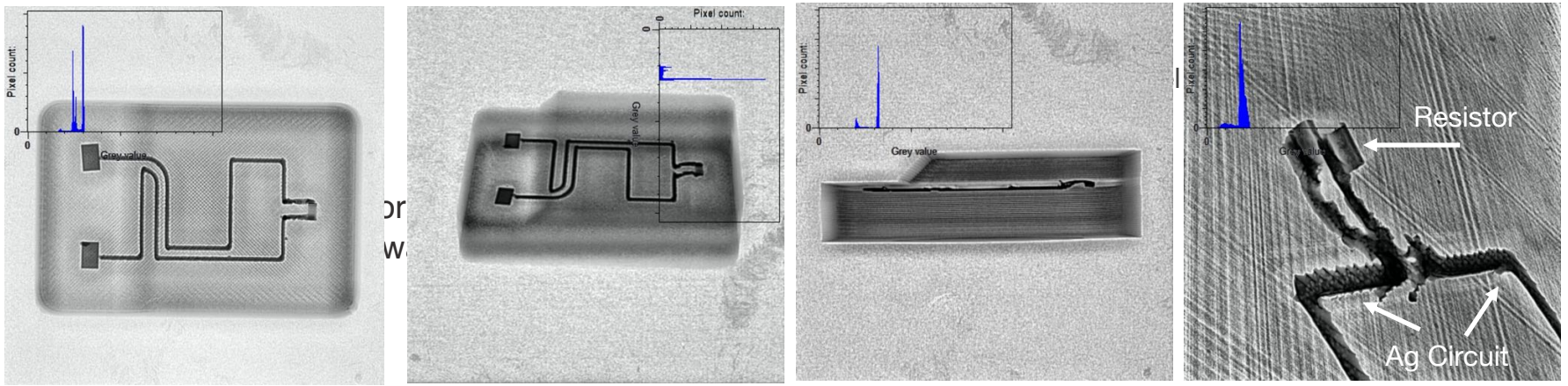
Masking of : 1.Masked Sensor 2. Printed circuits on top with mask stopping ink spreading



Automotive Test Sample

PC-ABS Printed Body
2 Au plated contact pads
1 x 100 Ohm Resistor (CR 0603)
Ag PiezoJet Printed Circuit

Samples will undergo Thermal cycling, Damp Heat and Shock Tests

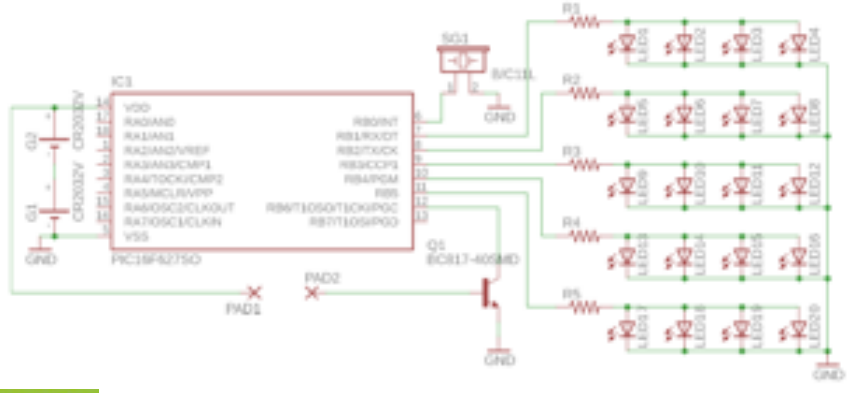


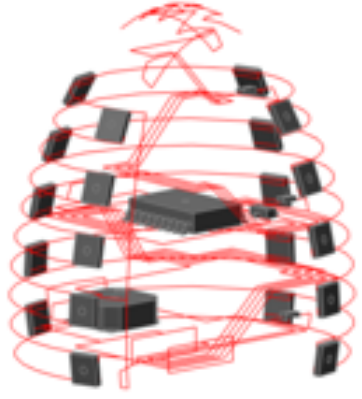
X-Ray Images

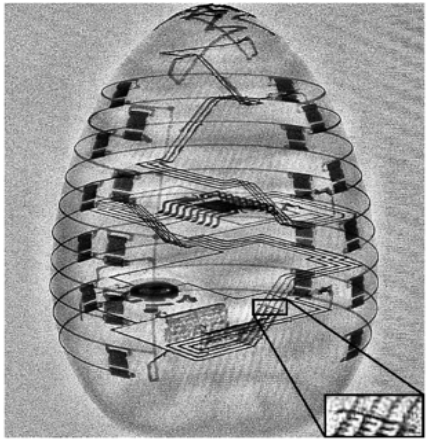
3D Printed Egg Timer

FAPS – University Erlangen-Nuremeberg

- 20 white LEDs mounted in five rings on the outer shell
- Embedded PIC16F627 microcontroller
- Powered by two 3 V button cells in series
- Touch switch realized by two comb-shaped pads and a transistor
- Piezo buzzer for acoustic signals
- Conductive path cumulative length of 2m







EU Manunet Project: AMPECS

1. Will develop fully Additive Manufacturing process for 3D Printing Electronics with Ceramic Substrates

2. The German-Spanish consortium will develop 3D printable ceramic materials for creating the structural body and integrate printed electronics into and onto this component.

3. End use applications will cover areas where harsh environments exists such as automotive and aerospace as well as in mobile communications.

Project Timeframe:1.6.17-31.5.20

FAE

Francesco Alberto S.A.U

manu net

Neotech AMT

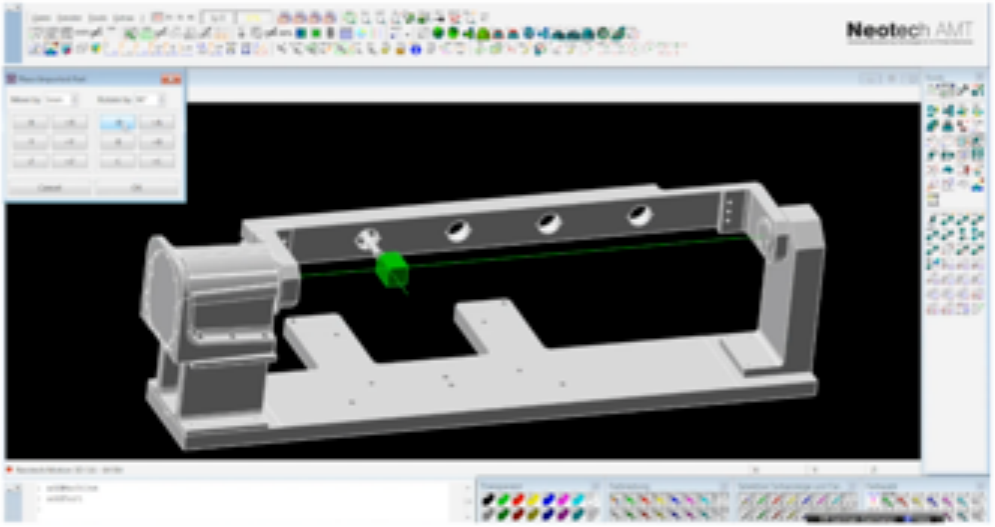
Advanced Manufacturing Technologies for 3D Printed Electronics

System Offerings

Neotech Products

Consist of 5 axis machine tools containing a variety of 3D capable print, pre- and post-processing tools with integrated software, training & service:

Print Platforms	Print/Functionalising Tools	Pre/Post-Processing
45X – multi head systems for volume manufacture	Piezo Jetting	CNC Machining
15X – “single” head system for R&D/Product Development	Aerosol Based	Plasma Cleaning
or custom size	Ink Jetting (Single & Muli-Nozzle)	Sintering (Light/Laser)
+ 3D CAD/CAM Software	Dispensing	UV Curing
	FDM	Adaptive Tool Path Vision System
	SMD Pick & Place	Laser Ablation



Summary

1. Designing 3D Printed Electronics process
2. Current Application Examples
3. Development to more complex device manufacture
4. “Fully Additive” 3D Printed Electronics

Neotech AMT

Advanced Manufacturing Technologies for 3D Printed Electronics

Thank you for your attention!

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