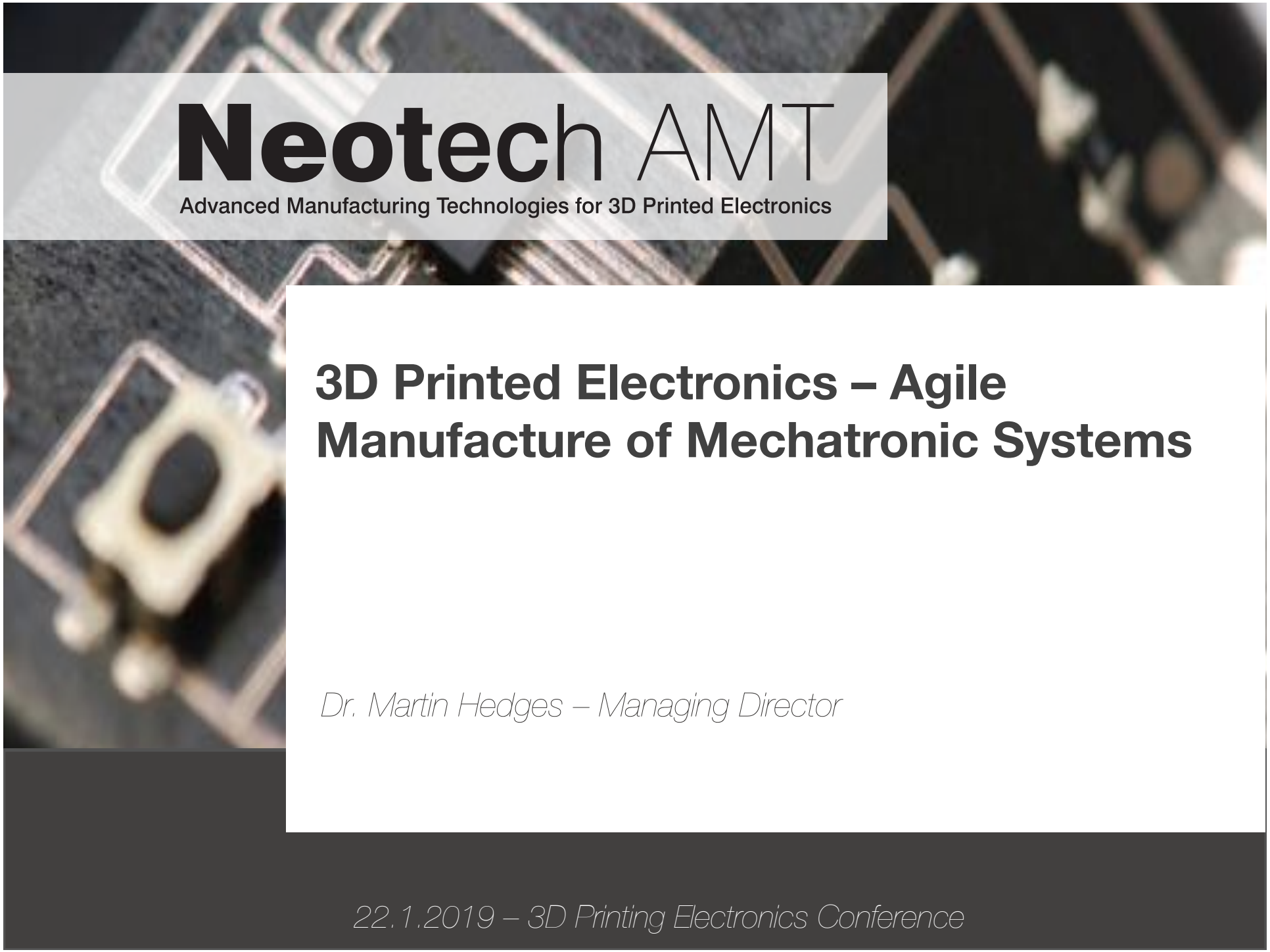


Neotech AMT

Advanced Manufacturing Technologies for 3D Printed Electronics

3D Printed Electronics – Agile Manufacture of Mechatronic Systems

Dr. Martin Hedges – Managing Director

22.1.2019 – 3D Printing Electronics Conference

Agenda

1. Company Overview

2. Designing a 3D Printed Electronics Process

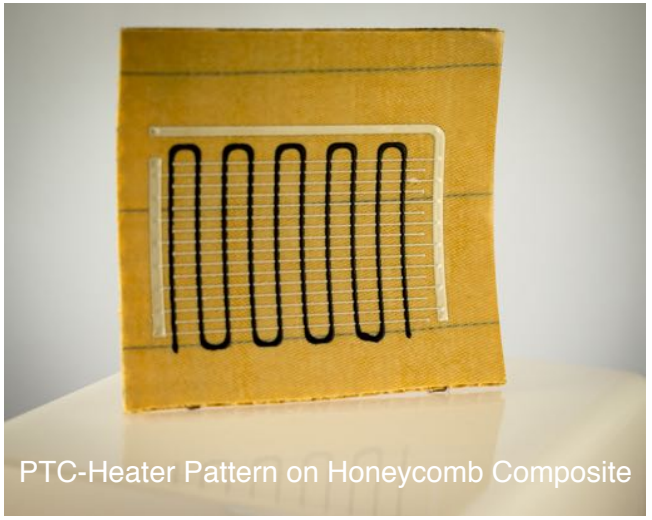
3. Application Examples

4. Beyond Simple Circuits

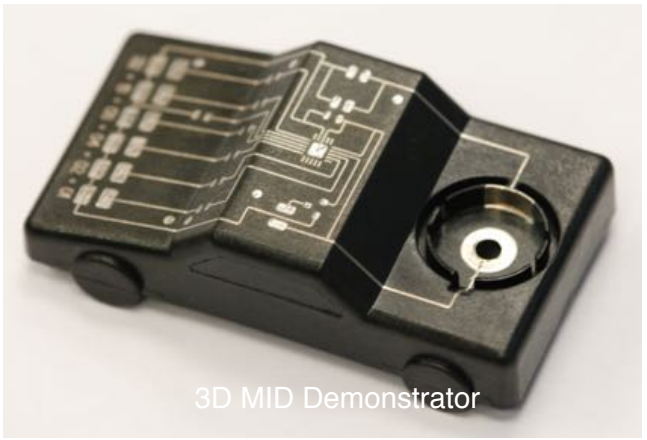
5. 3D Print Systems

Neotech AMT GmbH

- Neotech manufactures system for 3D Printed Electronics.
- Pioneering 3D PE development since 2009.
- First 3D capable system installed in 2010.
- First mass-production capable system of type 45X built 2012. EU/US/CN patent granted 2015.
- 1st commercial sale & install of mass production system in Q3 2013.
- 1st commercial mass production started on Neotech systems in Q3 2015.



PTC-Heater Pattern on Honeycomb Composite



3D MID Demonstrator

Market Need for 3D Printed Electronics

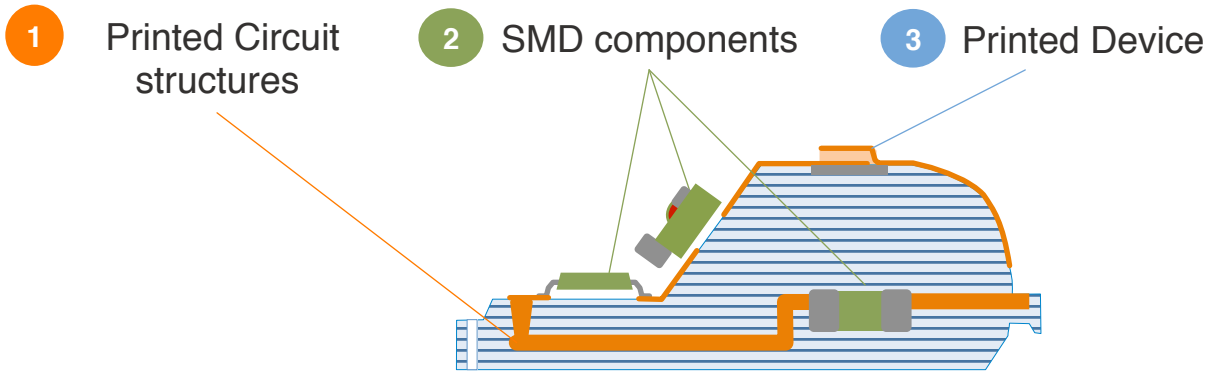
Design Flexibility	Economics	Environmental
Integration of Mechanics-Electronics-Optics	Reduced Part Count	Reduced Materials Mix
Flexibility of Shape	Shorter Process Chains	Simplified Recycling & Disposal
Minaturisation	Reduced Materials Use	Reduced Material Quantity
New Functionality	Increased Reliability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

Multi-station Printing
at LITE-ON Mobile Mechanical SBG

Tank Filling Sensor
Automotive

Methods for 3D Printed Electronics (3D PE)

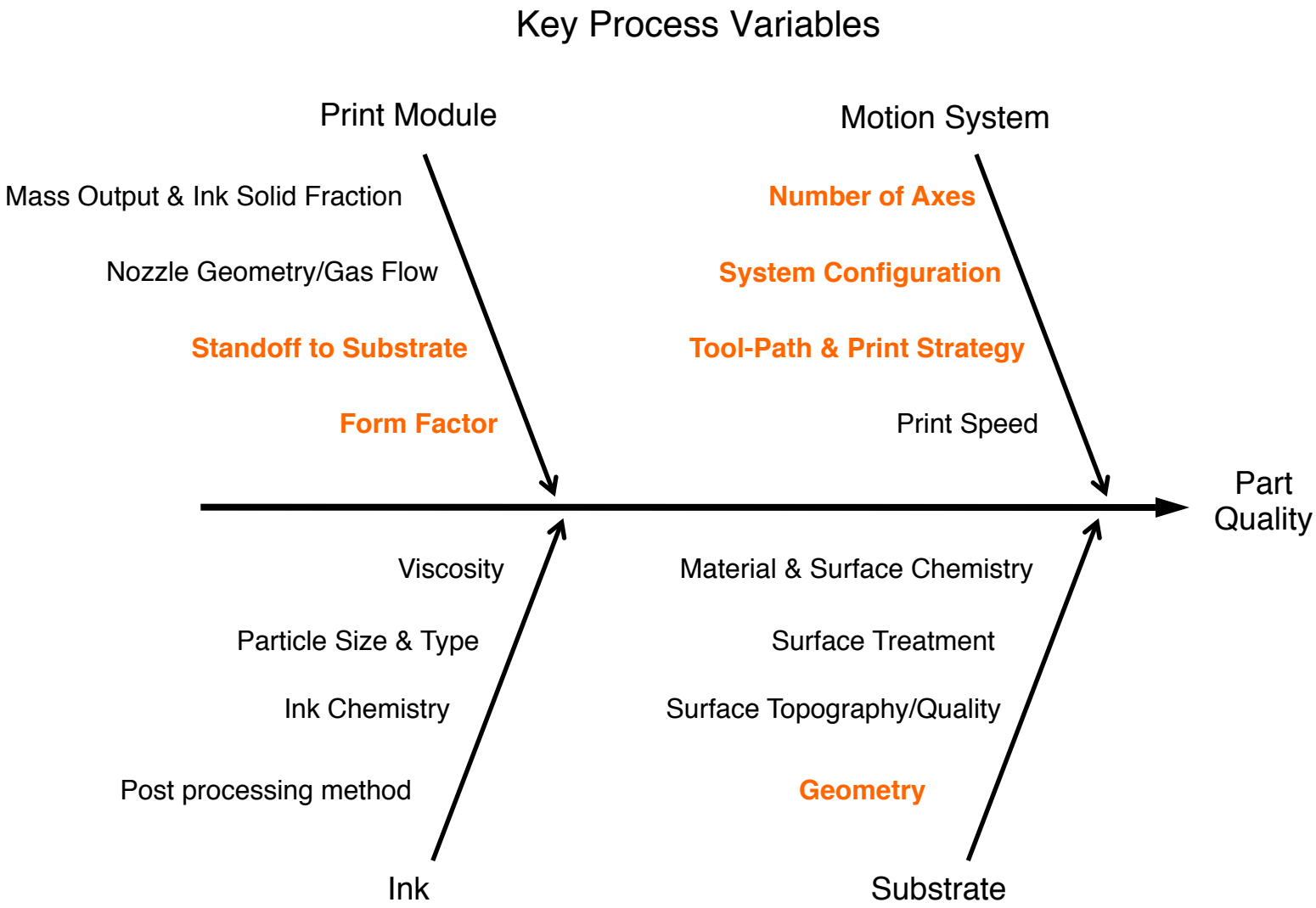
How to add electronic functionality to 3D shaped parts?



Method 1: Print on conventionally manufactured 3D parts: moulded, machined, composite
Development started 2010

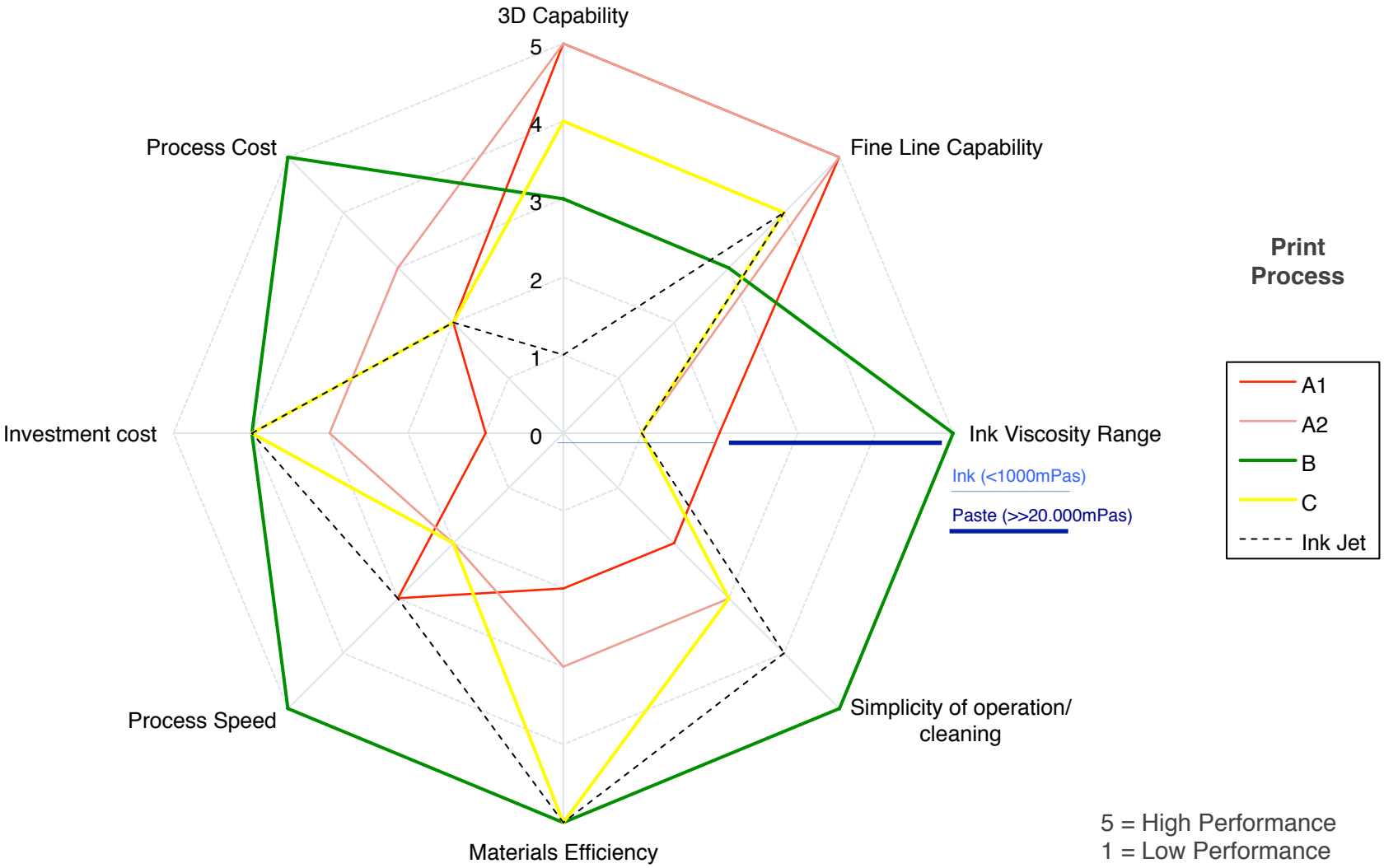
Method 2: Print on/in part manufactured layer-by-layer process: FDM, SLS, SLA, etc:
Development started 2016

Enabling a 3D Printing 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

Dealing with complex geometries

Motion 3D CAD/CAM Tool-path Generation Software

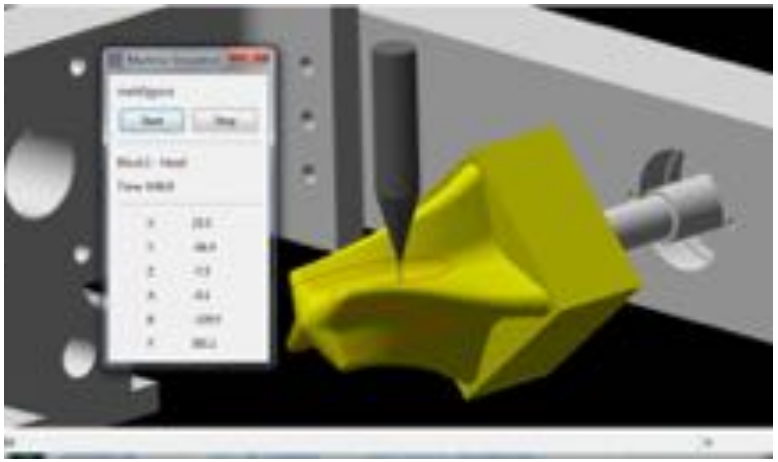
Simple process flow for 3+2 indexed to 5 axis simultaneous printing

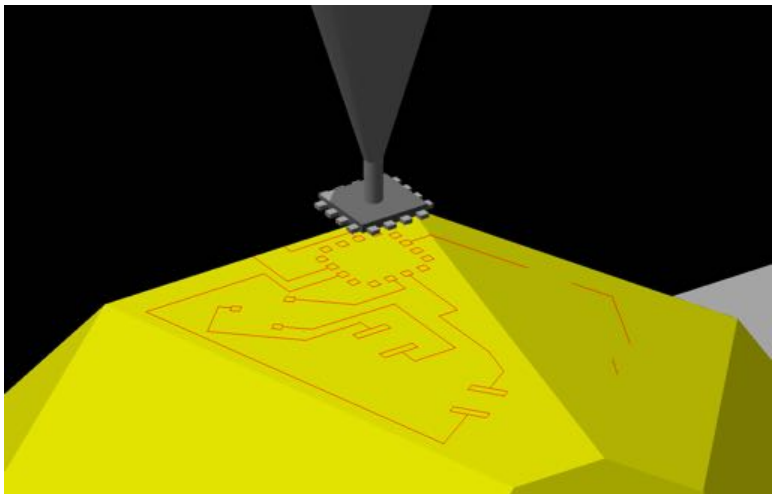
All process steps (3D Print, 3D Circuit Print, SMD Pick & Place, Pre-/Post-processing) in single machine code

Optimised cycle times via free definition of the print sequence

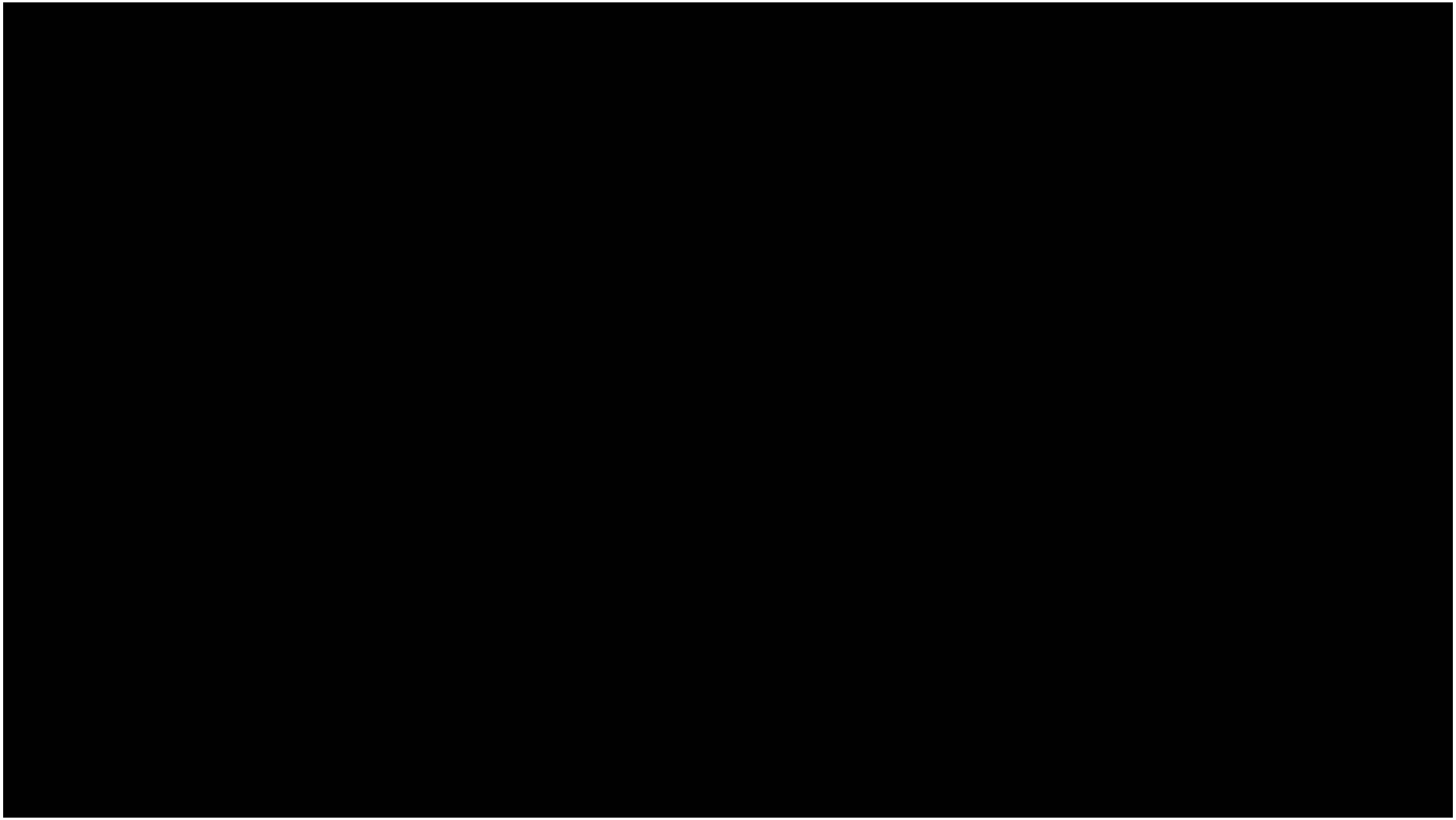
Printing path & machine motion simulation including collision detection

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





5 Axis Print Demonstration



Example of Dual Print Technolgies

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

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

Current Applications

Printed Antenna/Curcuits

1. Current Process Route: Printing Ag inks on filled PA resins and oven sinter
2. RF Performance: matches industry standard
3. Low temperature inks for PC/ABS
4. Production Costs: specific antenna designs show cost reduction of compared to current manufacturing techniques

Demonstration Antenna
Courtesy: LITE-ON Mobile Mechanical SBG

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

Switch Paddle Circuit

Automotive

Proof of Concept study

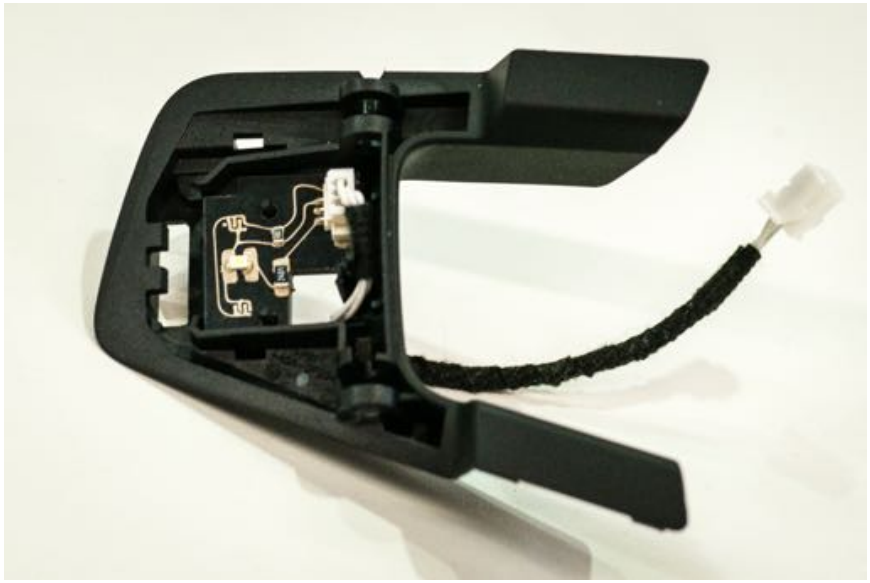
Target higher level of integration & cost saving

Circuit printed directly on switch paddle body – remove PCB

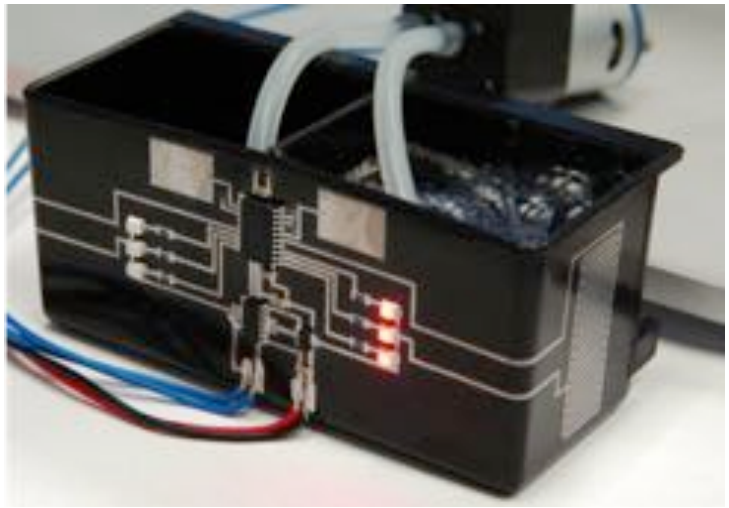
Next step replace connector cable with printed circuit/interconnect – cost saving

Courtesy:

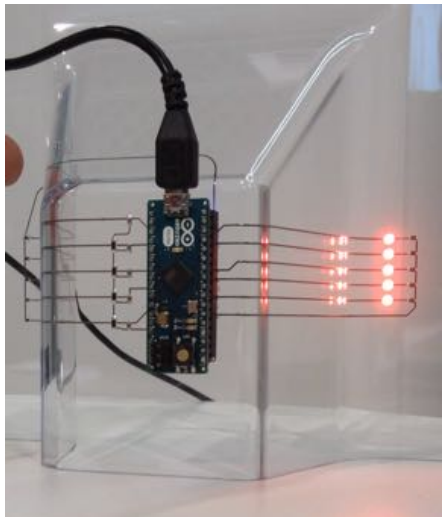
MARQUARDT



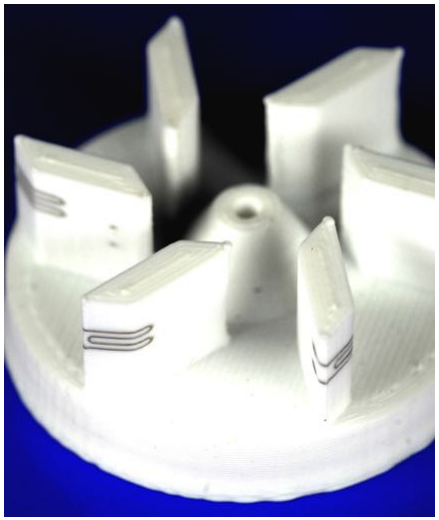
3D Printed Sensors



Tank Filling Sensor
(Capacitive)



Touch Sensor on
moulded PC
(Capacitive)



Strain Gauge on 3D
Printed PLA
(Fraunhofer IFAM)

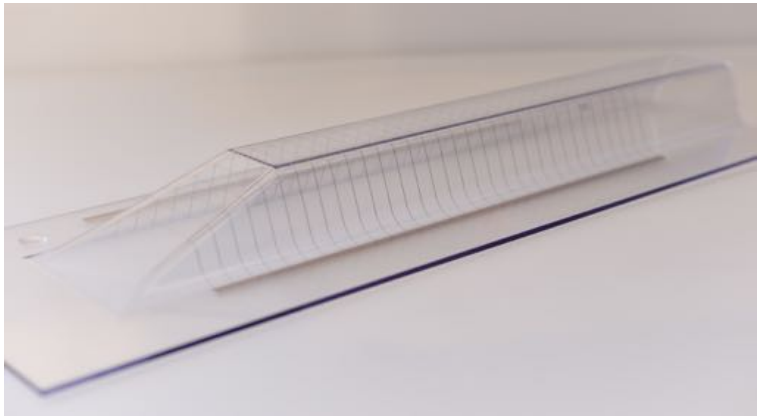
3D Heater Patterns on PC

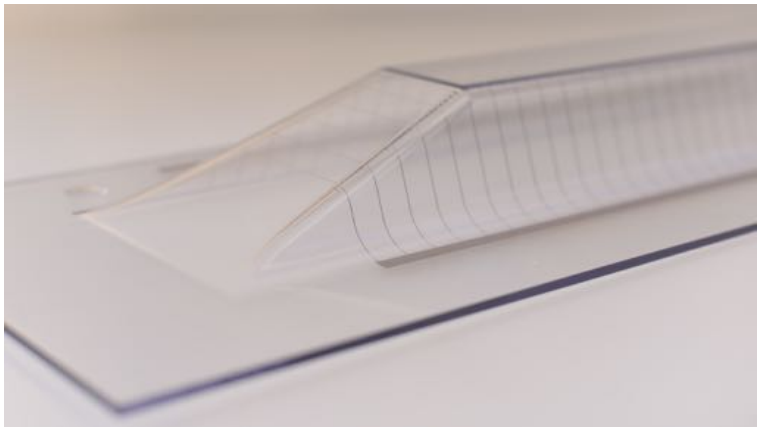
Automotive Glazing

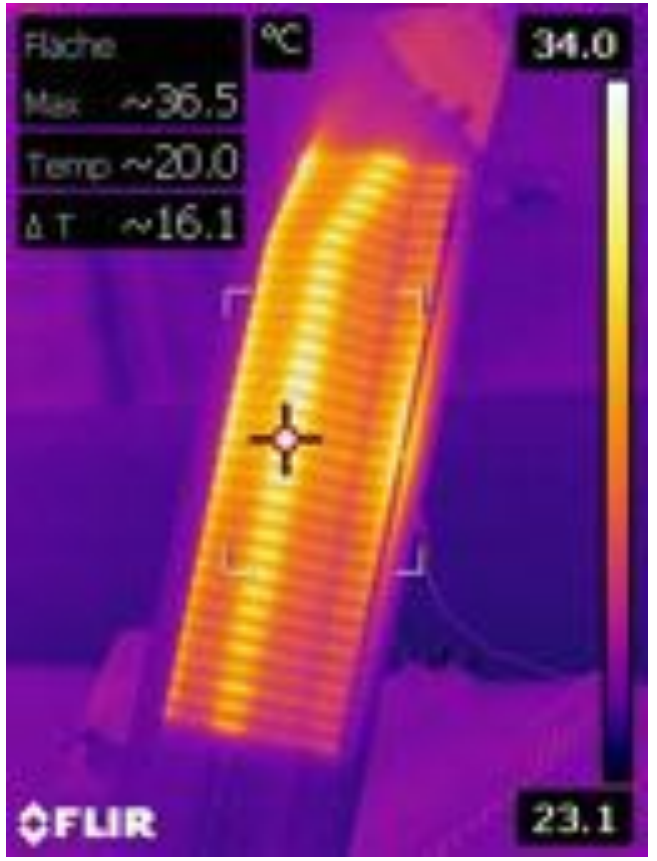
Ag heater circuits printed on large PC part: 750 x 250 x170mm (x-y-z)

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

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

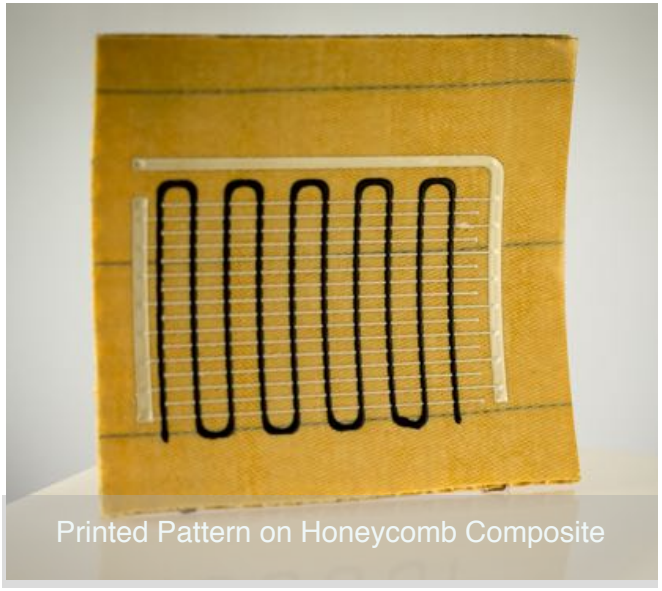




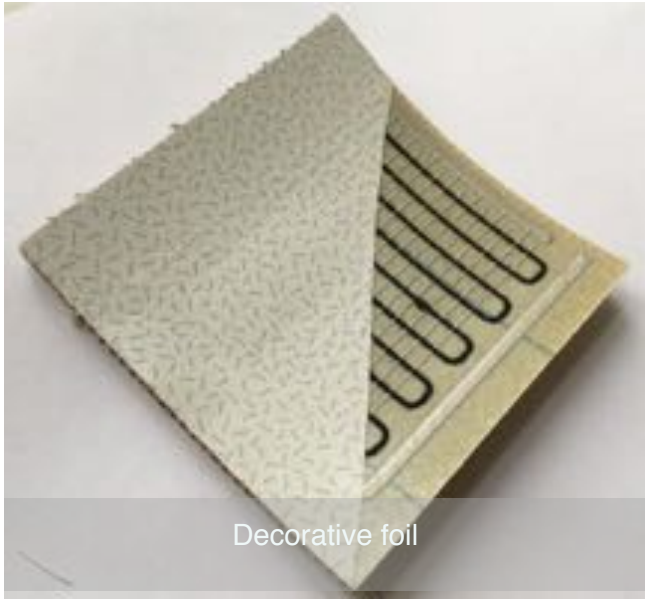


3D Heater Patterns on Honeycomb Composite

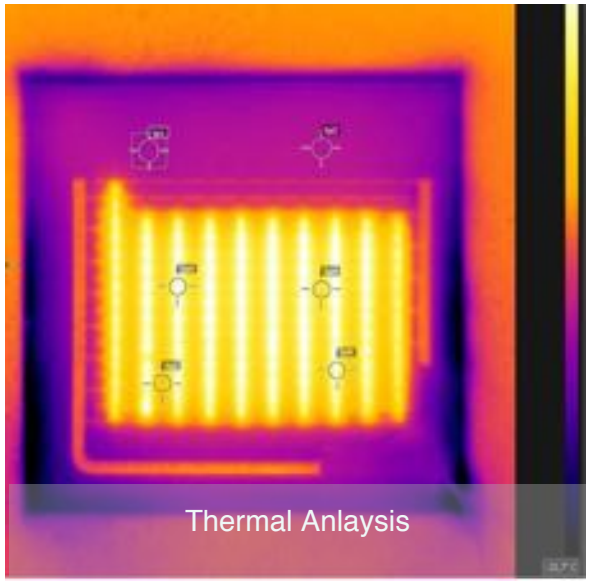
Aerospace – Cabin Interior



Printed Pattern on Honeycomb Composite



Decorative foil



Thermal Anlaysis

Ag circuit with PTC resistive heater: light weight, safe & integrated into cabin side wall.

Rear side cooled to under -20°C

Heater at 38°C

DLR FeVedis Project with Fraunhofer PYCO & FAPS

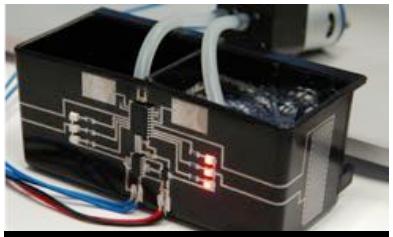
Beyond Simple Circuits?

Is it possible to add extra functionality to produce more sophisticated 3D Printed Electronics?

Component	*Function*
Conductors	Carry Current
Antenna	Broadcast/Receive
Sensors	Input
Heater	Heat Part
Resistors	Control Current Flow
Capacitors	Filter, Charge Storage
Inductors	Filter,Transform/Transfer
Diodes	Valve
Transistors	Amplify, Switch
Memory	Information Storage
Emitters	Display Output
Power Source	Energise Circuit

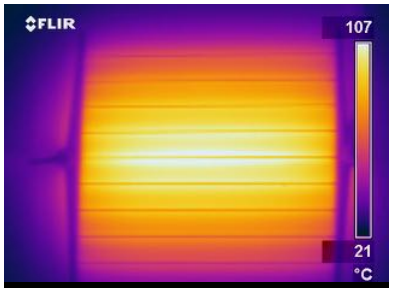
Additional Functionality for 3D Printed Electronics

3D Today



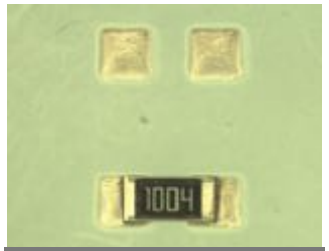
Circuits & Sensors

Antenna

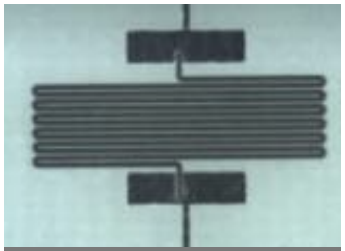


Heater Patterns

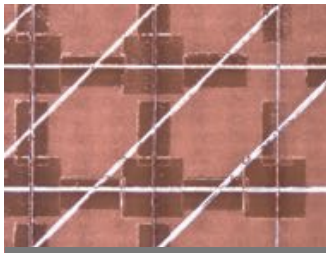
Printed in 2 to 2½D Today - 3D Future?



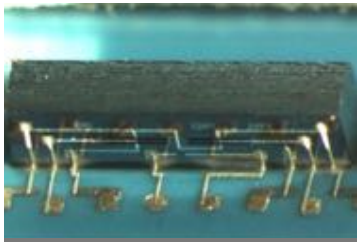
Chip Bonding[1]



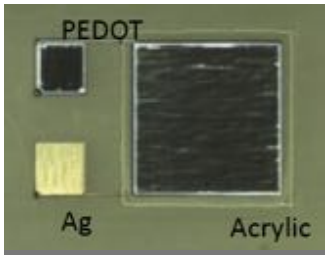
Resistors[1]



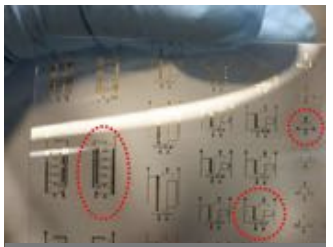
Multilayer Circuits[1]



3D Interconnects[2]



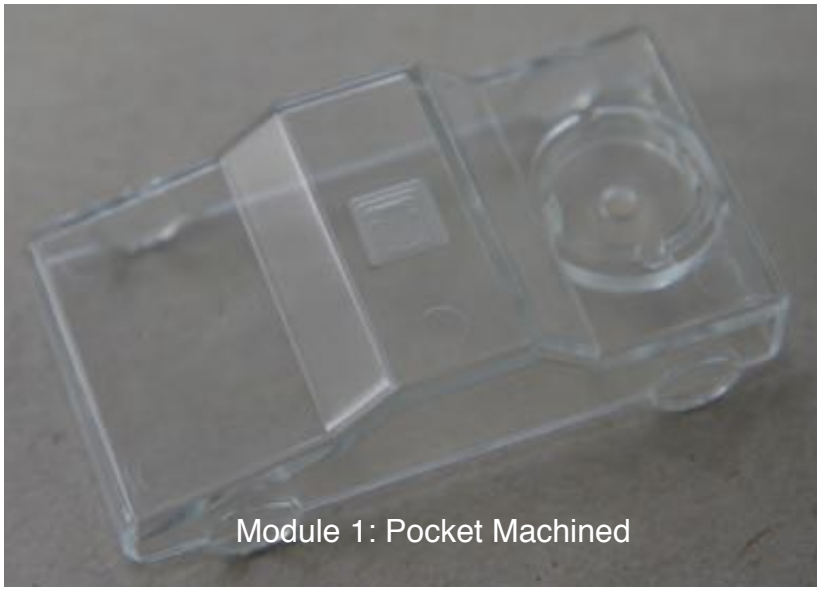
Capacitors[1]

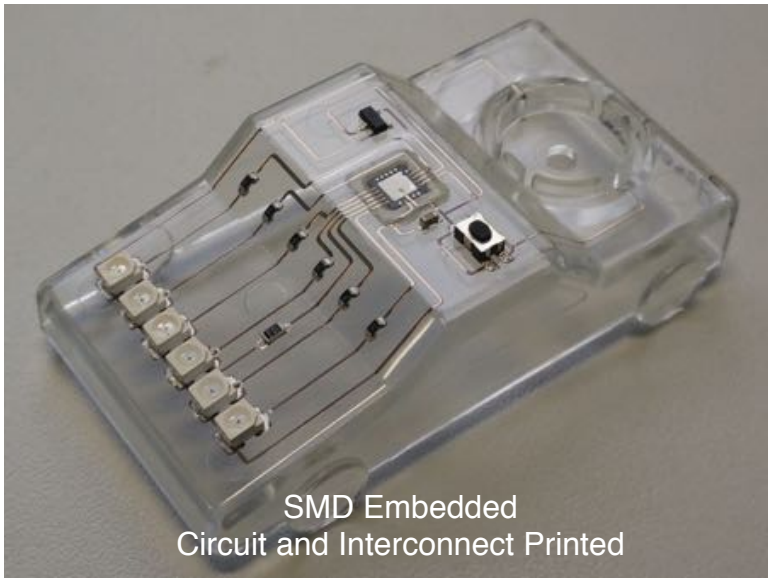


Transistor Circuits[1]

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

Embedding SMDs

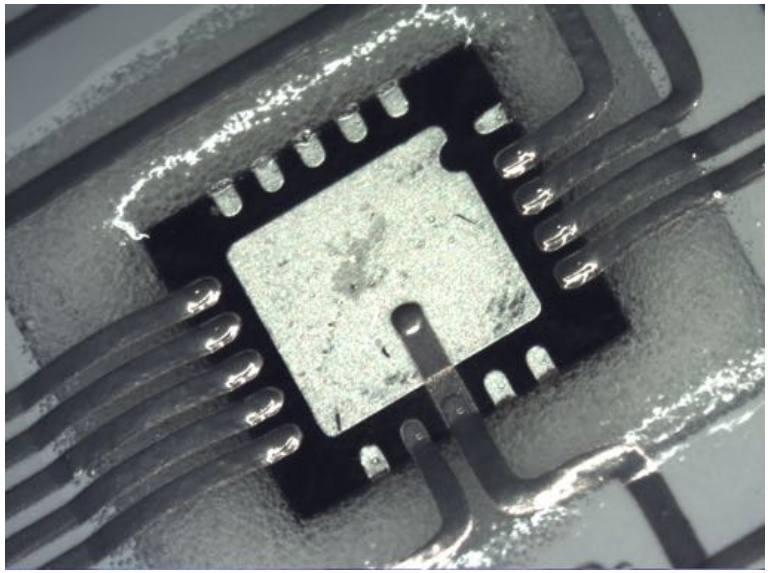

Module 1: Pocket Machined


SMD Embedded
Circuit and Interconnect Printed

QFN (Quad Flat No-lead) Microcontroller

Contact Pads 230μm

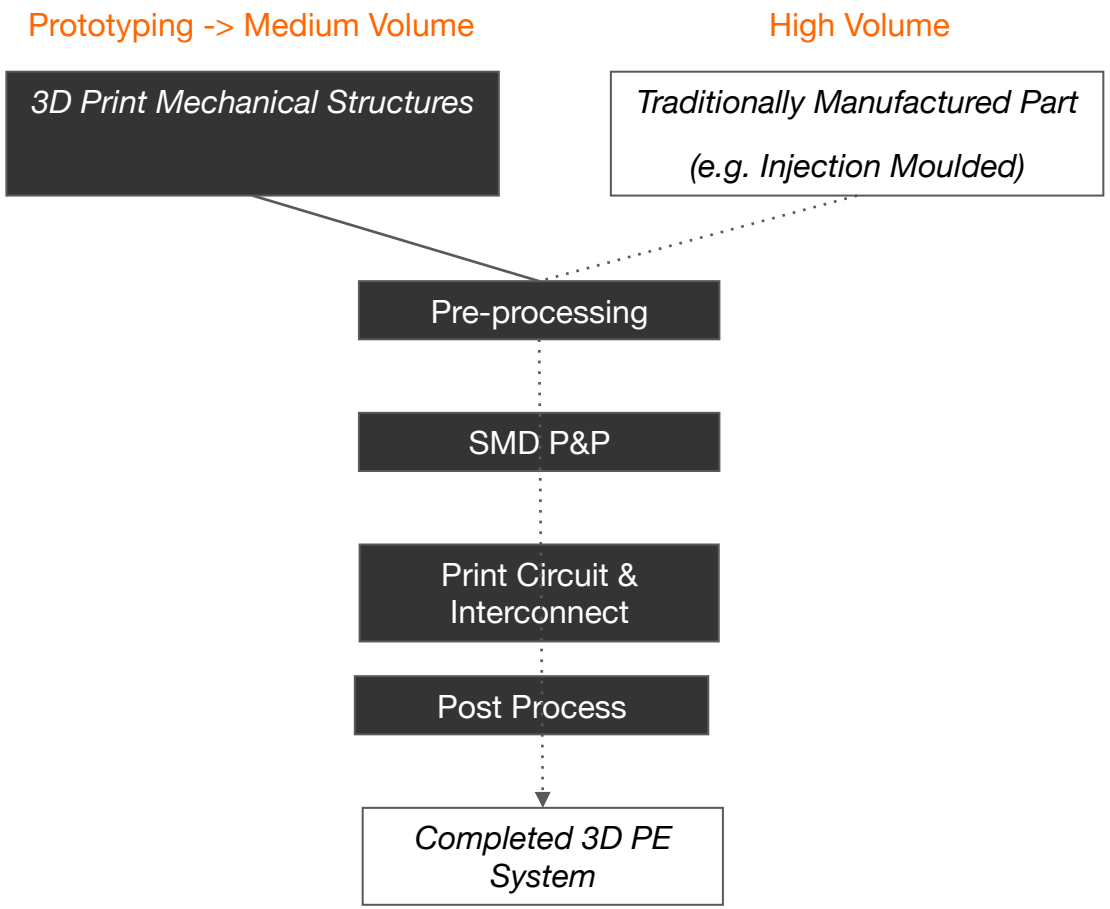
Fixed with 2 Component Epoxy



Project in cooperation with: FAPS

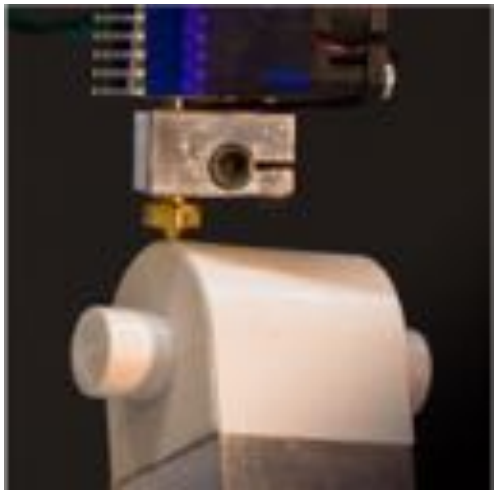
Tecnology Goal

To provide complete 3D Digital Manufacturing Process Chains spanning all production levels



“Fully Additive” 3D Printed Electronics

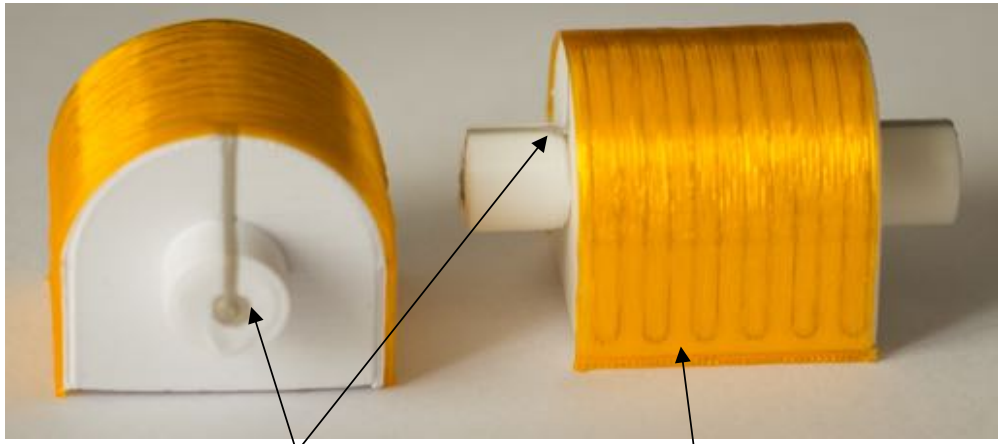
Combine electronics build of structural elements:
Fused Deposition Modelling (thermoplastics) & Dispensing (resins)



Single CAD/CAM interface for all processes in 5 axis:
1. Structural build
2. SMD pick & place
3. Circuit Printing and interconnecting SMDs
4. Pre- & Post-processing

5 Axis build enables novel geometries without support structures & improved mechanical properties compared to classical anisotropic 3D builds

Combination with 4 station print system for higher throughput

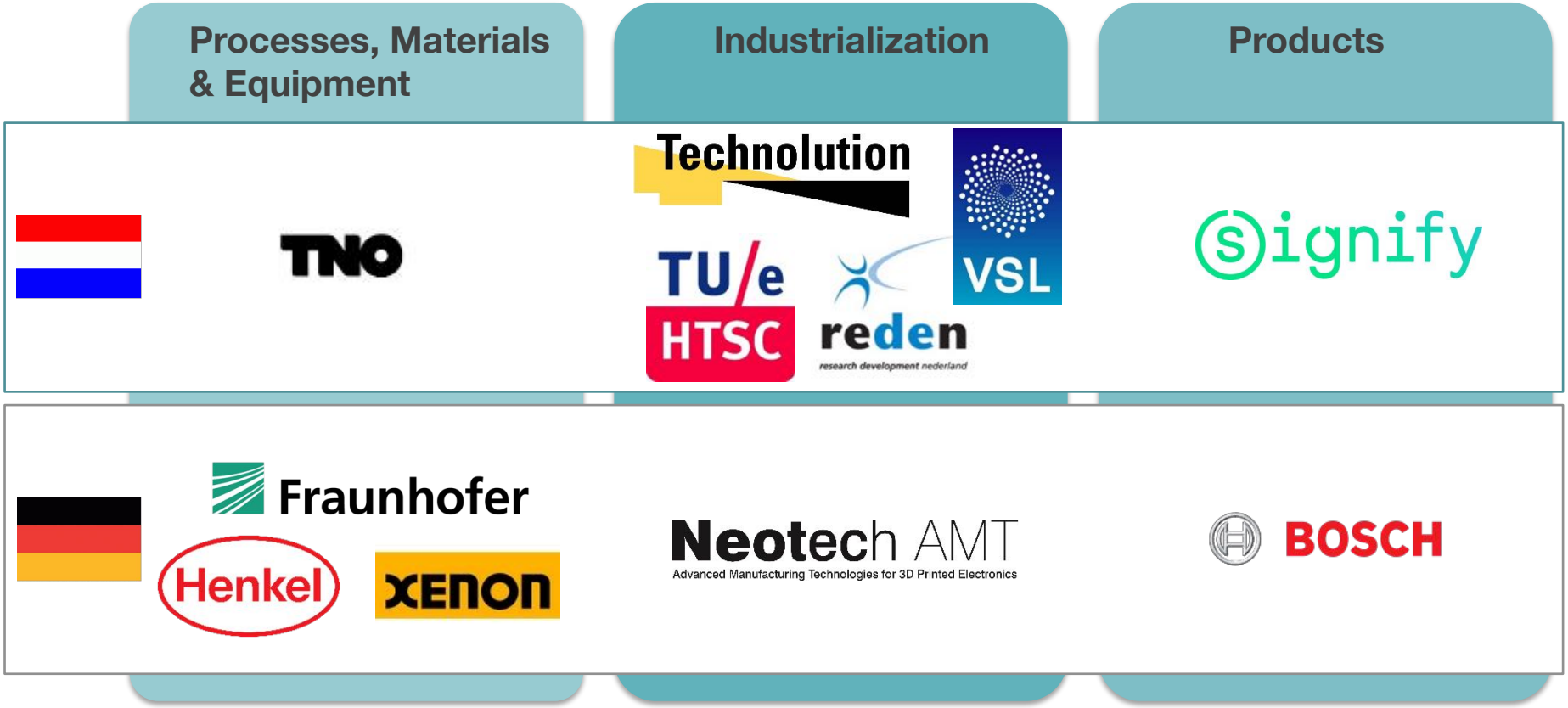


Thermal Image at 60°C

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 electrical products (LED luminaires, automotive adaptive sensors)



Project Timeframe:1.4.17-31.3.21

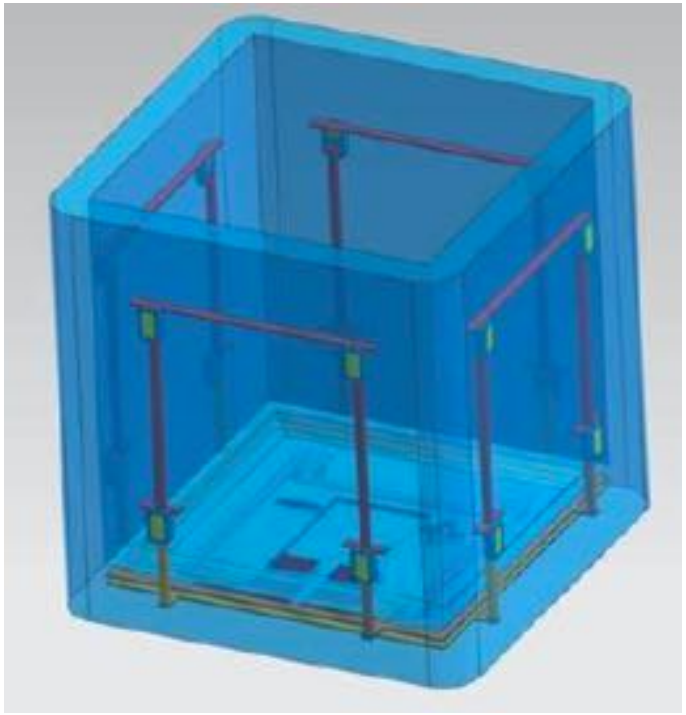
EU PENTA Project: Hyb-Man

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



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

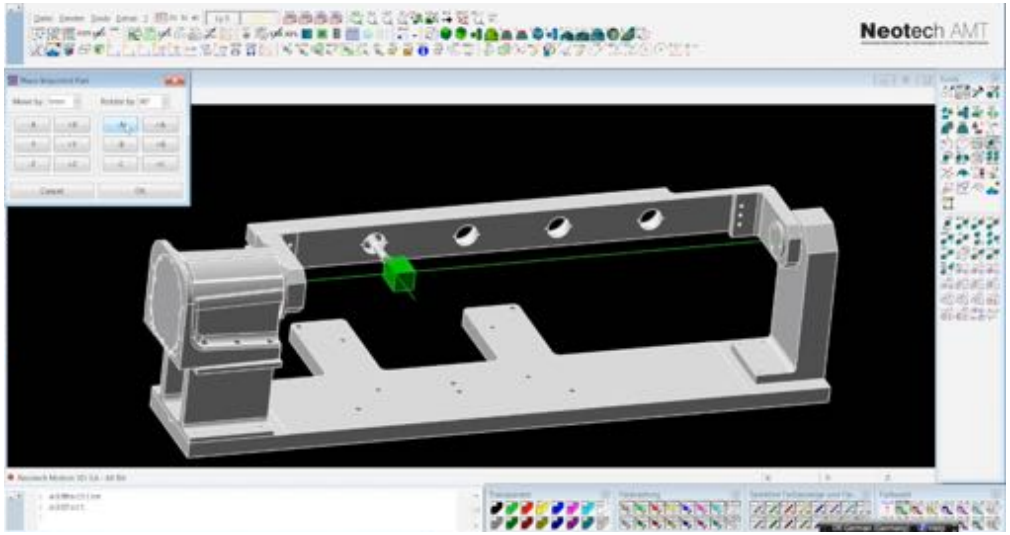
Advanced Manufacturing Technologies for 3D Printed Electronics

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 – Volume Manufacture	Piezo Jetting	CNC Machining
15X – R&D/Product Development	Aerosol Based	Plasma Cleaning
Custom Platforms	Ink Jetting	Sintering (Light/Laser)
CAD/CAM	Dispensing	UV Curing
Motion 3D	FDM	Adaptive Tool Path Vision System
	SMD Pick & Place	



Summary

1. Designing 3D Printed Electronics process
2. Current Application Examples
3. Scalable & Agile Process Routes
4. Modular Systems

Neotech AMT

Advanced Manufacturing Technologies for 3D Printed Electronics

Thank you for your attention!

Dr. Martin Hedges

Neotech AMT GmbH

Petzoltstr. 3- 90443- Nuremberg - Germany

Tel: +49 911 274 5501

mhedges@neotech-amt.com