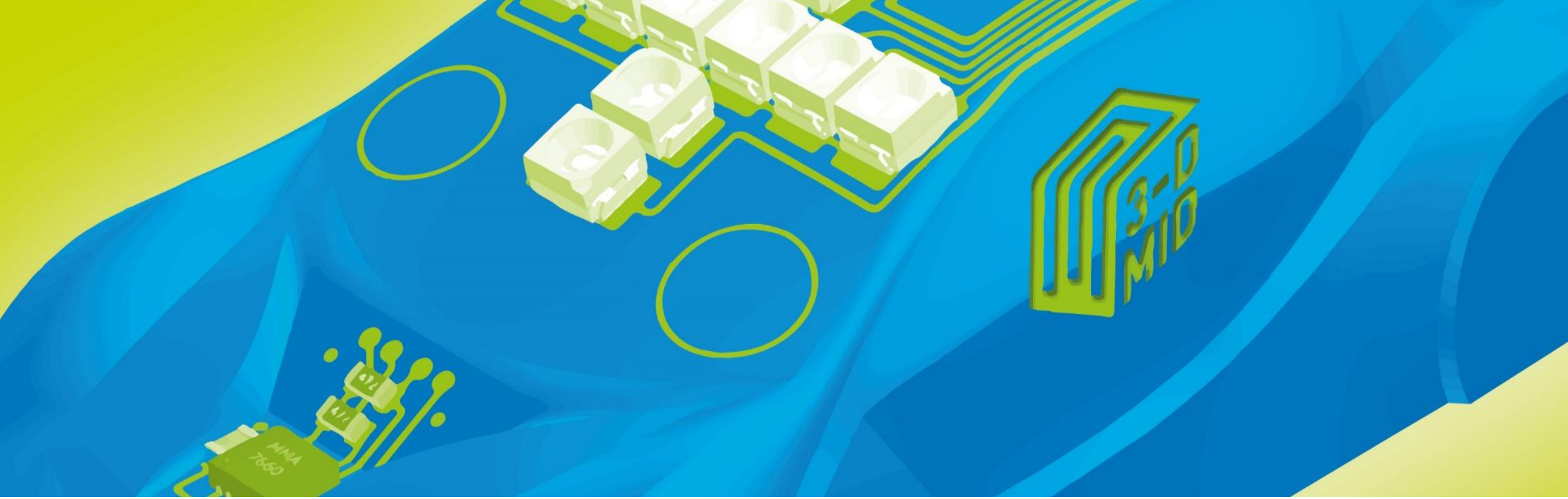


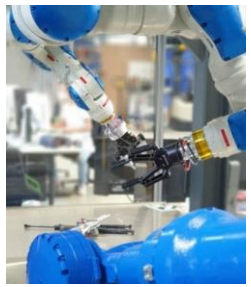
Forschungsvereinigung
Räumliche Elektronische Baugruppen
3-D MID e.V.

Innovative Fields of Application and Technologies for Mechatronic Integrated Devices (MID)

Prof. Dr. Florian Risch, FAU Erlangen-Nuremberg
rapid.tech 3D, 14th May 2025, Erfurt, Germany

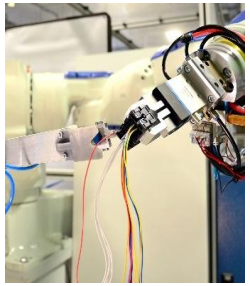
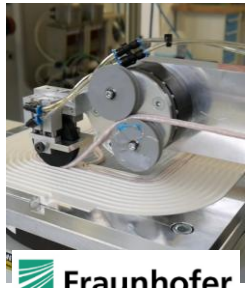
The Institute of Factory Automation and Production Systems focuses on the manufacturing of mechatronic products

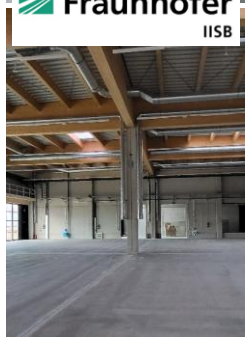
Prof. Dr. Jörg Franke				Prof. Dr. Florian Risch				
Robotics	Medical technology	Automation technology	Engineering-Systeme	Electric Drives Production	Battery Assembly	Electronics Production	Signal and power networking	Electric Road Systems
S. Reitelshöfer	J. Walter	T. Reichenstein	M. Schobert	M. Baader	tbd.	N. Thielen	P. Bründl	tbd.







Fraunhofer IISB

Technische Fakultät Erlangen	Auf AEG Nürnberg	Hallstadt

Dr. Alexander Kühl / Akademische Leitung & Prozessexzellenz

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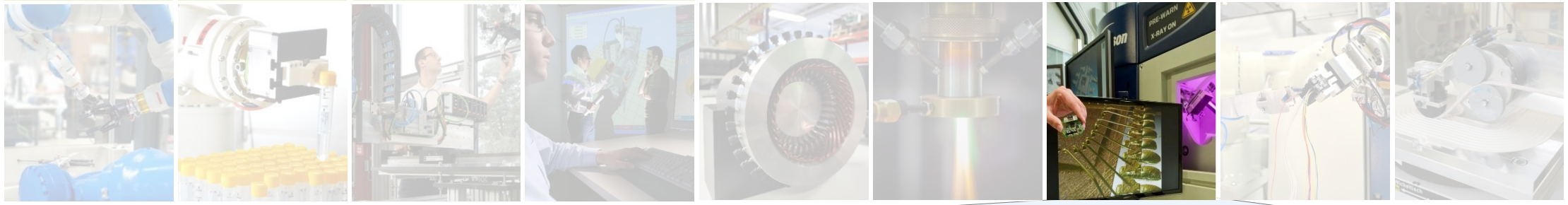
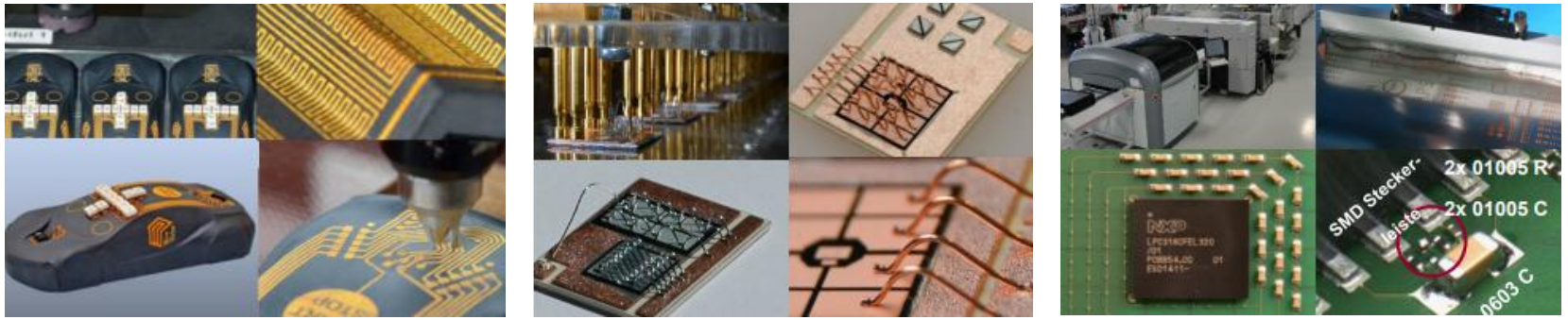


	3D-MID-Technologies (Mechatronic Integrated Devices)	Power Electronics	Sustainable SMT/THT Electronics Production
Digitalization			
Quality Assurance / Testing			
Additive Electronics / Mechatronics			
Interconnection Technologies			



The terminology of MID as Molded Interconnect Devices was introduced more than 30 years ago.

1993

Molded Interconnect Devices (MID)

1993: Foundation of
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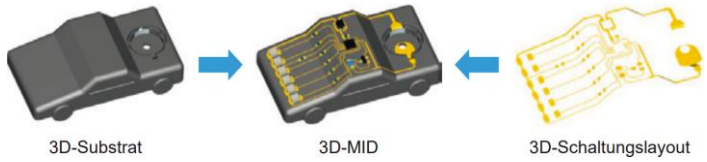
- Focus on **injection molded interconnect devices,** structured metallization, mechanical, electrical, optical, fluidic and thermal functionalities.
- Variety of processes for base substrate and conductive structures



Molded Interconnect Devices (MID)

Innovative process technologies of Molded Interconnect Devices enable promising approaches for generating innovative mechatronic systems.

Technology push

Basic substrate + Conductive structure

Innovative production technologies for the functionalization of conductive structures

- (Multi-component) Injection molding
- Laser-based structuring
- Hot stamping
- …

Fields of application for Molded Interconnect Devices

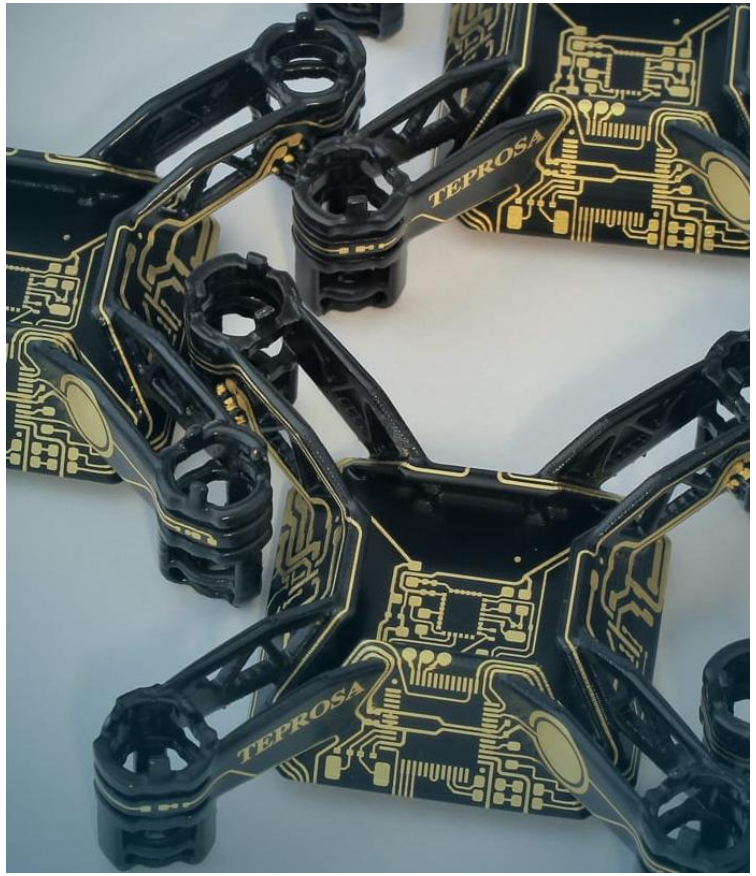
Application pull

Innovative fields of application of Molded Interconnect Devices

- Molded thermoplastic base materials
- Conductive, metallized structures
- 2D
  2,5D
  3D
- Integration of functions (mechanical, electrical, thermal, optical, fluidic, magnetical)

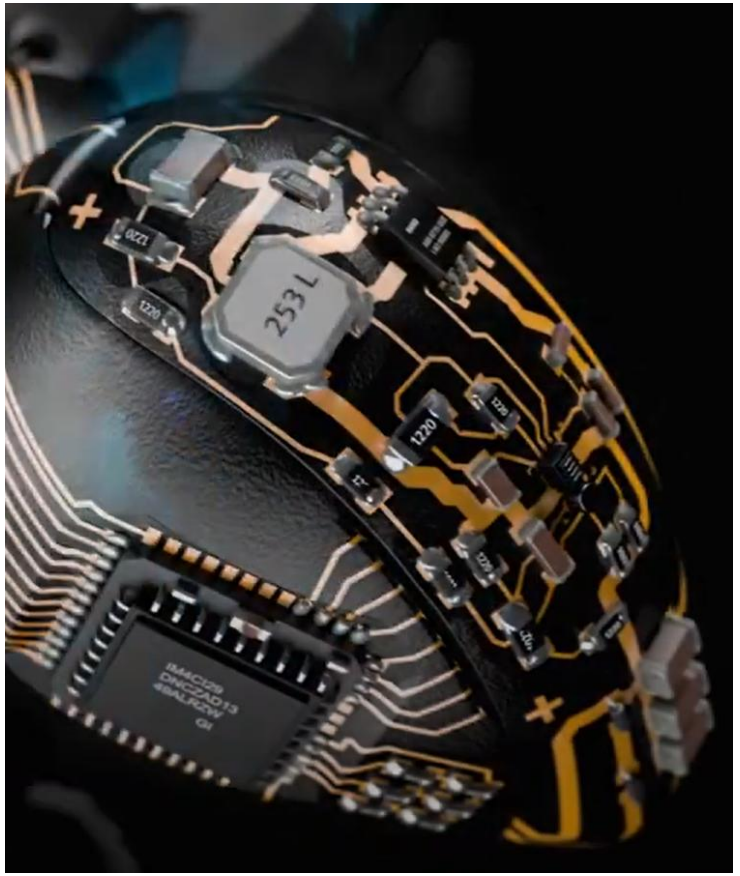
Creative ideas and the advantages of Molded Interconnect Devices are constantly leading to new and interesting applications.

Design freedom in development and production	Integration of electronic and mechanical functions	Possible miniaturization	Weight reduction	.. and more



Quelle: Teprosa MIDCopter

Quelle: Harting, 3D-Circuits drug delivery implant



Quelle: Festo BionicANTs

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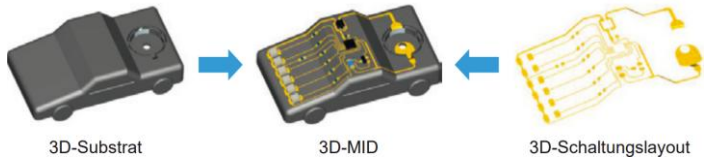

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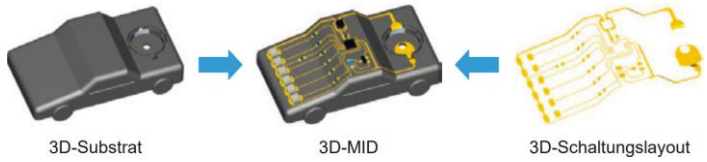
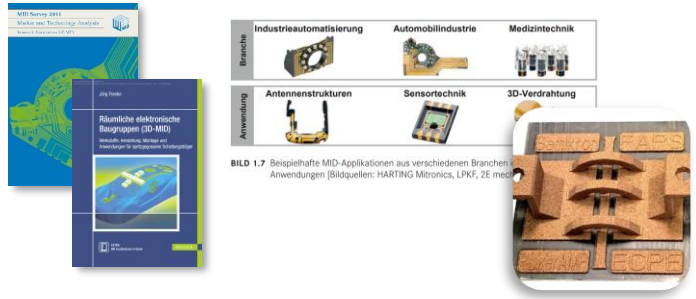


2014

Mechatronic Integrated Devices (MID)

- Extension from
  - **“Molded Interconnect Devices”** to
  - **“Mechatronic Integrated Devices”**
- takes into account that MIDs do not necessarily have to be injection-molded from plastic but also can be made from **other materials such as ceramics.**
- MID still closely associated with traditional MIDs, even though there have already been many additional research projects especially with **Additive Mechatronics**



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Technology push

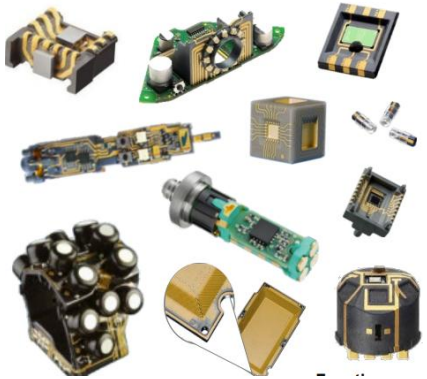
Innovative production technologies for the functionalization of conductive structures

Basic substrate + Conductive structure

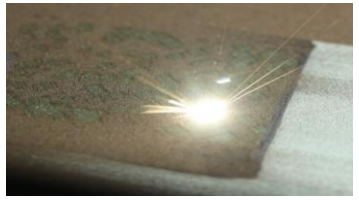
- (Multi-component) Injection molding 
- Laser-based structuring 
- 3D Printing 
- Spraying (APS) 
- SLM 
- …

Fields of application for Mechatronic Integrated Devices

Molded Interconnect Devices



Additive Mechatronics

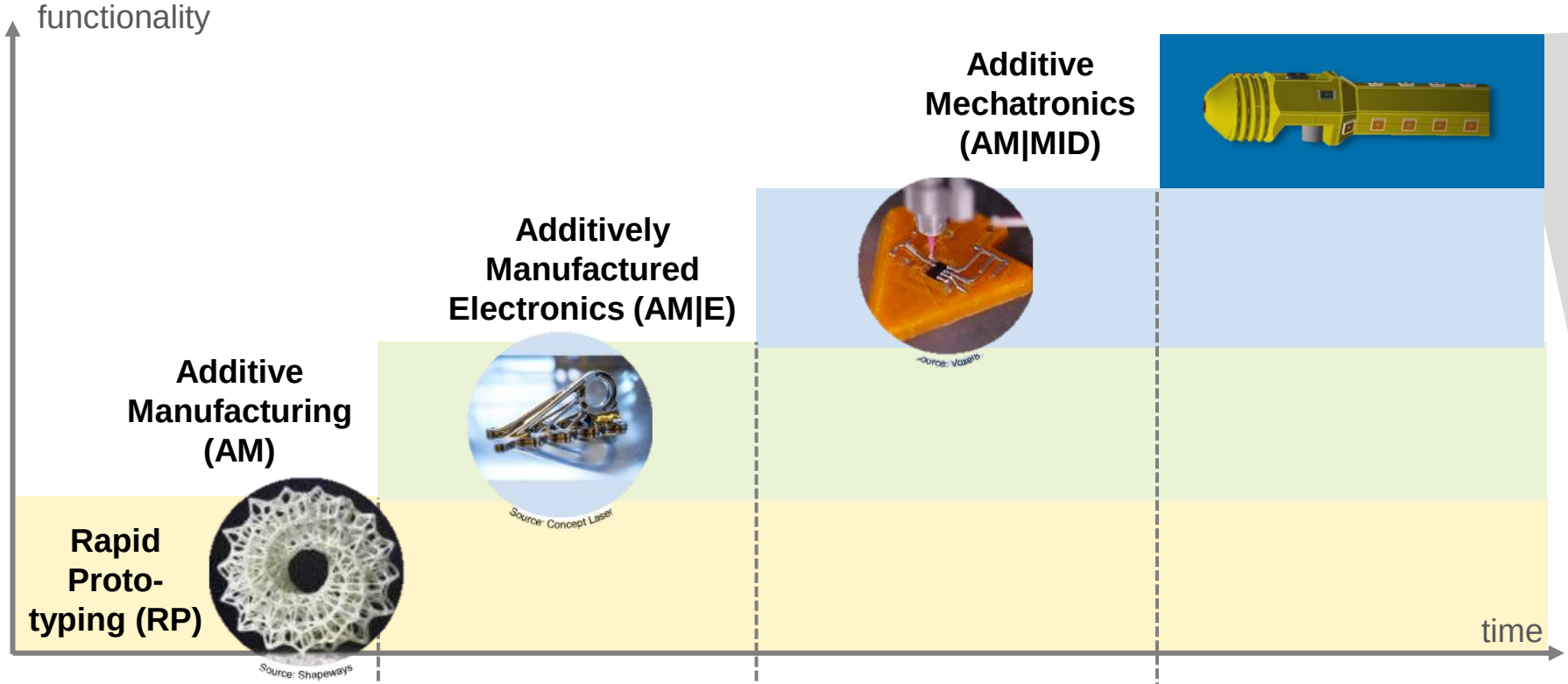


Application pull

Innovative fields of application of Mechatronic Integrated Devices

- Molded thermoplastic base materials, and other materials such as ceramics
- Conductive, metallized structures
- 2D
  2,5D
  3D
- Integration of functions (mechanical, electrical, thermal, optical, fluidic, magnetical)

Mechatronic Integrated Devices are combining ceramic substrate materials, 3D printing technologies and high temperature stable functionalization of spatial circuit carriers.



Geometrical objects

- No physical requirements, except for the geometry
- Example: design studies

Mechanical objects

- Parts with high mechanical requirements
- Example: structural bracket

Electronic objects

- Integration of electronic circuits on 3D surfaces
- Example: printed circuit boards (PCBs), 3D circuit carriers

Mechatronic systems

- Products with integrated mechatronic functions
- E.g. 3D PCBs with integrated electronics and mechanics

Electrical functions, e.g.

- Circuitry, cables
- Antennas
- Connectors, switches
- Shielding

Sensor functions, e.g.

- Resistive
- Capacitive / inductive
- Photo-voltaic
- Strain gauge sensors

Actuating functions, e.g.

- Bi-metallic actuators
- Electric motors
- Di-electric Elastomeric Actuators

Control and other functions, e.g.

- Optical waveguides
- RFID
- OLED

In times of global supply chain uncertainty, Additive Mechatronics (AM|MID) are gaining increasing appeal due to their flexibility and resilience.

Quelle: NanoDimension

Miniaturization & Integration

Enable compact, complex designs by embedding elements like **sensors, antennas, or bio-components** directly into structures, **ideal for IoT, wearables, and implants.**

Sustainability & Supply Chain Resilience

Local, additive manufacturing **reduces waste and emissions,** while decreasing reliance on global supply chains.

Decentralized & Autonomous Production

Electronics can be produced on-site **in remote or critical environments** (e.g. disaster zones or even in the future in space).

Customized Electronics

Tailored devices for healthcare, industry, or prosthetics produced in **small batches, allowing individualized solutions.**

Faster Innovation Cycles

Hardware iterations within a day, **making development processes more agile,** closer to software paradigms.

Cost-Efficient Low-Volume Production

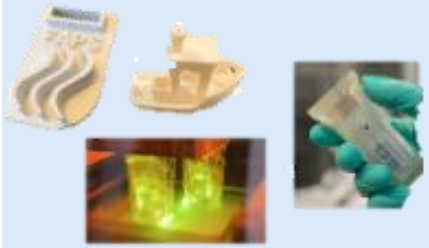
Additive methods support design freedom and confidentiality, reducing costs for small series and **keeping sensitive IP in-house.**

The research field of technology Additive Mechatronics (AM|MID) has a broad base of process chains at the Institute for Factory Automation and Production Systems.

Field of Additive Mechatronics
at the Institute for Factory Automation and Production Systems

Additive Manufacturing of Insulators

Fused Filament Fabrication with ceramics, Liquid AM with silicon materials

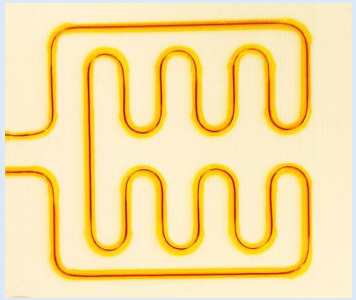


Metallization of Ceramics (PE and solid state batteries)

Plasma coating, selective laser melting

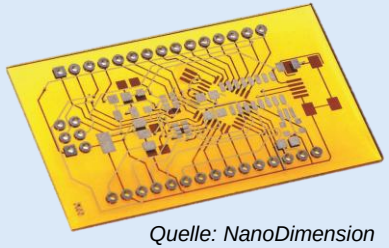
Wire Encapsulating

with specialized printing head technology



Additive Electronics

Aerosol Jet, Nano Jet Piezojet, Dispenser



Quelle: NanoDimension

Additive Mechatronics

5-axis printing system for AM of 3D-MID in one process

Increasing functionality

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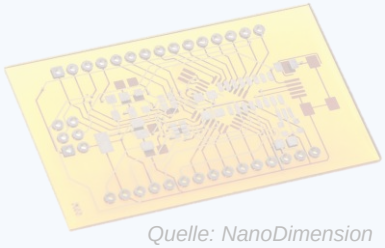


Quelle: NanoDimension

Additive Mechatronics

5-axis printing system for AM of 3D-MID in one process

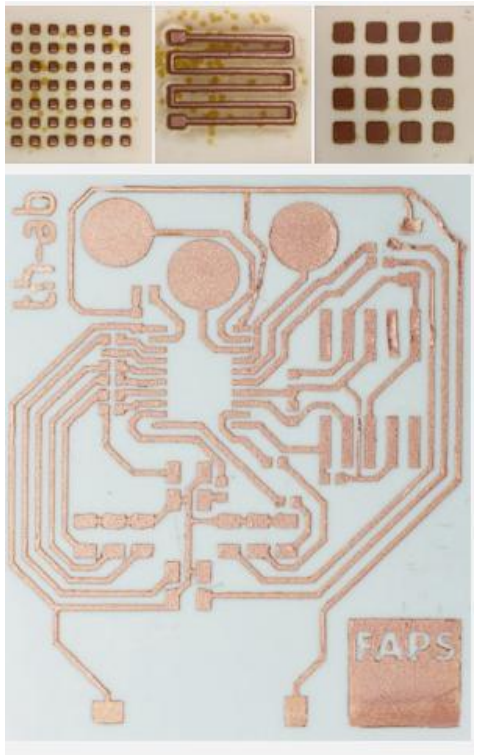
Increasing functionality

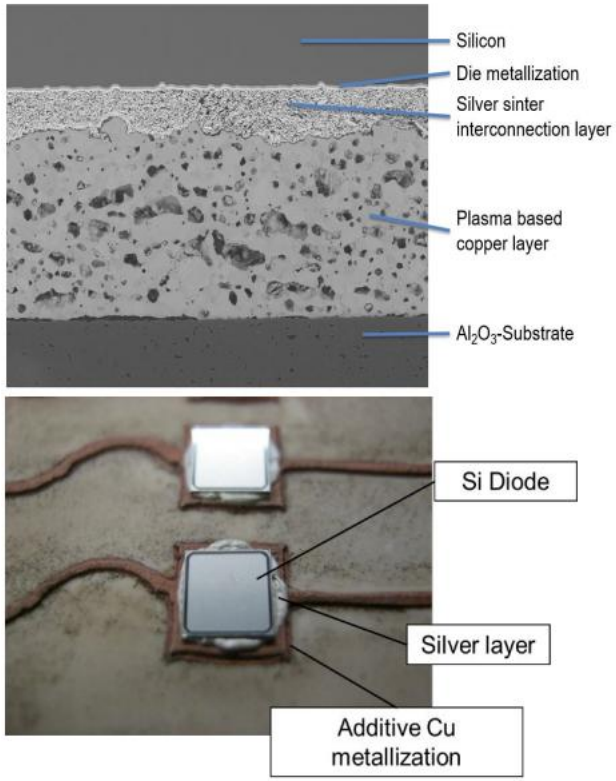
3D conductor tracks can be deposited on thermally robust materials such as ceramics for different applications by plasma based copper deposition approaches.

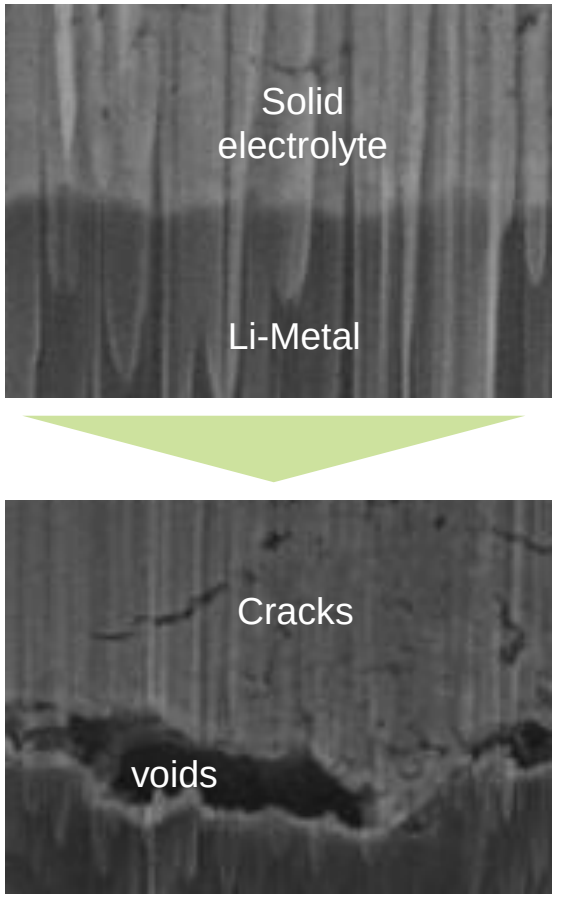
Plasma based copper coating deposition on ceramic materials in Power Electronics

Cross industry technology transfer for alternative applications

Solid state batteries with complex 3D interfaces







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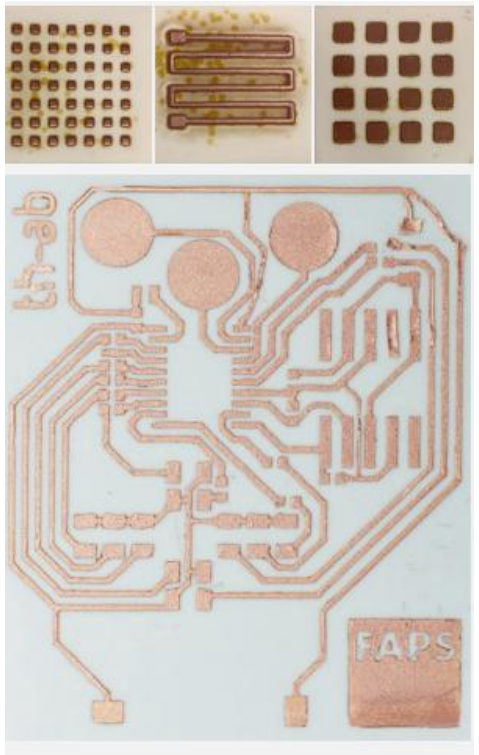
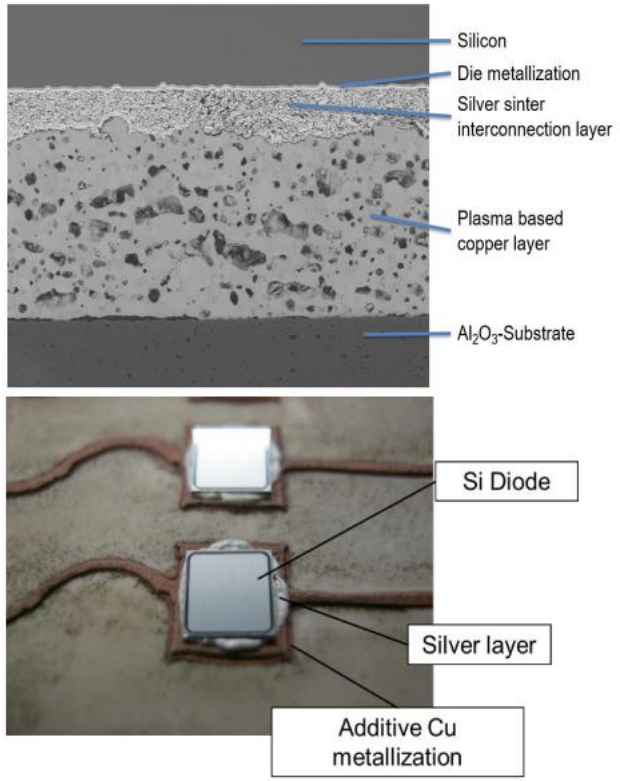
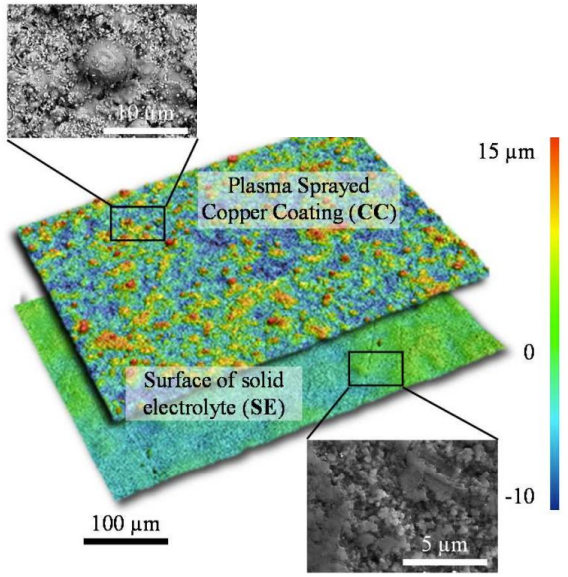
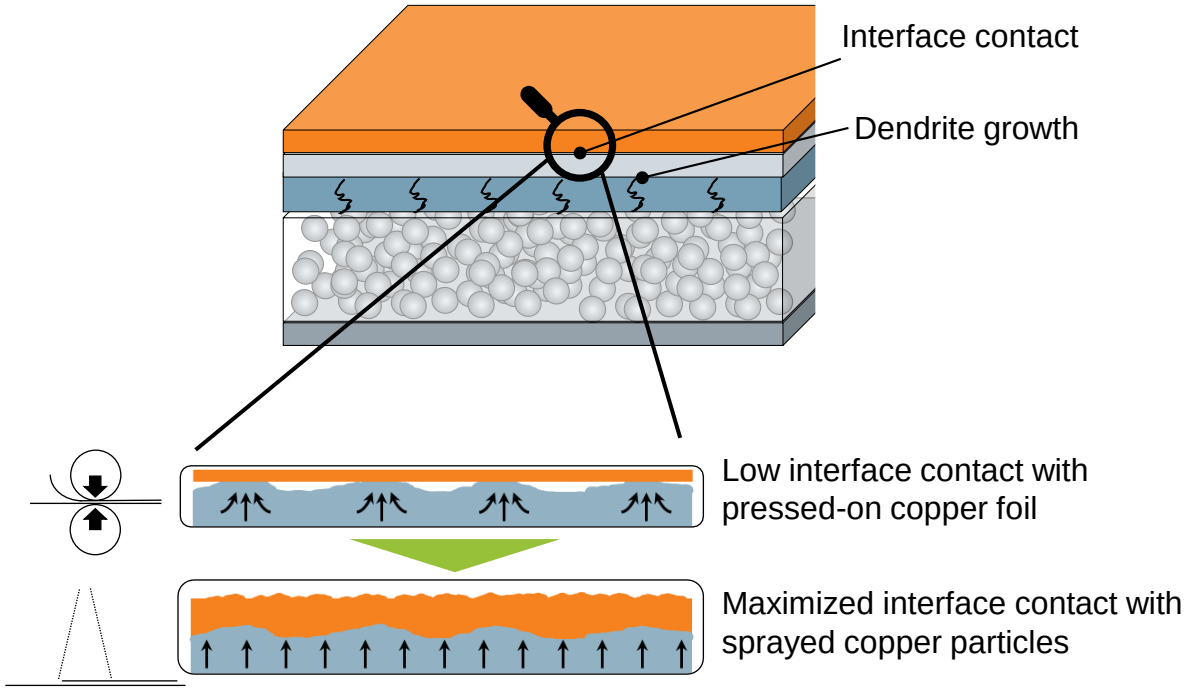


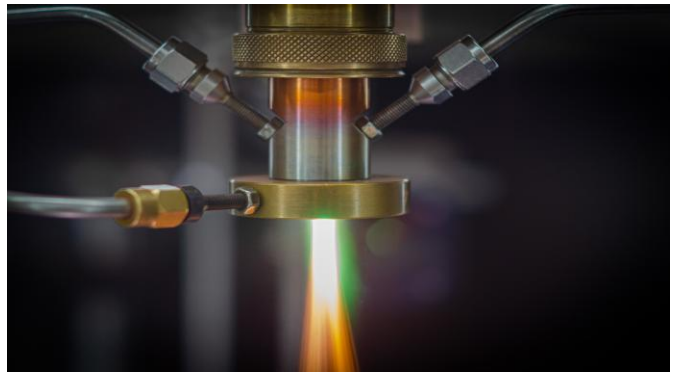




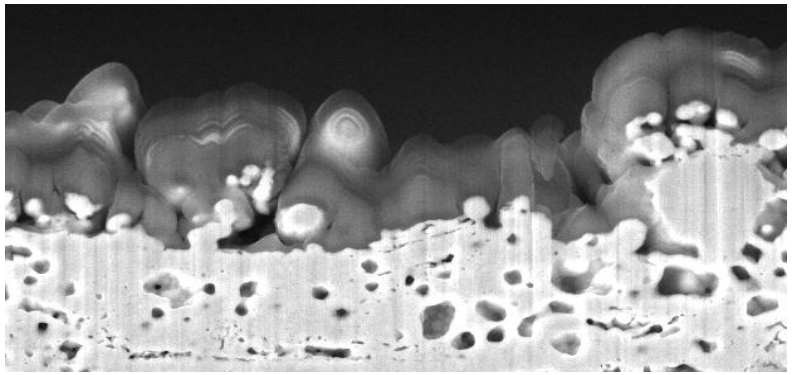
The disadvantage of solid-state batteries is (still) the production of SSBs atmospheric plasma spraying can solve this.

Schematic structure of an AFSSB (anode free solid state battery)





Plasma torch for atmospheric plasma spraying of copper particles



SEM image in the FIB section of APS sprayed copper particles (current collector)

The research field of technology Additive Mechatronics (AM|MID) has a broad base of process chains at the Institute for Factory Automation and Production Systems.

Field of Additive Mechatronics
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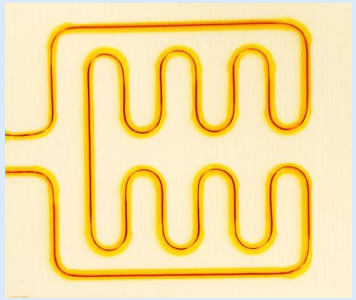

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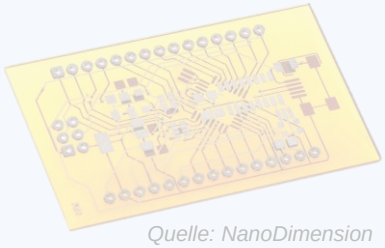


Quelle: NanoDimension

Additive Mechatronics

5-axis printing system for AM of 3D-MID in one process

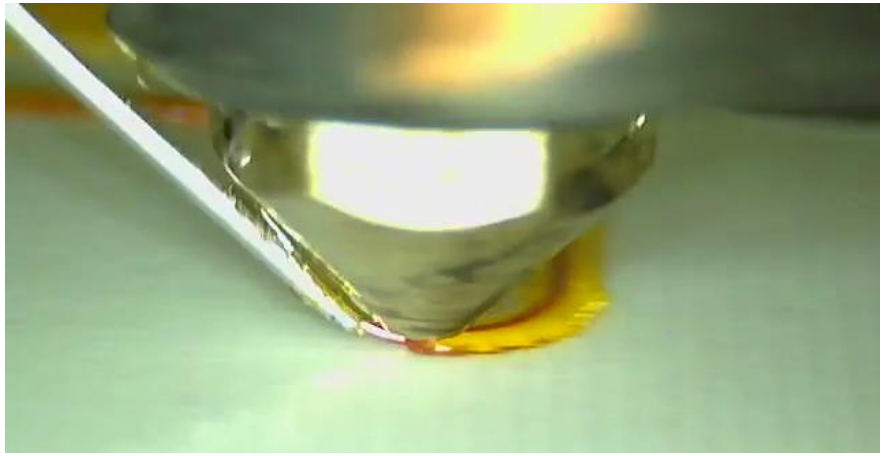
Increasing functionality

The Wire Encapsulating Additive Manufacturing print head allows wires to be laid and encapsulated on 3D surfaces.

Kronos 15XSA

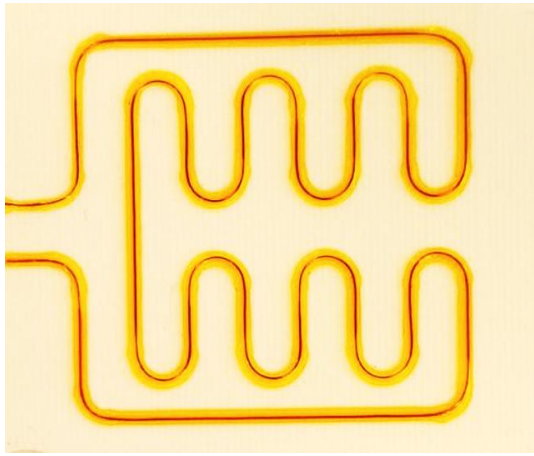
Wire Encapsulating Additive Manufacturing

- Depositing individual wires or strands
- Fixation and encapsulation using Fused Filament Fabrication (FFF)
- The entire print head can be rotated endlessly around the Z-axis
- The 5-axis kinematics also allow free-form surfaces to be structured



Close-up of the WEAM process

Printed coil



Printed heating structure

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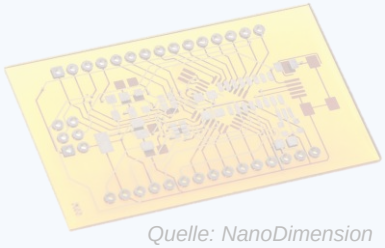

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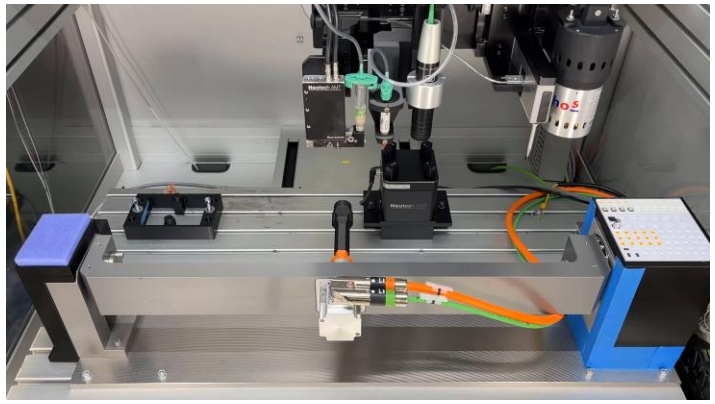
Increasing functionality

A 3D-printed light bulb demonstrates the potential of additively manufactured electronics for customizable lighting products.

CAD model of the light bulb

3D-printed light bulb

- 3D printing of the base body in any shape allows the implementation of creative designs and functional requirements.
- Printing the electrical circuit directly onto the surface enables complex layouts without conventional circuit boards.
- Products can be personalized and adapted to individual preferences for unique lighting solutions.
- Additive manufacturing processes lead to a reduction in material consumption and waste.



Production of the light bulb

Functional demonstrator

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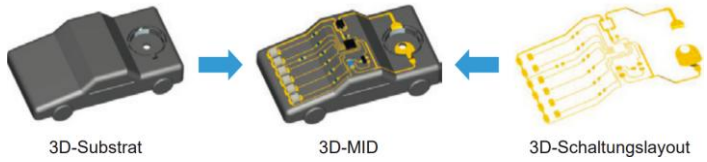

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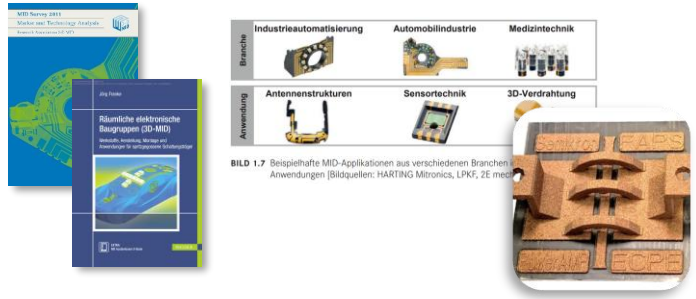


Mechatronic Integrated Devices (MID)

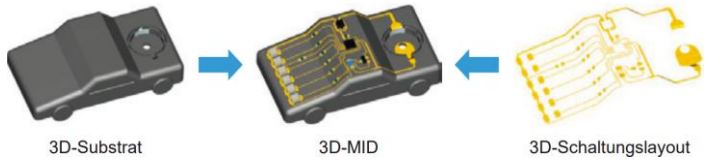
The terminology of MID was introduced more than 30 years ago.

1993 | **2014** | **2024**

Molded Interconnect Devices (MID)

1993: Foundation of
Research
Association 3-D MID e.V.

- Focus on **injection molded interconnect devices,** structured metallization, mechanical, electrical, optical, fluidic and thermal functionalities.
- Variety of processes for base substrate and conductive structures

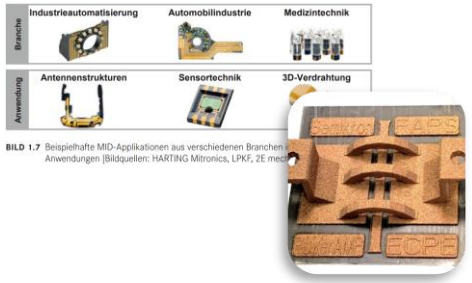


Mechatronic Integrated Devices (MID)

2014, extension from

- **“Molded Interconnect Devices”** to
- **“Mechatronic Integrated Devices”**

- takes into account that MIDs do not necessarily have to be injection-molded from plastic but also can be made from **other materials such as ceramics.**
- MID still closely associated with traditional MIDs, even though there have already been many additional research projects especially with **Additive Mechatronics**



2024, it is the aim to strengthen

Mechatronic Integrated Devices (MID)

in the context of emerging innovative process technologies for mechatronic products on

- **any base material,**
- **any conductive material,**
- **and any geometry**

with its wide variety of potential applications**.**

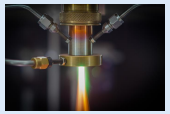
Sources: BMW, Lucid, Quantum Scape

Innovative process technologies of Mechatronic Integrated Devices (MID) enable promising approaches for generating innovative mechatronic systems.

Technology push

Innovative production technologies for the functionalization of conductive structures

Basic substrate + Conductive structure

- (Multi-component) Injection molding 
- Laser-based structuring 
- 3D Printing 
- Spraying (APS) 
- SLM 
- …

Fields of application for Mechatronic Integrated Devices

Molded Interconnect Devices

Additive Mechatronics

Application pull

Innovative fields of application of Mechatronic Integrated Devices

- Molded thermoplastic base materials, and other materials such as ceramics
- Conductive, metallized structures
- 2D
  2,5D
  3D
- Integration of functions (mechanical, electrical, thermal, optical, fluidic, magnetical)

Innovative process technologies of Mechatronic Integrated Devices (MID) enable promising approaches for generating innovative mechatronic systems.

Technology push

Innovative production technologies for the functionalization of conductive structures

Basic substrate + Conductive structure

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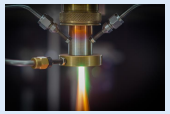
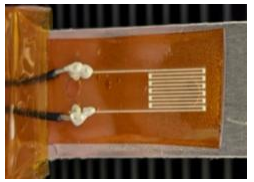
- Spraying (APS) 
- SLM 
- Wire laying, wire assembly 

Fields of application for Mechatronic Integrated Devices

Molded Interconnect Devices

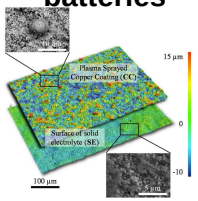
(3D) Printed Electronics Flex Electronics



Packaging

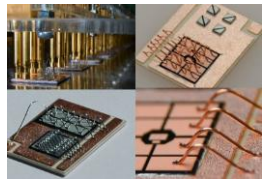
Source: heraeus

Surface coatings / batteries

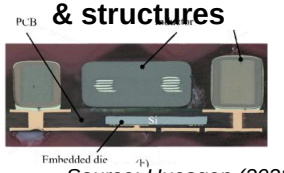


Additive Mechatronics

Power Electronics



Embedded components & structures



Source: Huesgen (2022)

Assembled inductivities

- Any base substrate material
- Any conductive material & components
- Any shape and geometry
- Integration of functions (mechanical, electrical, thermal, optical, fluidic, magnetical)

Application pull

Innovative fields of application of Mechatronic Integrated Devices

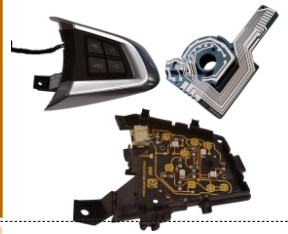
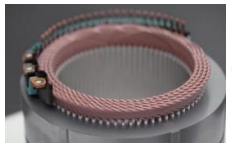
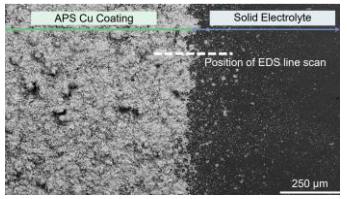
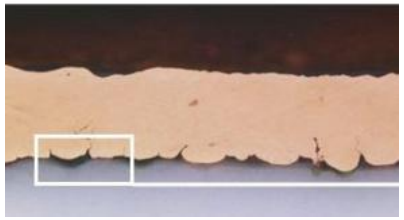
There is a strong application pull, driven by megatrends such as the electrification of vehicles, autonomous driving functions, humanoid robotics, innovative HMIs, medical technology, etc.

Strong application pull by innovative mechatronic systems

Automotive / Mobility	Robotics / Manufacturing	Consumer / Communication

Sources: Tesla, Apple

“Examples” of sub-classes of Mechatronic Integrated Devices that will be supported by 3-D MID Research Association for the development of innovative mechatronics.

	Automotive / Mobility	Robotics / Manufacturing	Consumer / Communication
Mechatronic System			
Mechatronic Modul / Sub-System	     		
MID as inde-pendent, functional device combining mechatronic functions			
Mechatronic Component / Part	    		
Material-Level	   		

Sources: Tesla, Apple, Figure, Harting, LPKF, BMW

Summary: The 3-D MID Research Association e.V. strengthens the support of innovate Mechatronic Integrated Devices (MID) on a material, component, module and system level.

- **1993**, initial MID-focus on injection **Molded Interconnect Devices**, with **structured metallization** and mechanical, electrical, optical, fluidic and thermal functionalities.

- **2014**, extension to **Mechatronic Integrated Devices** took into account that MIDs do not necessarily have to be injection-molded from plastic but also can be made from **other materials such as ceramics** and additional research projects with **Additive Mechatronics**

- **2024**, it is the aim to strengthen **Mechatronic Integrated Devices (MID)** in the context of emerging innovative process technologies for mechatronic products on **any base material, any conductive material, and any geometry** with its wide variety of potential applications**.**

SAVE-THE-DATE: As a specialist congress, the Mechatronic Integration Discourse provides a platform for industry and science to exchange ideas.

SAVE-THE-DATE
Juli 2.-3., 2025
ACC Amberg, Germany

- The International IEEE MID Congress (**Mechatronic Integration Discourse**) is a **scientific congress** organized and conducted by the research association 3D MID e.V., which deals with current topics on MID technologies.

- The **Mechatronic Integration Discourse** has established itself as an important meeting place for experts from industry and science and attracts around 200 participants who exchange information on the latest research results, technological developments and practical applications.

SIEMENS

IPC WORKS

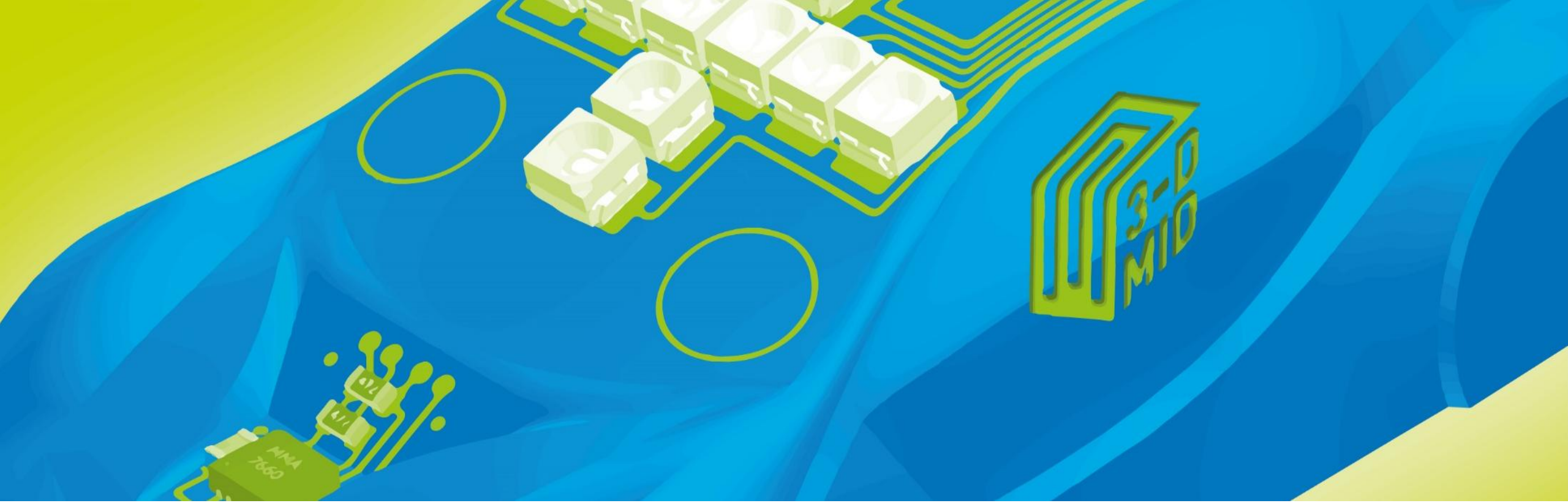
Become a member of the 3-D MID e.V. network for Mechatronic Integrated Devices and benefit from the numerous services and the network.

Research and development	Knowledge database	Marketing	Events and professional network
We support the **promotion** of MID technologies	We provide **knowledge** about MID technologies	We create **publicity** for MID products and technologies	We promote **networks** and **technology transfer**

DLR Projektträger

INDUSTRIELLE GEMEINSCHAFTSFORSCHUNG

cornet
Collective Research Networking



THANK YOU

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