

Chemnitzer Seminar 2023:
Electronic Packaging and Applications

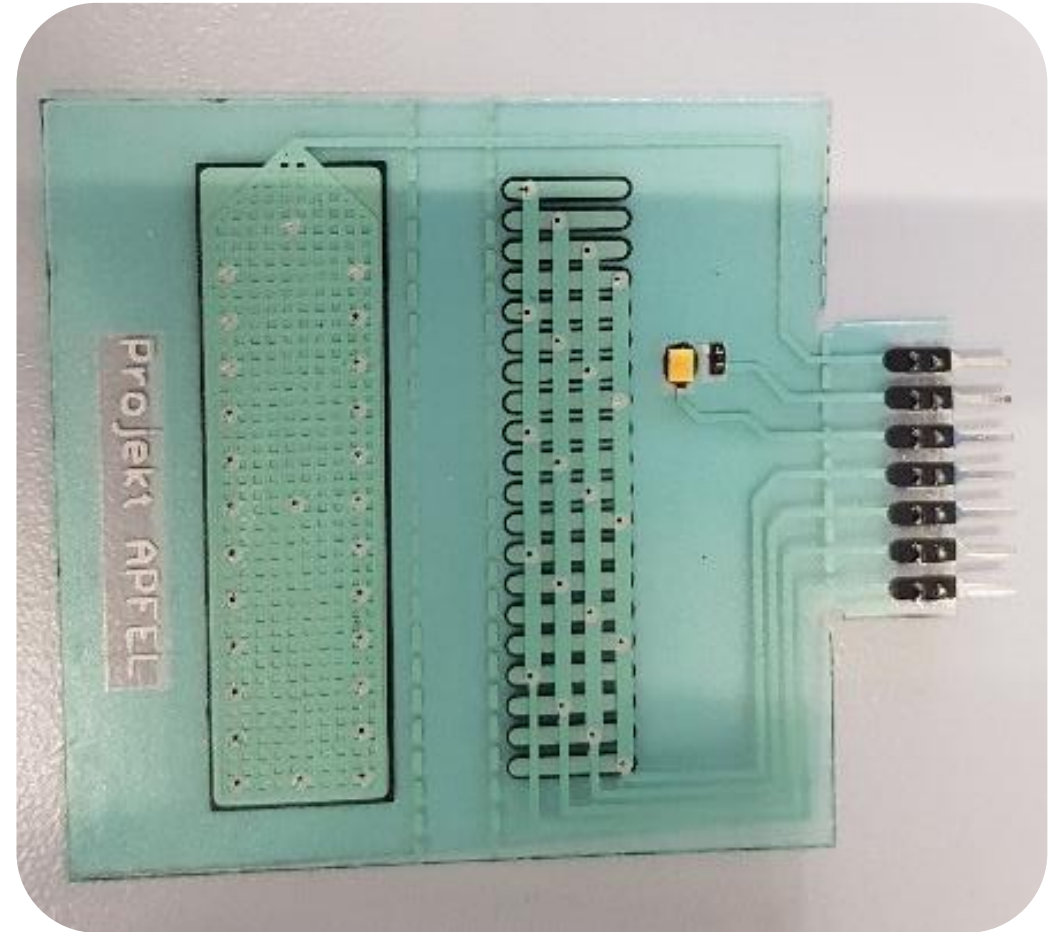
Valeri Fitz,
Fraunhofer ENAS

Titel:
"Additive manufacturing and packaging
technologies for flexible substrates towards wound
treatment and diagnostics"

Outline

Additive manufacturing and packaging technologies for flexible substrates towards wound treatment and diagnostics

- Fraunhofer ENAS, short overview
- Introduction: Layer Depositions Technologies & Materials
- Research & Application examples
 - Project Bevor Fever
 - Project APFEL
 - Project Nano Sticky
- Conclusion



Fraunhofer ENAS

Short Introduction

Chemnitz European Capital of Culture in 2025



243.659 inhabitants
(06/2021)



Chemnitz University of
Technology:
About 10.000 students



About 18.500 Industrial
and handicraft enterprises
(06/2021)



Nonacademic RTOs: Fraunhofer IWU and
Fraunhofer ENAS, Saxon Textile Research
Institute e.V. (STFI)



Main industry: automotive
industry and its components
suppliers, mechanical and
plant engineering



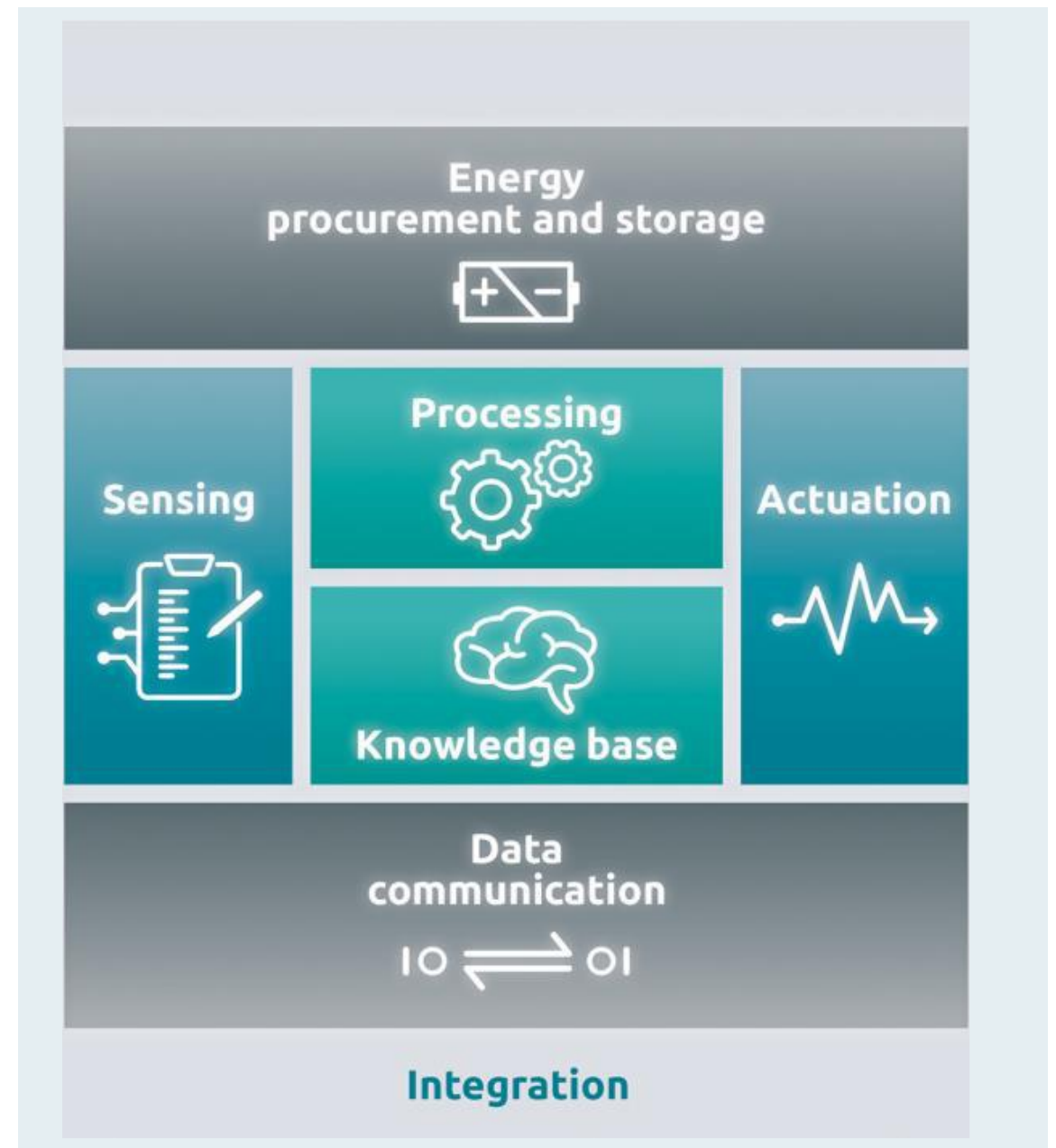
Leading R&D place for micro system
technology, sensors and textile

Main Working Field

– Smart Systems Integration

- Self-sufficient intelligent technical systems or subsystems with advanced functionality
- Combine sensing, actuation and data processing, informatics / communication
- Autonomous systems
- Highly reliable, often miniaturized, predictive, linked in networks
- Their operation being further enhanced by their ability to mutually address, identify and work in consortia

→ Basic components for the Internet of Things





Fraunhofer ENAS and Center for Microtechnologies (ZfM) at TU Chemnitz

Cluster of clean rooms at ZfM: 1000 m², 300 m² of them are class ISO 4
Fraunhofer ENAS: 1400 m² of laboratories, 400 m² of them with improved cleanliness

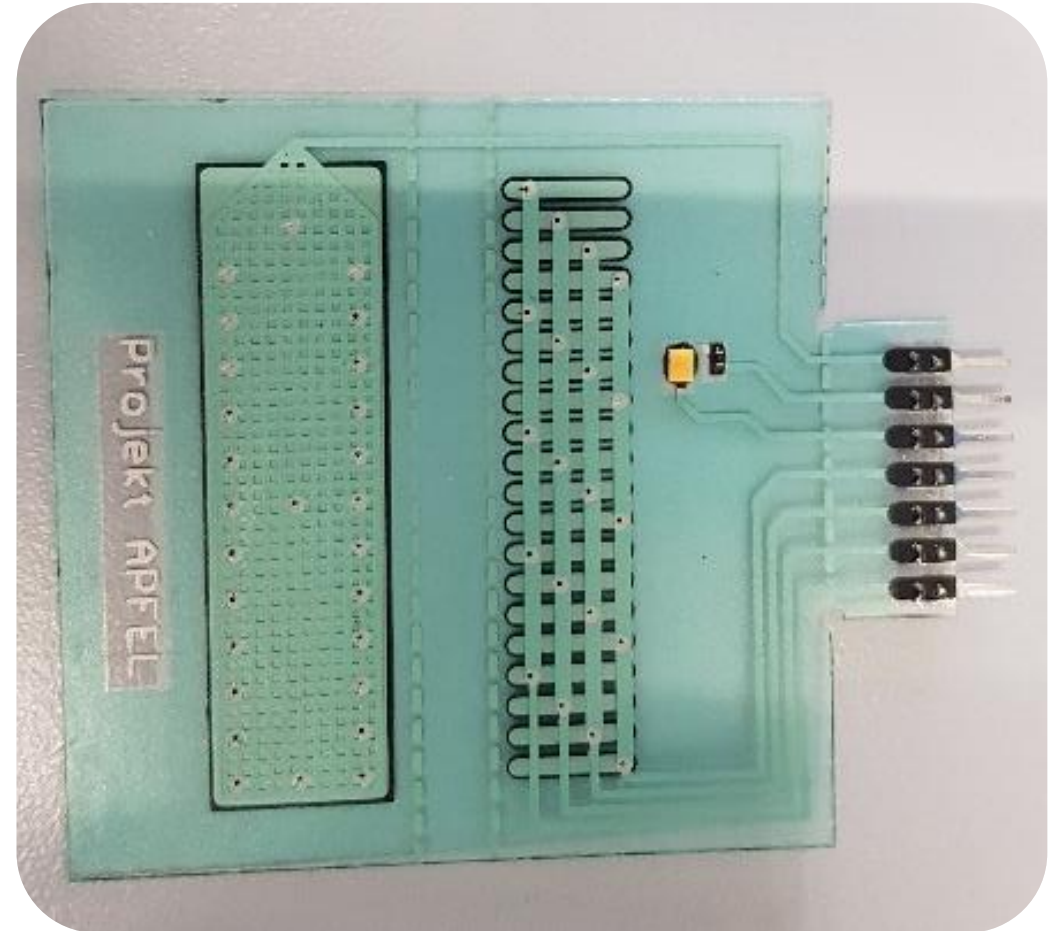
Fraunhofer ENAS

“Additive manufacturing and packaging technologies for flexible substrates towards wound treatment and diagnostics”

Outline

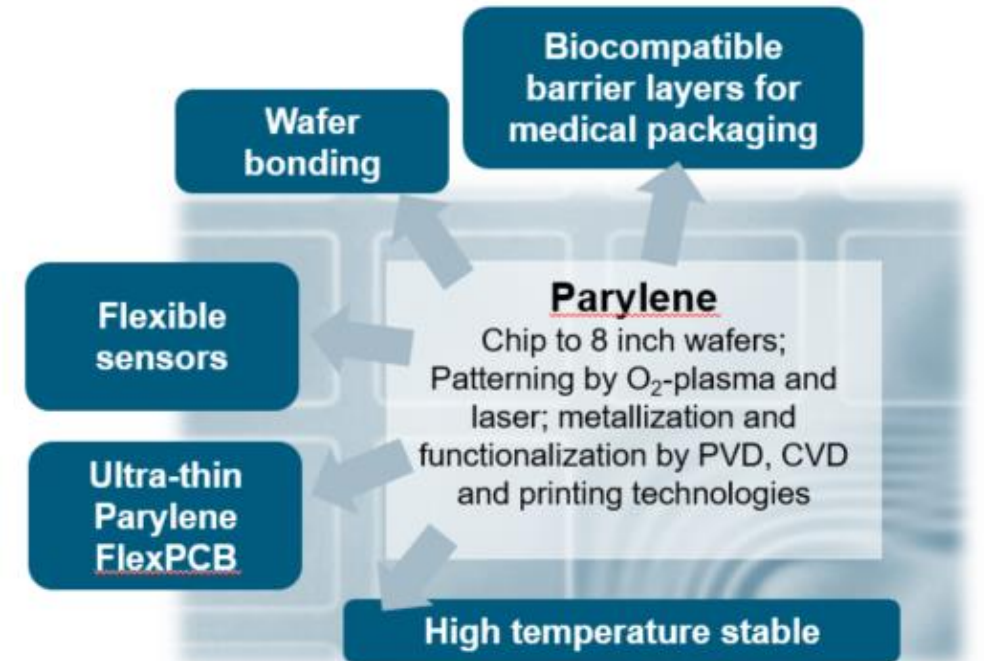
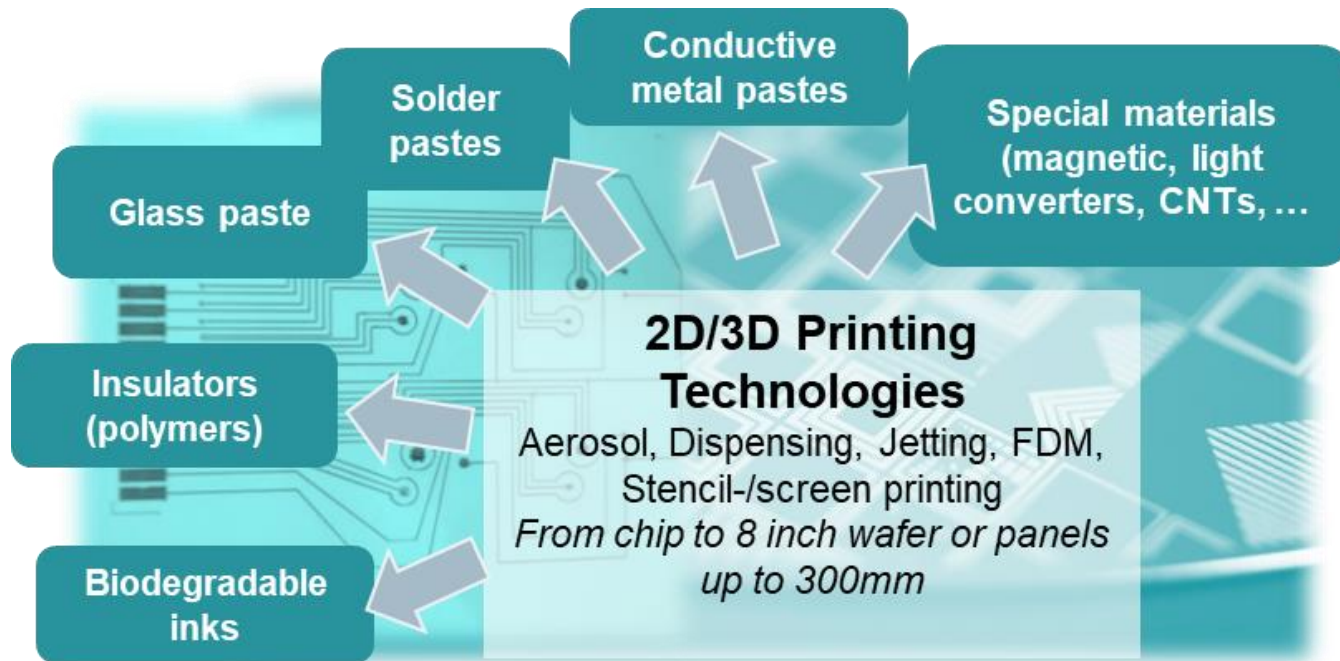
Additive manufacturing and packaging technologies for flexible substrates towards wound treatment and diagnostics

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Introduction:

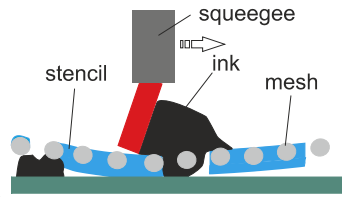
Layer Deposition Technologies & Materials



Introduction:

Additive Technologies in Semi/ MEMS fabrication chains

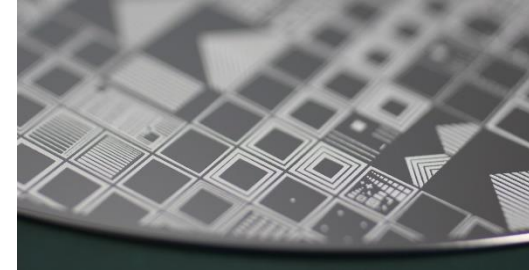
Screen/Stencil
Printing



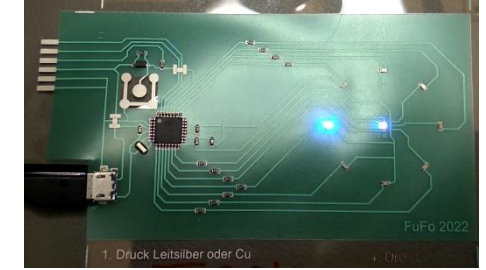
Precision screen-/stencil printing

MATERIAL EXAMPLES

Glass frit for WL/CL Bonding
Conductive / Insulating paste systems / printed electronics
Solder pastes
Application specific materials

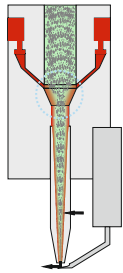


Printed glass frit on WL for Bonding from CL to 8" Wafer



Fully printed circuit on flex polymer substrate

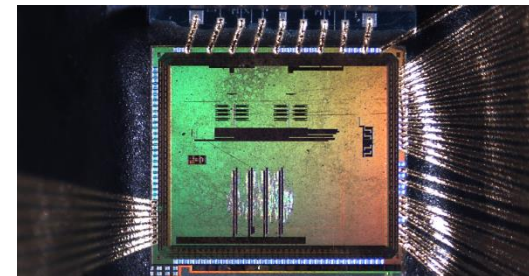
Aerosol Jet



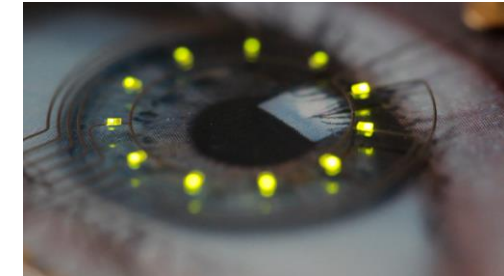
Precision Jetting down to 10µm

MATERIAL EXAMPLES

Conductive or insulating inks
Nanoparticle based Solder pastes
Application specific nanoparticle inks (i.e. optics, resins, ..)

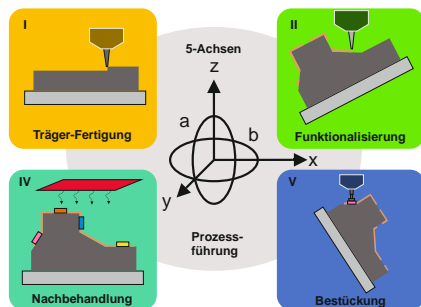


Aerosol-Jet printed interconnects using Ag nanoparticle inks



Aerosol-Jet printed interconnects and SMT on optics / co-polymer

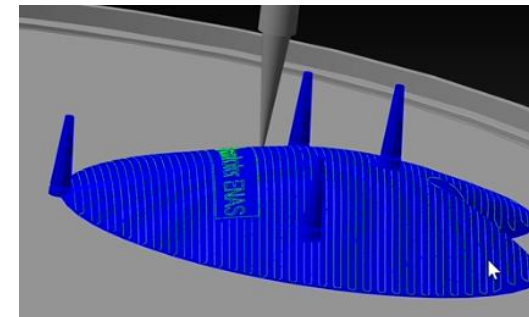
3D Cluster



Precision Jetting / Dispensing

MATERIAL EXAMPLES

Ag paste
Cu paste
Ceramic pastes
Insulators, glass paste, solder paste, adhesives, ...



3D CAD CAM Strategy



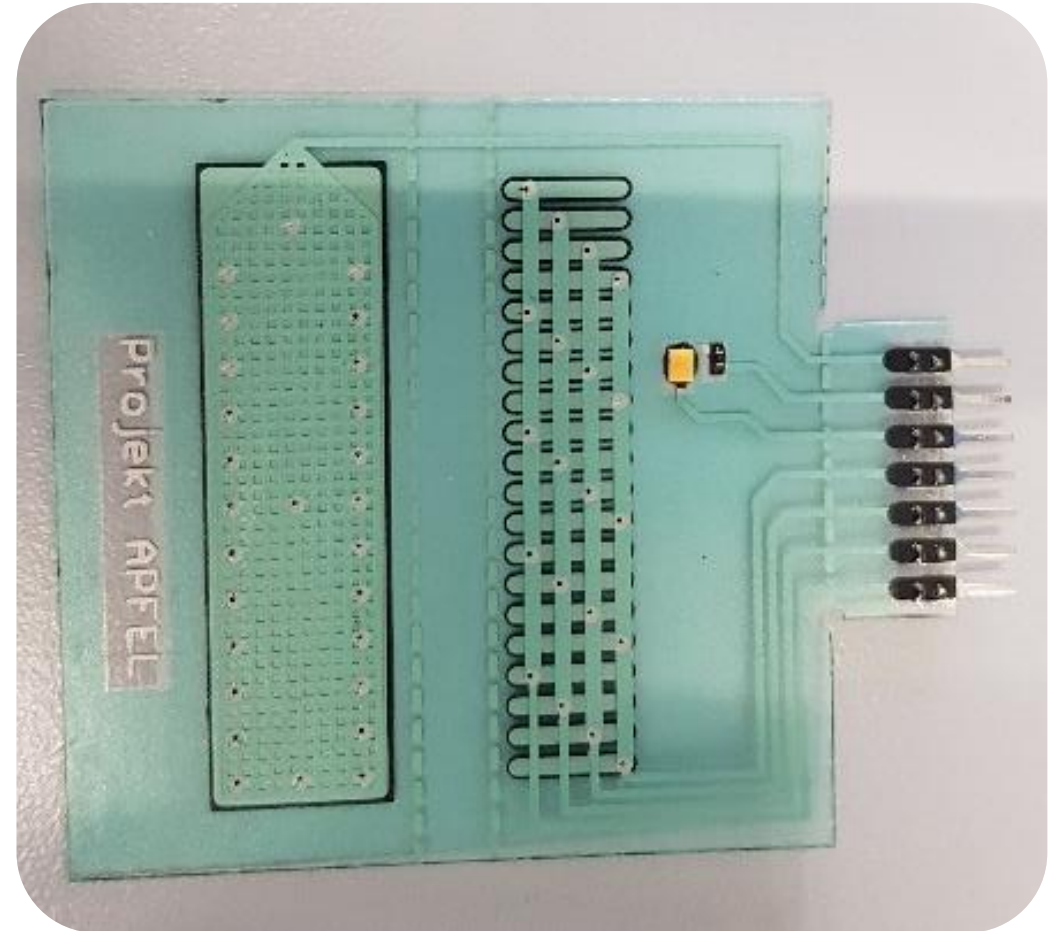
Conformal dispensing on 3D substrates (i.e. out of injection moulding)

From 2D towards 3D

Outline

Additive manufacturing and packaging technologies for flexible substrates towards wound treatment and diagnostics

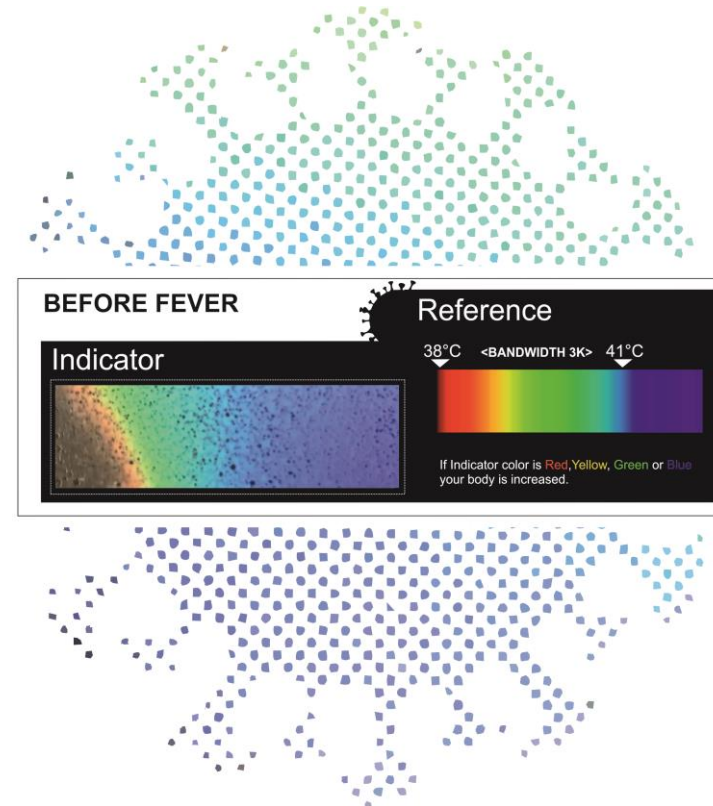
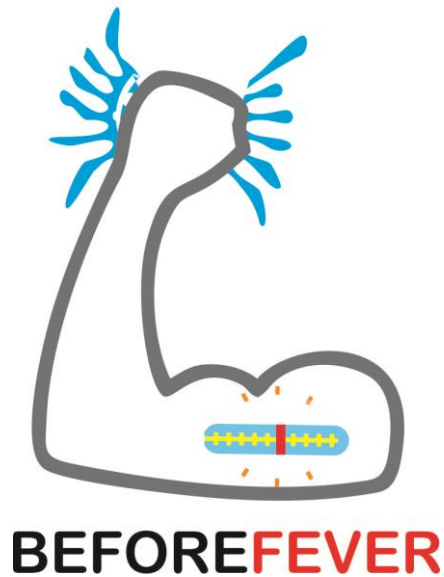
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Application examples

Project Bevor Fever - Introduction

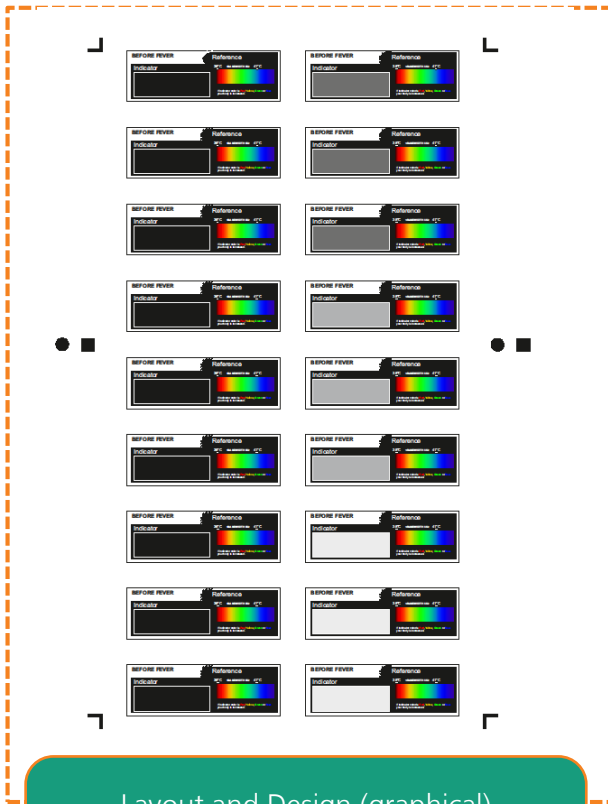
- Wearable low cost thermometer for early indication of (SARS-CoV-2)-virus infections
- Screen printing of thermochromic materials



Demonstrator of printed thermochromic pigments on flexible film substrates.

Application examples

Project Bevor Fever – R&D Activities



Layout and Design (graphical)
Test and adaption of Ink-Jet process
(together with PM - TUC)



R&D
Screen Printing vs. dispensing

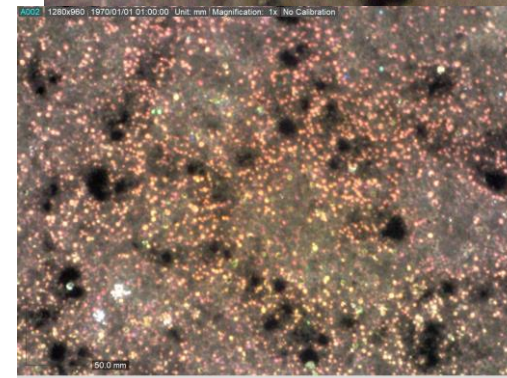
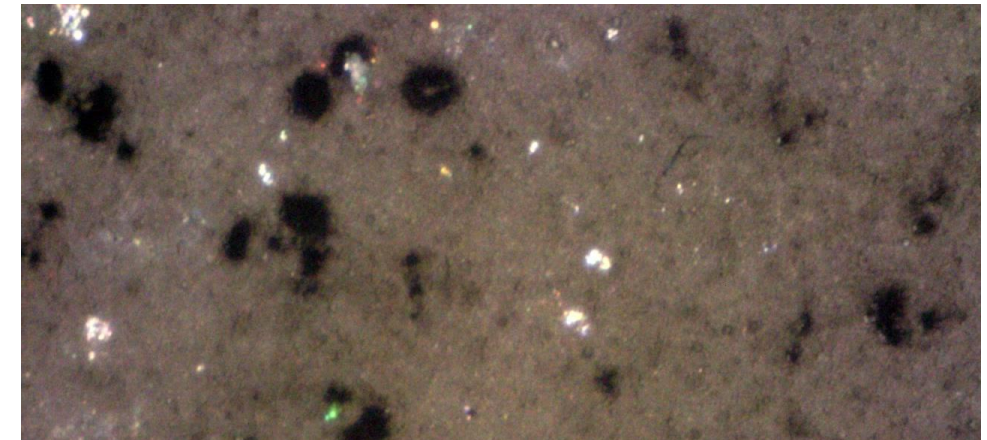
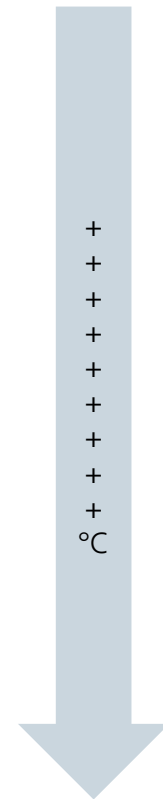
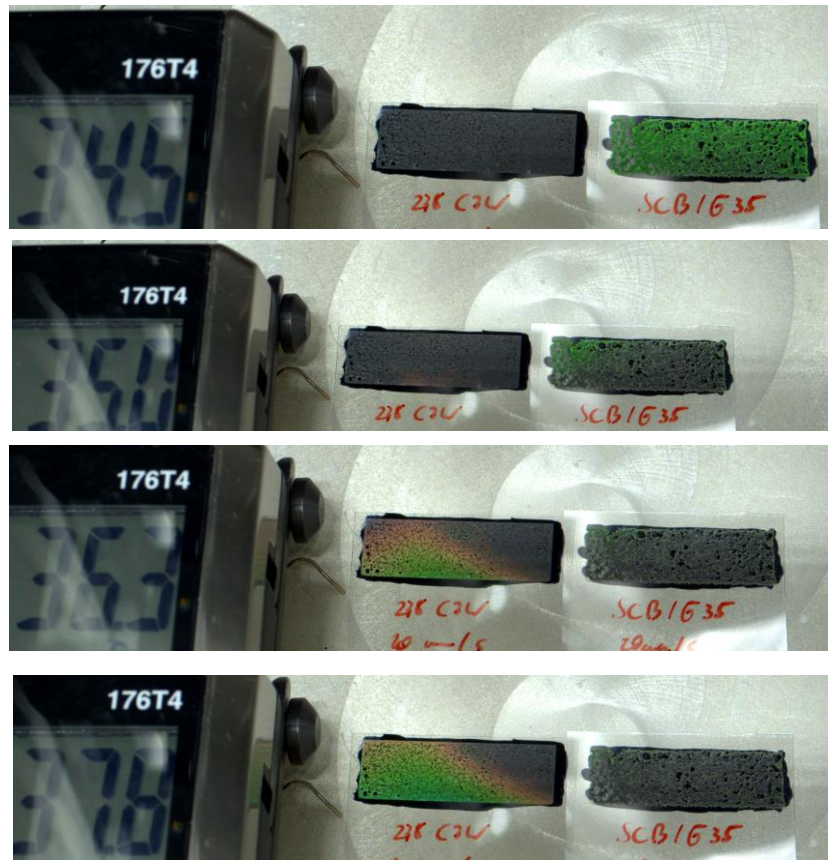


Testing
Temperature vs. color

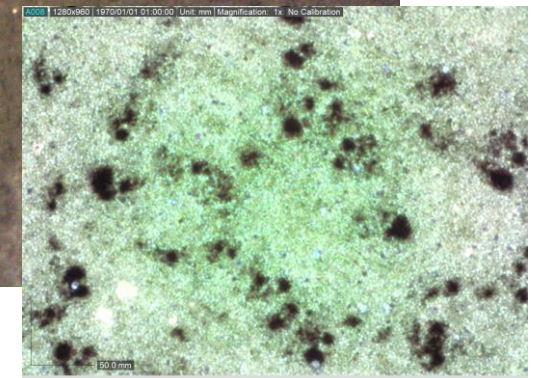
Application examples

Project Bevor Fever – R&D Activities

- Characterization using hot plate and microscope / camera



Temperature sensitive @36,6°C

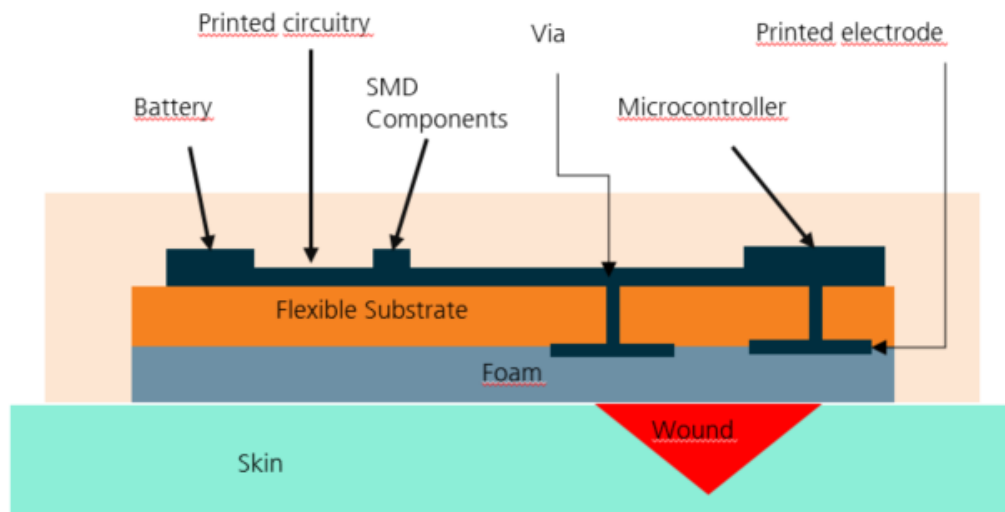


Temperature sensitive @39,9°C

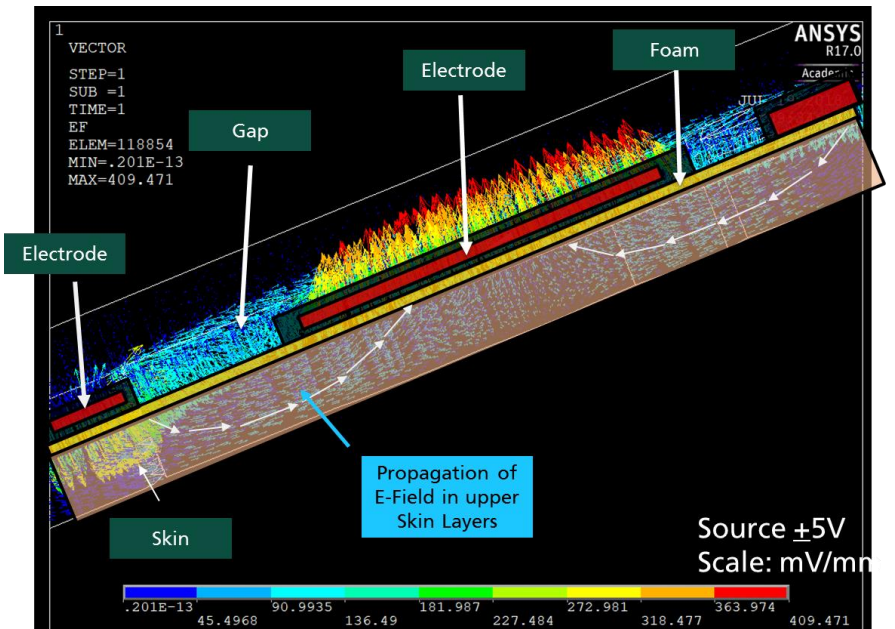
Application examples

Project APFEL - Introduction

- Project APFEL: Active wound patch with electrical stimulation
- Approach: formation of ion gradients / endogenous electric fields
- Generation of an electric field at the wound by printed electrodes
- Electric gradient causes tissue movement and growth in tissue
- Accelerated and improved wound healing



Concept flexible PCB: wound patch with active electrodes



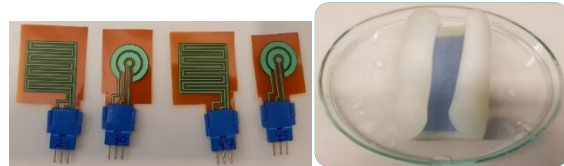
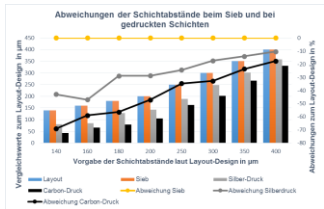
Simulation of electrical field in upper skin layers

Application examples

Project APFEL – R&D Activities

Screen Printing

- Development of screen printing processes for Ag / Carbon Multilayers as well as insulating layers

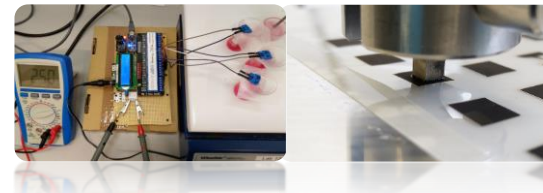


Technology Demonstrators

- Demonstrators for functional tests in cell medium (Cytotoxicity)
- Scratch Assay Tests to demonstrate wound healing (Partner TUD)

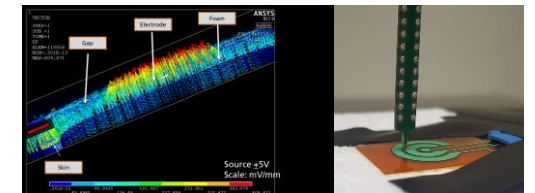
Functional Tests

- Reliability of electrodes in application scenario (cell medium, 37°C, Voltage)
- Characterization of Adhesion of printed layers



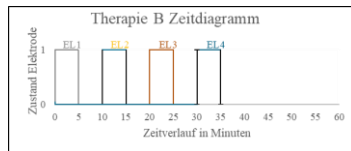
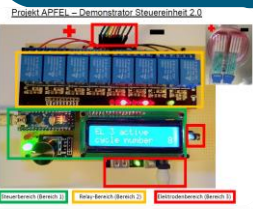
Simulation

- Simulation of electrical field by involved dielectric materials
- Validation of ANSYS models by dynamic simulations and near field scanner



Electronics

- Electronic development for testing with therapeutical ON/OFF cycles (4 medical electrodes are tested in parallel)

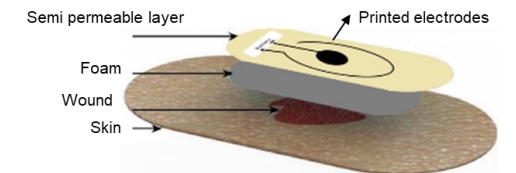


Demonstrators

- Integration of conductive features, through holes and SMD components as a technology demonstrators



Ongoing activities for clinical trials

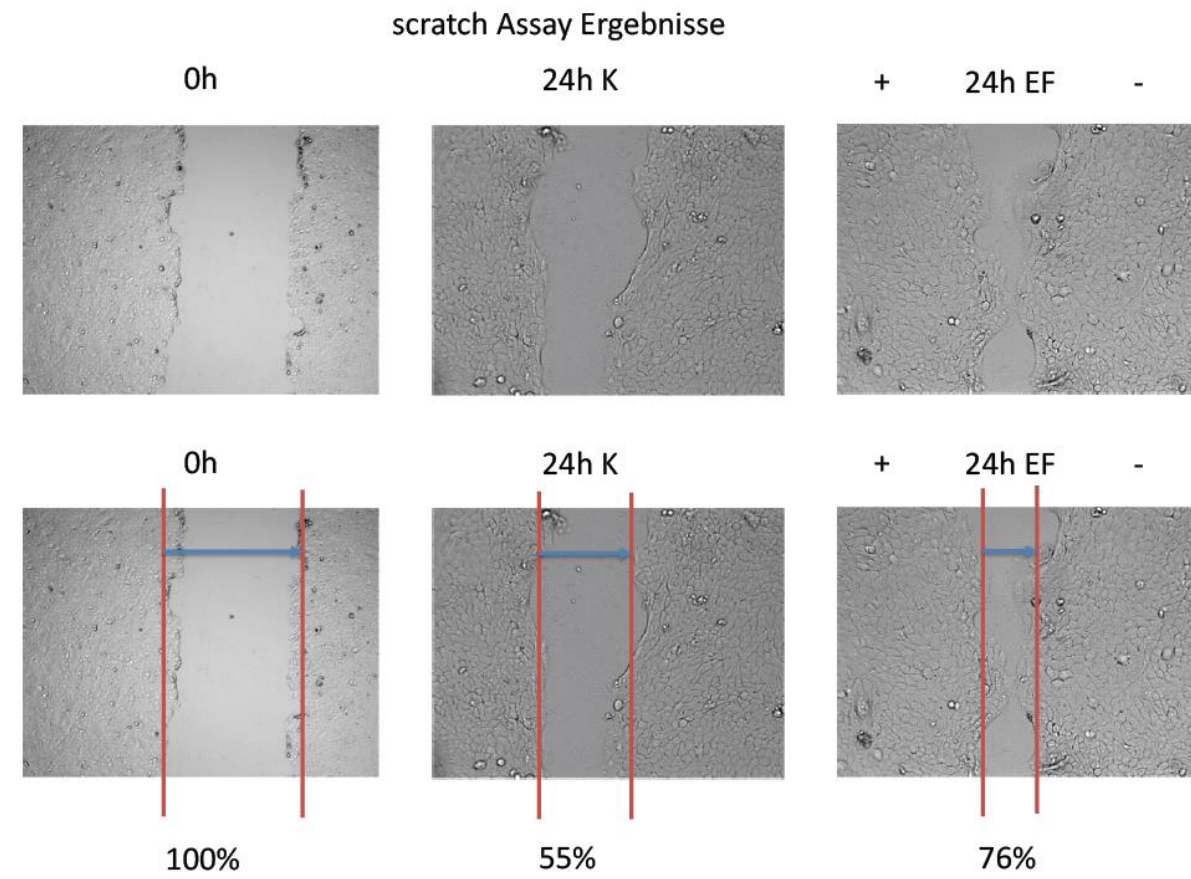


Application examples

Project APFEL – Scratch Assay Results



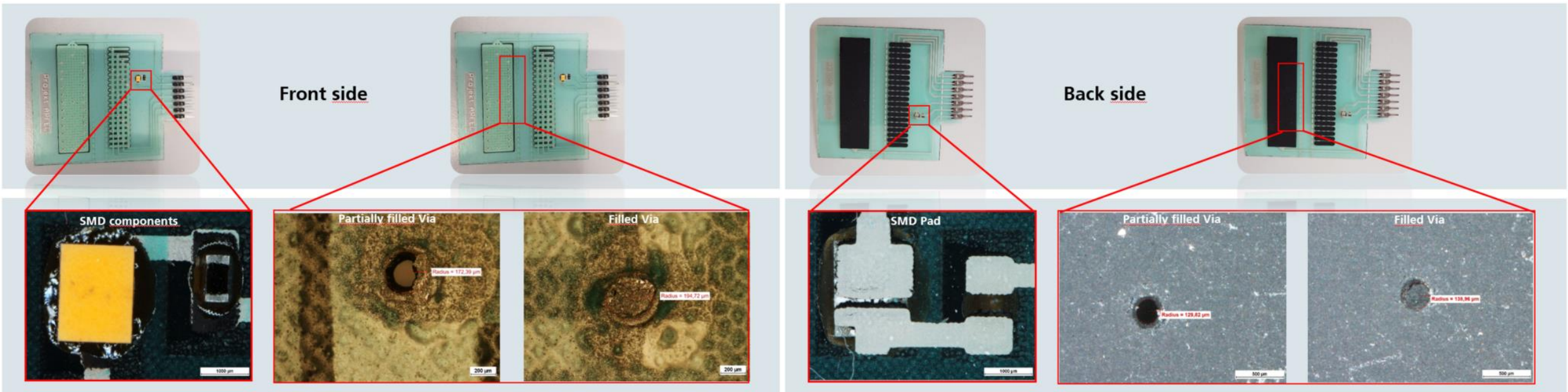
Experimental procedure



Scratch Assay Results

Application examples

Project APFEL – Demonstrator Sample



Demonstrator of the active wound patch. Printed multilayer wiring with electrical through-hole connection on wound patch with mounted electronic components.

Research examples - Parylene

Project NANOSTICKY

- R&D of self-adhesive substrates (e.g. adhesive free skin patches)
→ Inspiration from nature (adhesive lamellae on gecko toe pads)
- Fabrication of 3D Parylene structures using hot-embossing
→ reproducible process with good quality of the side walls
- Process parameters:
 - Hot-embossing temperature and forces
 - Detachment temperature and speed
 - Anti stiction agent
 - Cooling

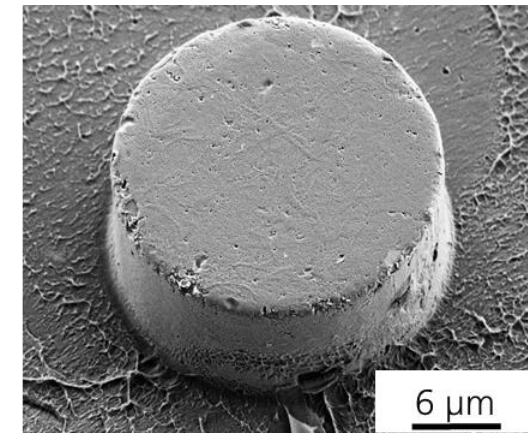
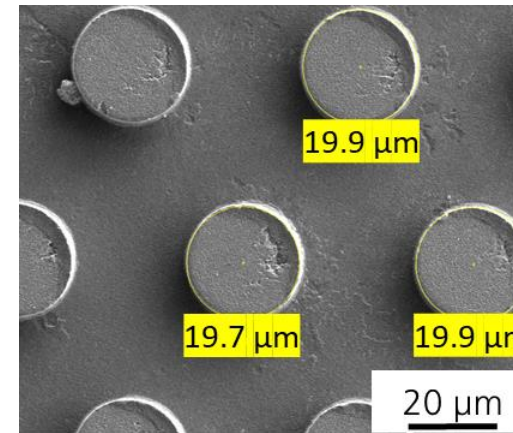
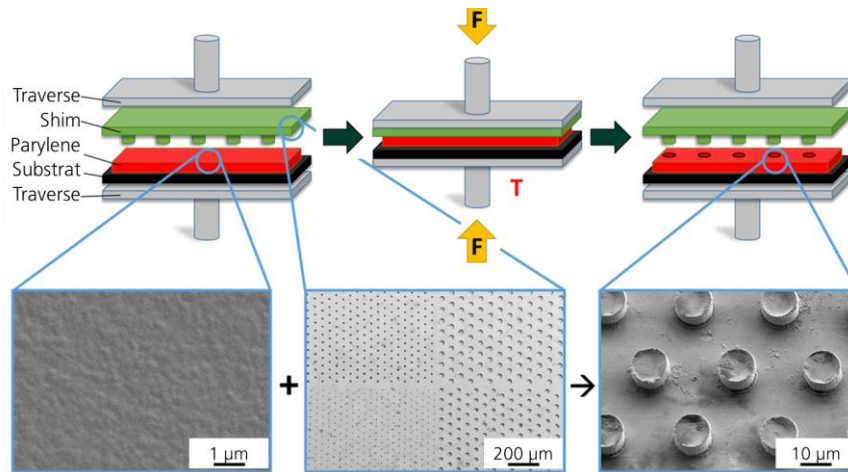
Learn from nature - Gecko



toe pad

lamellae

setae (hair-like structures)



Conclusion

- Additive manufacturing / printing enables a wide variety of electronic grade materials (conductive, insulating, sensitive) and is suitable for flexible substrates
- Multilayer printing and via technologies enable further miniaturization or increased functionality / area
- Most commercial available materials are electronic grade materials and biocompatibility needs to be proofed for medical applications
- Digital printing (maskless) enables product individualization for individualized medical applications (i.e. scanning a wound → design changes to adjust medical patches to wound size → patient specific wound patch fabrication)
- Accelerated wound healing was demonstrated by smart wound patch by in-vitro scratch assays

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