Fraunhofer IZM

E-Textiles Technologies – Merging Electronics and Textiles

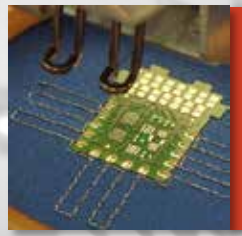
Malte.von.Krshiwoblozki@IZM.Fraunhofer.de – Groupmanager System on Flex

OVERVIEW

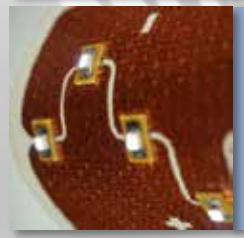
Fraunhofer Society and
IZM introduction

E-Textiles Applications

E-Textiles @ Fraunhofer IZM



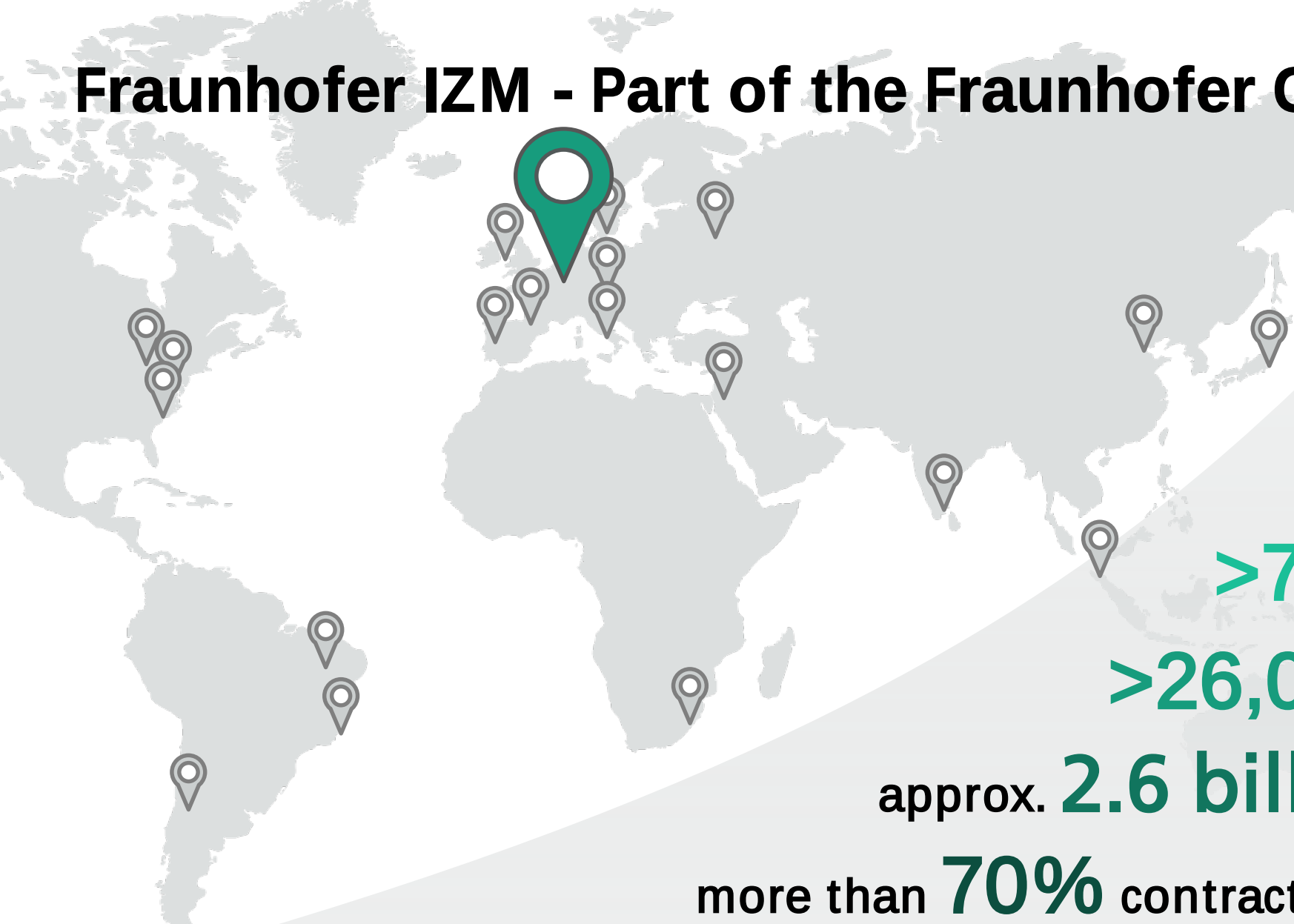
Materials and Circuit
Manufacturing



Interconnection and Testing

Projects

Fraunhofer IZM - Part of the Fraunhofer Gesellschaft



Fraunhofer Gesellschaft

>70 institutes worldwide

>26,000 employees

approx. **2.6 billion €** turnover

more than **70%** contract research

Fraunhofer IZM at a Glance
Reliability and Microintegration

Founded in **1993**

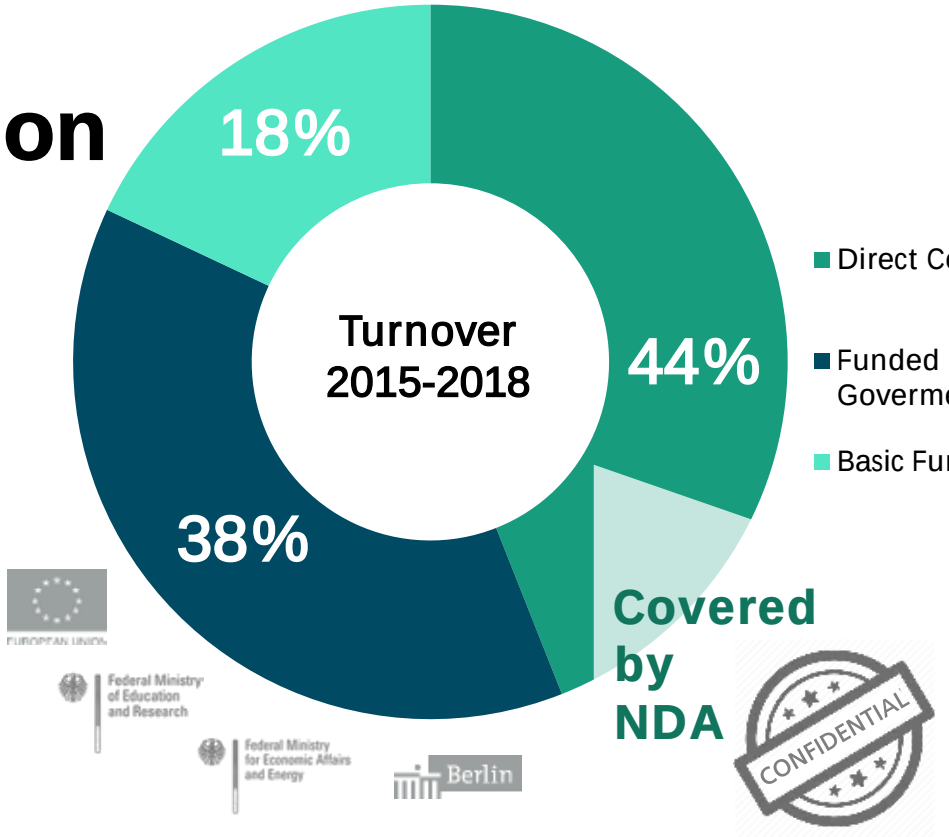
33.7 million € turnover in 2018

BERLIN

DRESDEN

260 FULL-TIME EMPLOYEES

147 TRAINEES; STUDENTS, AND PHD RESEARCHERS



Long-term contract with

Technical University of Berlin

Approx. 65 additional staff

Fraunhofer IZM – A World-Class High-Tech Environment

>10,000 m² laboratory space

>60 laboratories & measuring rooms

>7,000 pieces of equipment

in 2018

3.7 million €

infrastucture investments

17.7 million € for Forschungsfabrik Mikroelektronik Deutschland

LABORATORY TYPES

- INTEGRATION AT WAFER LEVEL LAB
- INTEGRATION AT SUBSTRATE LEVEL LAB
- ADVANCED SYSTEM ENGINEERING LAB
- MATERIALS, RELIABILITY, AND SUSTAINABLE DEVELOPMENT LAB

E-Textiles Applications

wearable

E-textile power and data bus

Capacitive EMG Sensor

Textile SmartPixel Display

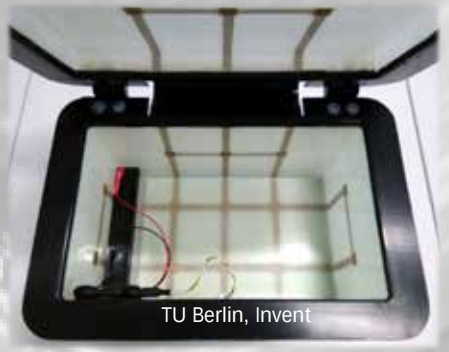
Sporty Superhero Bicycle Jacket

Knee brace – Angle measurement

technical

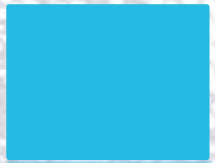
Automotive interior: lighting and control

Cut protection fabric with cut detection

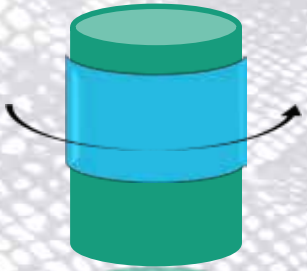


Glass fiber reinforced composite battery box with embedded Sensor network

What is Stretch??? And how can it be achieved in electronics??



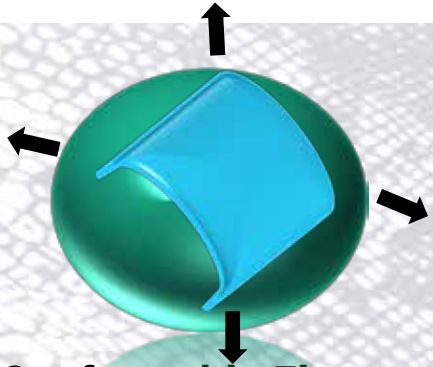
Rigid Electronics



Flexible Electronics

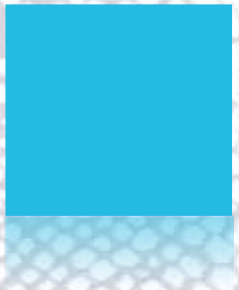
Only 1 direction bending possible

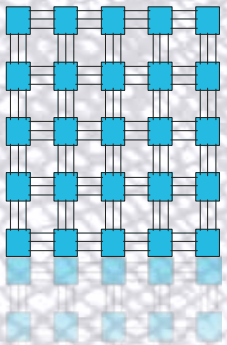
Comfort for manufacturing (like Roll-2-Roll, automotive)

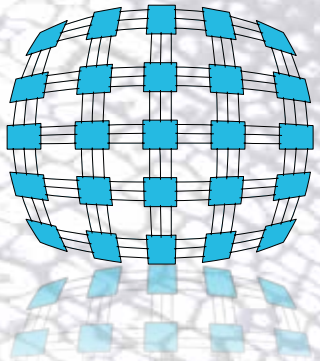


Conformable Electronics

Comfort for End-Users needs







Rigid/flex islands

Stretchable areas in between

Textile-Technologies

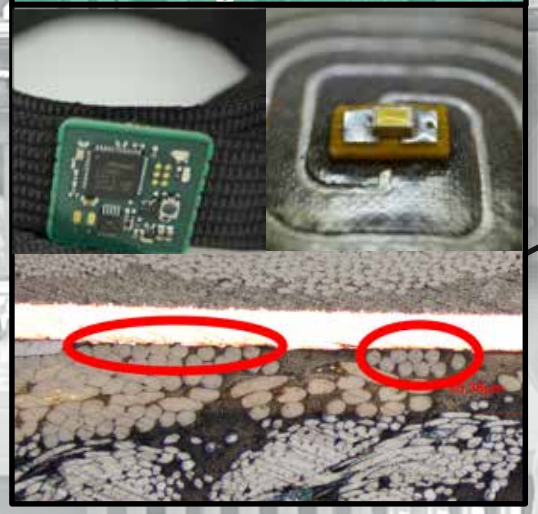
Materials (conductors) for e-Textiles

Textile Circuit Manufacturing

Textile Integrated Systems

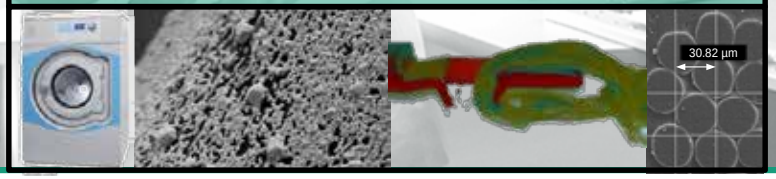
TexLab
SOFT HARD SMART

Integration & Interconnection Technologies



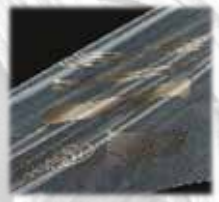
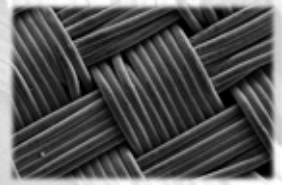
E-Textile System Development

Testing and Analysis



Materials (conductors) for e-textiles

There is a diversity of conductive materials for e-textile applications on the market.

Coated fibers, yarns, threads	Stranded wires / litz wires	Hybrid wires	Inks / metal foil	Conductive Fabrics
	 		 	  
• STATEX • Noble Biomaterials • Imbut • Syscom Advanced Materials • Amann • Madeira • …	• ELEKTRISOLA • Fisk Alloy • Bekeart • Karl Grimm GmbH & Co.KG • …	• ELEKTRISOLA • ZIMMERMANN (Novonic) • Yarn service provider • Amann • Clevertex • …	• Du Pont • Creative Materials • Fraunhofer IZM • SensingTex • …	Woven, knitted, non-woven • STATEX • Metal Textiles (METEX) • …

textile character

Conductivity (textile character)

textile character

E-textile Circuit Manufacturing

Textile
Circuit
Board
Technology

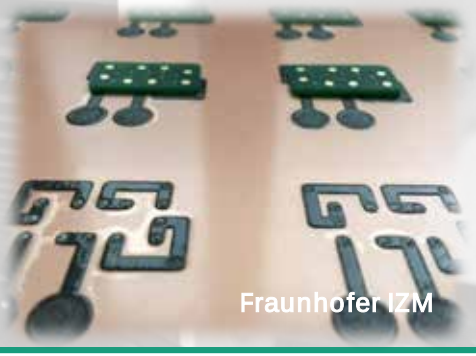
Technische Universität Berlin

Fraunhofer IZM

TexPCB technology

materials
MDPI and ACS Style
Dils, C.; Werft, L.; Walter, H.; Zwanzig, M.; von Krshiwoblozki, M.; Schneider-Ramelow, M. Investigation of the Mechanical and Electrical Properties of Elastic Textile/Polymer Composites for Stretchable Electronics at Quasi-Static or Cyclic Mechanical Loads. *Materials* **2019**, *12*, 3599.

- **TexPCB** is a **highly robust Textile-based Circuit Board** made of metallized polymer fabrics (woven, knitted or nonwovens) that are laser-structured into conductive patterns and embedded into a matrix of thermoplastic elastomer films.
- **TexPCB** :
  - **high freedom of design**
  - **tunable stretchability** by respective materials selection and geometric design
  - **Conductive contact** openings through structured coverlay e.g. for electrodes are possible **on both sides**.
- High **reliability** for cyclic **mechanical stress** as well as **washability**



Integration Technologies – General challenges

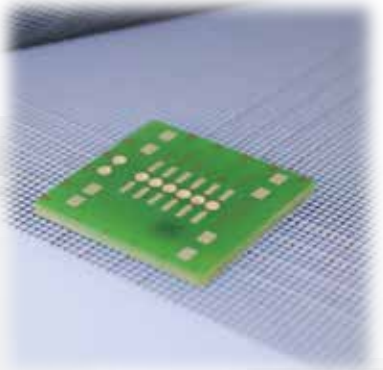
The textile industry and the electronics industry are not alike. Production facilities as well as products differ in many ways.

Textiles	Electronics
Limp, dimensionally unstable, often (anisotropically) stretchable → handling and alignment of components is challenging	Rigid (FR4) or foil often with support material to guarantee dimensional stability during manufacturing
Manufacturing environment is often full of particles (fibers)	Cleaner manufacturing environment (particles lead to errors)
Strong degradation or melting of most textile materials above 200 °C can be expected → contacting electronics is challenging	Peak temperature during reflow soldering above 250 °C (for std. solder)

- Suitable machinery to handle and manufacture e-textiles on large scale is still not available
- New technologies to enable a higher degree of integration are necessary (Customers want unobtrusive wearables, fully integrated, to be handled as textiles)
- **Mechanical stress** needs to be kept **away** from **electrical contacts (hard to soft transition area)**

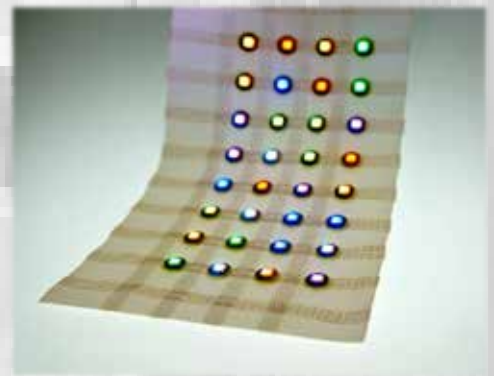
Interconnection Technologies: Adhesive Bonding

- Integration of electronic modules into textile circuits
- Mechanical and electrical interconnection
- Contacting insulated wires
- High I/O count possible
- Contacts on the bottom side à no peel forces can act on the contacts
- Compatible with woven, knitted, embroidered and TexPCB substrates

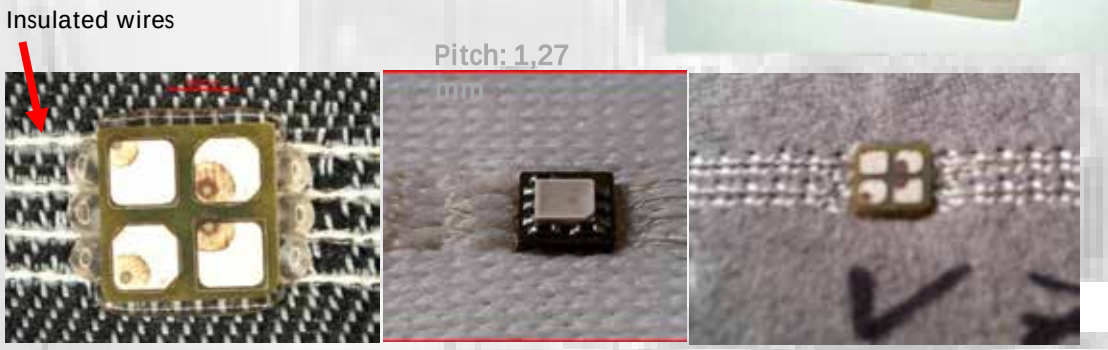


Alarm Textile

Textile display



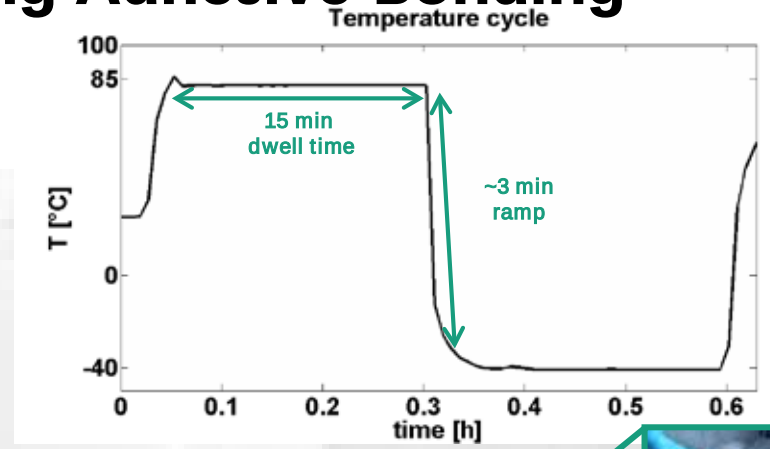
Ultra robust textile ribbing with insulated high performance conductors for power and data transfer
+
bonded sensor modules

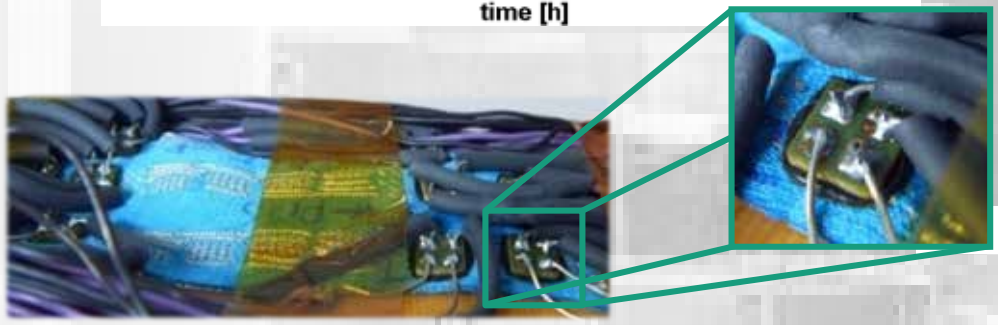


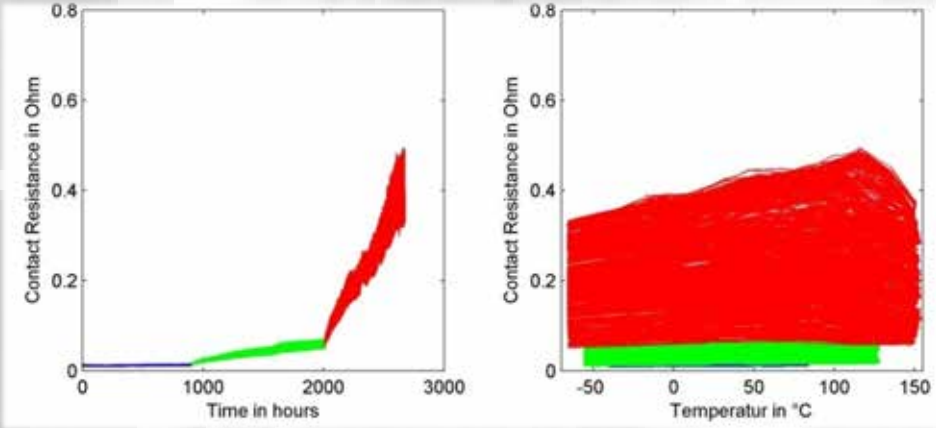
Woven substrate | Knitted substrate | Embroidered substrate (soutache)

Interconnection Technologies: Reliability Testing Adhesive-Bonding

- Temperature cycling (JEDEC JESD22 A104C)
  - 1000 cycles at different ranges
- Humidity tests (JEDEC JESD22 A101B)(85°C/85%H)
  - 1000h
- Wash cycling tests (ISO 6330)
  - 20 cycles







-40 °C – 85 °C | 1000 cycles
-55 °C – 125 °C | 1000 cycles (same samples)
-60 °C – 150 °C | 1000 cycles (same samples)

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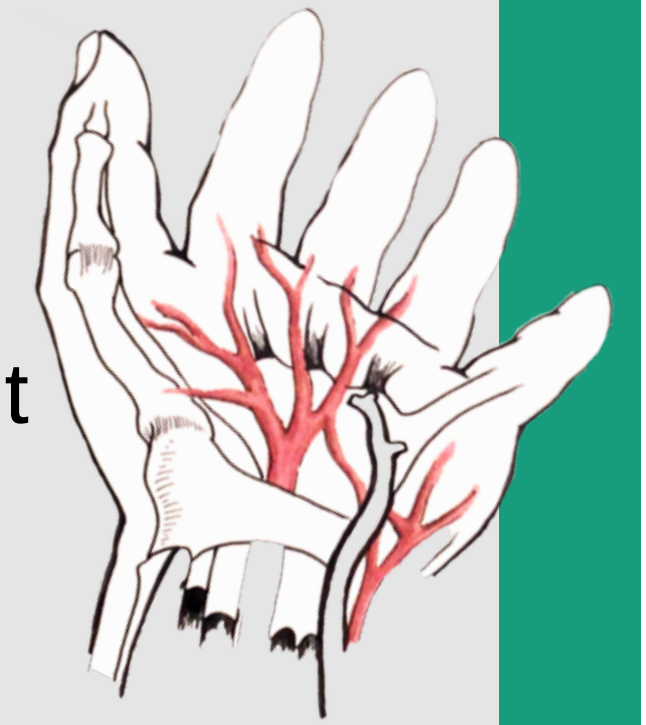
Interconnection Technologies: Large Area – High Precision Bonder

- Towards commercializing of adhesive bonding
- Prepared for large textile substrates (1x1 m² operation area)
- For bonding fine pitch circuitry modules with a multitude of I/Os
- Fast prototyping and manufacturing process development

GHOST – feel it.

The FMD Space Pilot Project

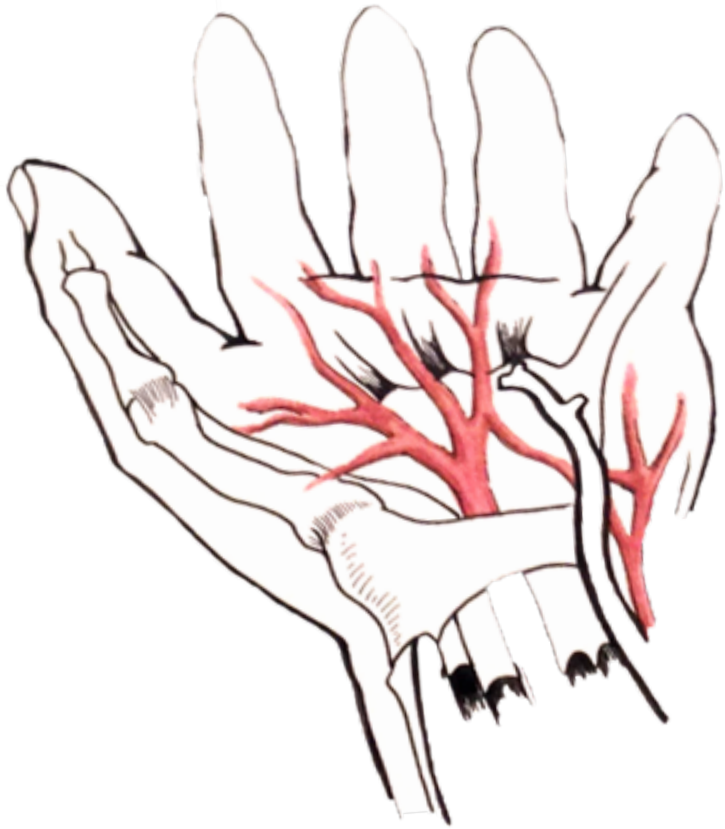


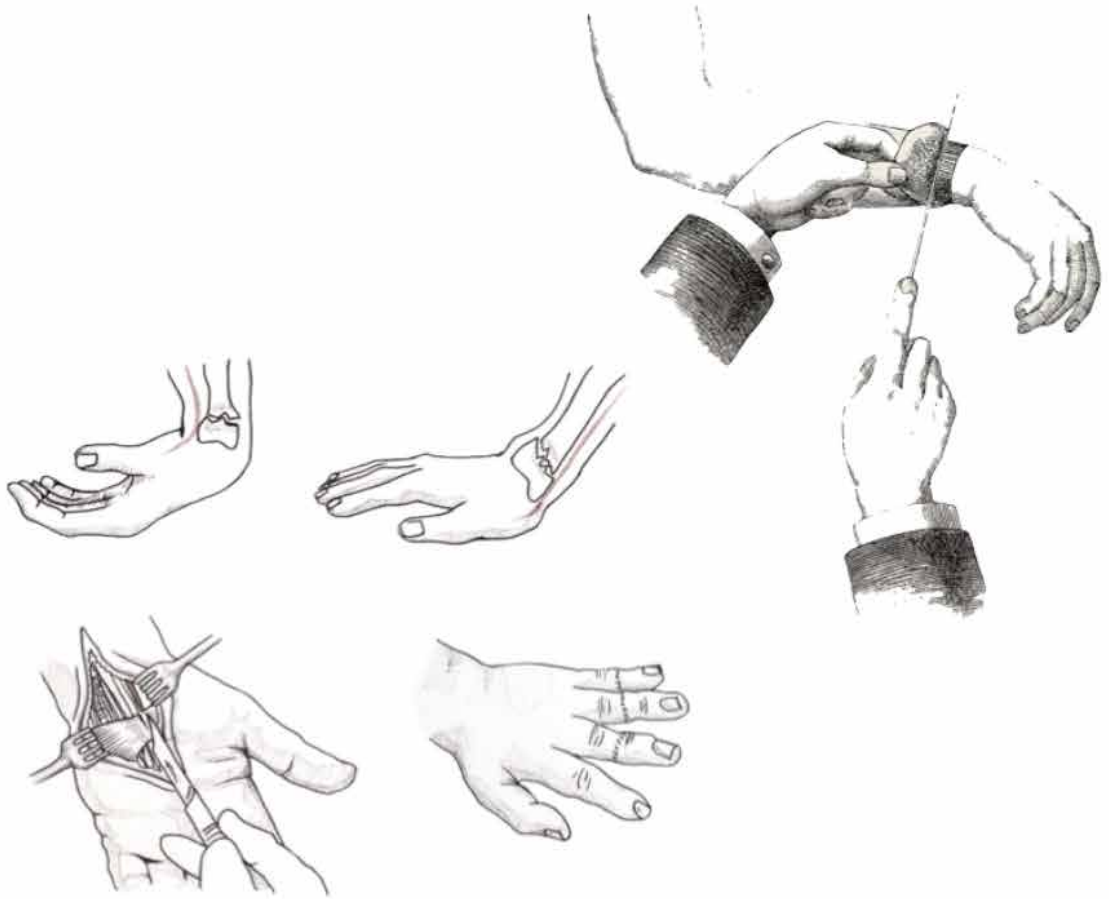
Forschungsfabrik Mikroelektronik Deutschland

A cooperation of Fraunhofer MIKROELEKTRONIK, FBH, ihp, Technische Universität Berlin

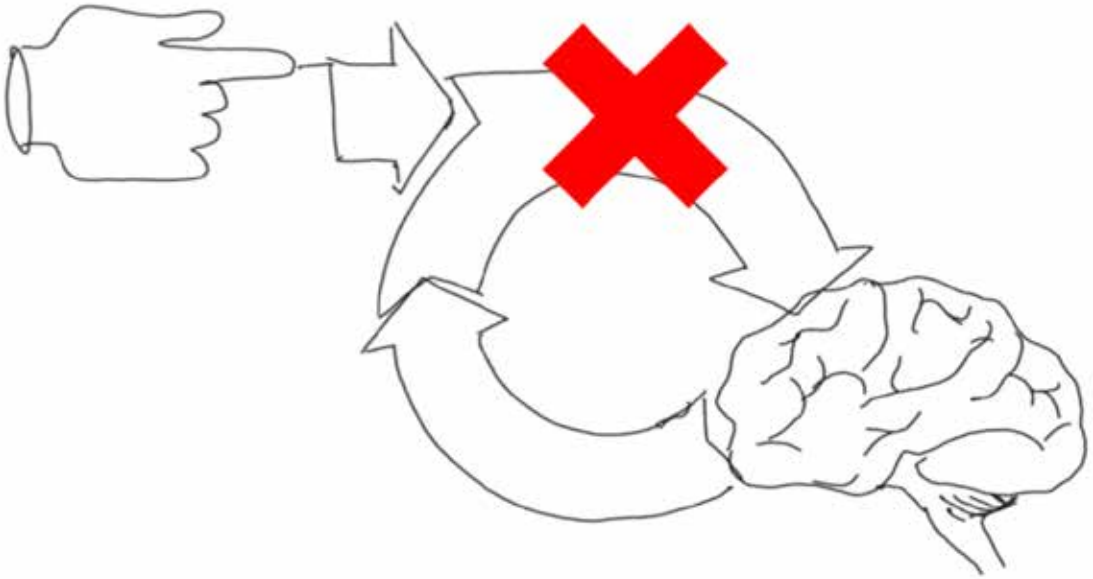
Fraunhofer IZM

Problem:
Irreparable Nerve Damage or Amputation





Incomplete Feedback Loop
ð No Proprioception



No feedback about enviroment

-Injury hazard

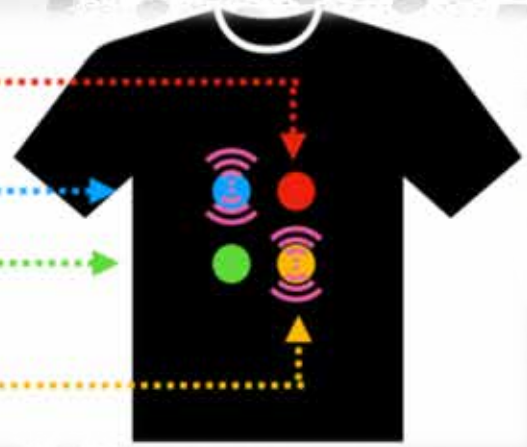
Lack of functionality

-Less usage

Lack of self-attribution

-Phantom pain

GHOST – feel it. Project



FMD Institute
Fraunhofer HHI

Sensor Glove

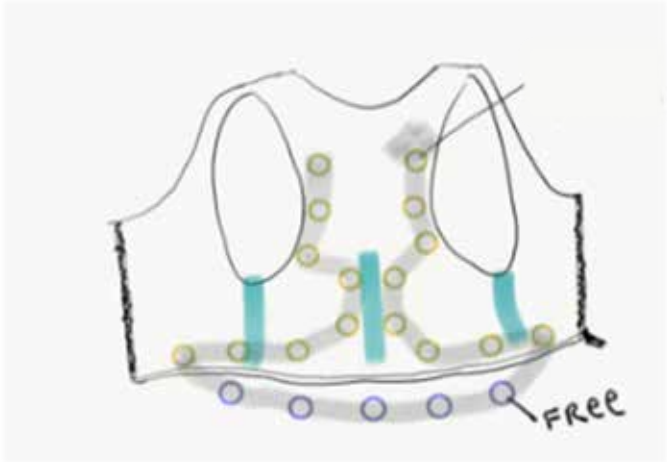
Start-up
GHOST – feel it.

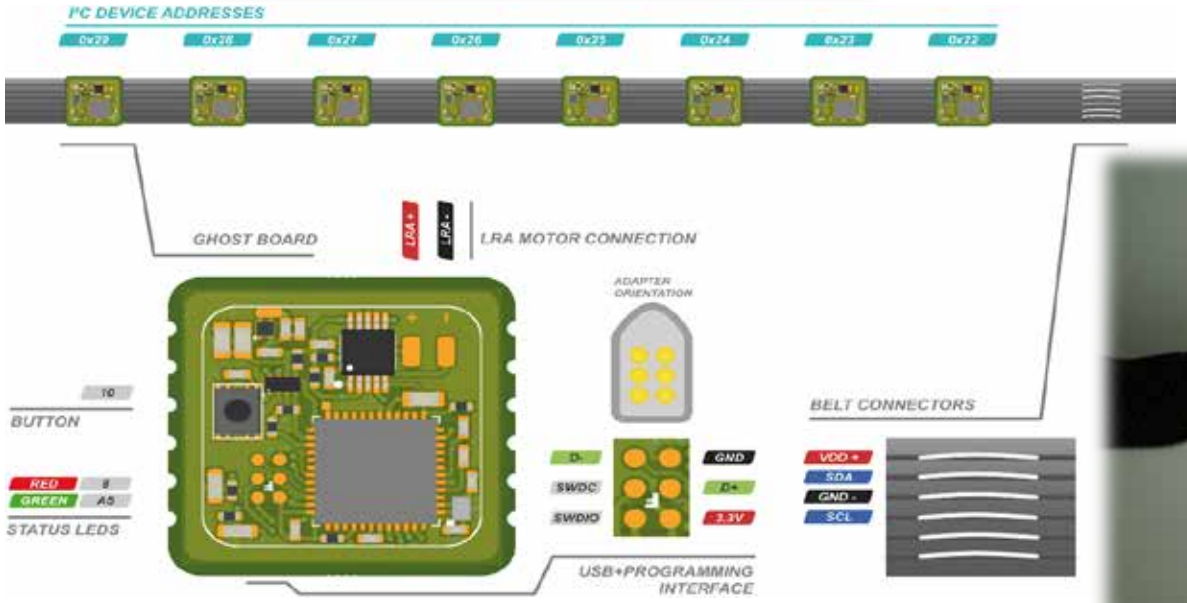
Haptic Language

FMD Institute
Fraunhofer IZM

Textile Actuator

System **Design and Prototype**





Wash Testing for smart textiles

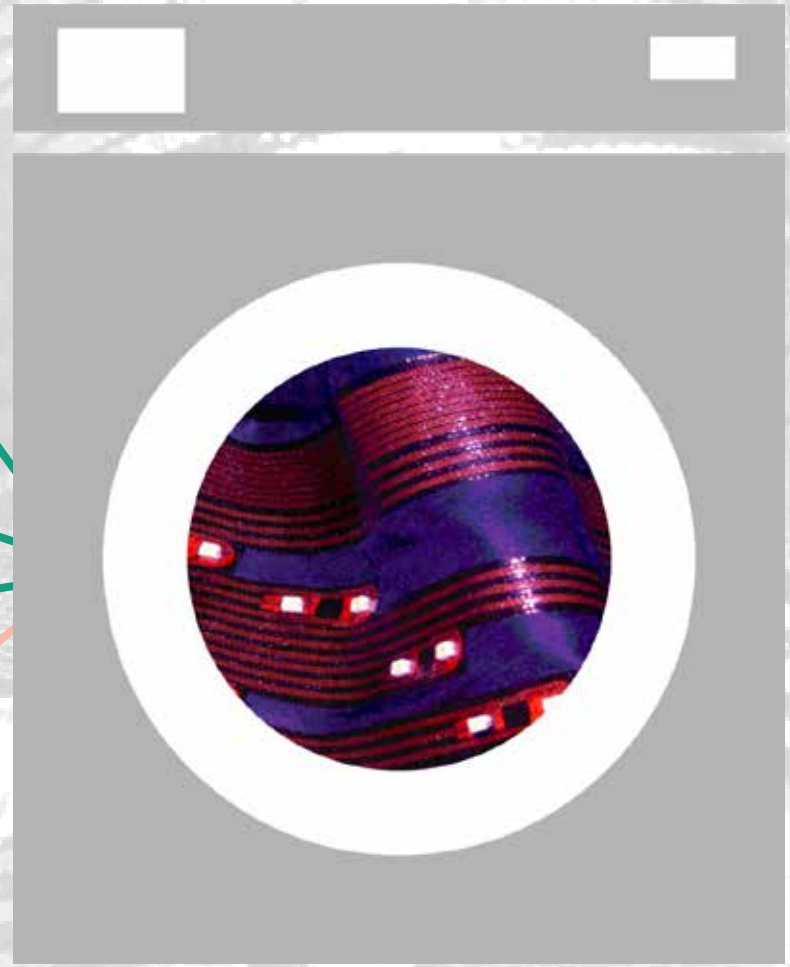
Influence of …

washing temperature

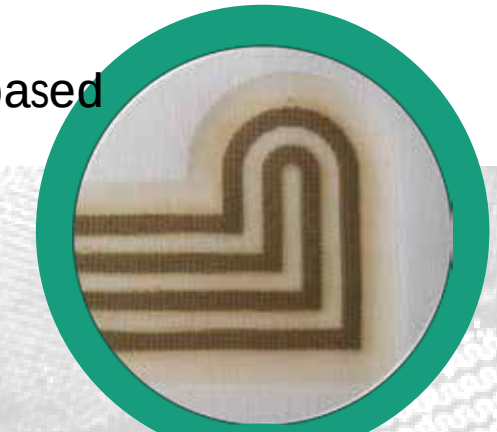
washing time

mechanical action

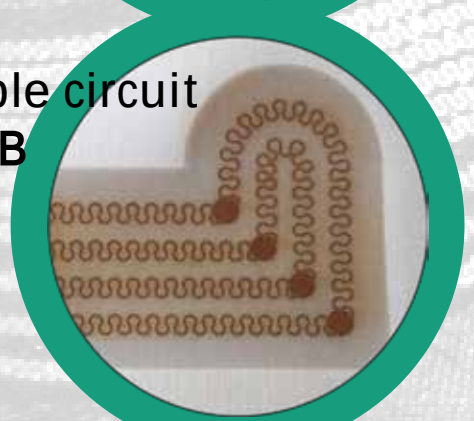
textile substrate



textile based **TexPCB**



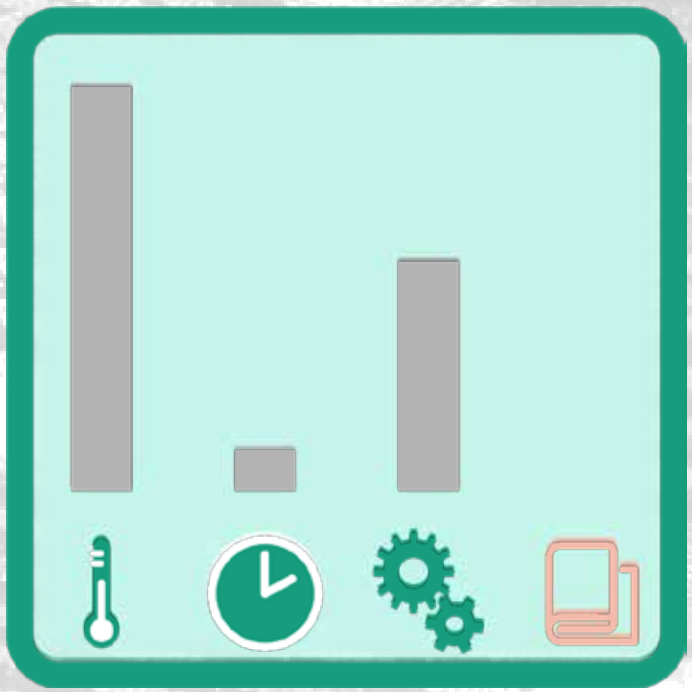
Stretchable circuit board **SCB**

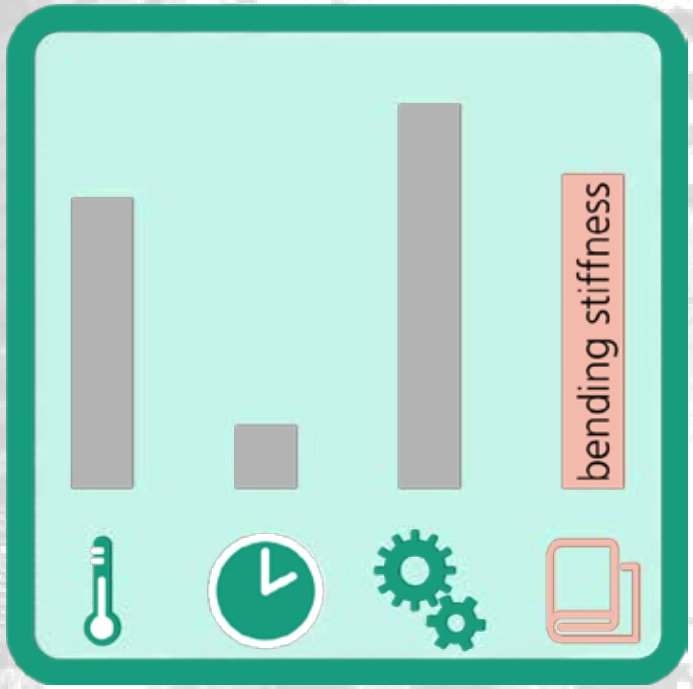


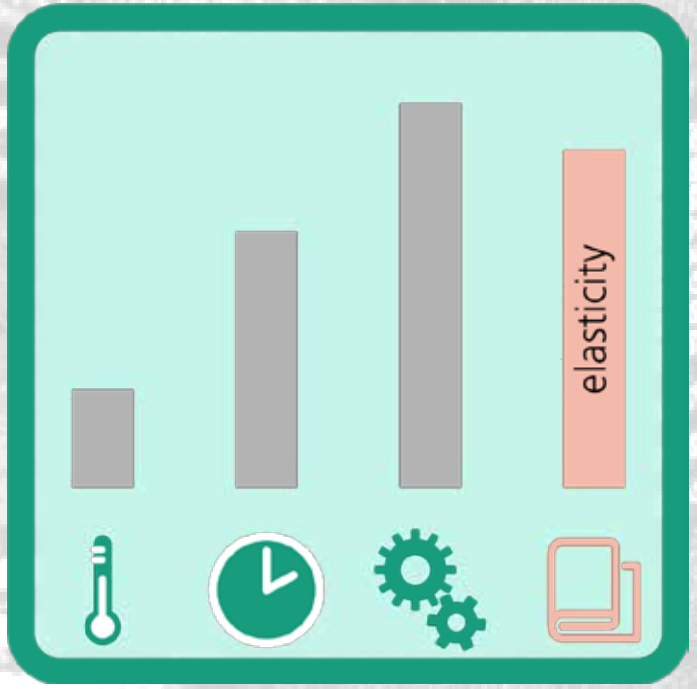
TFP embroidery

Wash Testing - results

Paper pending – Journal of the Textile Institute







textile based
TexPCB

Stretchable
circuit board
SCB

TFP
embroidery

Wash Testing – lessons learned

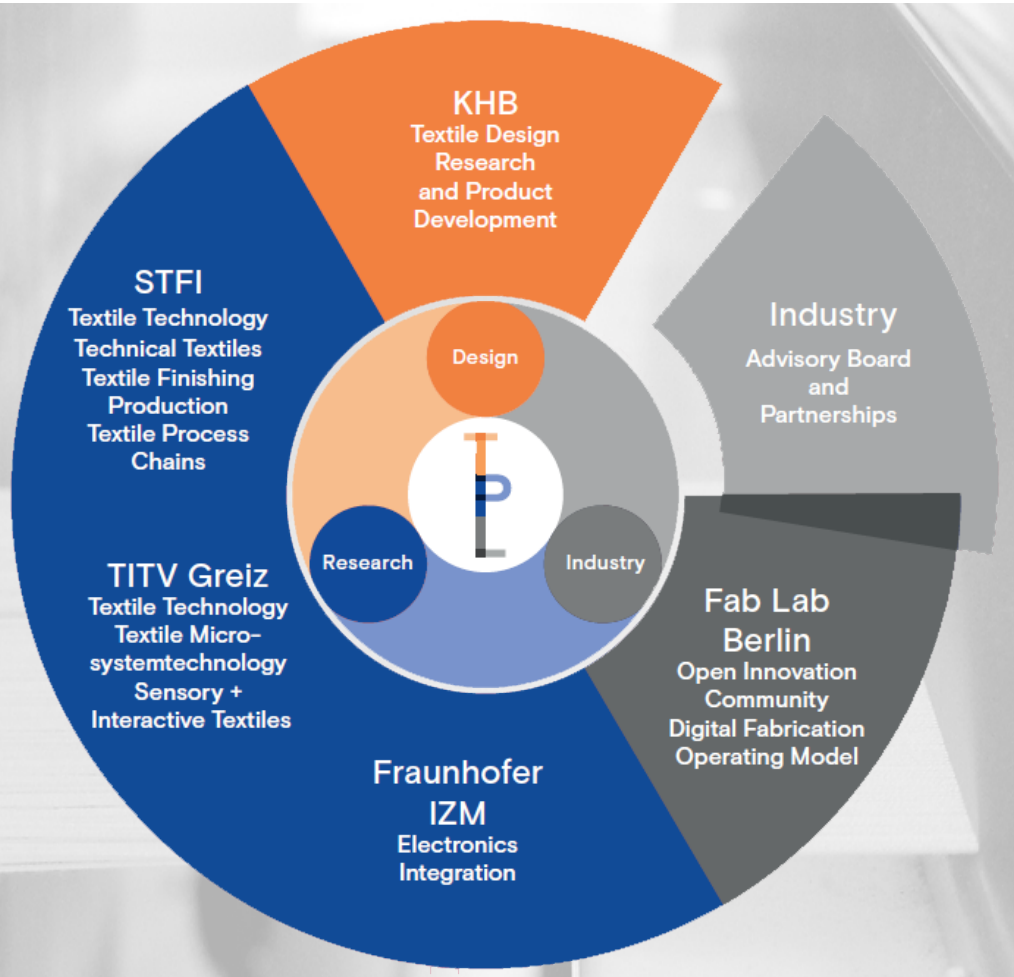
Washability of smart textiles **has to be improved** to guarantee **usability** and **wearability** and for better user acceptance.

Common standards and **accelerated test protocolls** are needed for comparable assertions of washability.

Washability results depend on **textile substrates**, type of **circuit path** and **processing parameters**.

Textile Prototyping Lab Berlin

The first open laboratory for the development of high-tech textiles in Germany.
A platform for the promotion of Open Innovation and networking between research, design and industry.



https://www.textileprototypinglab.com/

Berzina, Zane; Glomb, Essi Johanna; Diaz Rodriguez, Sara; Große, Anna; von Krshiwoblozki, Malte; Wolf, Heiko; et al. (2019): Textile Prototyping Lab - A Platform and Open Laboratory for the Promotion of Open Innovation and Networking between Research, Design and Industry. figshare. Conference contribution.

https://doi.org/10.17028/rd.lboro.9724700.v1

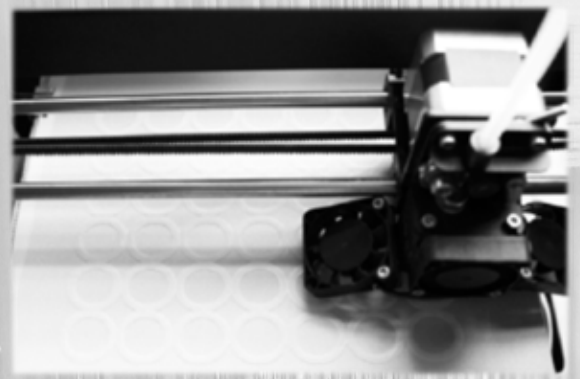
Textile Prototyping Lab Berlin

Lab + Technologies

Central Lab / Focus Labs

Focus:

3D Printing
Weaving, Knitting, Embroidery
Electronics
Finishing
Testing
Material and Sample Archive



We would love to cooperate with you!

Fraunhofer Institute for
Reliability and Microintegration IZM

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futureTEX

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