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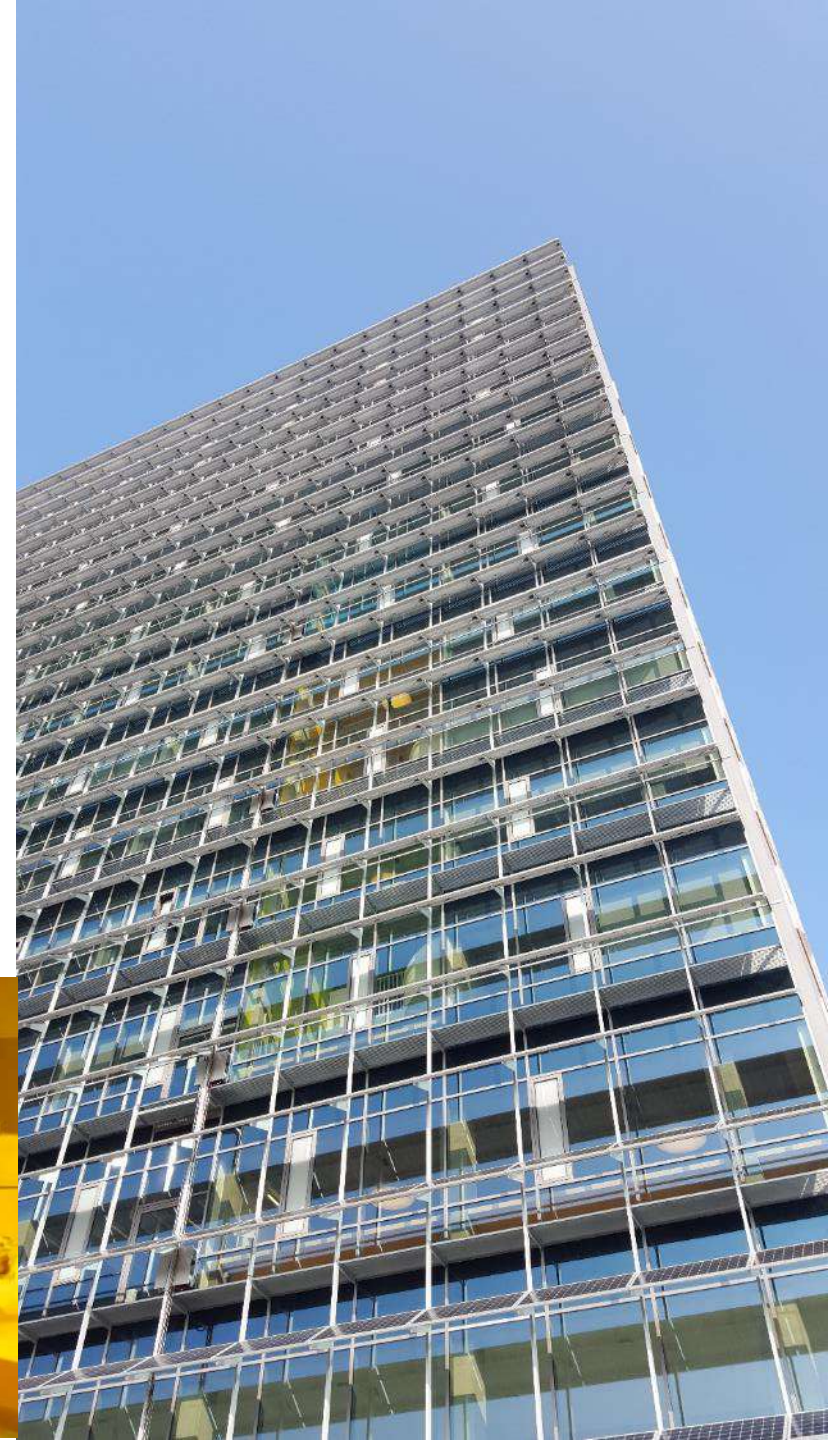
**“STRUCTURAL ELECTRONICS AND E-TEXTILES”
FOR SMARTEES2 WORKSHOP**

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IMEC - CMST

FACTS & FIGURES

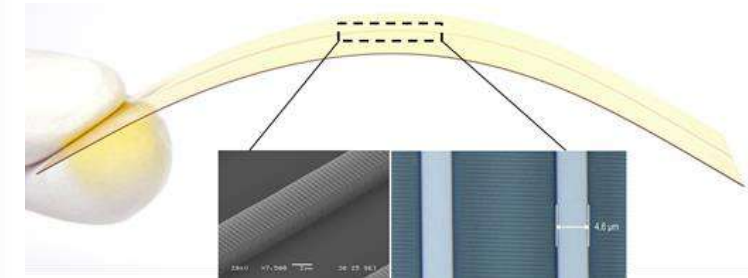
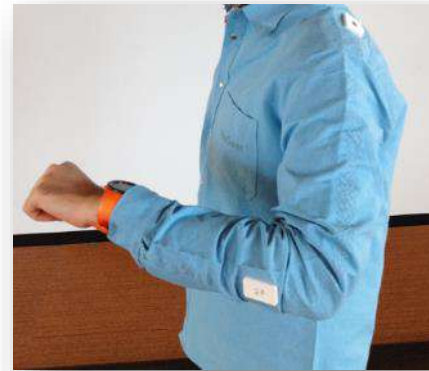
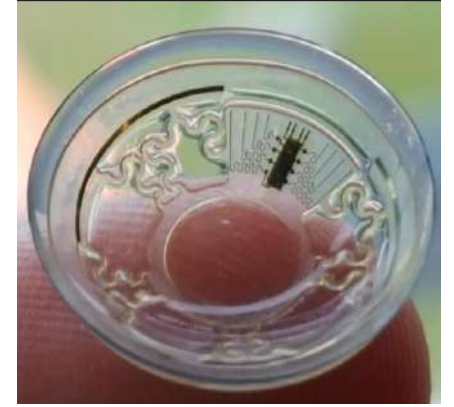
- Research Group Center for Microsystems Technology
- Situated on the Technologiemark in Gent-Zwijnaarde, Belgium
- Affiliated lab with imec and Ghent University
- Research group of ~ 60 people



IMEC - CMST

RESEARCH TOPICS

- CMST is designing and developing microsystems such as implantable devices, smart contact lenses, optical sensors and devices for IoT
- Developing technology platforms such as
 - flexible and stretchable electronics ←
 - opto-electronic packaging
 - polymer waveguides
 - liquid crystal technology
 - microfluidics
 - thin chip packaging
- Bringing together expertise from electronics, mechanics, physics and chemistry
- Fundamental research projects and funded collaborative projects



CONTENTS

- Stretchable electronics
- Structural electronics
- E-Textiles
- Conclusions

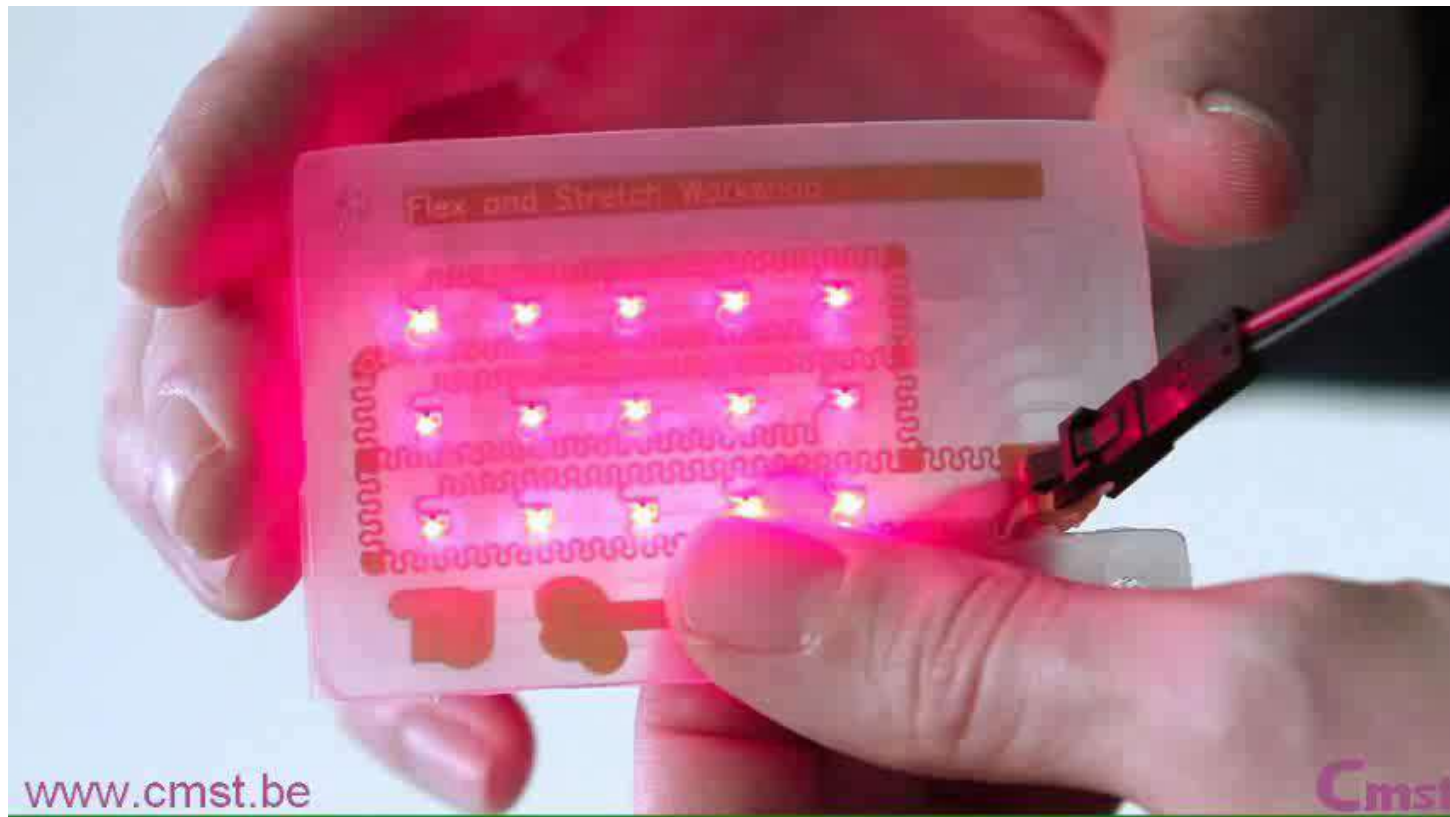
CONTENTS

- **Stretchable electronics**
- Structural electronics
- E-Textiles
- Conclusions

STRETCHABLE ELECTRONICS

CONFORMABILITY

- Our developed platform for stretchable electronics offers conformability



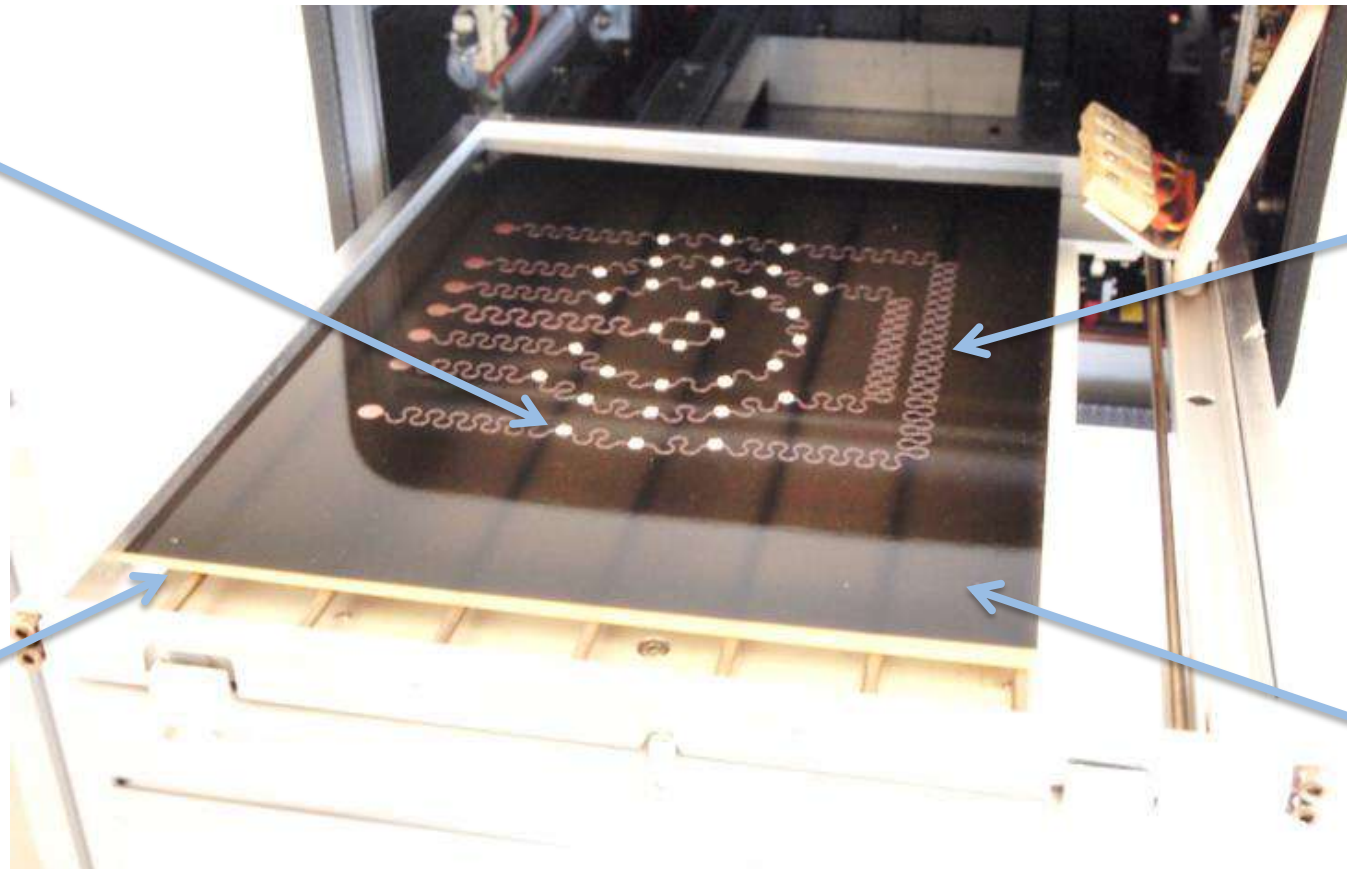
STRETCHABLE ELECTRONICS

MANUFACTURING METHOD

- Principle of using temporary carrier to produce stretchable circuit : all harsh PCB style steps (Cu etch, high T solder assembly) done in absence of embedding polymer

Functional island

Stretchable interconnects



Rigid carrier

Temporary Adhesive layer

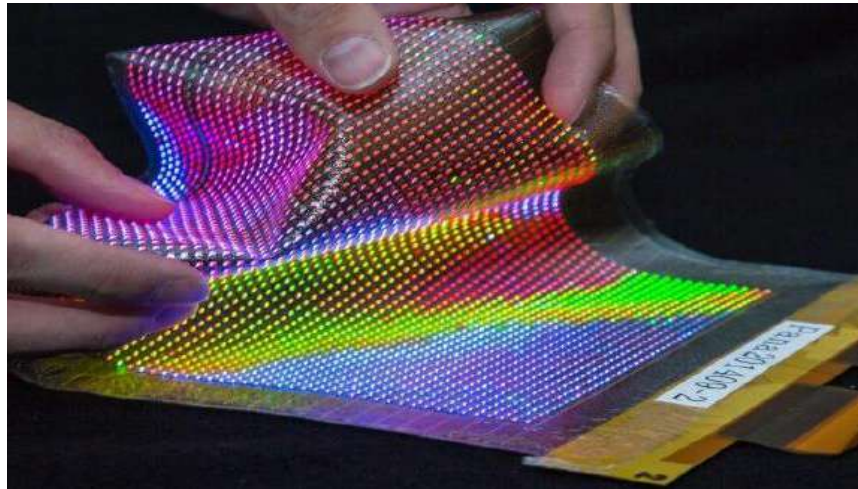
STRETCHABLE ELECTRONICS

ADVANTAGES OF OUR APPROACH

- Our process has some advantages compared to e.g. traditional screenprinting directly on plastic/elastic substrates:
 - Use of copper: for applications where high power is needed
 - Starting from (multilayer) flexible circuit that is transformed into stretchable circuit
 - Versatility of encapsulation materials and methods



Stretchable circuit embedded in silicone



Stretchable circuit embedded in TPU



Stretchable circuit embedded in PC

CONTENTS

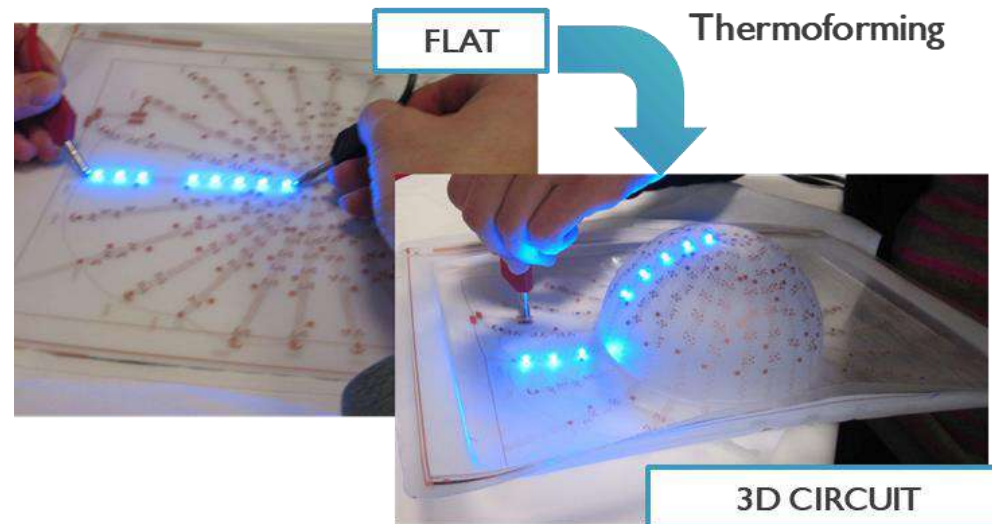
- Stretchable electronics
- **Structural electronics**
- E-Textiles
- Conclusions

STRUCTURAL ELECTRONICS

INTRODUCTION

Structural electronics

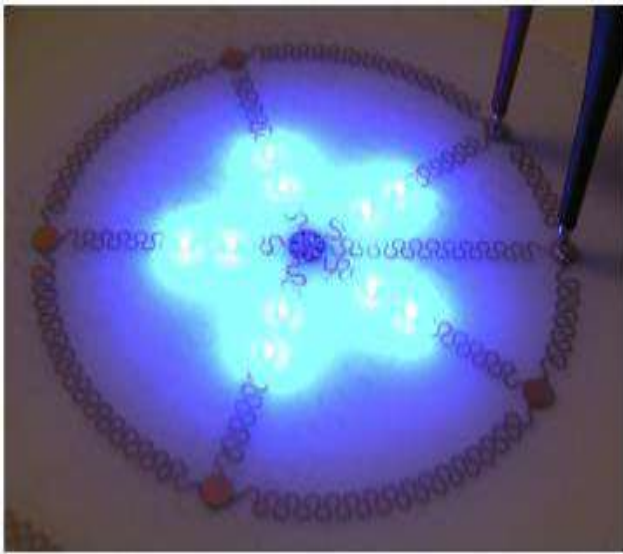
- refers to a next-generation based electronics technology, which involves functional electronic circuitries, across **irregular-shaped architectures**.
- is expected to replace bulky load-bearing structures within a circuitry with smart electronic components that can **conform to complex shapes for ensuring optimum space utilization**.
- offers **different and better ways of implementing electronic functionalities** (lighting, sensors) into the products.



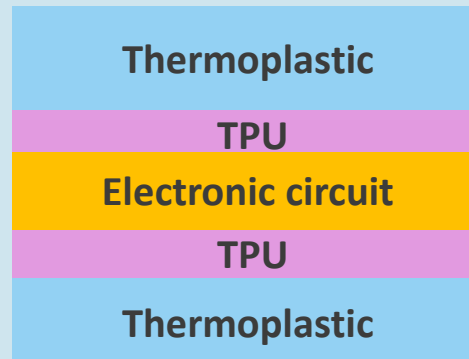
FABRICATION PROCESS @ IMEC/UGENT

FABRICATION AND LAMINATION

Fabrication of flat electronic circuit



Typical material stack



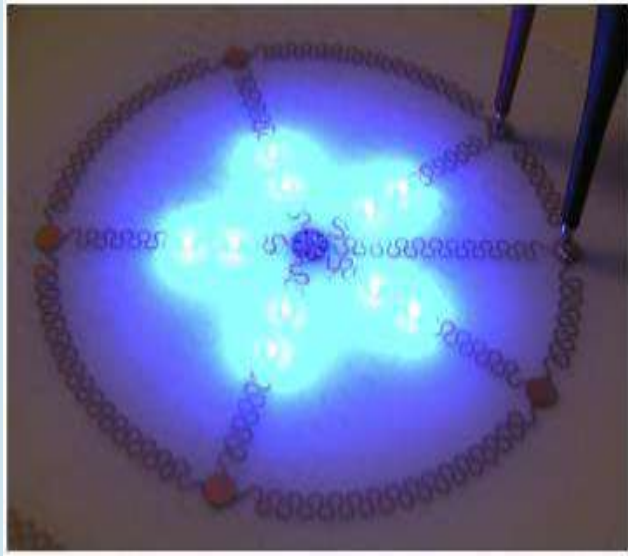
Properties

- Conductors:
Etched copper / Printed silver
- Thermoplastic:
PC / PP / PETG / etc.
- Electronic functionality:
Lighting
Sensing (touch)
Antennas

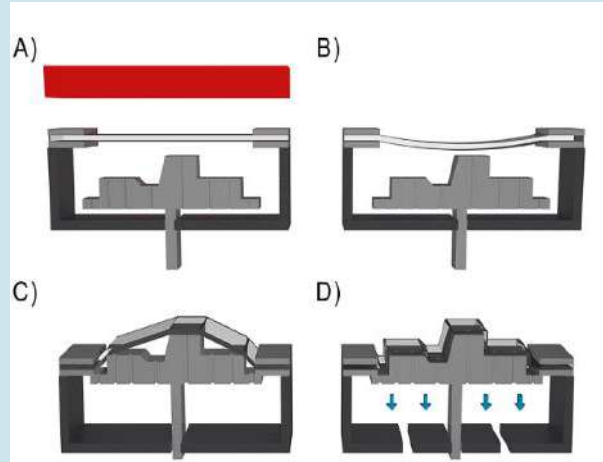
FABRICATION PROCESS @ IMEC/UGENT

THERMOFORMING

Fabrication of flat electronic circuit



Thermoforming

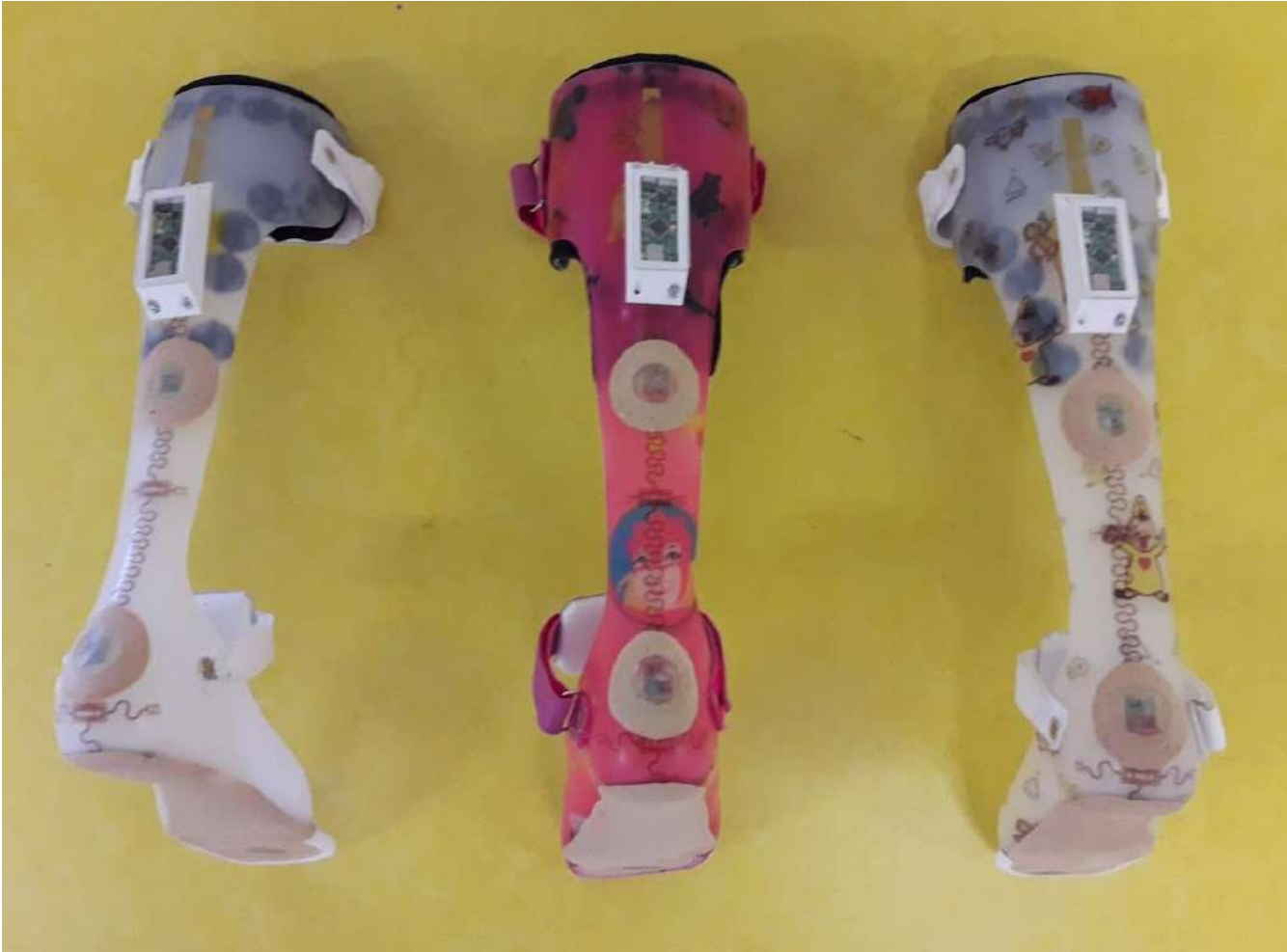


3D circuit



EXAMPLES OF REALIZATIONS OF STRUCTURAL ELECTRONICS

SMART ANKLE FOOT ORTHOSES WITH MOVEMENT SENSORS



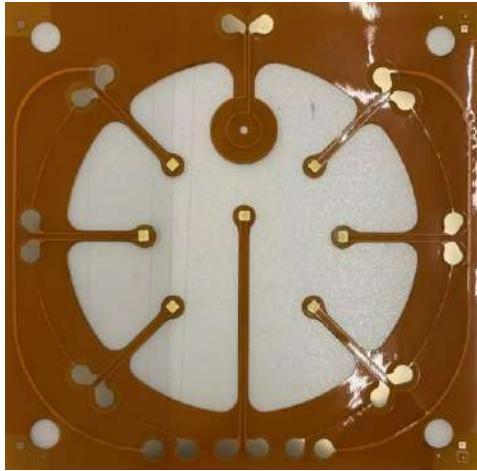
- For gait analyses of impaired people
- Orthoses with 3 built-in movement sensors
- Local signal processing and BLE communication
- Based on a stretchable circuit embedded in the plastic material surviving a thermoforming process to form the orthoses shape

MORE EXAMPLES USING LEDS

POSITIONING 7 LEDS IN DESIRED SPATIAL 3D LOCATION

We have used here non-stretchable circuits to control the LED component position and make the process reproducible.

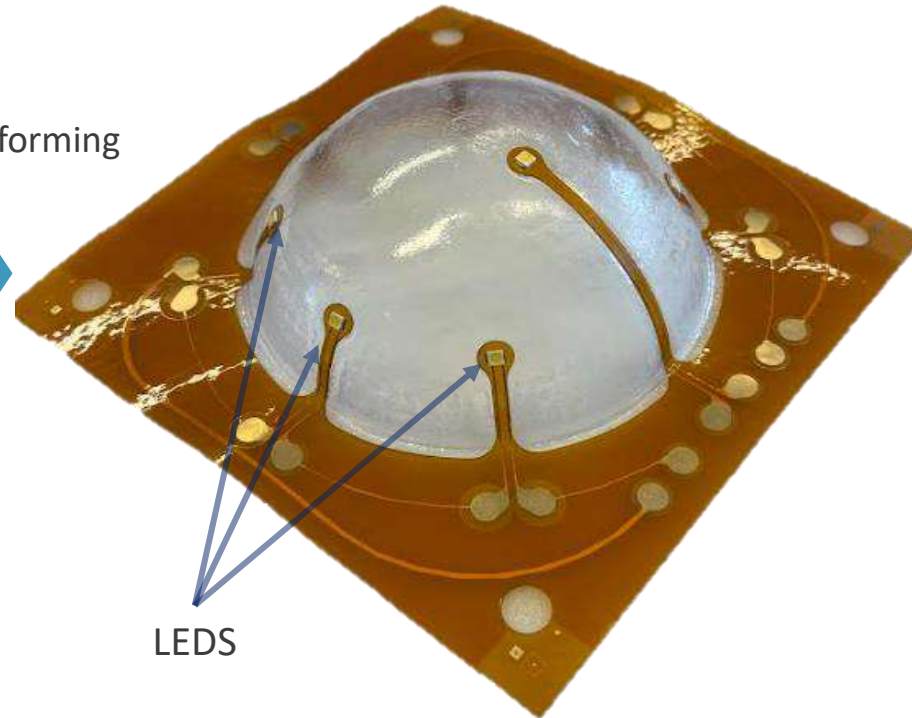
2D fabricated stack



Thermoforming



3D shape (after thermoforming)



Functionality after thermoforming

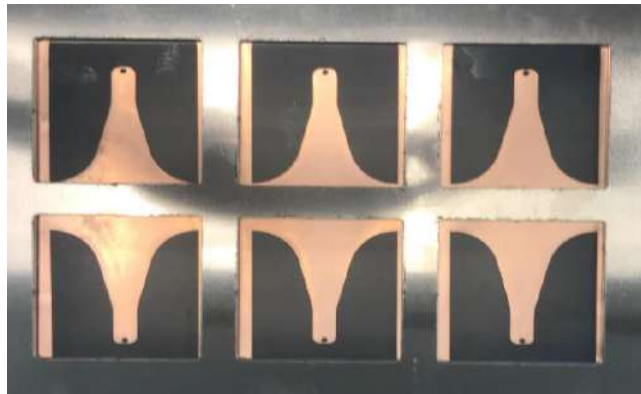
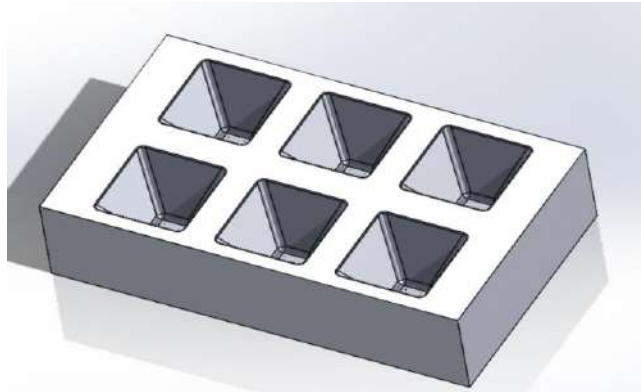


MORE EXAMPLES USING LEDS

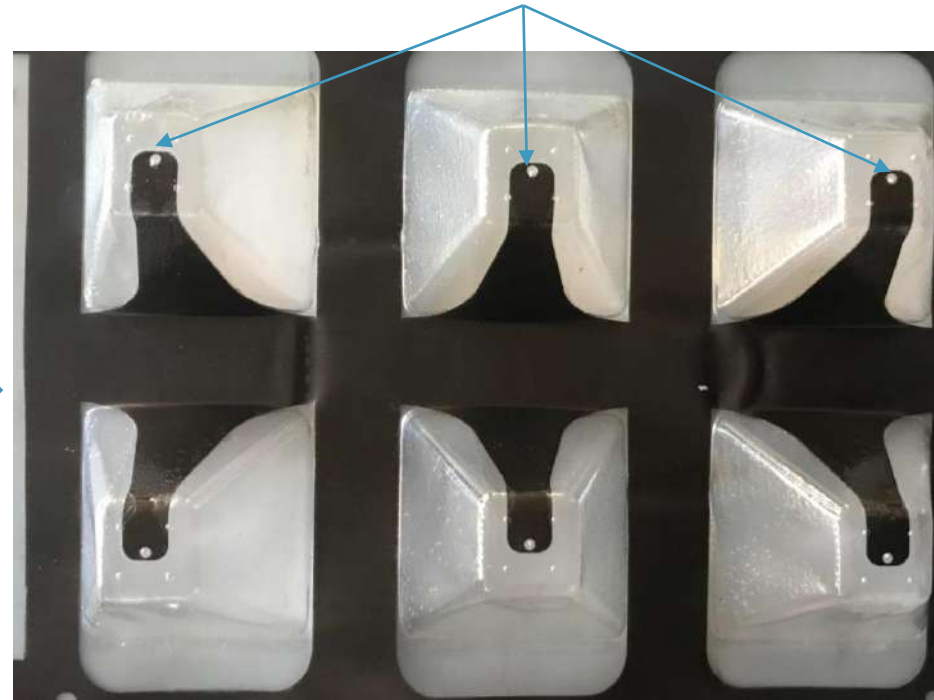
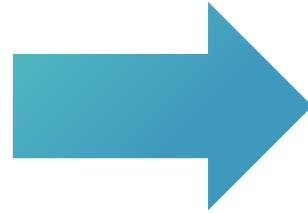
LUMINAIRE APPLICATION

We have used here non-stretchable circuits to control the LED component position and make the process reproducible.

All the LEDS (Circles) are in the same place in the bottom of the cavity



Thermoforming



CONTENTS

- Stretchable electronics
- Structural electronics
- **E-Textiles**
- Conclusions

INTRO E-TEXTILES

WHAT?

Features of e-textile

- Sensing
- Actuating
- Powering
- Data processing
- Communicating
- Interconnecting



E-Textile Garments



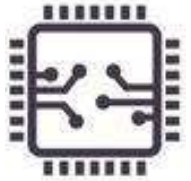
Technical textiles

This needs integration of electronics, while **preserving** the original textile properties.

INTRO E-TEXTILES

E-TEXTILES @ IMEC

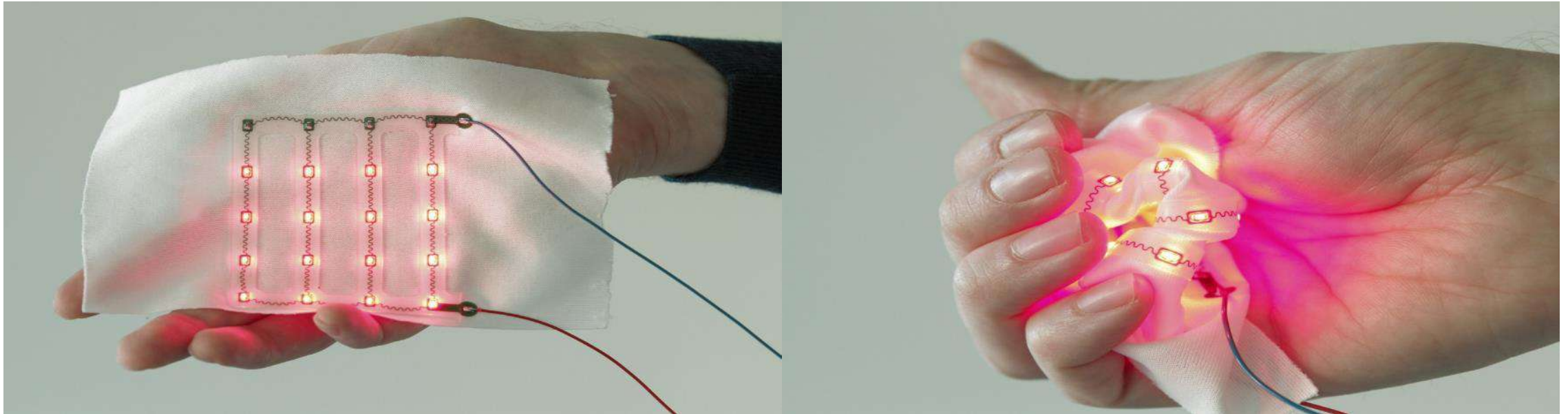
- Focus on development of packaging technologies to realize electronic circuits compatible with properties of textiles
- Investigate reliability of these systems
- Realization of prototypes in different projects



E-TEXTILES

STRETCHABLE ELECTRONICS AS BASE

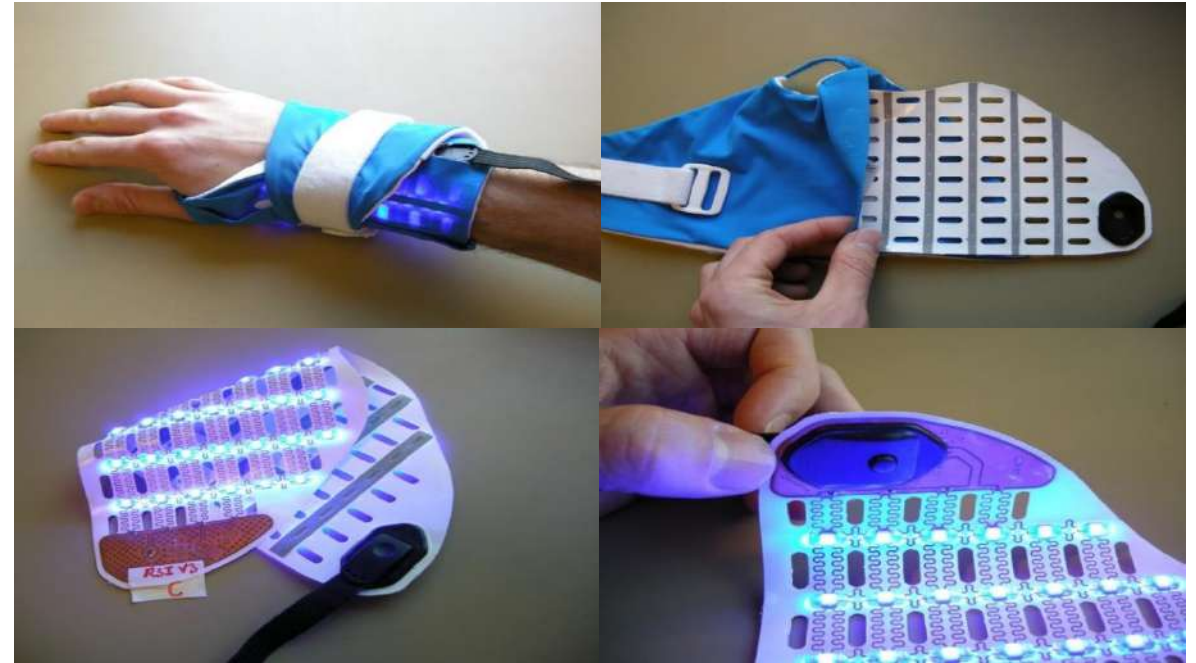
- Stretchable electronics are used as base for integration of electronics in textiles



STRETCHABLE ELECTRONICS

AN EXAMPLE: CONFORMABLE WRIST-BASED PHOTOTHERAPY DEVICE

- Phototherapy: using light for relieve of pain
- Fully integrated (LEDs, passives,...) on foil
- Highly conformable to the hand by using stretchable electronics technology
- Embedded in silicone for wear comfort and washability



E-TEXTILES ARCHITECTURE @ IMEC-CMST

APPROACH



- We develop building blocks for systems as shown in the picture.

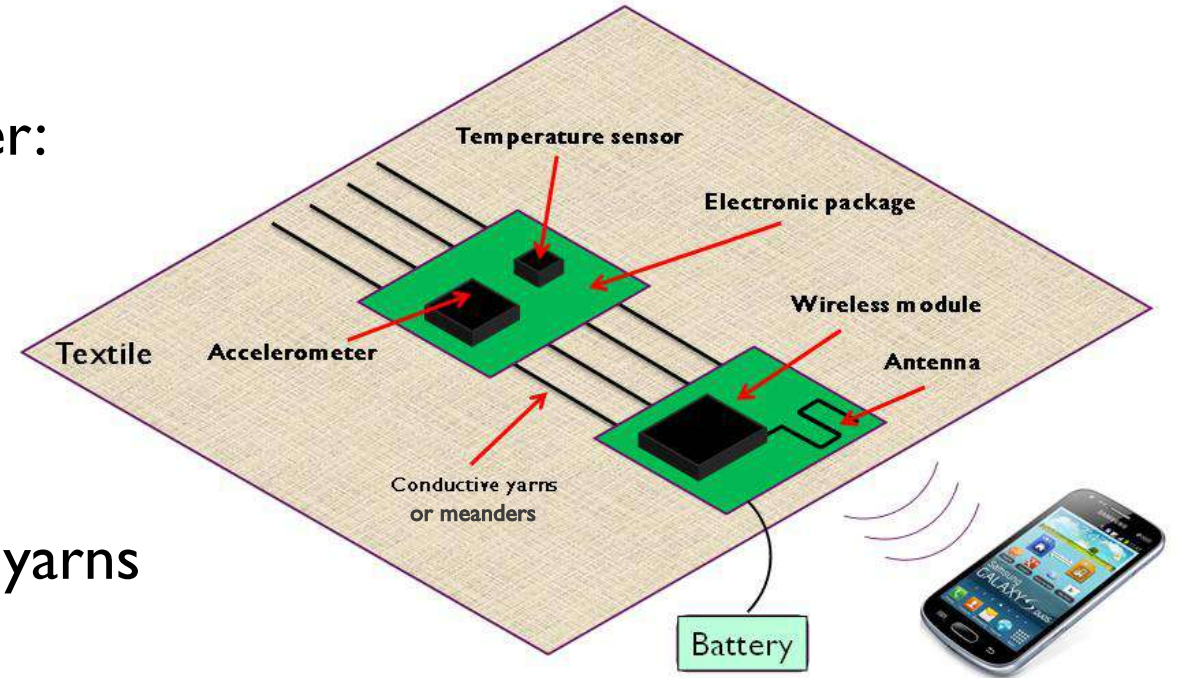
This needs:

- Sensing
 - Actuating
 - Powering
 - Data processing
 - Communicating
 - Interconnecting
- It's not very efficient to make very large stretchable circuits → Splitting them up in smaller parts and use **meanders** or **conductive yarns** to interconnect them

WEARABLES AND E-TEXTILES

REALIZATION OF BUS SYSTEMS

- Smart nodes interconnected with each other:
 - Sensor/Actuator nodes
 - Data processing nodes
 - Wireless communication nodes
 - Powering nodes
- Stretchable interconnections or conductive yarns as way to interconnect them



Stretchable interconnects

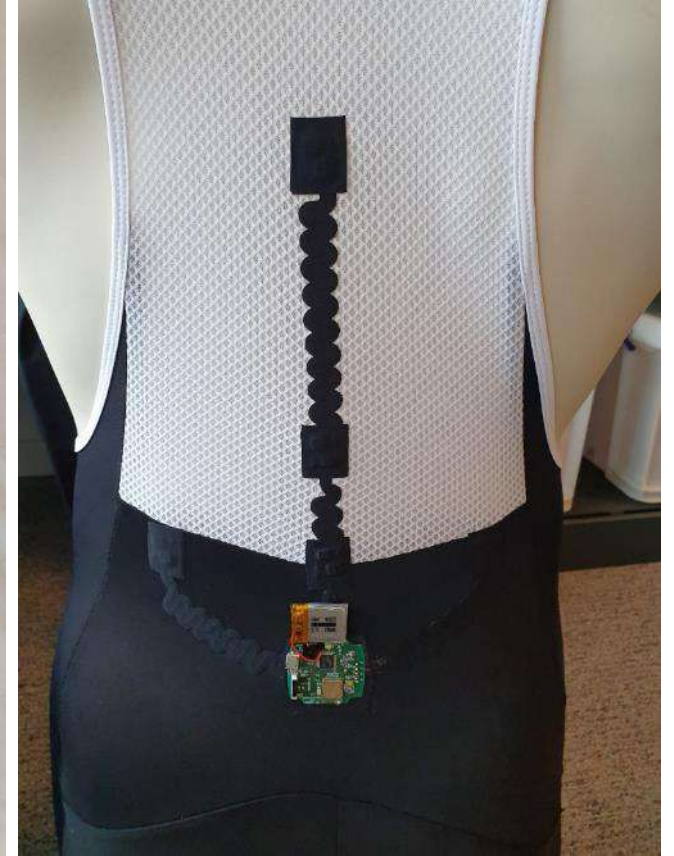
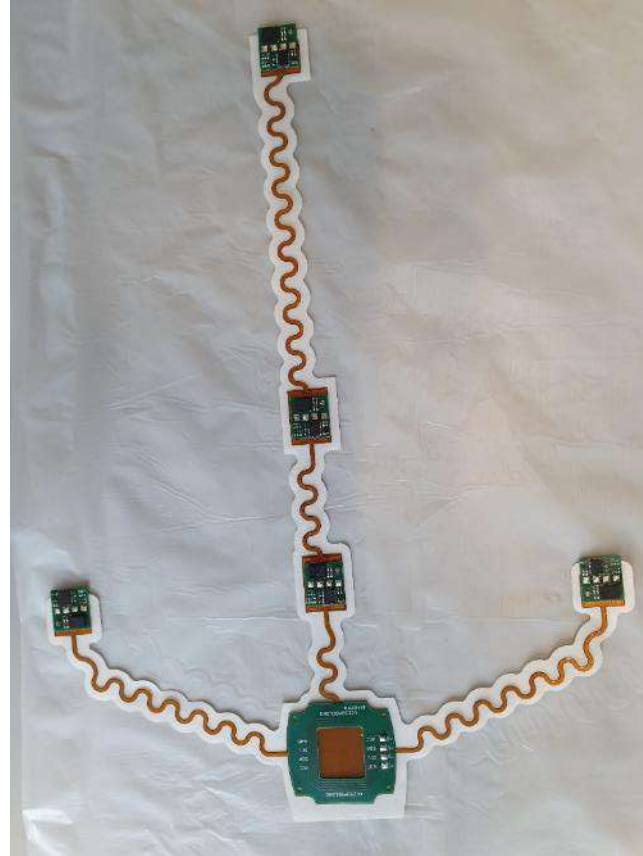


Conductive yarns

BIKESHIRT WITH INTEGRATED SENSORS

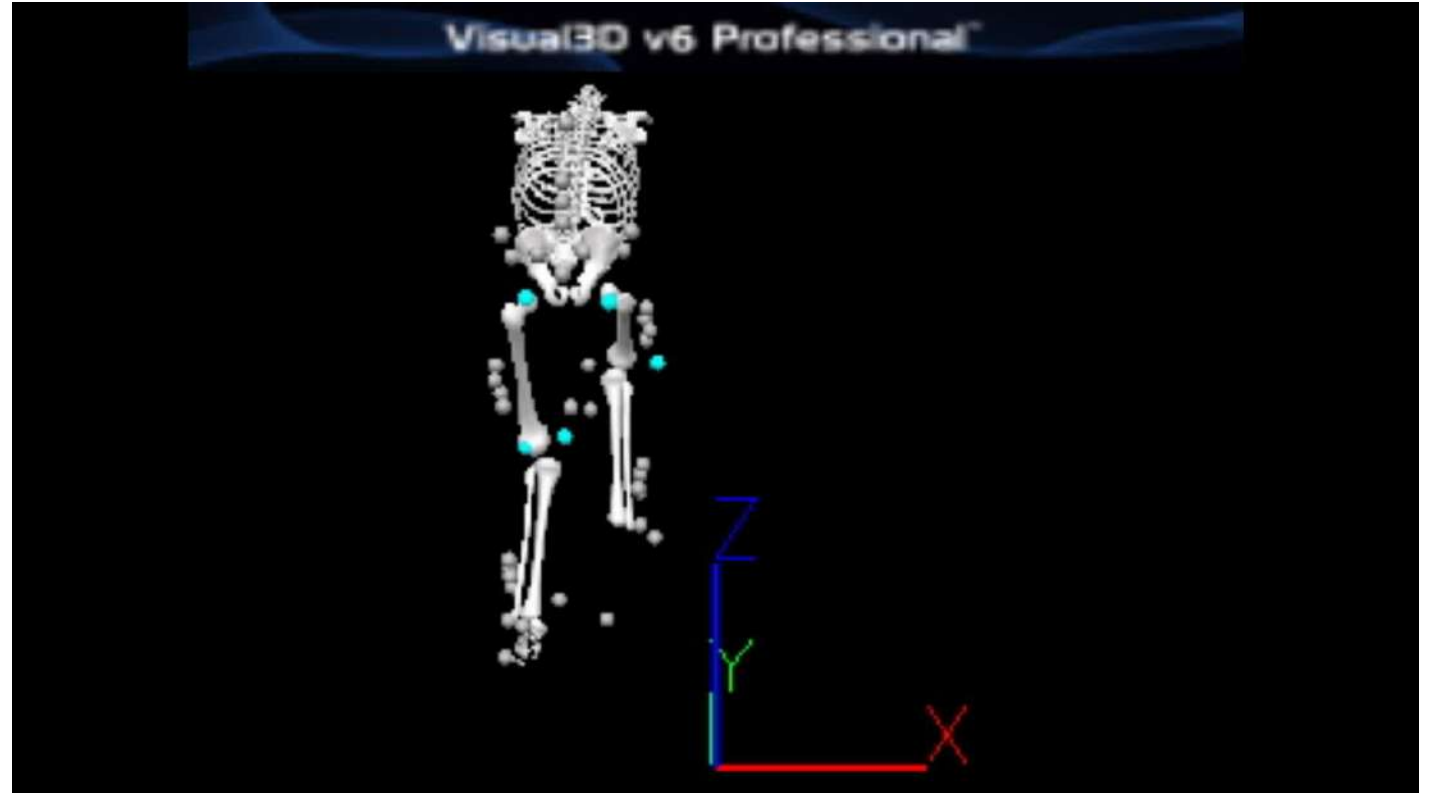
NANO4SPORTS PROJECT

- Measure curvature of lower spine
 - 3 movement sensors along spine
- Measure hip movement
 - 2 movement sensors at hip
- 50Hz readout
- Bluetooth



BIKESHIRT WITH INTEGRATED SENSORS

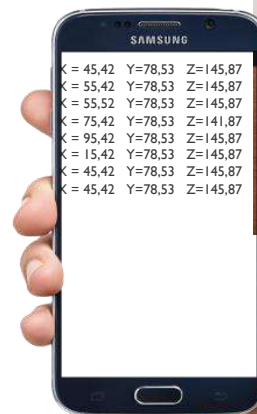
NANO4SPORTS PROJECT



Functional prototypes are available for measurements.

WEARABLES AND E-TEXTILES

STRETCHABLE FABRICS WITH CONDUCTIVE YARNS AND SENSOR NODES



Sensor data is captured on smartphone / smart home infrastructure

Elasta

BEKAERT
better together

GYSEMANS CLOTHING GROUP

umec

sirris

HoGent

RESEARCH ON WASHABILITY

RECENT PUBLICATIONS



- [Testing for Wearability and Reliability of TPU Lamination Method in E-Textiles](#)

P.Veske, F. Bossuyt, J. Vanfleteren, Sensors 22 (1), 156, 2021

- [Development and washing reliability testing of a stretchable circuit on knit fabric](#)

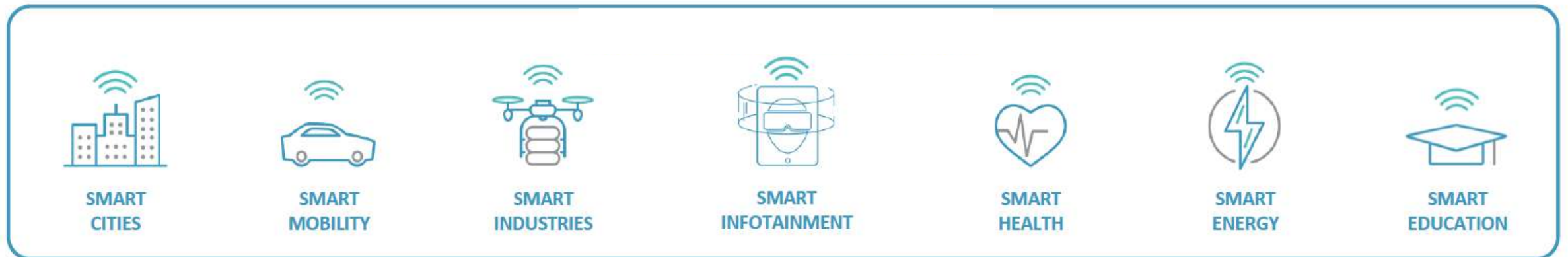
P.Veske, P. Bauwens, F. Bossuyt, T. Sterken, J. Vanfleteren, Applied Sciences 10 (24), 9057, 2020

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- **Conclusions**

CONCLUSIONS

- The big picture for structural electronics and e-textiles is extremely promising.
 - For structural electronics: unprecedented design possibilities to combine plastics and electronics
 - For e-textiles: unquestionable potential when combining the comfort, feel and look of textiles with the functionality, connectivity and intelligence of electronics.
- A lot of application domains can benefit from it:



CONCLUSIONS

- At CMST, we focus on:
 - Development of packaging technologies and processes
 - Investigate reliability
- In the scope of different projects, we realize prototypes together with the industry

Got inspiration from this presentation for your application? Contact us for a talk!



Offices



Cleanroom



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