STRETCHABLE ELECTRONICS

OVERVIEW PRESENTATION

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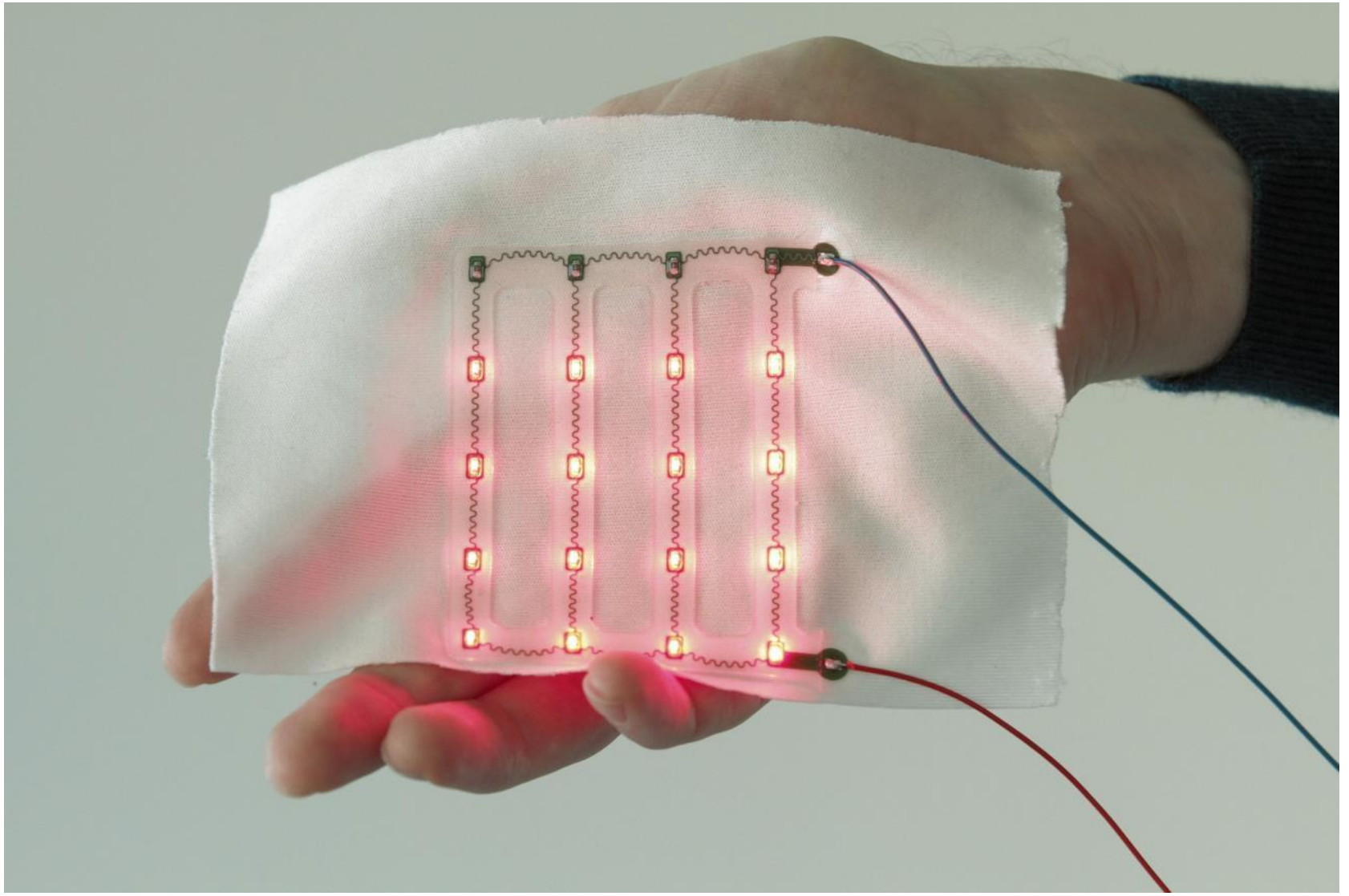
WE MAKE ELECTRONIC DEVICES STRETCHABLE



LEDs on textile

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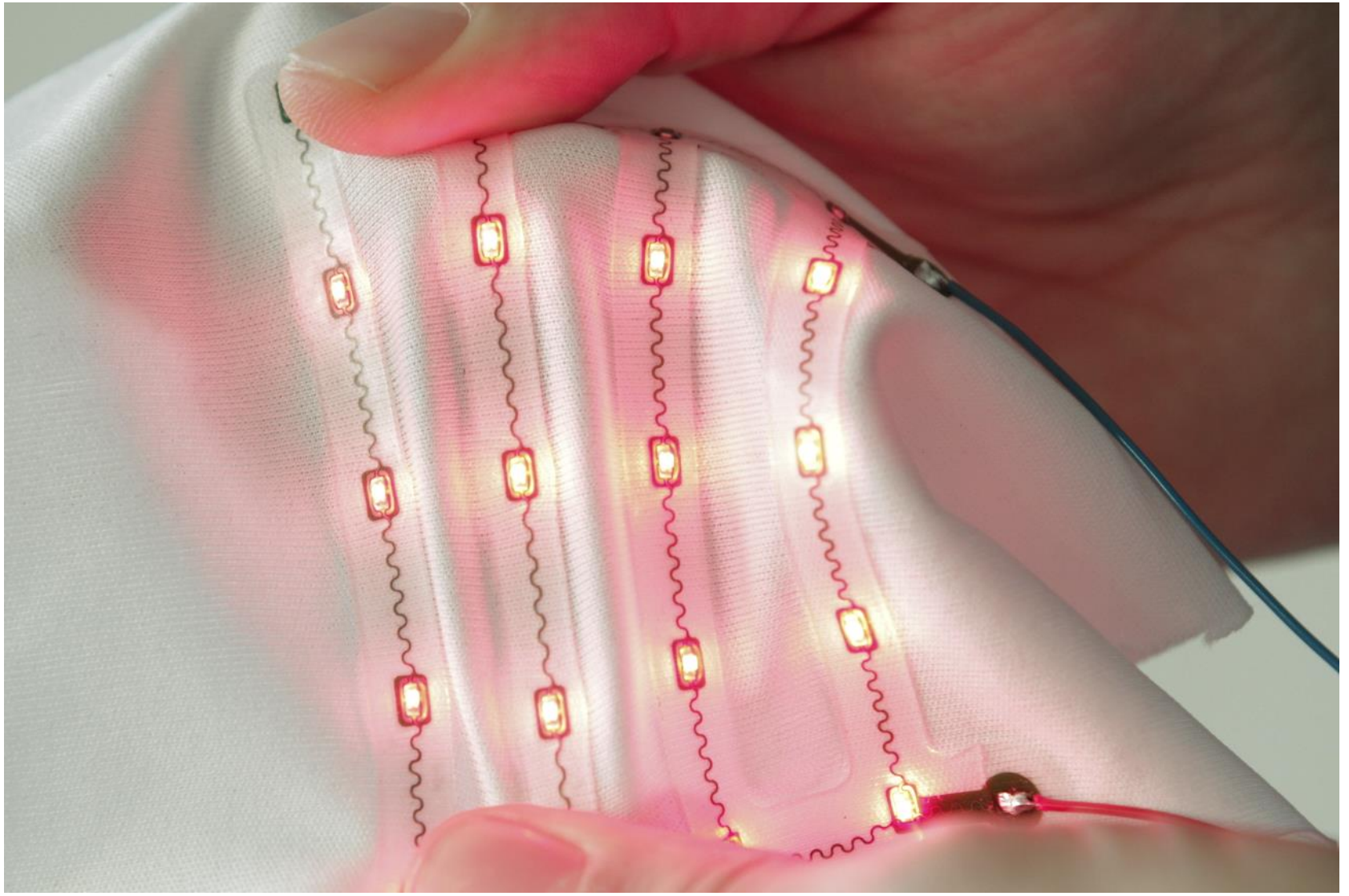

LEDs on textile

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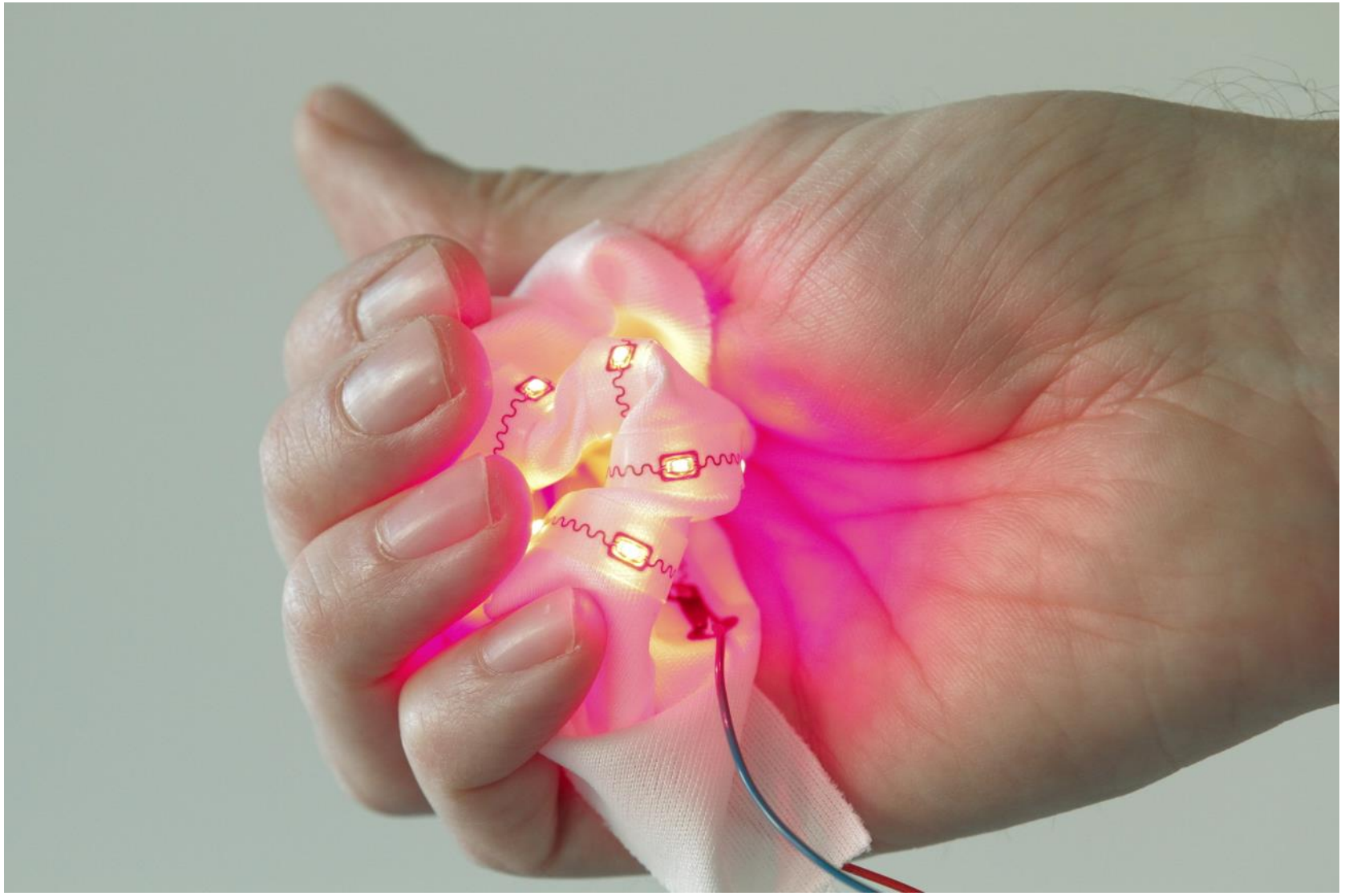

LEDs on textile

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WE MAKE ELECTRONIC DEVICES STRETCHABLE

Repititive Strain Injury Wristband

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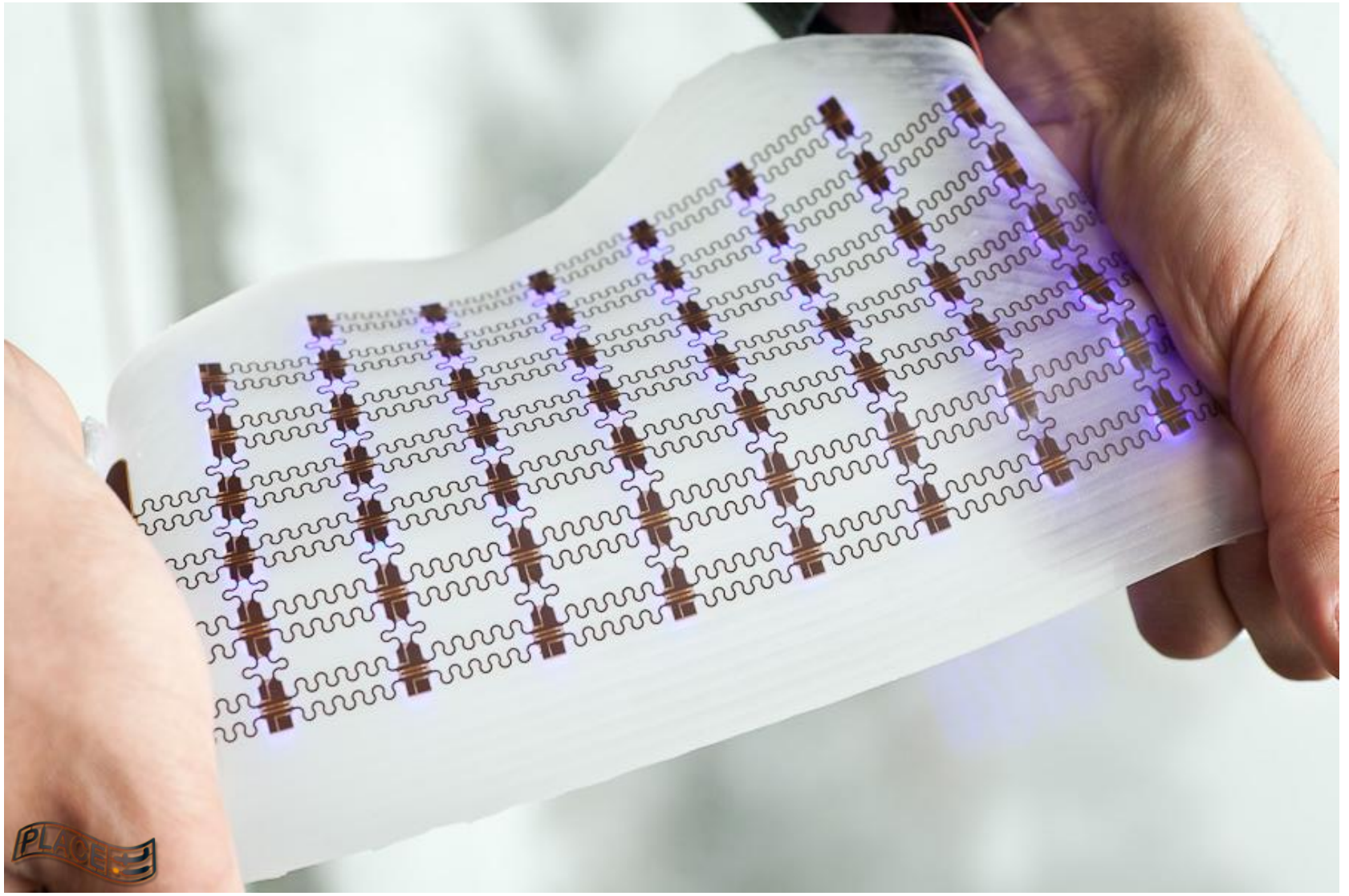

Repititive Strain Injury Wristband

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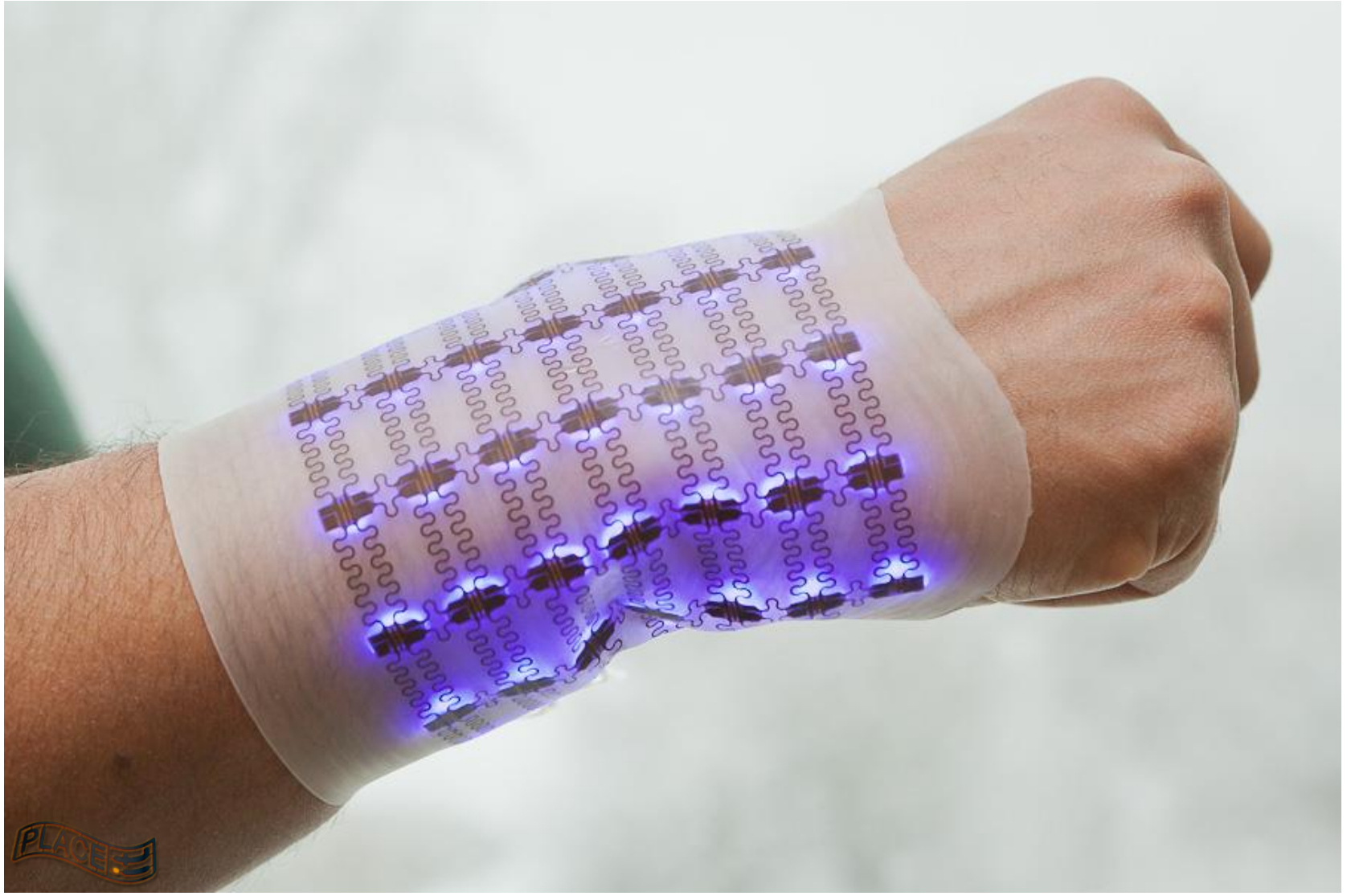
WE MAKE ELECTRONIC DEVICES STRETCHABLE



Repititive Strain Injury Wristband

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WHY STRETCHABLE?

Some reasons…

… it allows for applications that are able to deform according to the human body

… it allows for devices that are made in one size and are accommodated to their final shape

… it allows 3D, randomly shaped objects produced in a conventional way

… it improves the reliability of devices subjected to strains

... and probably much more

The design space for products is opened up with stretchable electronics!

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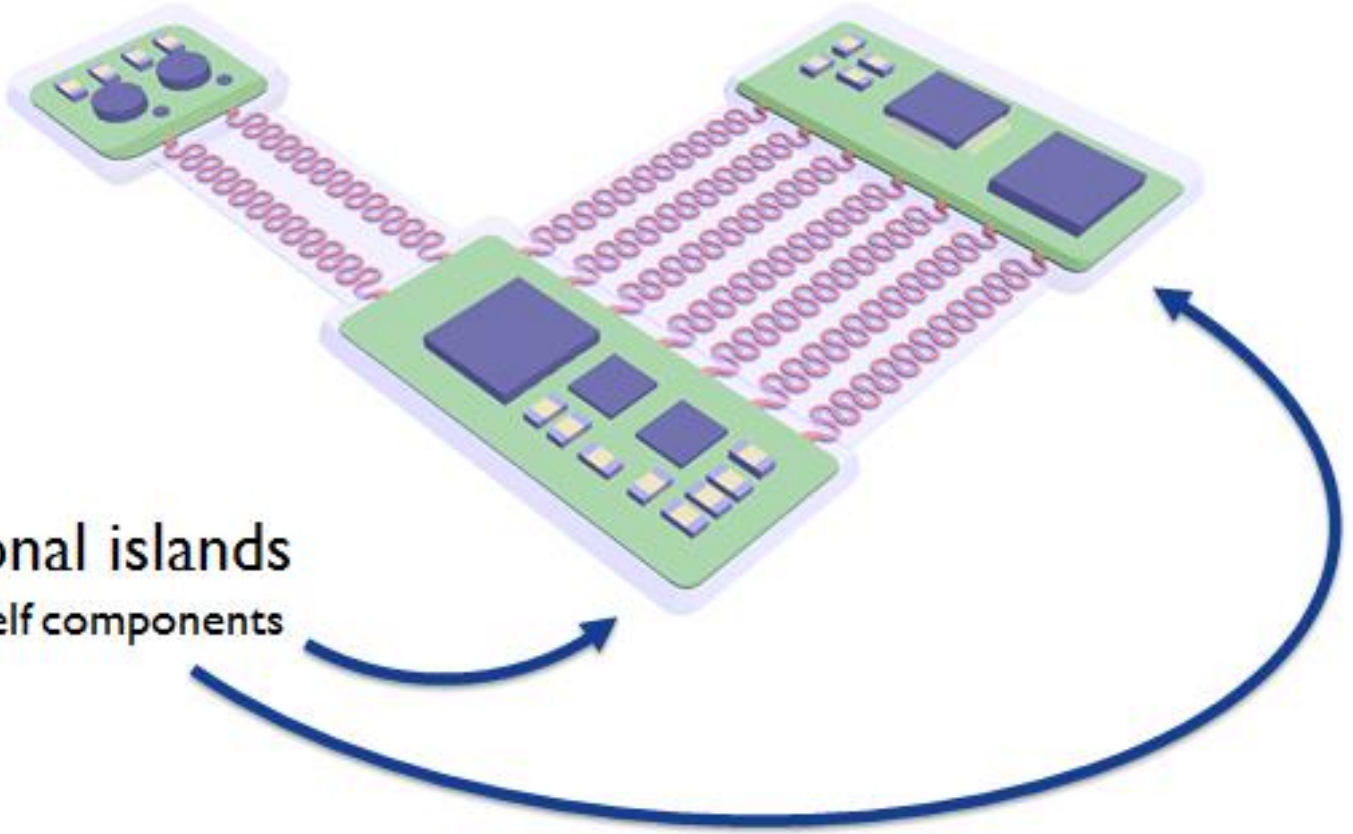
STRETCHABLE ELECTRONICS: OUR CONCEPT



Flexible, functional islands

containing off-the-shelf components

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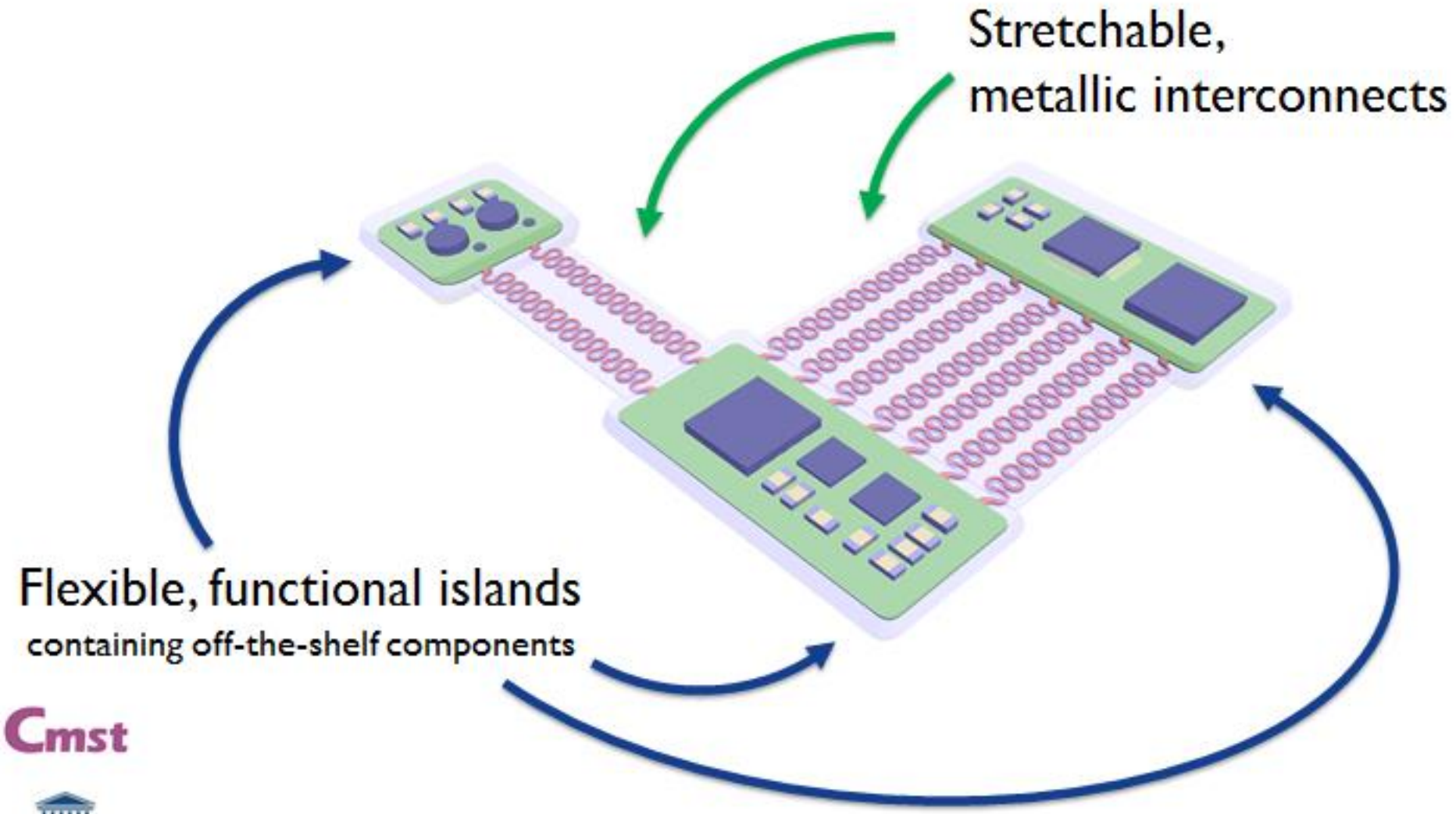
STRETCHABLE ELECTRONICS: OUR CONCEPT



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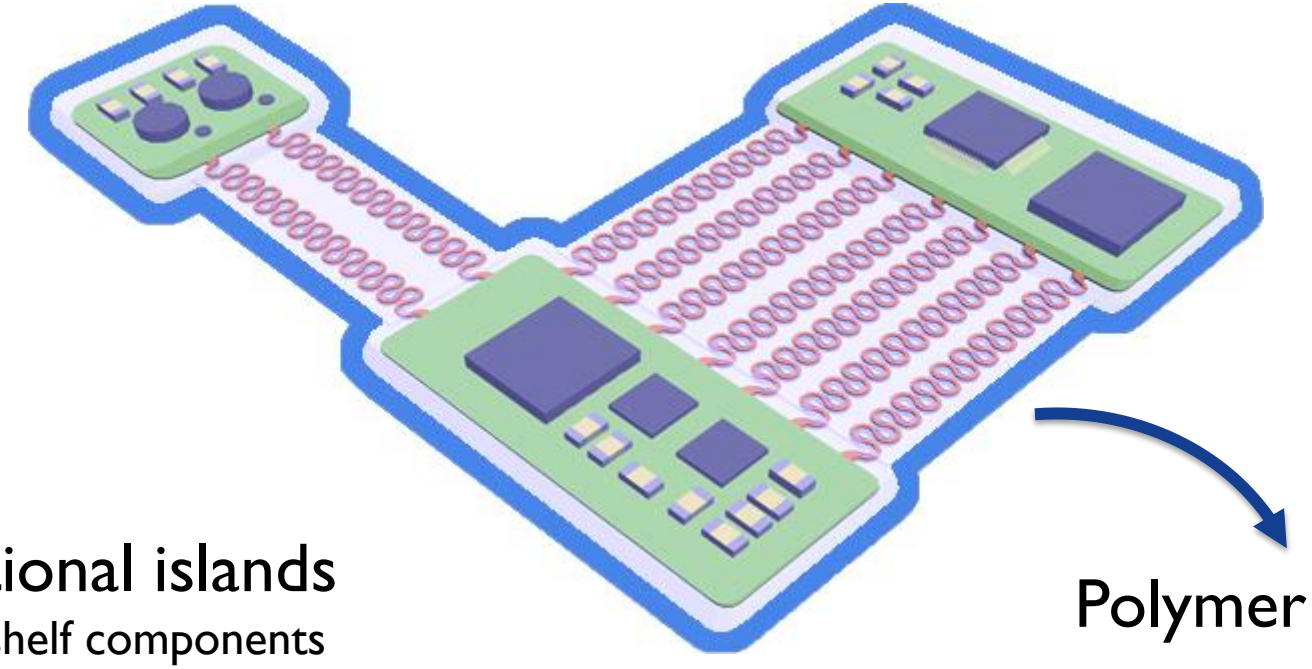
STRETCHABLE ELECTRONICS: OUR CONCEPT

Stretchable,
metallic interconnects



Flexible, functional islands
containing off-the-shelf components

Polymer encapsulation

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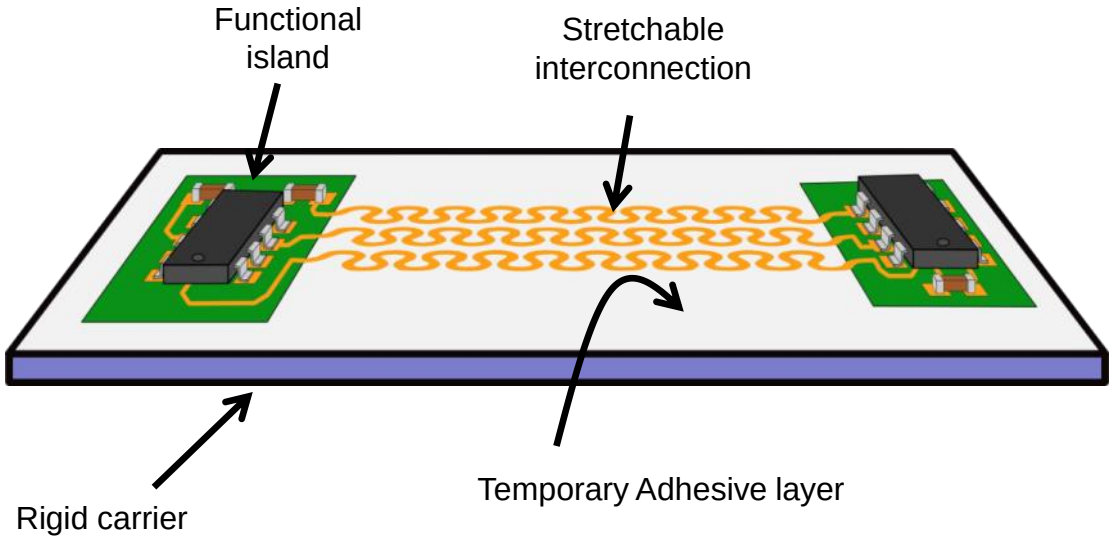
FABRICATION PRINCIPLE

- **Temporary carrier** to produce stretchable circuit on



- **All fabrication steps are printed circuit board fabrication techniques**
  e.g. Lamination, dry film photoresist lithography, etching, laserablation, etc.

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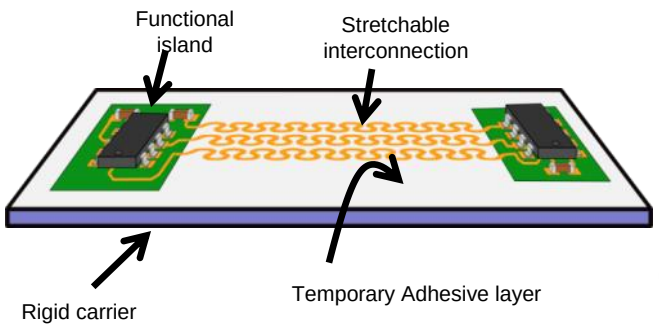
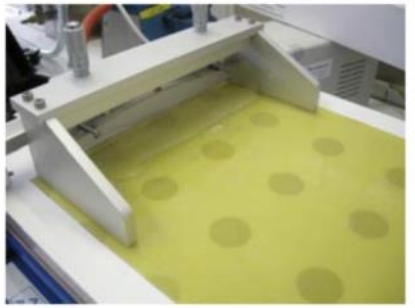
FABRICATION PRINCIPLE

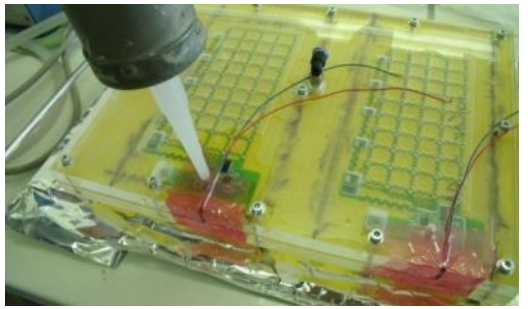
- **After the standard PCB steps, an (2 step) encapsulation step takes place**



Doctor blading liquid polymers (e.g. PDMS, PU)

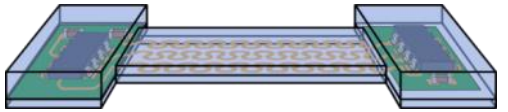


Low pressure moulding (e.g. PDMS)



Sheet lamination (e.g. TPU)

Dispensing, etc.



Completely encapsulated device

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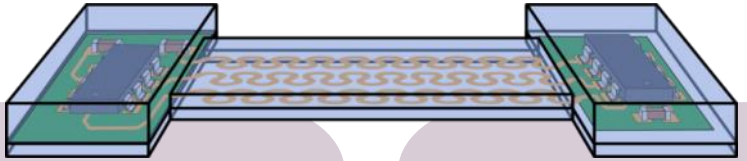
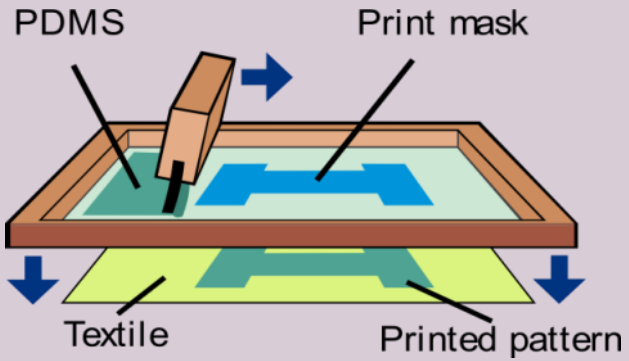
TEXTILE INTEGRATION

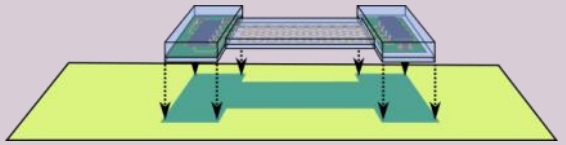


Stretchable module

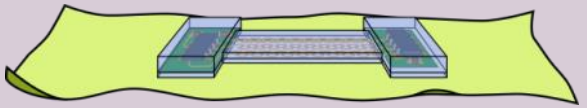
Modules with PDMS encapsulation



1) Print



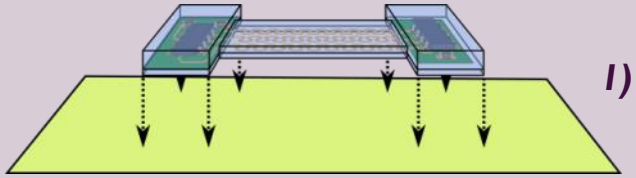
2) Place



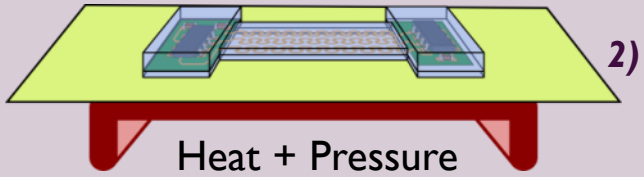
3) Cure

Process based on the screen printing of a glue layer

Modules with Thermoplastic encapsulation (e.g. PU)

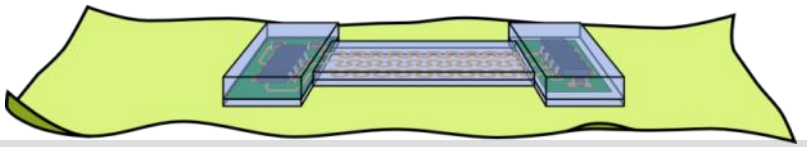


1) Place



2) Laminate

Process based on lamination



Module on textile

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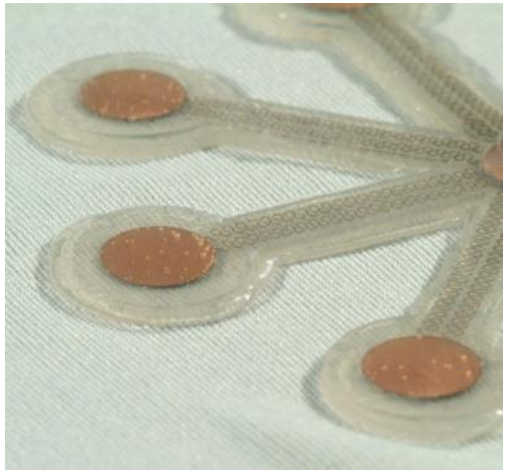
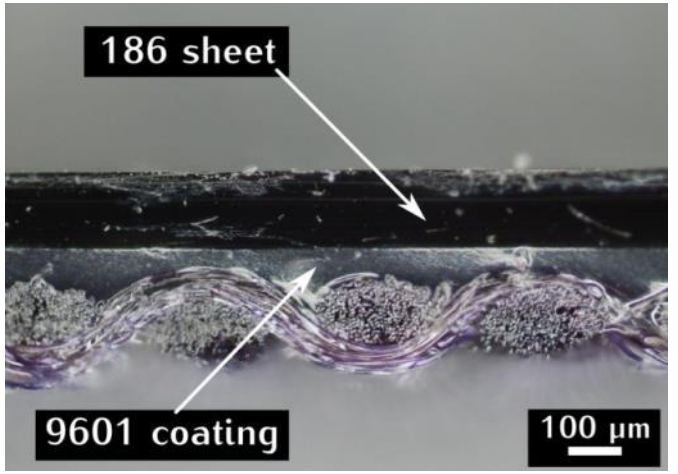
TEXTILE INTEGRATION

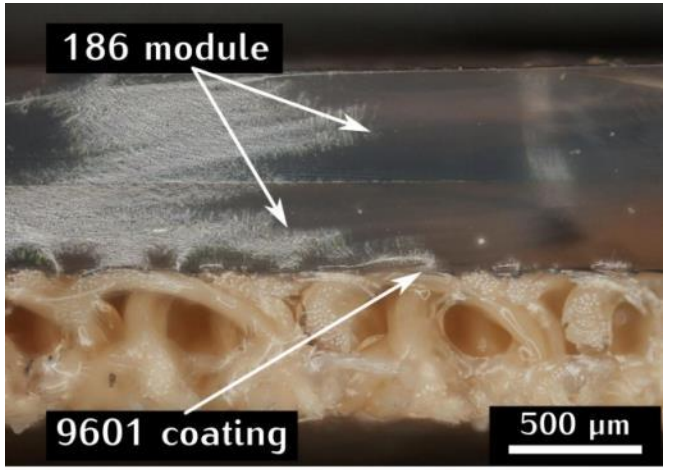
Examples



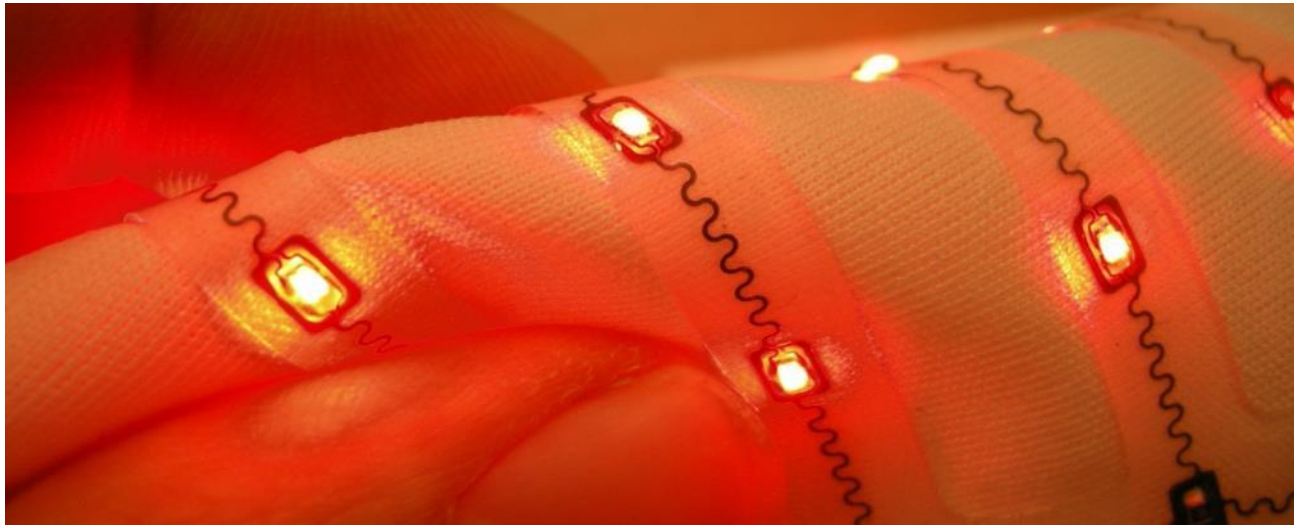
PDMS test module on a knitted fabric



Cross section: PDMS on a woven fabric



Cross section: PDMS on a knitted fabric



PU encapsulated LED array on a knitted fabric

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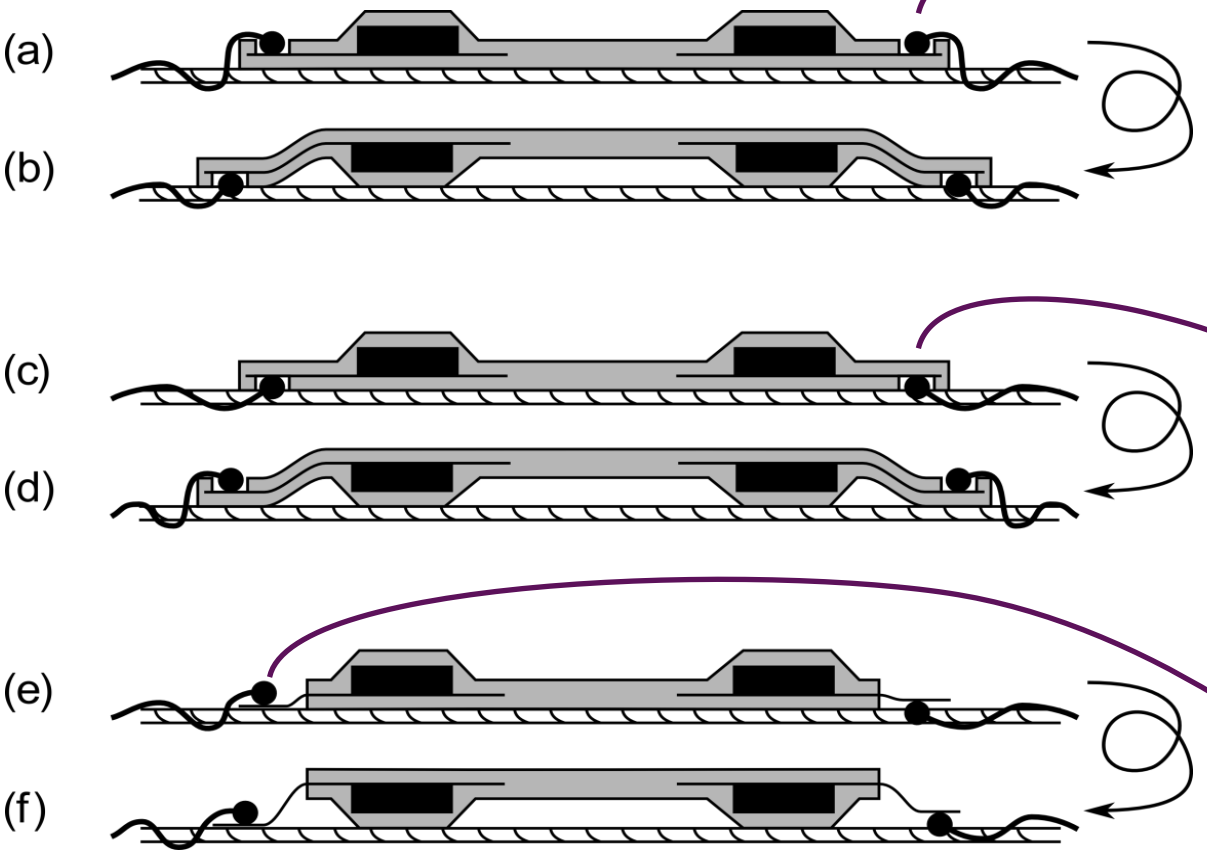
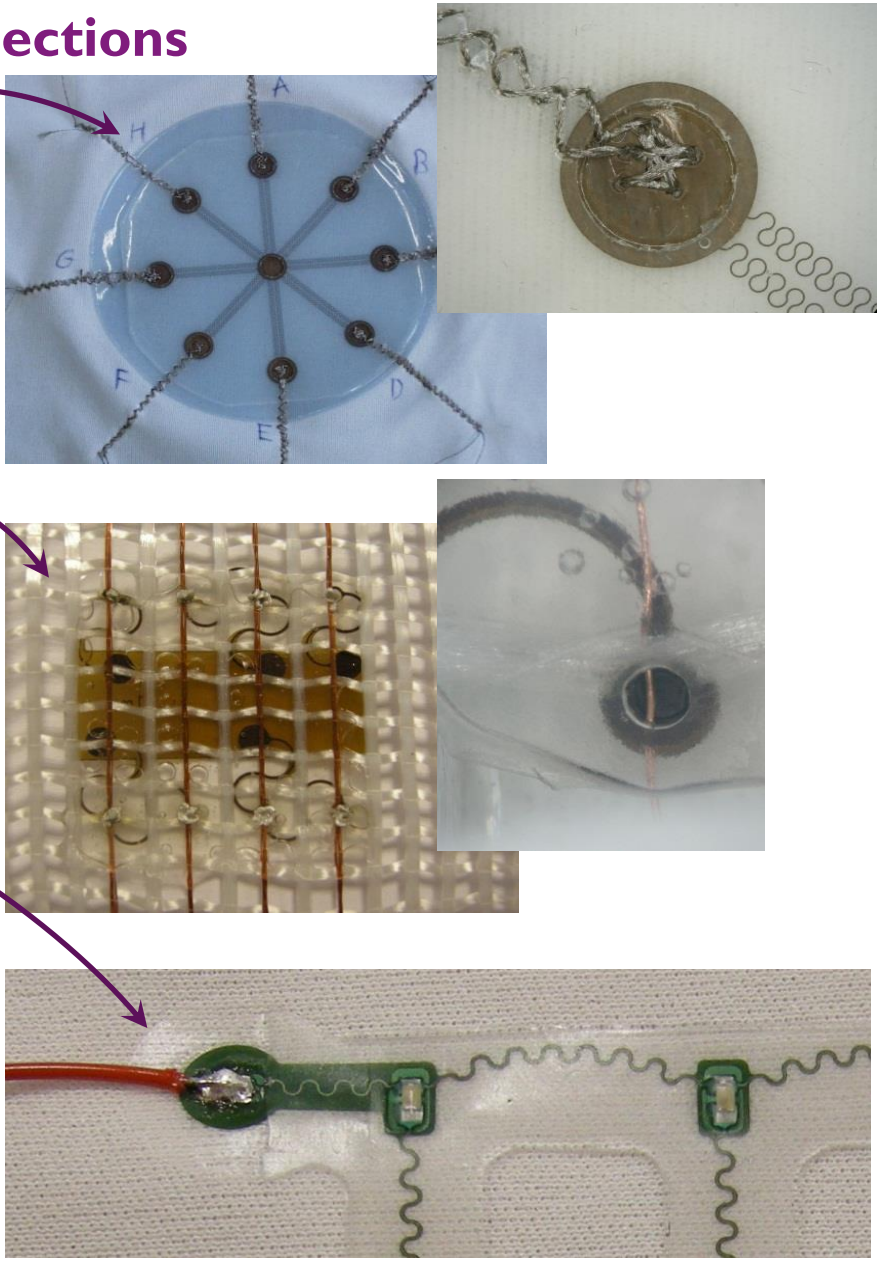
Textile integration of stretchable modules

Textile based conductive interconnections



Different configurations possible



Different solutions possible

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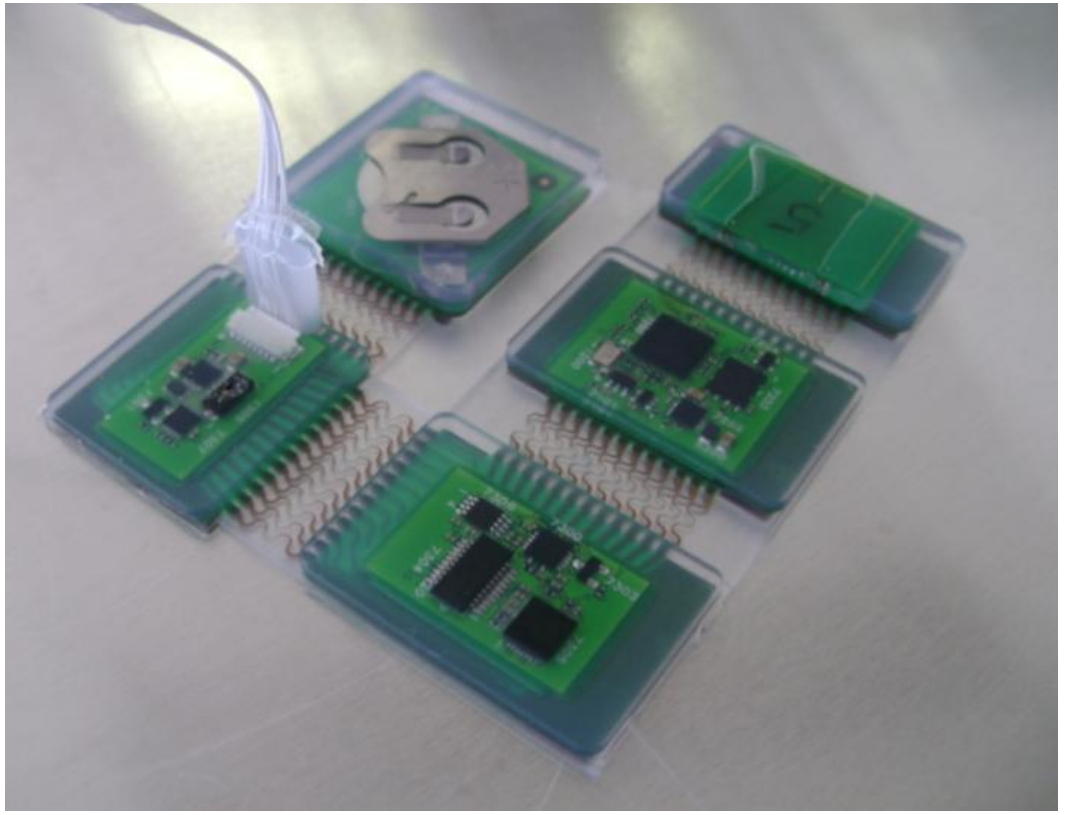
DEMONSTRATORS



Philips Activity Monitor

The activity monitor consists of 5 4-layer electronic interposer boards which are mounted on a SMI substrate and completely embedded in Sylgard 186.
The system includes a wireless link, a rechargeable battery circuit and accelerometers for activity detection.

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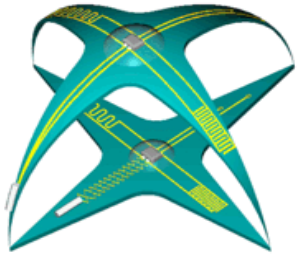
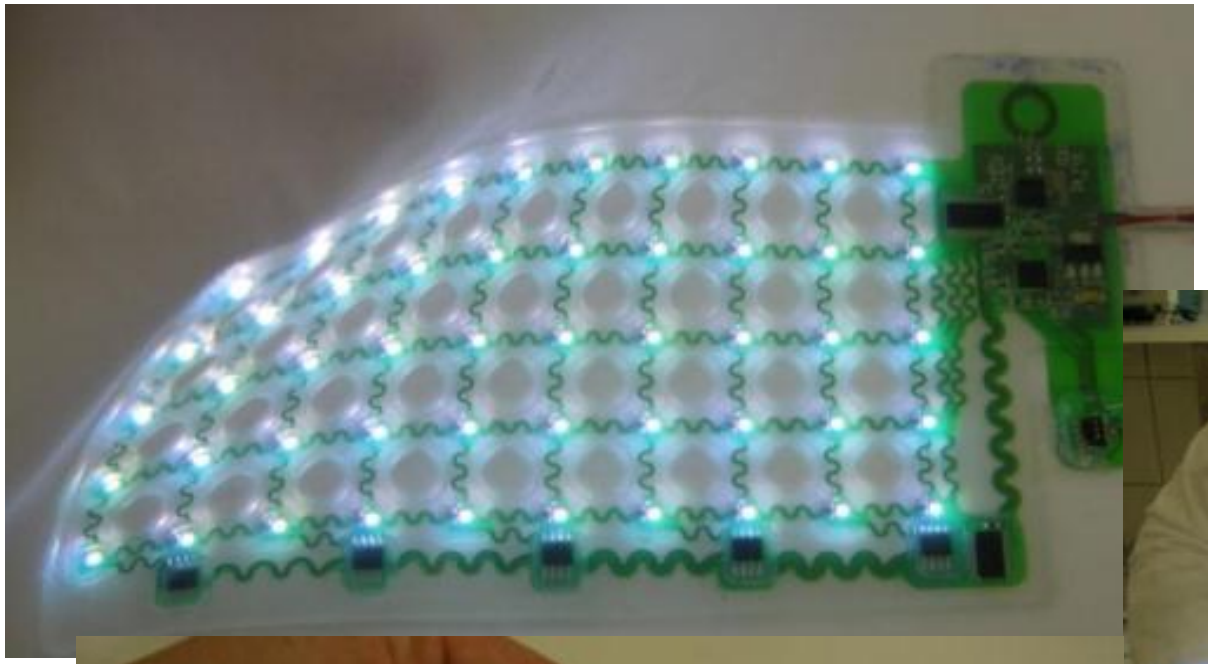
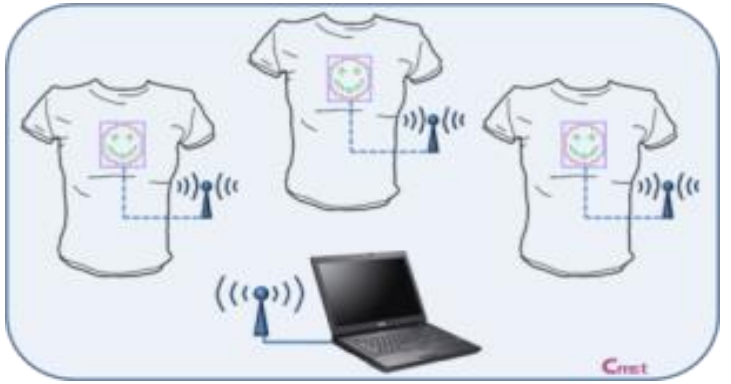
Developed in EU Project Stella



DEMONSTRATORS

Party Shirt (5x10 full color led matrix)

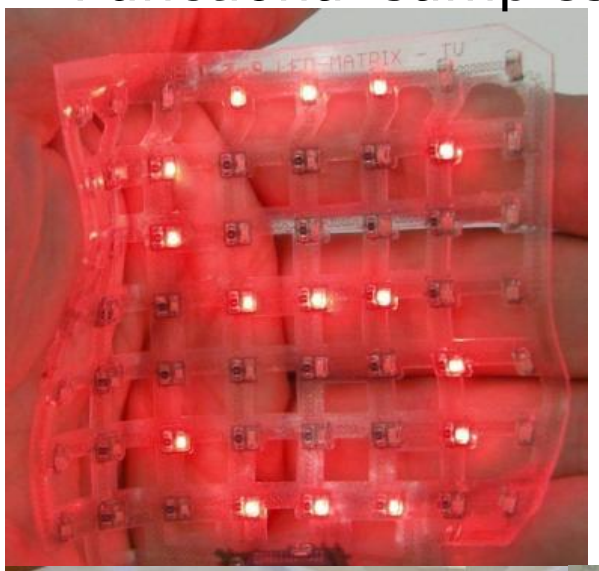
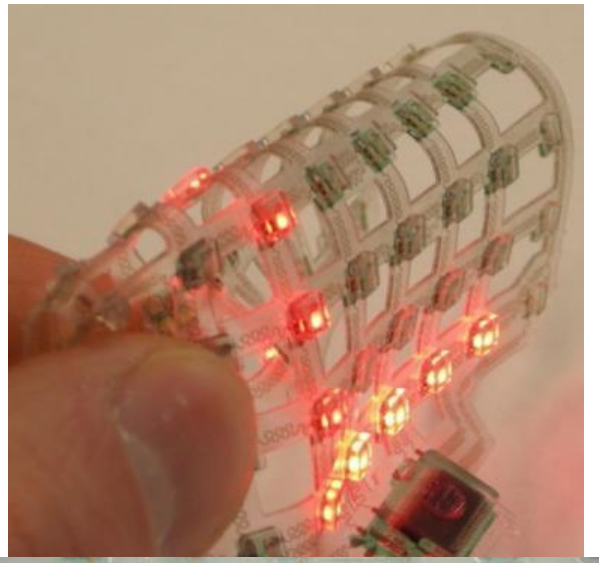


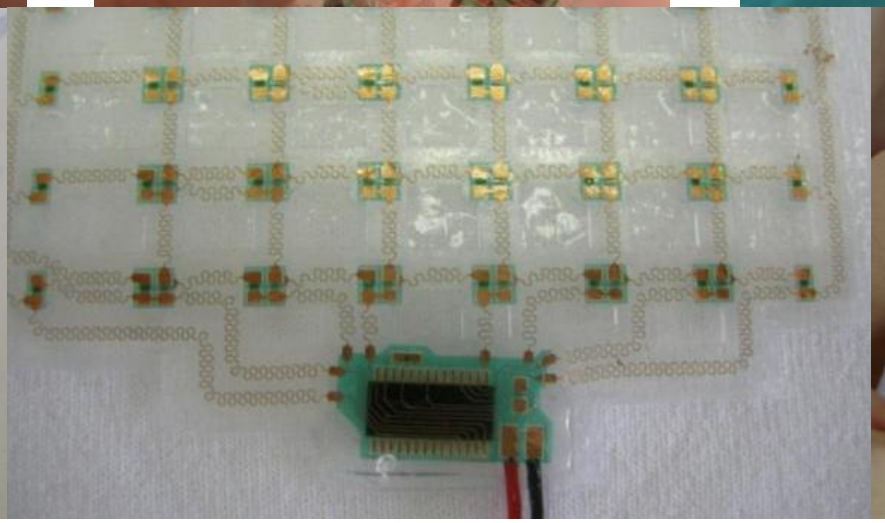
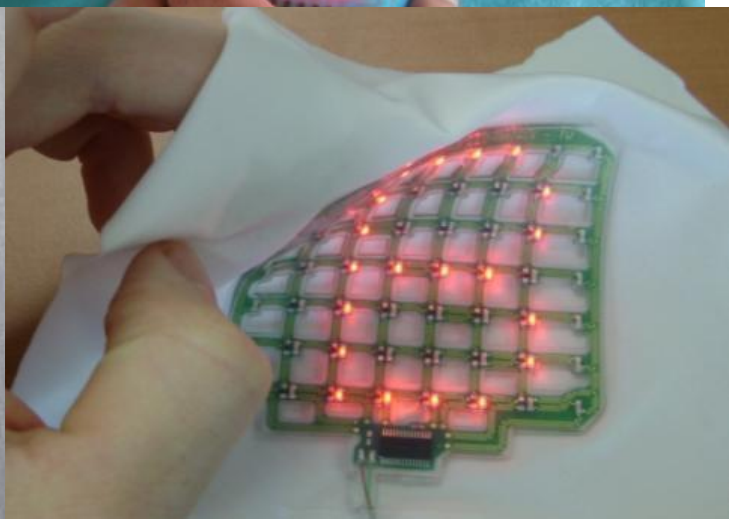


Fully integrated in T-shirt

DEMONSTRATORS

- 7x8 Led matrix designed for testing and developing the technology
- Functional samples are used as demonstrators

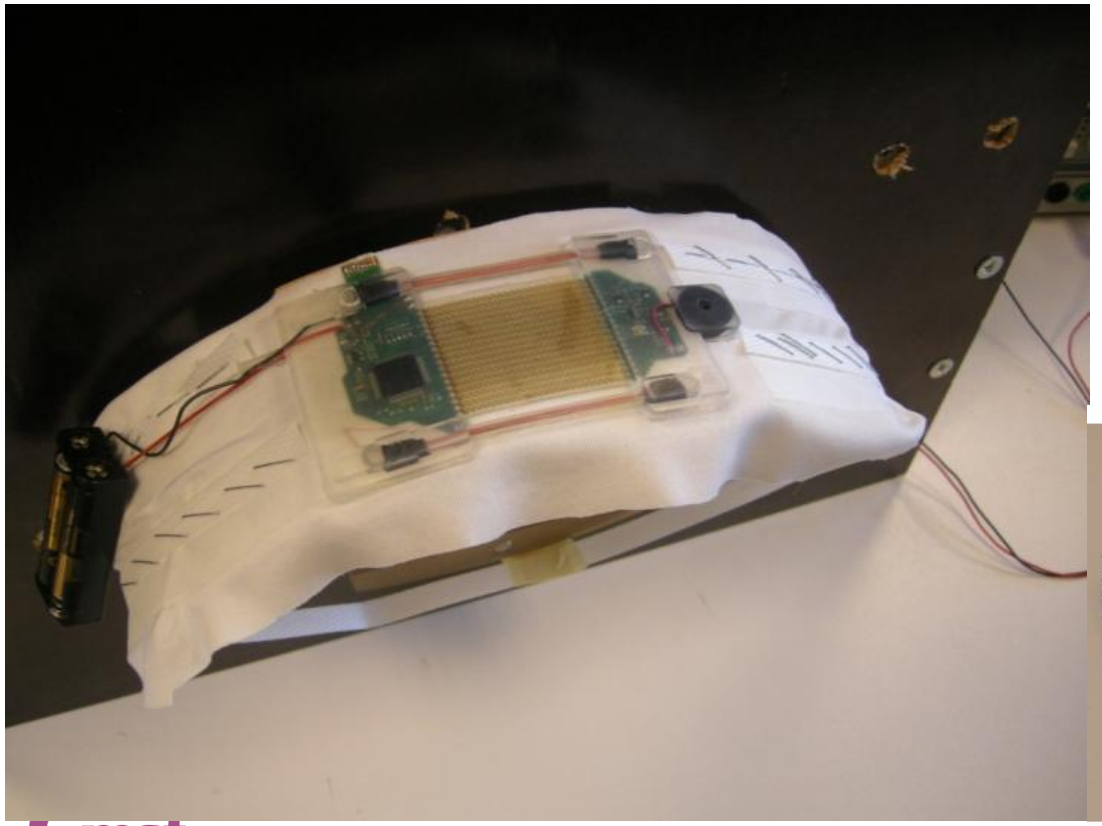




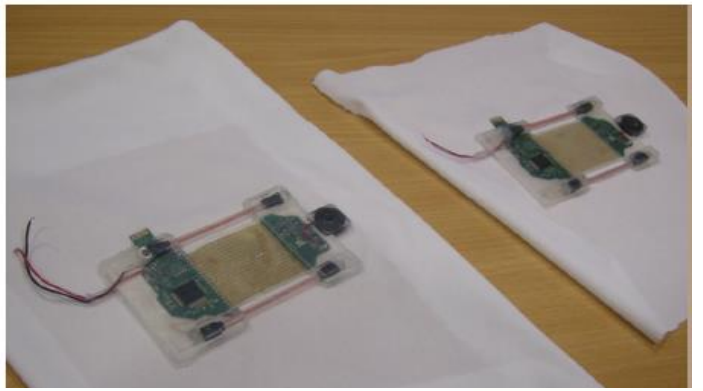
Developed in Belgian project Sweet

DEMONSTRATORS

Verhaert Baby breathing demonstrator

The demonstrator contains 79 components, 2 rubbery rulers and a buzzer. The rubbery rulers are integrated in the moulded device acting as sensors for the breathing detection.

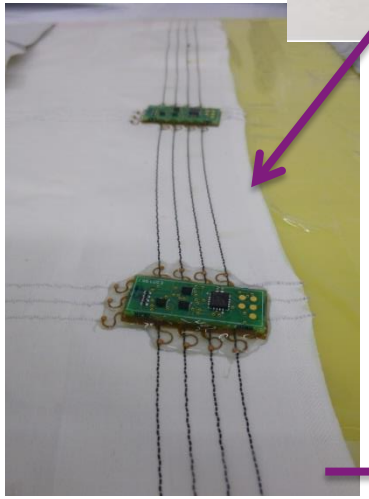


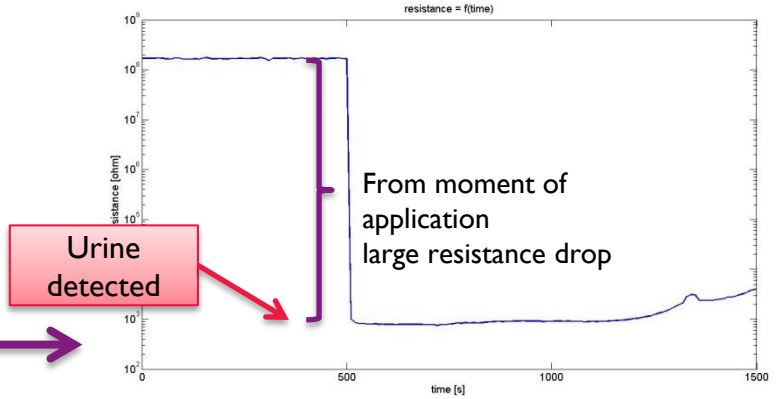


Developed in EU Project Stella

DEMONSTRATORS

Smart hospital bed linen





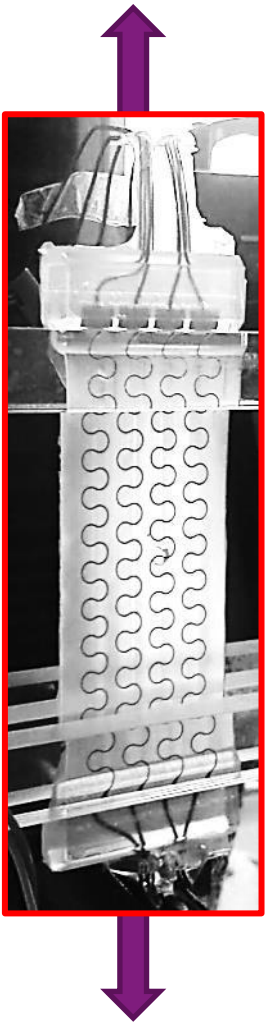
Conductive yarns (acting as sensors) in combination with integrated readout electronics

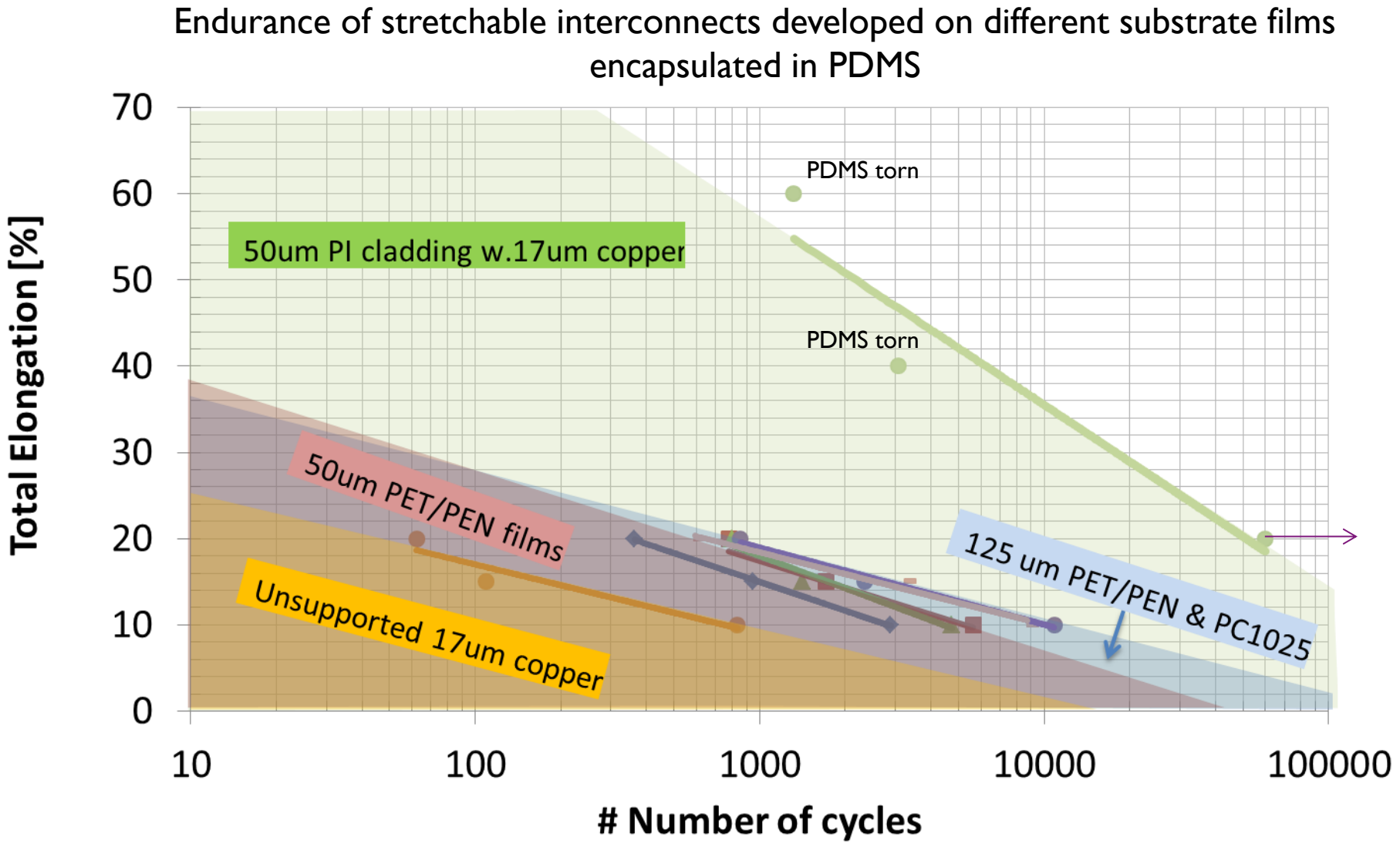
Measurements: Urine detection

- **Assets:**
  - Urine detection
  - Quantitative sweat measurement
  - Quality of health care increases
  - Effort from nursing personnel reduced
- **Beyond the state-of-the-art**
  - Measurement techniques
  - Integration techniques
  - Integrated conductive yarns
- **Future work**
  - Measurements in real environment
  - Reliability of the concept after washing

HOW MUCH STRETCHABLE?

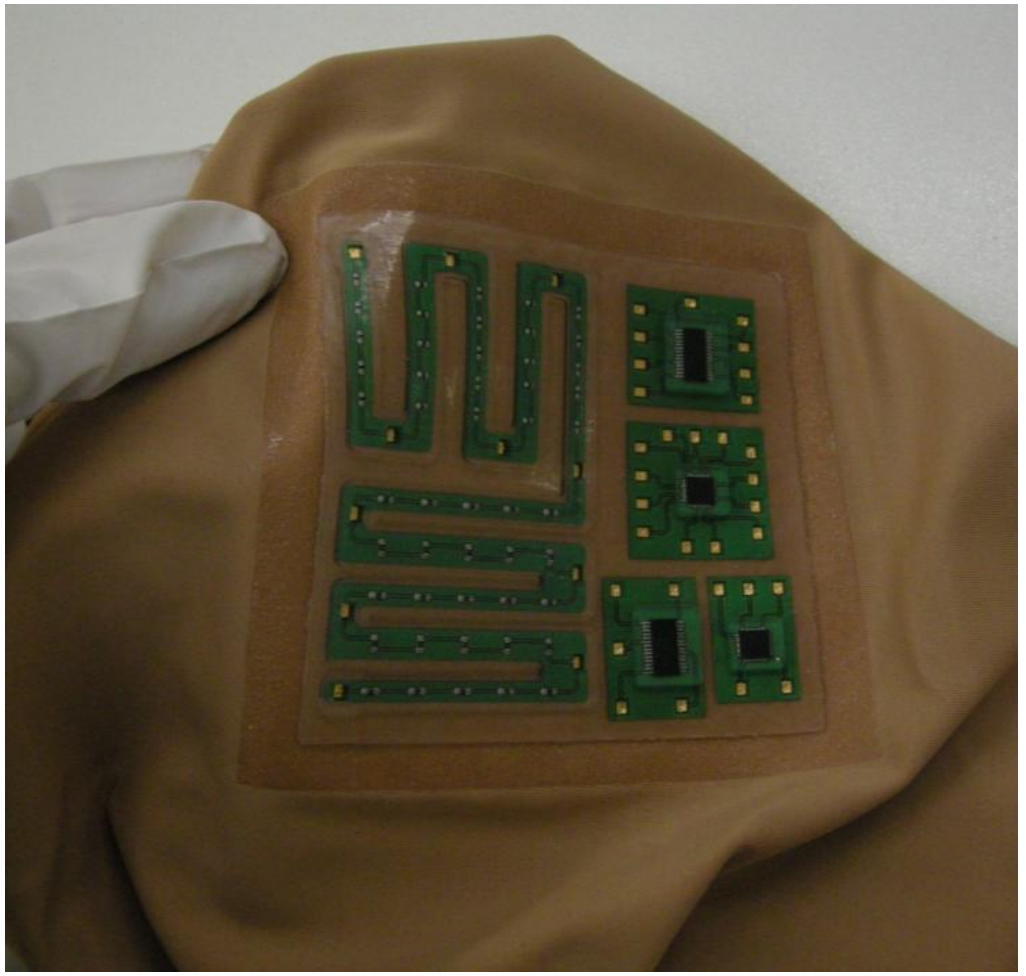
PERFORMANCE COMPARISON-EXAMPLE





WASHABLE?

Washing reliability of SMD solder contacts on flexible islands



Washing reliability test sample on a knitted fabric

Test sample info

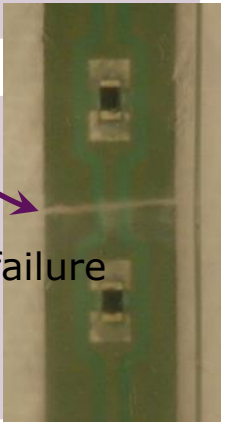
- FCB: 50 µm PI, 18 µm Cu, Ni/Au finish
- Daisy chain of 0 Ohm resistors: 0603 and 0402 package
- Dummy IC's with daisy chain: TSSOP 28 and QFN 32
- Total of 220 SMD contacts that can cause failure
- 43 measurement pads to detect broken contacts in the chains
- Pads accessible trough openings in PDMS encapsulation
- Encapsulated modules placed on knitted or woven fabrics

Test conditions

- Domestic washing - 40°C – ISO 6330 method 5A
- Washed with or without protective bag (PB)
- Open air line drying before measurement
- 25 cycles tested

Results after 25 cycles

- On woven, PB: defects in FCB, no contact failure
- On woven, no PB: defects in FCB, no contact failure
- On knitted, PB: no defects
- On knitted, no PB: no defects



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TECHNOLOGY COMPETITIVE ADVANTAGES

Conventional circuit manufacturing processes (PCB based)
Stretch circuit technique uses a rigid carrier substrate and introduces the soft stretchable carrier only after circuit fabrication.

Manufacturing process is independent of final encapsulation material, which can be various types of polyurethane (PU) or silicones (PDMS). Encapsulation material can easily be selected based on the final use of the device

Stretchable interconnects exhibit superior reliability compared to other approaches
Lifetime of stretchable interconnects for cyclic endurance is extensively tested, metal meander shapes are optimized as function of max. elongation in order to obtain maximum reliability.

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PROTOTYPING STRETCH CIRCUITS

- Technology has been developed with industrialization in mind

- Prototyping value chain is available:
  a mix of internal & external manufacturing possibilities
  - Internal: PCB prototyping line at CMST, Gent

  - External: Co-operation with partners in Flanders (manufacturing, materials, testing)

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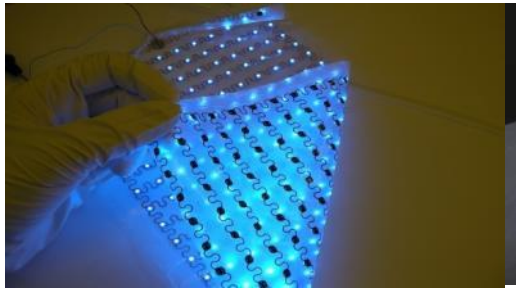
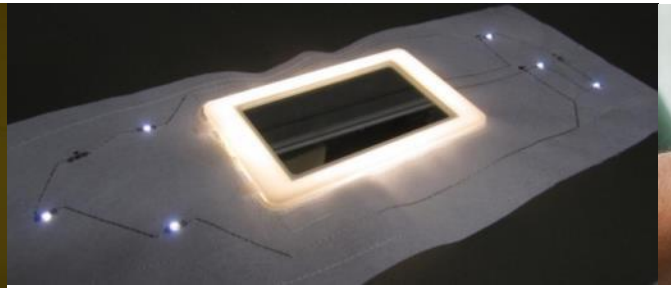
PROTOTYPING STRETCH CIRCUITS

- Prototyping projects are running for companies involved in
  - sport activities
  - music & performance
  - fashion

- Prototyping in a number of European projects

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CONCLUSIONS

Stretchable electronics technology

- ✓ New design space for products is opened up with stretchable electronics.
- ✓ Reliable stretchable technology available
- ✓ Prototyping stretchable devices possible

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