STRETCHABLE ELECTRONICS

OVERVIEW PRESENTATION
WE MAKE ELECTRONIC DEVICES STRETCHABLE

LEDs on textile
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Repititive Strain Injury Wristband
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Repetitive Strain Injury Wristband
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!
STRETCHABLE ELECTRONICS: OUR CONCEPT

Flexible, functional islands containing off-the-shelf components
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Stretchable, metallic interconnects
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Stretchable, metallic interconnects

Polymer encapsulation
FABRICATION PRINCIPLE

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

![Diagram showing the fabrication principle with labels for Functional island, Stretchable interconnection, Rigid carrier, and Temporary Adhesive layer.]

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

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

Heat + Pressure

Process based on lamination

Module on textile
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
Textile integration of stretchable modules

Textile based conductive interconnections

Different configurations possible

Different solutions possible
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.

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
Smart hospital bed linen

▸ 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

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

Measurements: Urine detection

From moment of application large resistance drop
Endurance of stretchable interconnects developed on different substrate films encapsulated in PDMS

- 50um PI cladding w.17um copper
- 50um PET/PEN films
- Unsupported 17um copper
- 125 um PET/PEN & PC1025

HOW MUCH STRETCHABLE?

PERFORMANCE COMPARISON-EXAMPLE
WASHABLE?
Washing reliability of SMD solder contacts on flexible islands

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 through 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
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.
- 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)
PROTOTYPING STRETCH CIRCUITS

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

- Prototyping in a number of European projects
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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