Integrating electronic circuits in arbitrarily 2,5D shaped plastic objects

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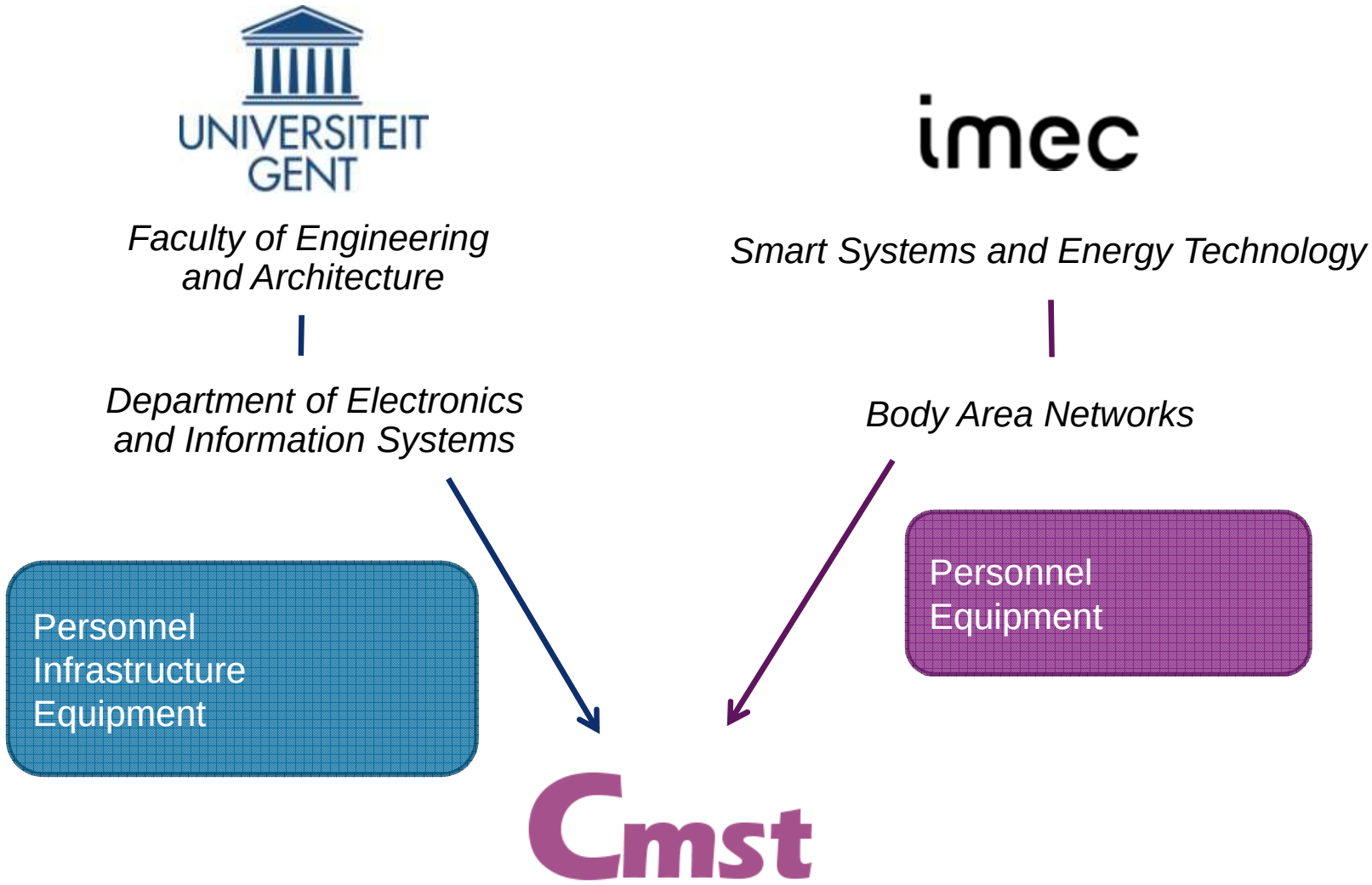
CMST: Centre for Microsystems Technology



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Research @ CMST

@ Tech campus Zwijnaarde

700+ m^2 cleanroom

~55 FTE

Strongly active in applied research programmes with partners in Flanders, Europe and worldwide

Partner in Holst Centre

Holst Centre
Open Innovation by imec and TNO

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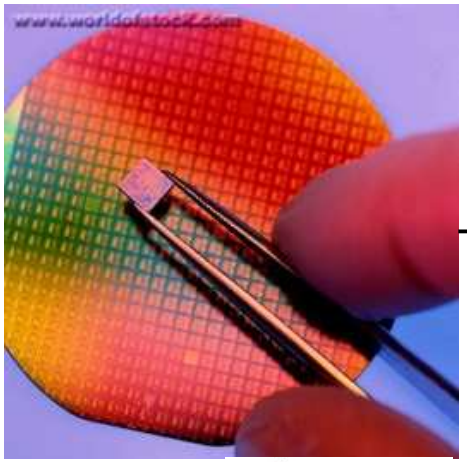
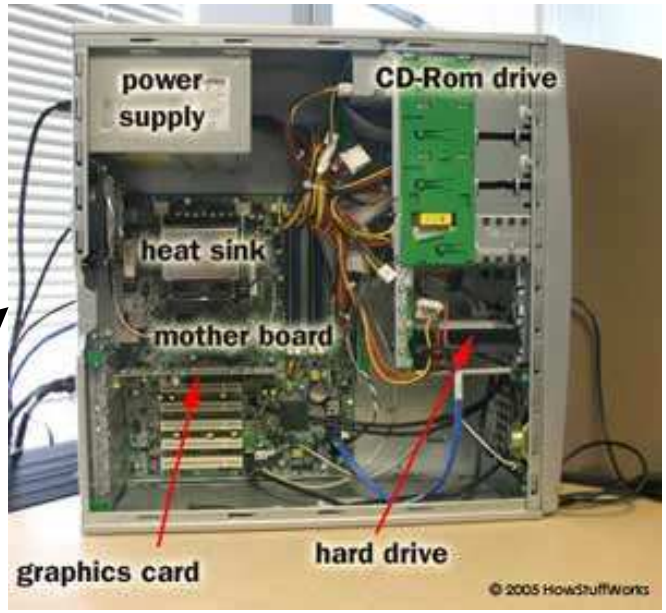
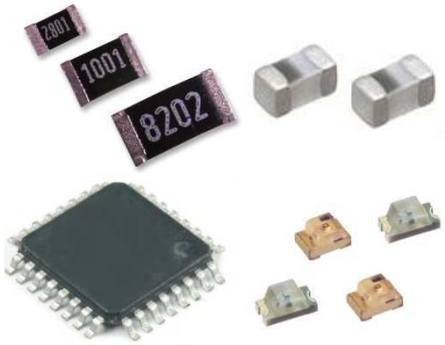
Traditional electronics; flat & rigid

Flat silicon wafer & chips



Rigid boards (PCB)

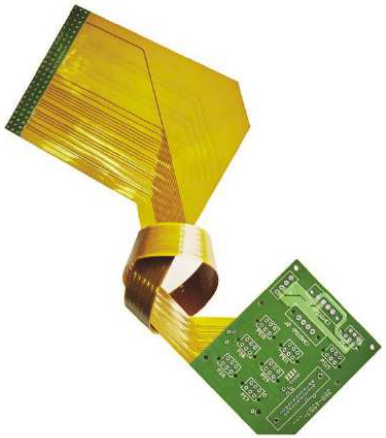


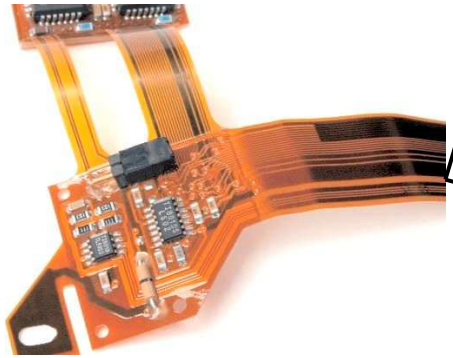


Rigid electronic components

Today: Flexible and flex-rigid electronics

Rigid boards (PCB)





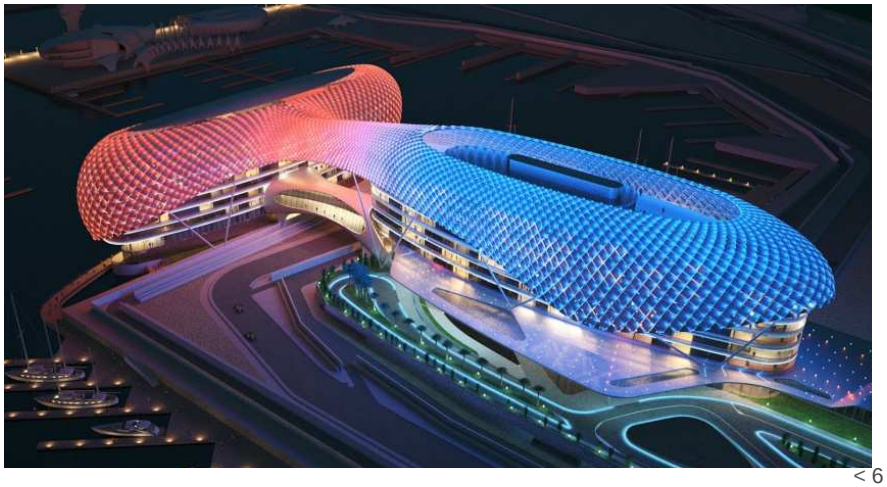
Flexible foils

Interest in rigid *free form* 2,5D circuits

Applications :

- 2.5D light sources
- automotive interiors
- free form keyboards
- consumer electronics, e.g. free form touch panels; ….

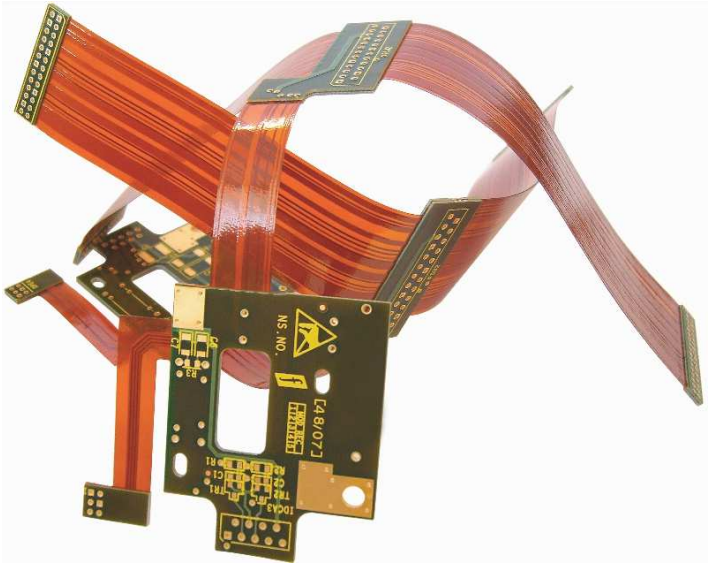
(Kinesis)



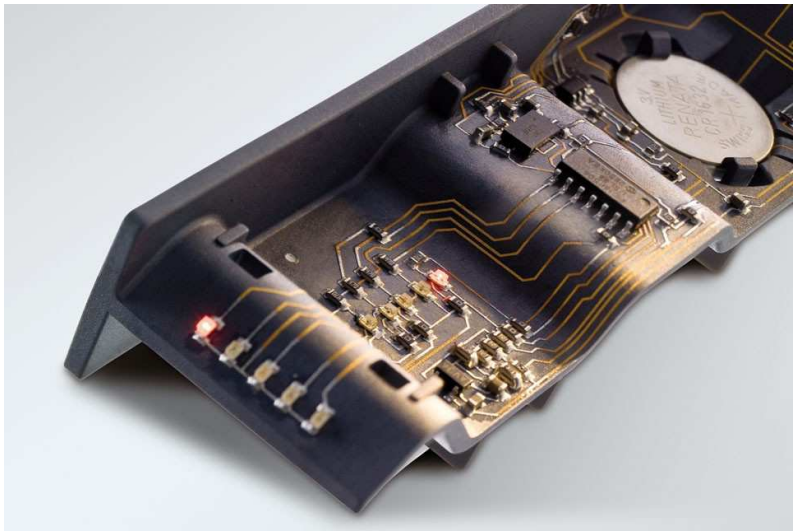
Current solutions far from optimal

Current technologies used :

- Flex-rigid boards : expensive, limited reliability (connectors), limited design freedom (approximation of ideal free-form)
- 3D-MID (Moulded Interconnect Device) : use of special polymers for selective Cu plating (expensive), 3D component assembly (slow compared to 2D assembly)



Flex-rigid board



3D-MID

Goal

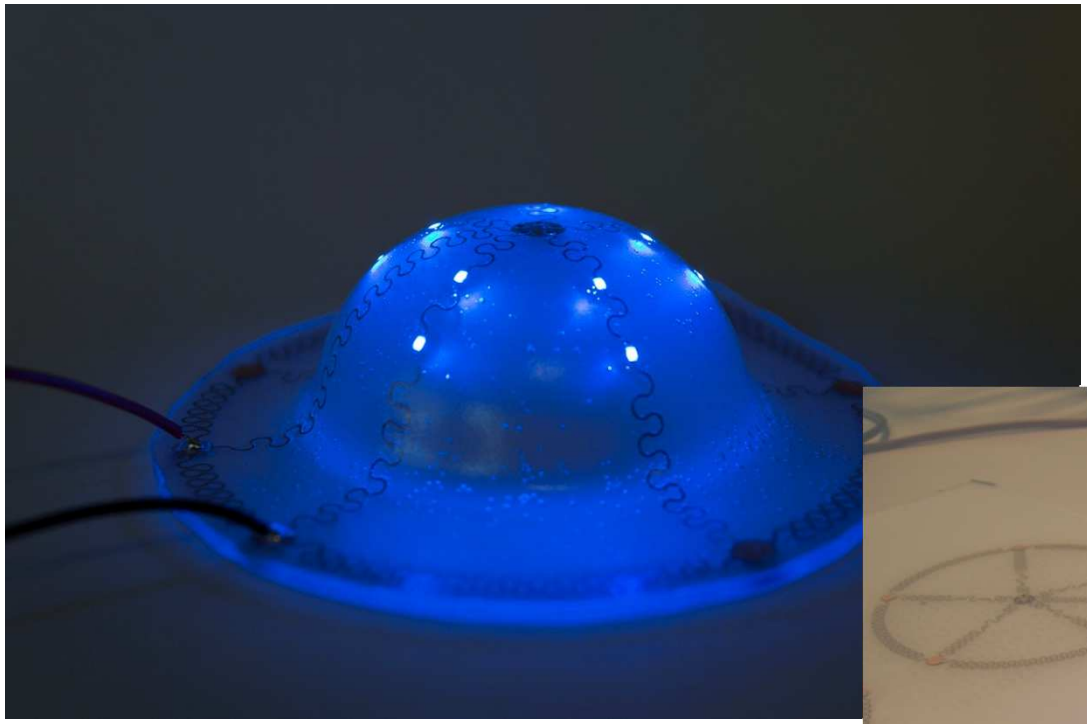
Develop a technology platform to realise free form 2,5D rigid circuits, *compatible with standard industrial processes*.

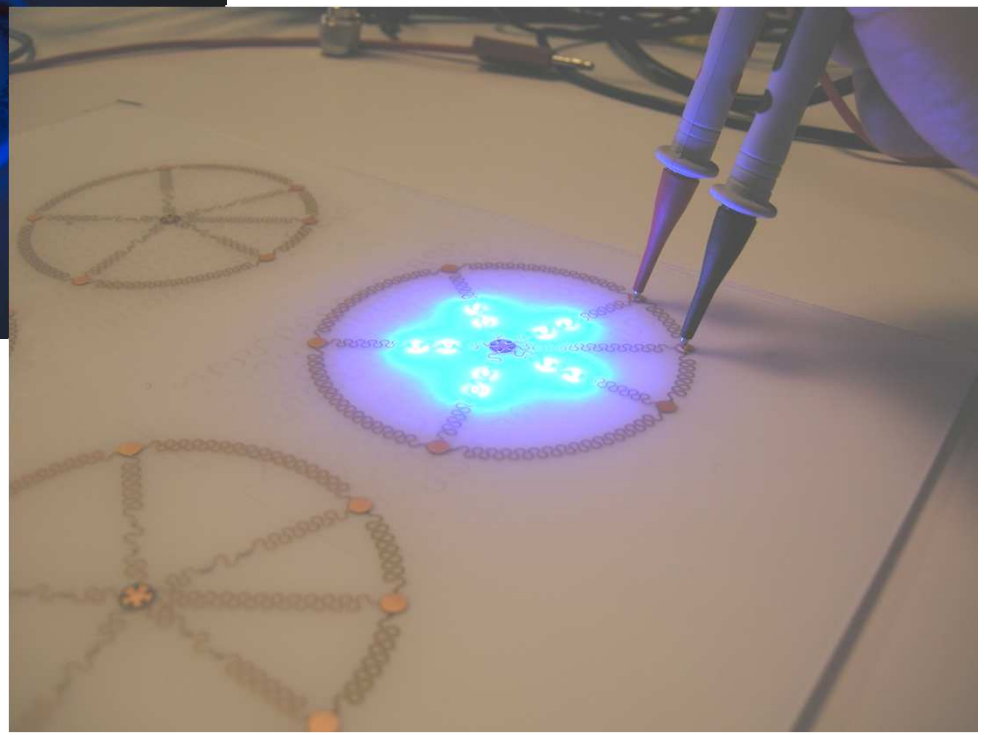
- Fact #1 : In industrial environment : electronic circuits are produced and assembled on **flat substrates** (rigid or flex)
- Fact #2 : Demand for complex systems requires the use of off-the-shelf components like commercial IC's : microcontrollers, memory, display drivers, radio chips, etc. These are assembled using lead-free soldering or sometimes adhesive assembly technologies

→ Use of printed components usually not an option

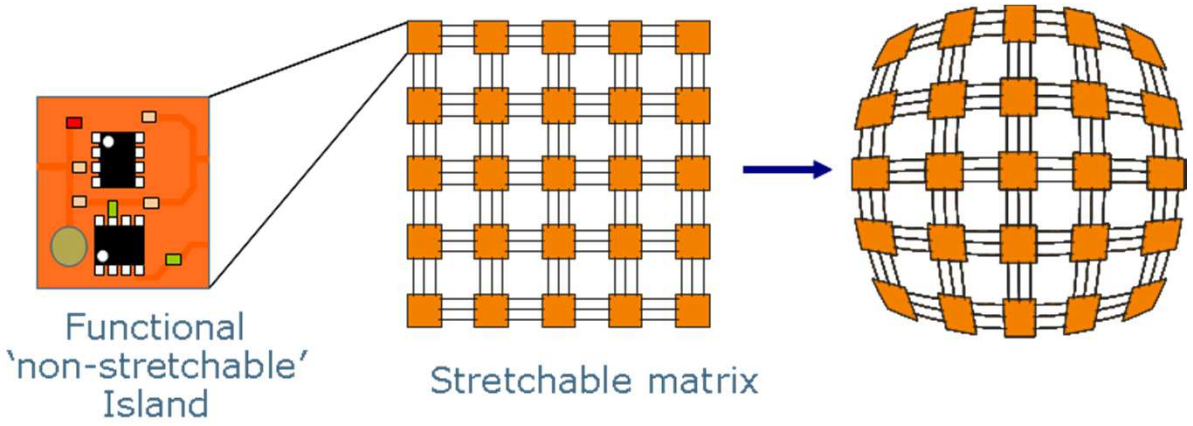
World's first plastic micro processor (8-bit)
(Holst Centre with Polymer Vision)

Result (work in progress)





Approach:
1) create a stretchable circuit



- Start from off-the-shelf sensors and electronic components
- Assemble components on small flexible PCBs → 'functional islands'
- Interconnect functional islands by stretchable wiring

Reliable stretchable interconnections (1/4)

Cu, (or Au, Ag,..) are intrinsically not, or very little stretchable

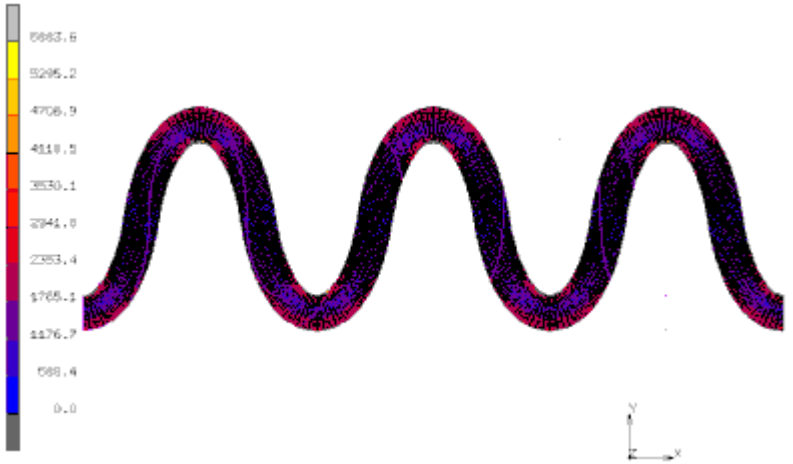
→ How to obtain stretchable interconnections ?

1) without changes in conductivity during stretch/release
2) reliability not affected due to extreme/very regular deformation

<u>Without changes in conductivity</u>

Pattern Cu interconnection lines in meandering shape

→ 2D springs, in-plane of PCB

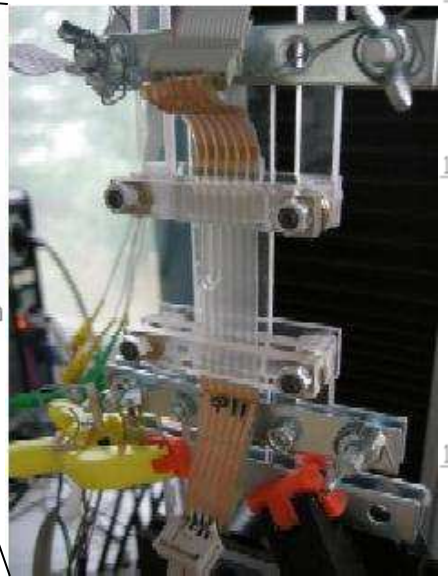


Mechanical reliability testing

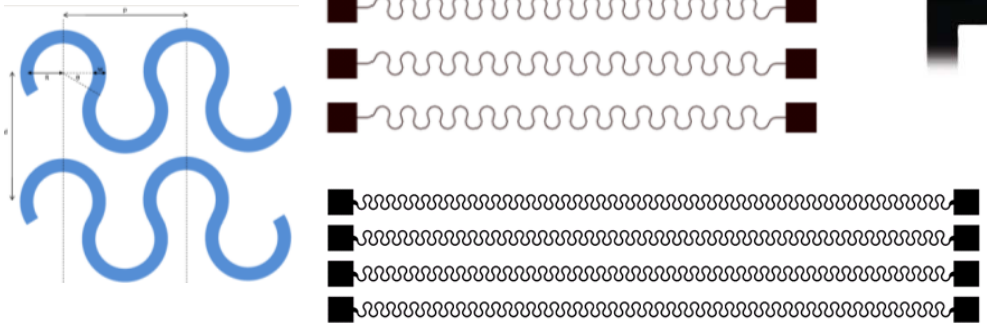
Cyclic stretching & releasing of interconnection test samples

Number of cycles before electrical failure is determined for different max. elongations (2.5%, 5%, 10%, 20%, …)

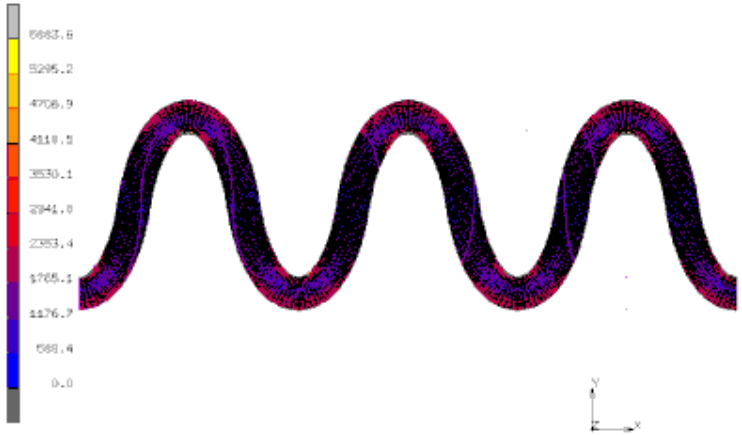
- Test setup measures in-situ conductivity of meander tracks by 4-point measurement
- Maximum elongation & strain rate are set

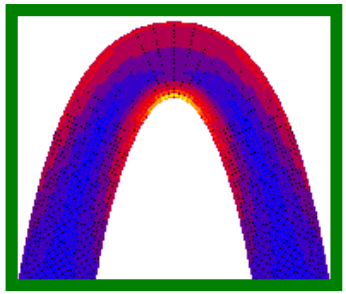


Instron 5543



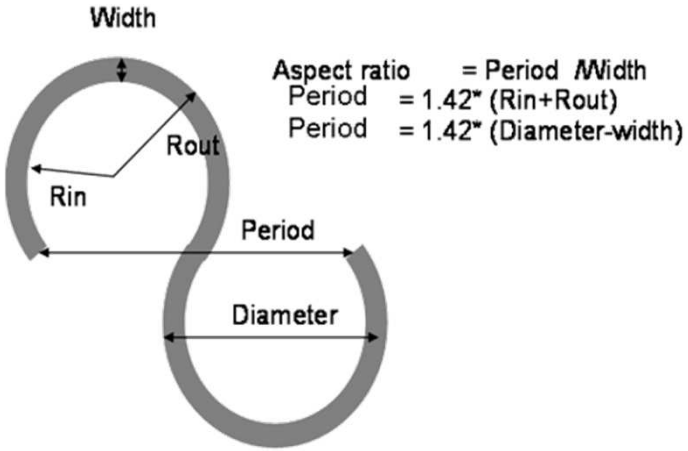
Reliable stretchable interconnections (2/4)



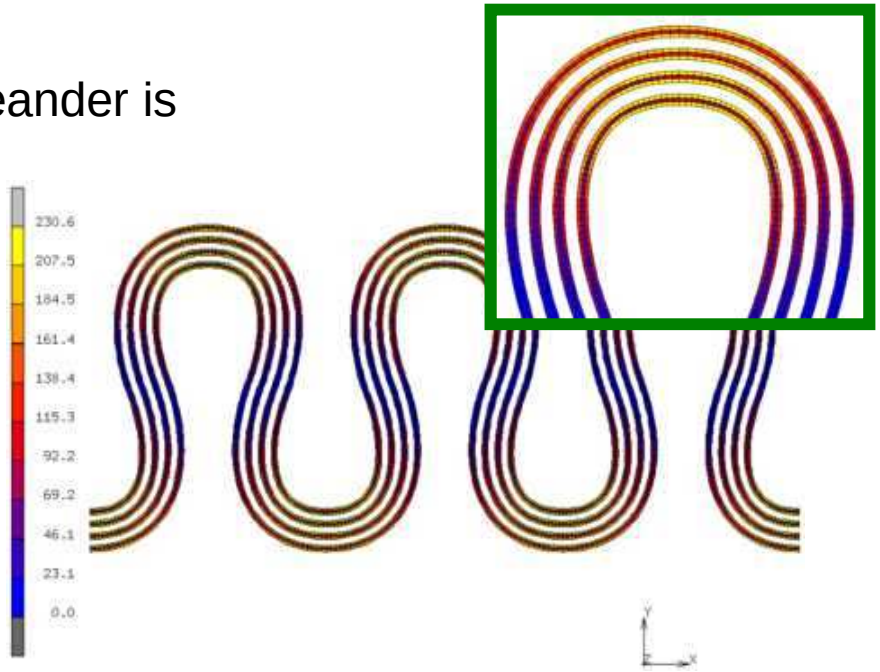


Stresses during elongation are locally too high

Simulations show that ‘horse shoe ’shaped meander is optimal geometry

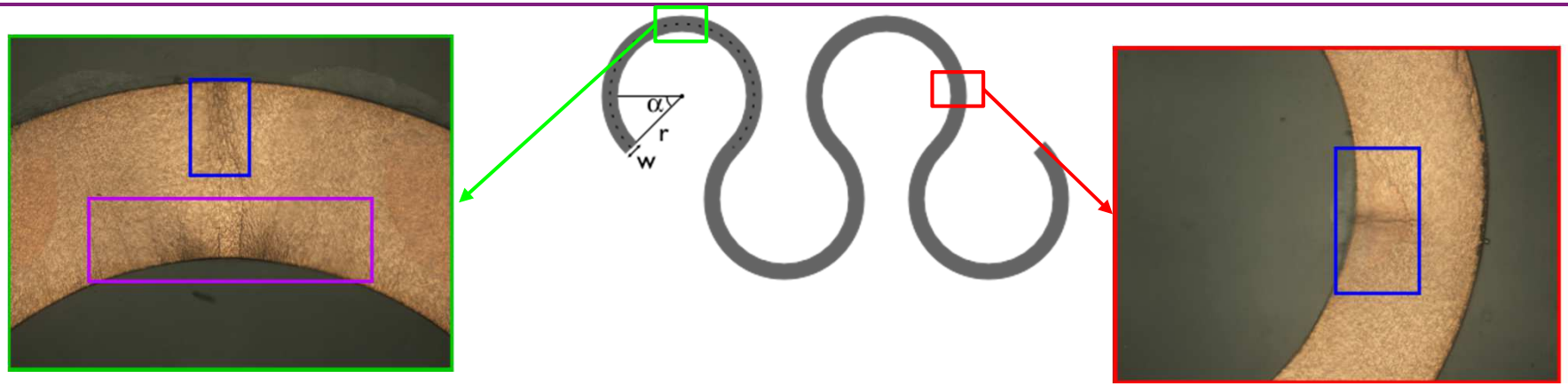


Aspect ratio = Period /Width
Period = 1.42* (Rin+Rout)
Period = 1.42* (Diameter-width)



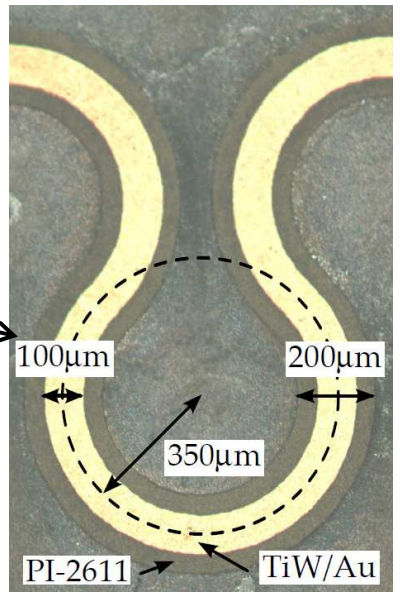
Multi-track horse shoe meander

Reliable stretchable interconnections (3/4)



Crack propagation can be postponed by introducing a supporting meandering polymer material underneath the Cu

Au meanders
Poly-imid supporting layer
Width 200um



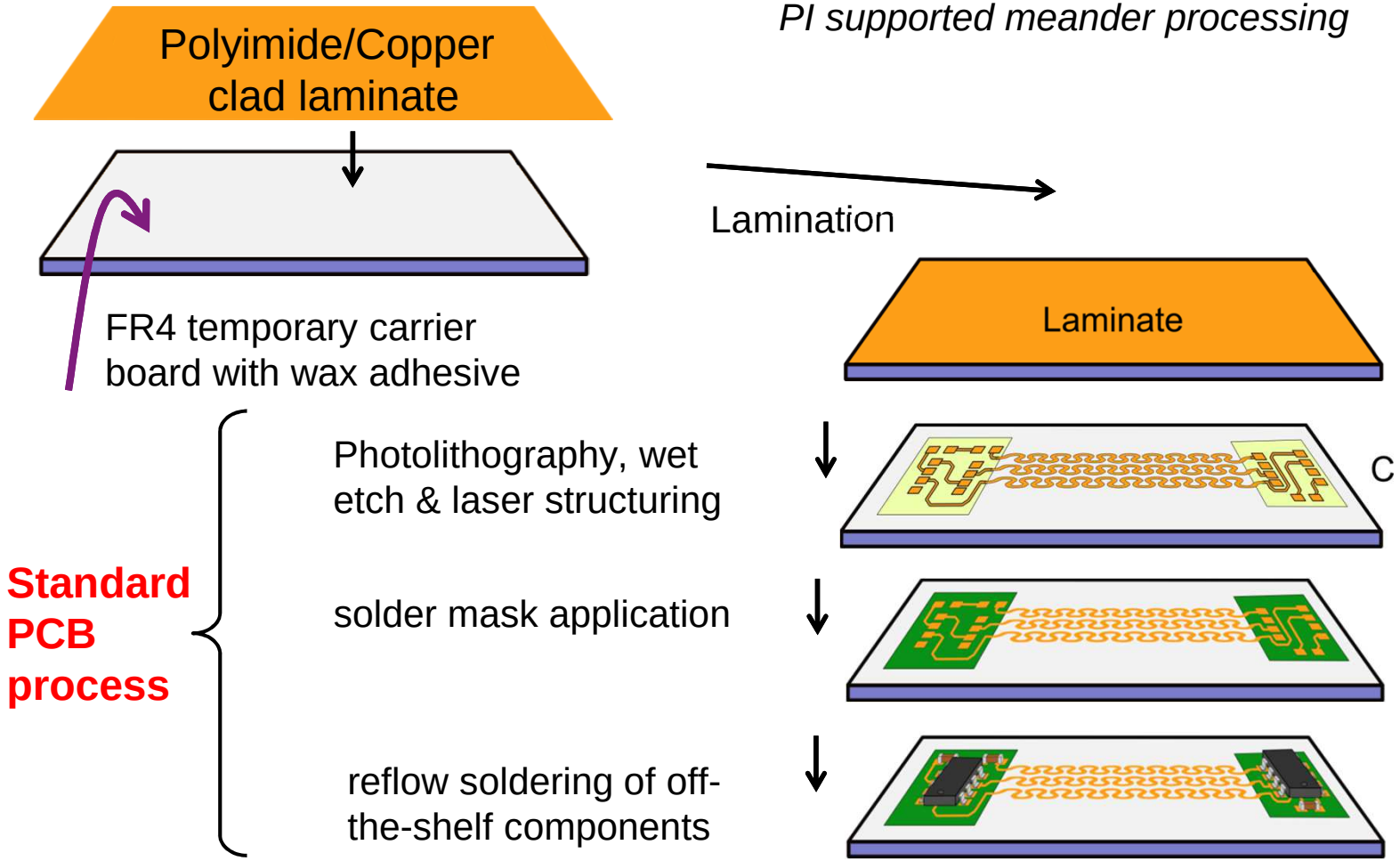
Reliable stretchable interconnections (4/4)

Smooth stretch-flex transition is essential

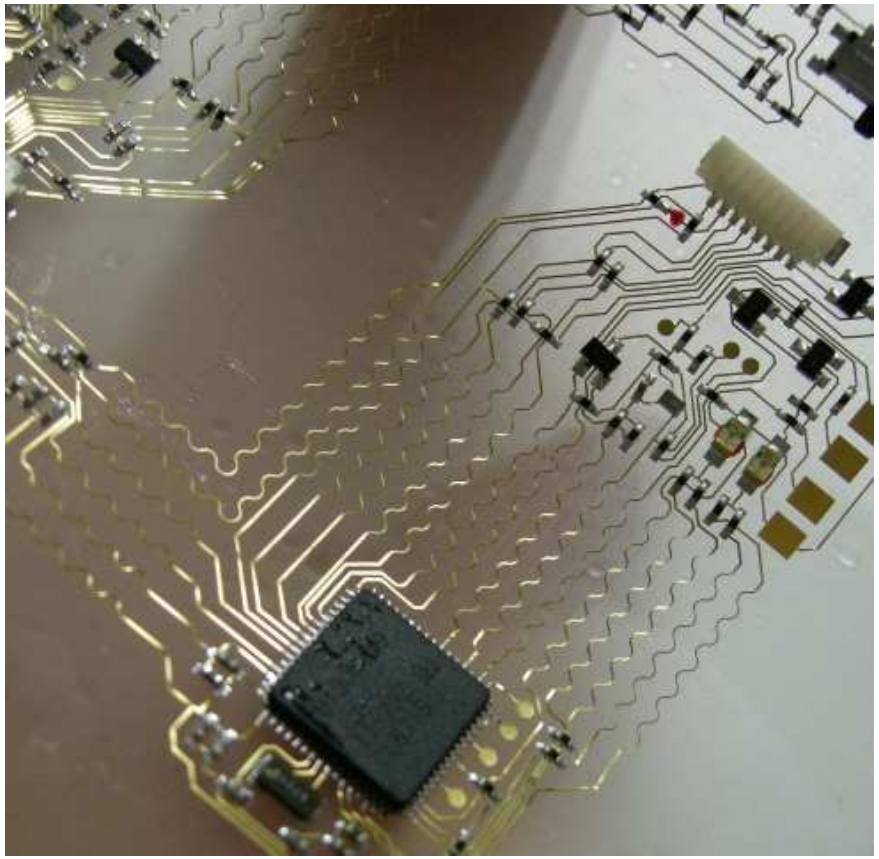
process flow: largely standard PCB processing

Stretchable Molded Interconnect (SMI) technology:

PI supported meander processing

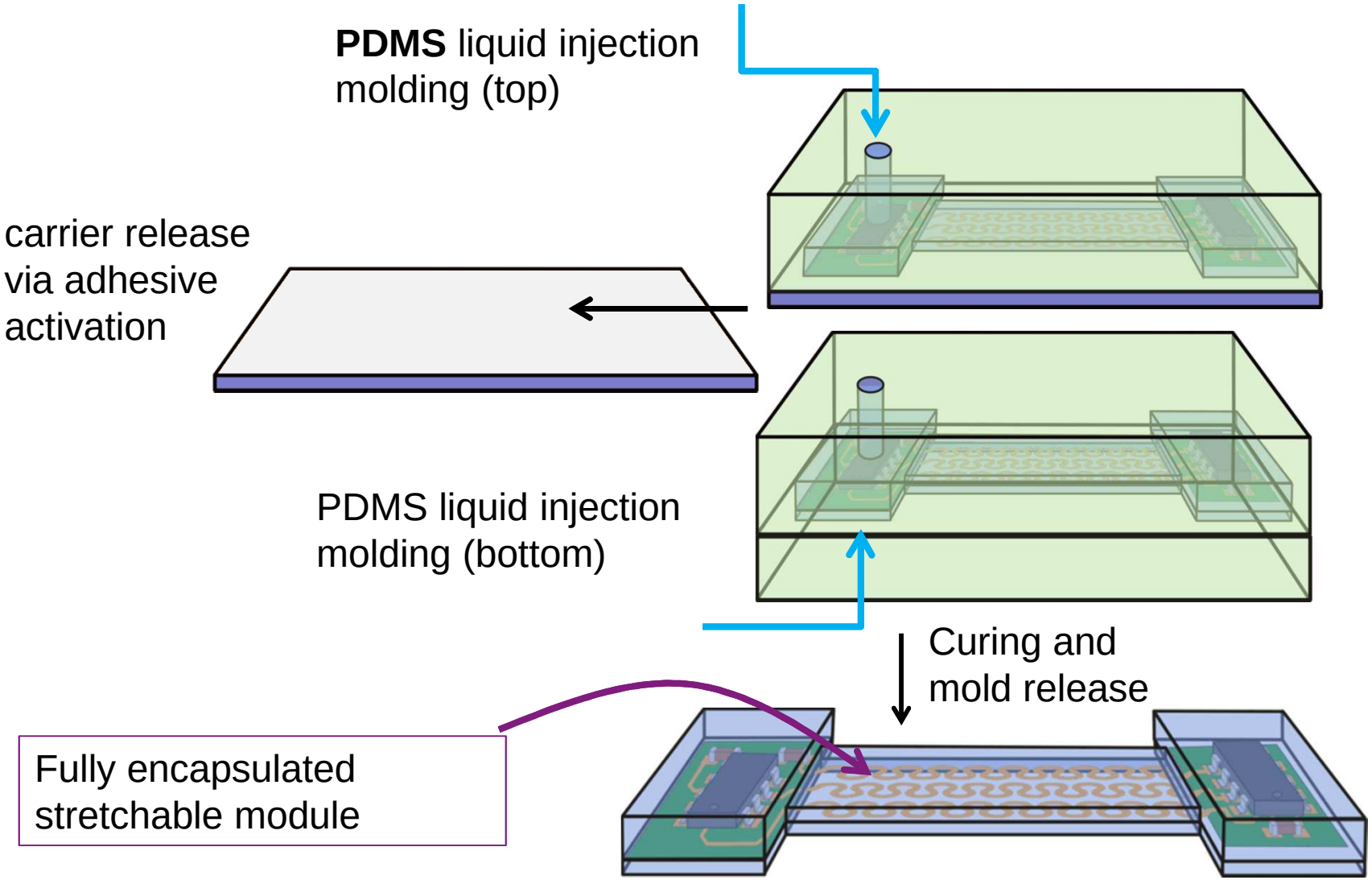


Results: Stretchable electronic circuit



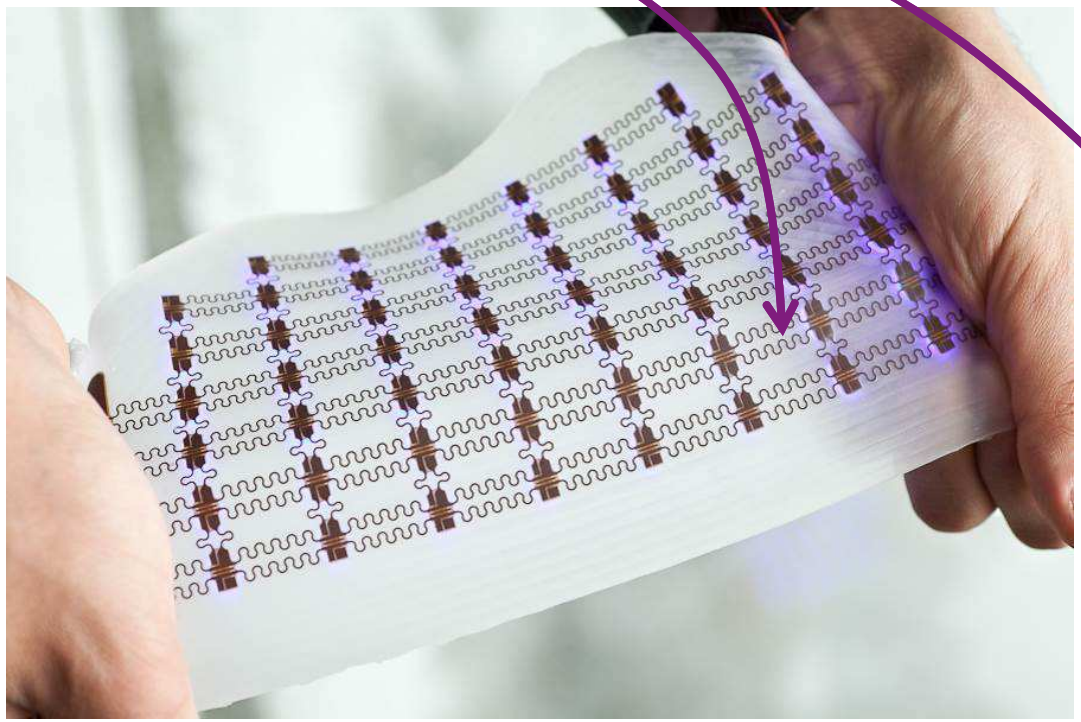
Fragile circuit → needs embedding

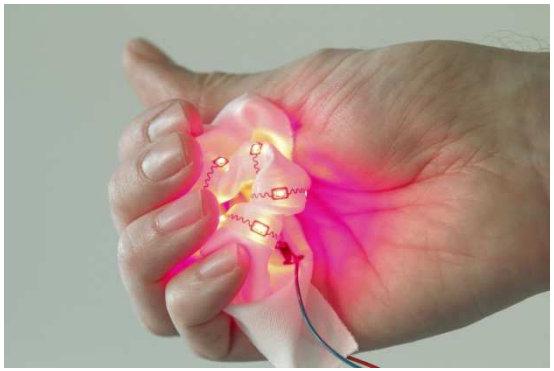
a) For stretchable systems: encapsulation in elastic polymer such as PDMS or PU

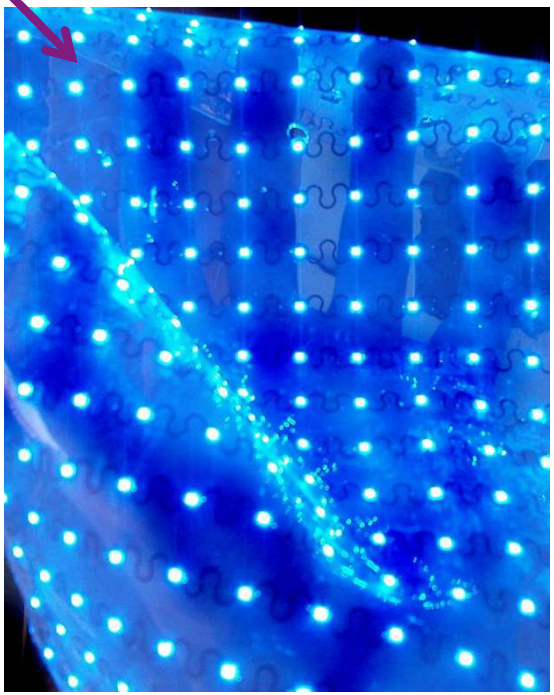


Demonstrators

Fully encapsulated stretchable module

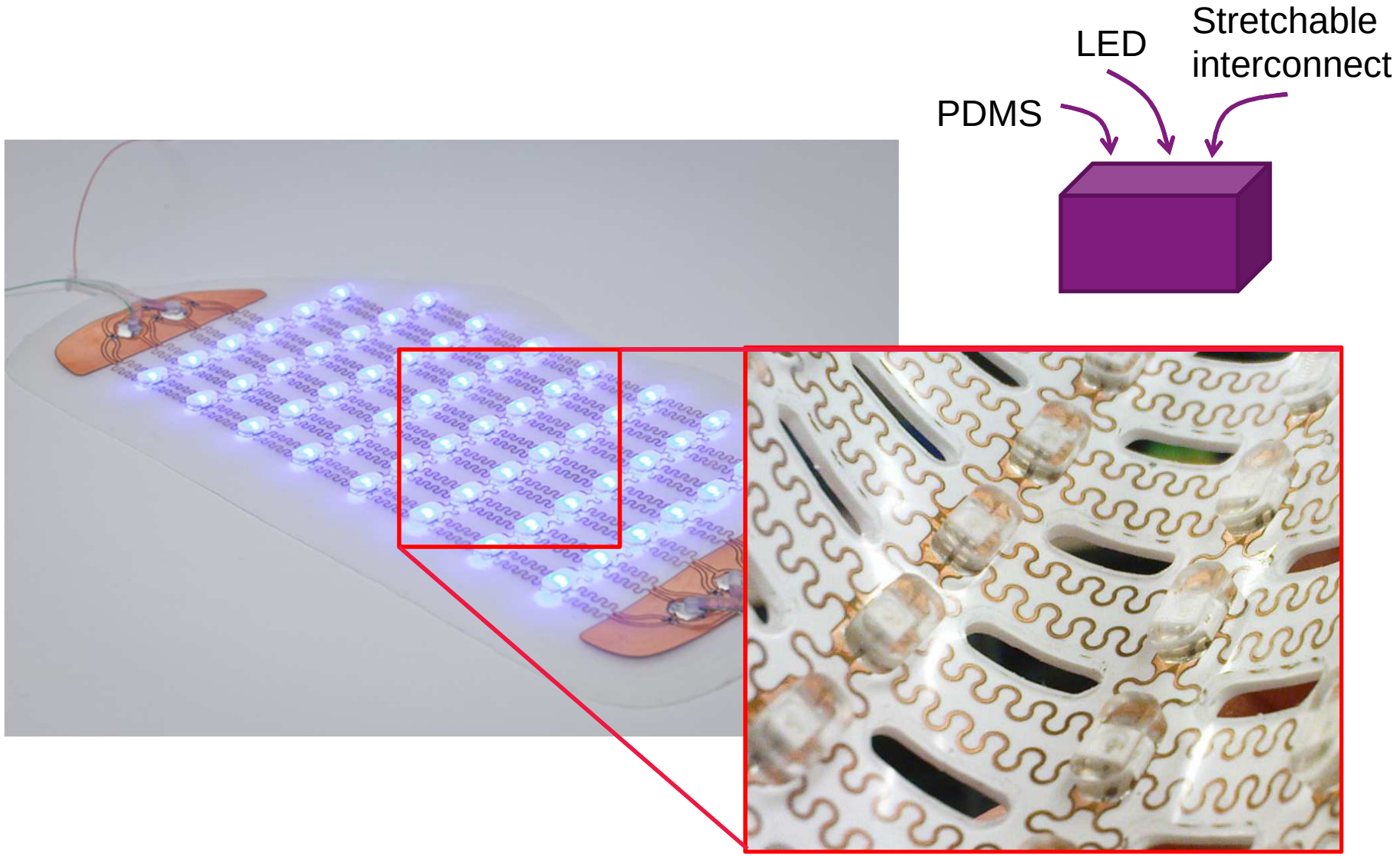






Flexible, stretchable, drapable... conformable!

RSI - the blue light therapy device



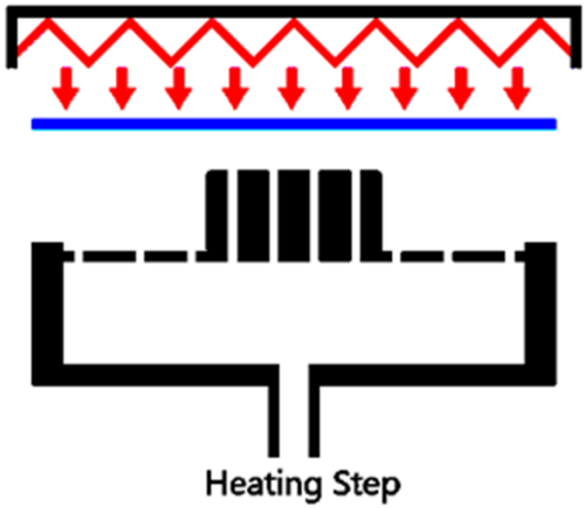
b) For rigid free form systems

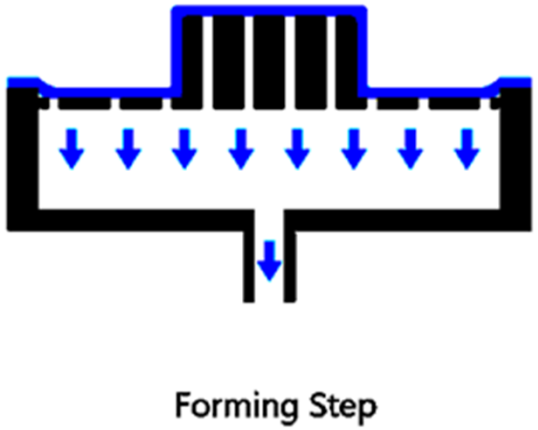
Replace elastic polymer carriers (PDMS, PU) by **thermoplastic materials** (PET, PMMA, PU, PC/ABS…)

Thermoplastic polymer is applied after circuit fabrication

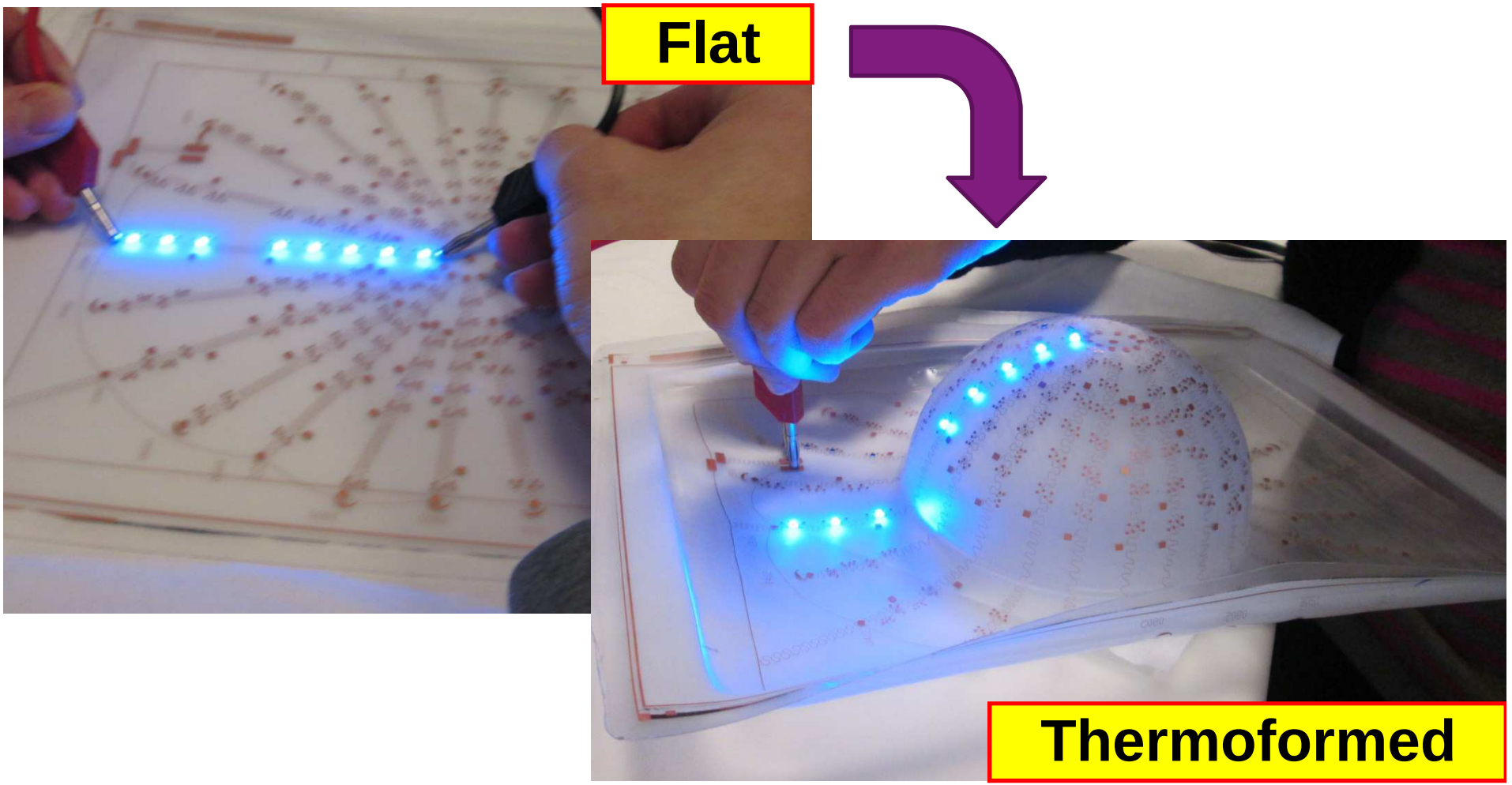
→ e.g. using new co-extrusion and lamination tool that will be installed in P3lab

The flat circuit is thermoformed over a dedicated forming tool





Rigid free form 2,5D circuits

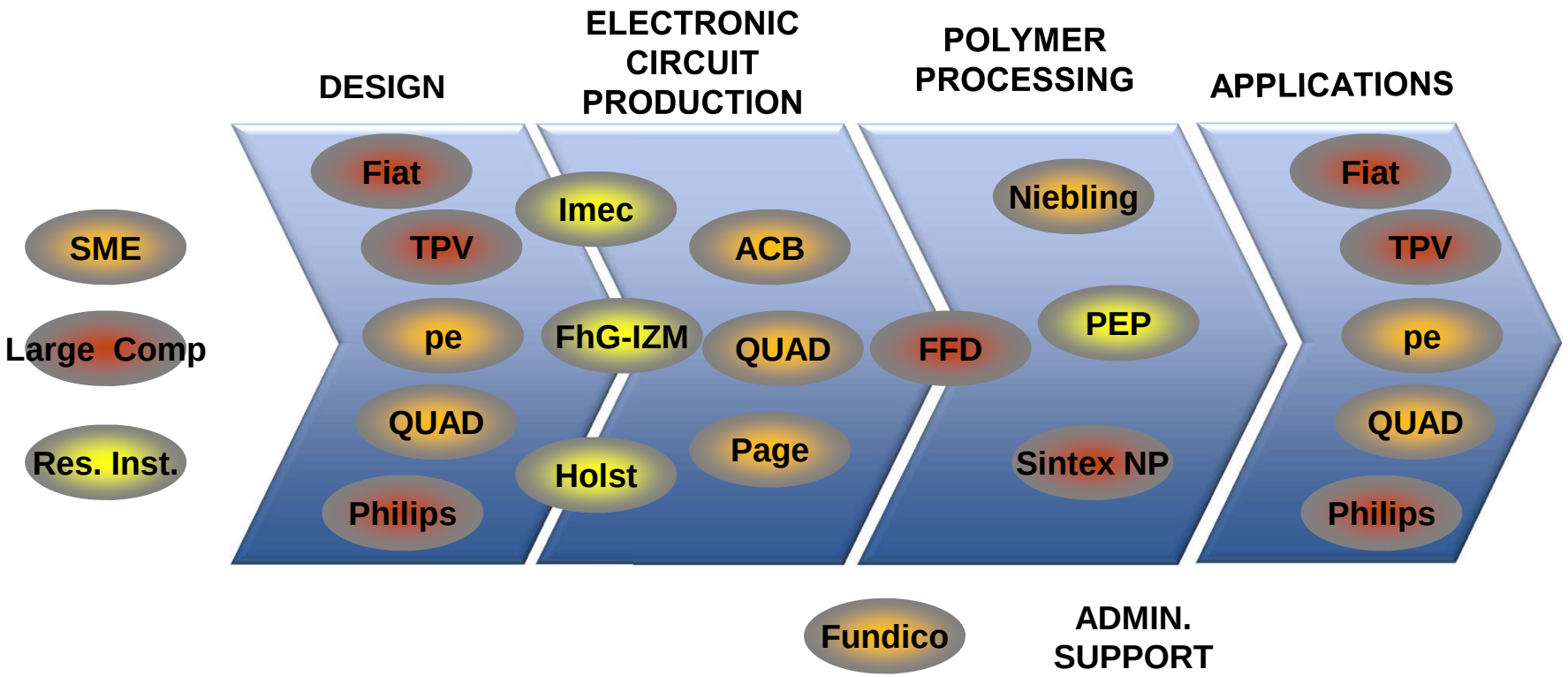


Rigid free form 2,5D circuits

1-time stretchable interconnects needed instead of dynamically deformable connections → demands on reliability different from elastic circuits (larger 1-time deformation, resistance to

FP7-TERASEL (coordinated by CMST)

Aim : to establish near-to-production industrial value chain in 3 years time



Start 1/10/2013

15 partners :
imec (co-ordinator), FhG-IZM, Holst Centre, Philips Lighting, TPVision, Fiat, Freudenberg, ACB, Page, Niebling, Sintex NP, Quad, …

Conclusions

A technology platform to produce free form 2,5D circuits embedded in plastics has been developed

the technology uses conventional processing equipment, the originality lies in the combination / sequence of the processing steps and the design of the circuits

the technologies have reached a level of maturity, allowing considering transfer to an industrial environment

UGent/imec is interested in co-operation to make available / further develop / adapt the technologies to special needs, e.g. for display applications

Acknlowledgements

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  - ✓ EC-FP6-SHIFT, EC-FP7-TIPS
  - ✓ EC-FP6-STELLA, EC-FP7-PlaceIt, EC-FP7- PASTA, EC-FP7-TERASEL

Thank you !

Questions?

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