nano-tera.ch
swiss scientific initiative in health / security / environment systems

WiseSkin RTD 2013

FNSNF

Soft Skin Embedding and Powering Wireless Tactile Sensor Nodes

H. Michaud[(a)], E. Daskalaki[(b)], J. Baborowski[(b)], O. Vorobyov[(b)], J.R. Farserotu[(b)], and S.P. Lacour[(a)]

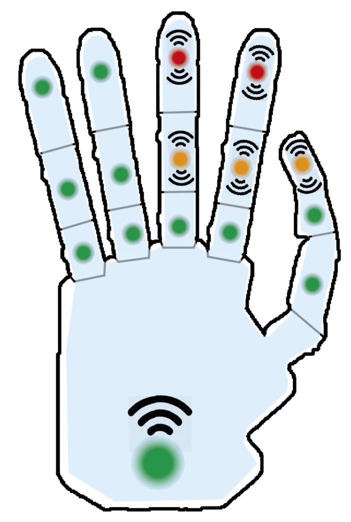
(a): Laboratory for Soft Biolelectronic Interfaces, EPFL, Lausanne (b): CSEM SA, Neuchâtel

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

csem

Objectives of the project

- Engineer a wearable, integrated skin with distributed tactile sensors.
- Integrate the artificial skin to a glove mounted on a robotic or prosthetic hand.
- Freedom of movement and comfort enhanced by a non-invasive, skin-like sensing system.
- Integration and scalability made easy thanks to wireless communication of tactile information [1].



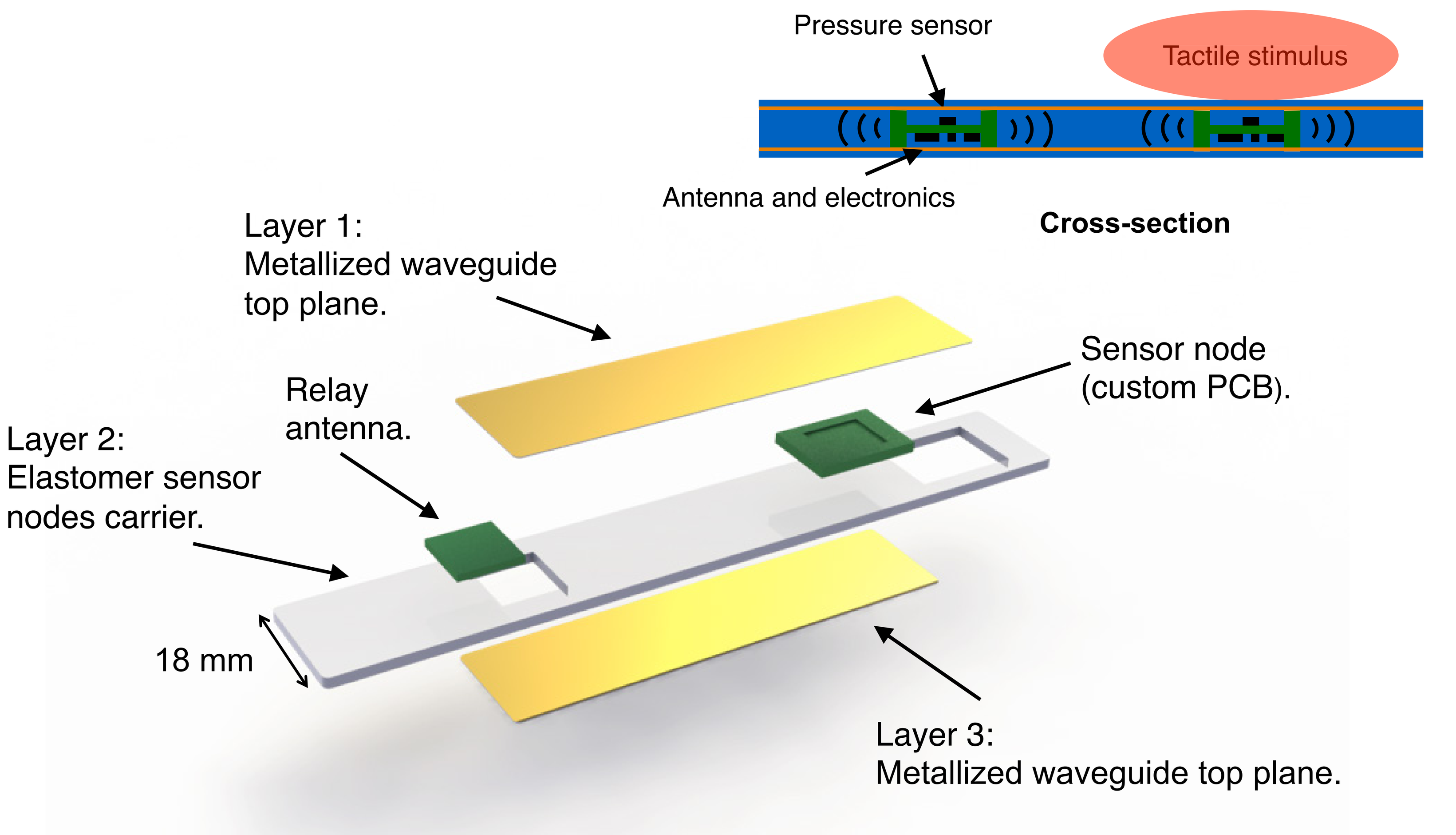
Sensing nodes mapped on a prosthetic hand

Conformal power distribution system

The conformal power distribution system (CPDS) fulfills 3 roles:
1) powering each sensor nodes;
2) acting as reflective planes for the electromagnetic waves;
3) maintaining electromechanical integrity when the finger bends.

- **Example of a sensing finger**

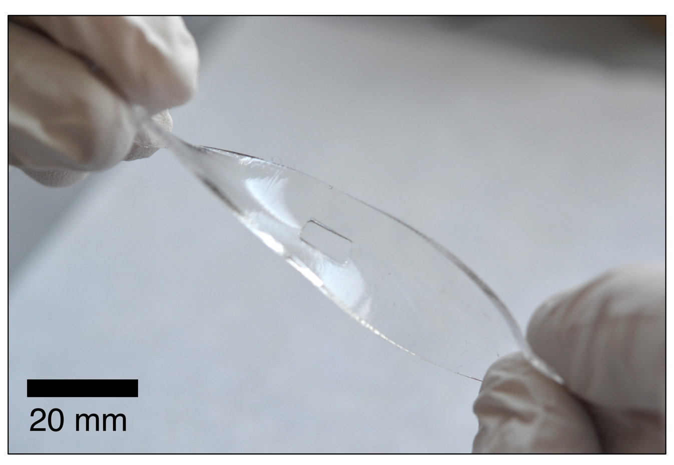
Integrated sensor nodes are distributed inside an elastomeric membrane. A sensor node is composed of one or several pressure sensors, their associated electronics and an antenna to transmit pressure data.



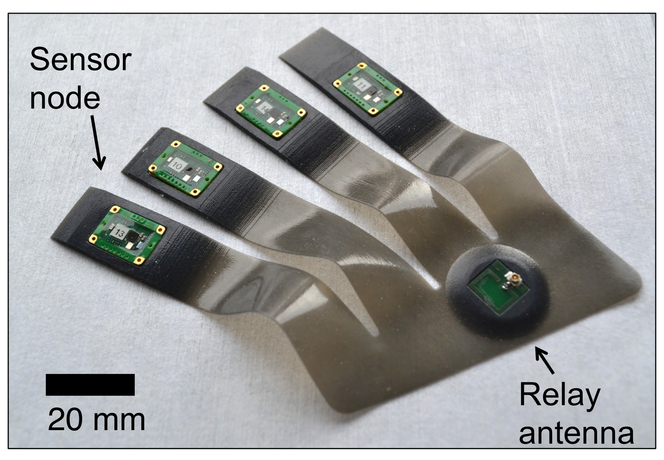
Layers 1 & 3 are in **elastomer** or **plastic. Layer** 2 is in **elastomer.** Total thickness **< 2 mm.**

- **Structure material for WiseSkin**

Two types of elastomer are investigated to form the sensor node carrier (layer 2) : polydimethylsiloxane *(*PDMS, elastic modulus E≈1.5 MPa*)* that has to be molded to host the sensor node, and TangoBlack (E≈0.3 MPa), a proprietary, 3D printable elastomer.



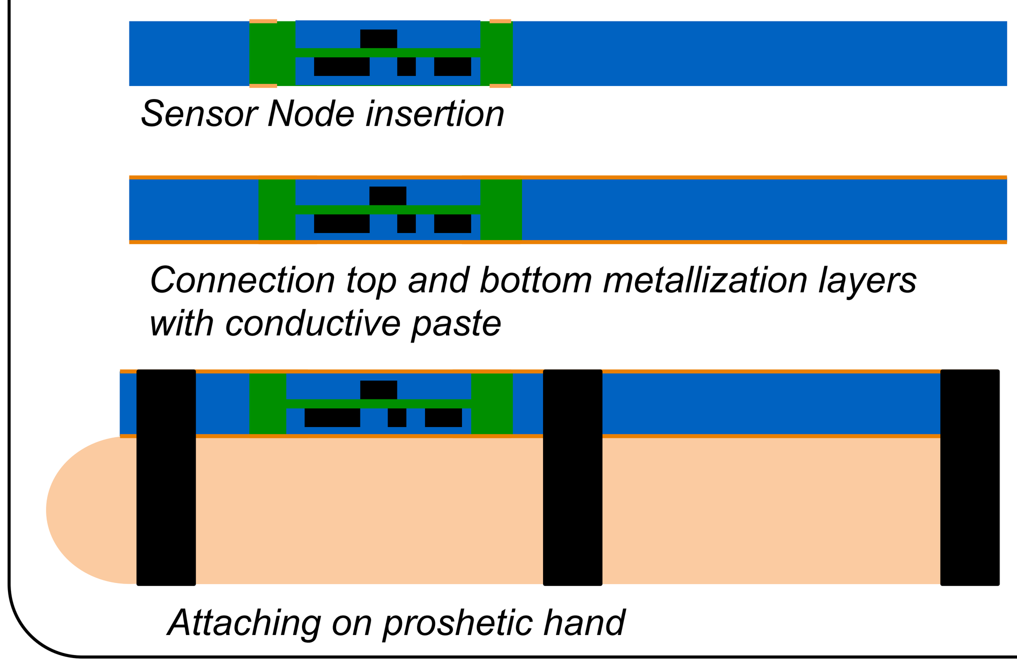
Molded PDMS sample



3D printed TangoBlack palm with sensor nodes inserted

Integration on a prosthetic hand

The skin system is composed of one palm element with four sensors and one relay antenna, and one thumb element with one sensor and one relay antenna.
The first full-scale prototype is powered by flexible metallized (Cr/Au 5/100 nm) polyimide layers. All sensors nodes were functional after integration.

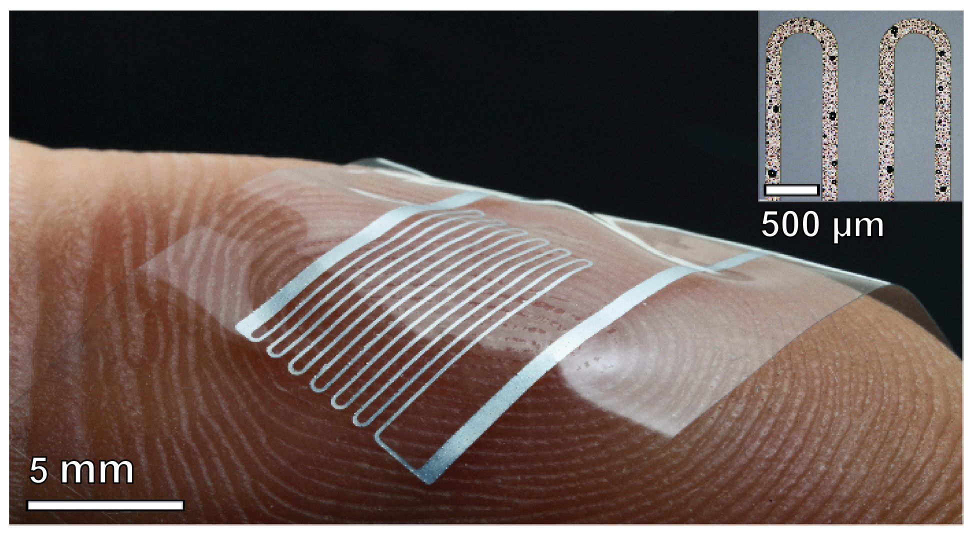


WiseSkin system integrated* on the Ottobock Myohand *Varyplus prosthetic hand

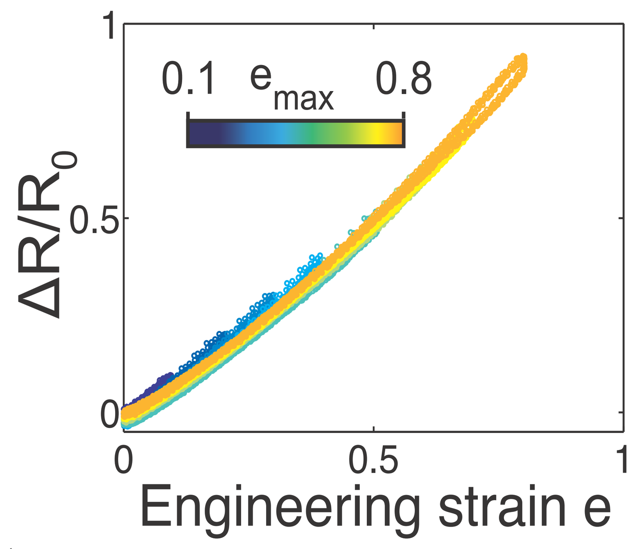
Towards fully elastomeric skin

- **Highly conductive stretchable thin films**

We developed a thin film metallization technique to produce gold-gallium films that combine a solid and a liquid metallic phases. The films have a sheet resistance of 0.5 Ω/sq as deposited and maintain high conductivity up to more than 300% of mechanical strain [2].



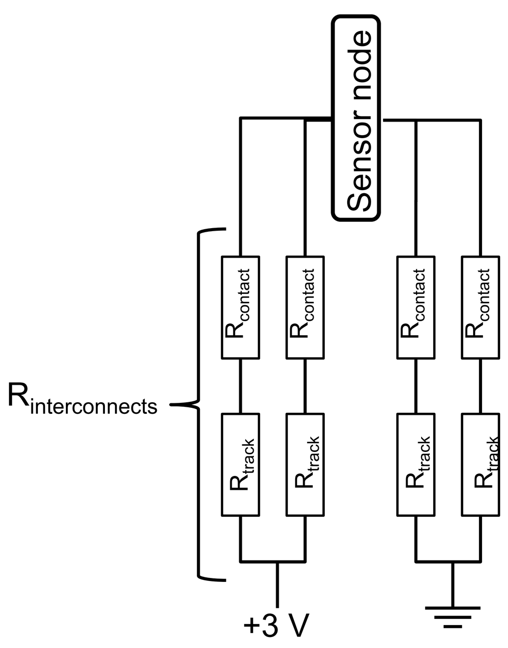
Patterns of biphasic films on a PDMS elastomer substrate

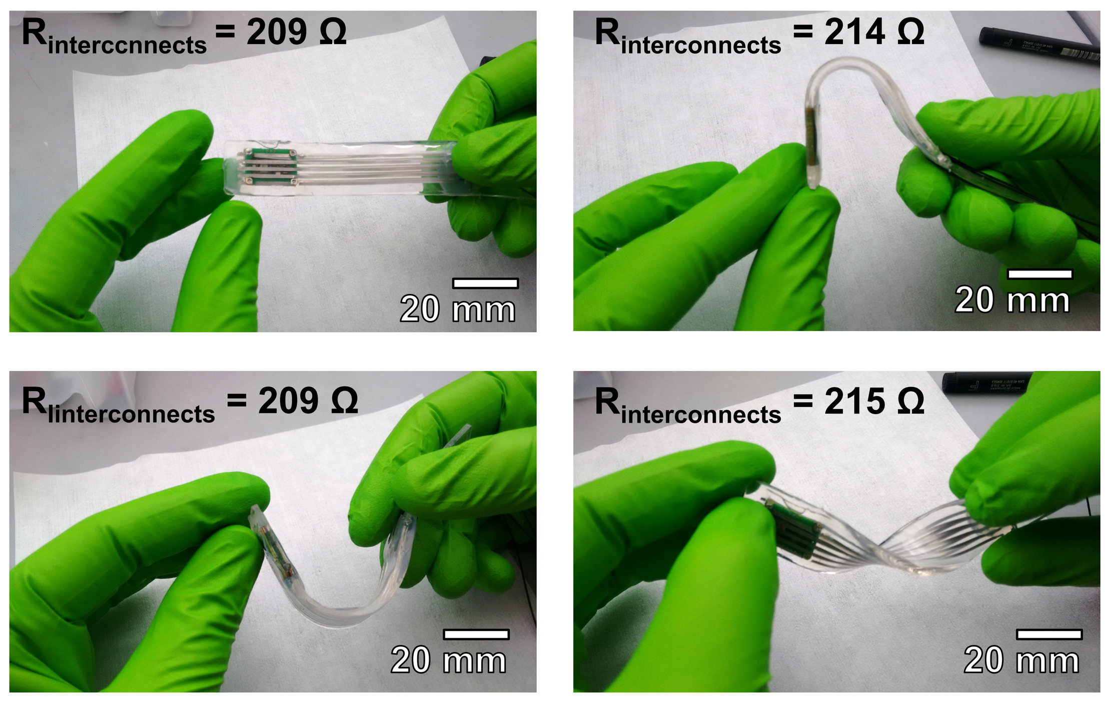


Change in resistance of the film as a function of uniaxial strain

- **Integration with WiseSkin sensor nodes**

We designed prototypes embedding one sensor powered by two soft metallization tracks. The electrical connection is maintained when the finger is bent or twisted. $R_{interconnects}$ is the resistance of two 150 x 1 mm^2 tracks in parallel and the contact resistance.





Conclusion and future work

- Elastomer materials can be patterned to enable insertion of wireless sensing nodes in a skin-like system. A system consiting of five wireless sensor nodes and two relay antennas was successfully mounted on a prosthetic hand.
- Further experiments will include mounting of the sensor nodes embedded in the fully elastomeric skin on the prosthesis in order to verify the robustness of the system.

References

[1] Farserotu, J.R. et al. "Tactile prosthetics in WiseSkin". In *Proceedings of the 2015 Design, Automation & Test in Europe Conference & Exhibition (DATE)*, 2015

[2] Hirsch, A., Michaud, H. O., Gerratt, A. P., De Mulatier, S., & Lacour, S. P. "Intrinsically Stretchable Biphasic (Solid–Liquid) Thin Metal Films". *Advanced Materials*, 2016