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Conformal power distribution system and waveguide for artificial skin

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

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csem

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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.

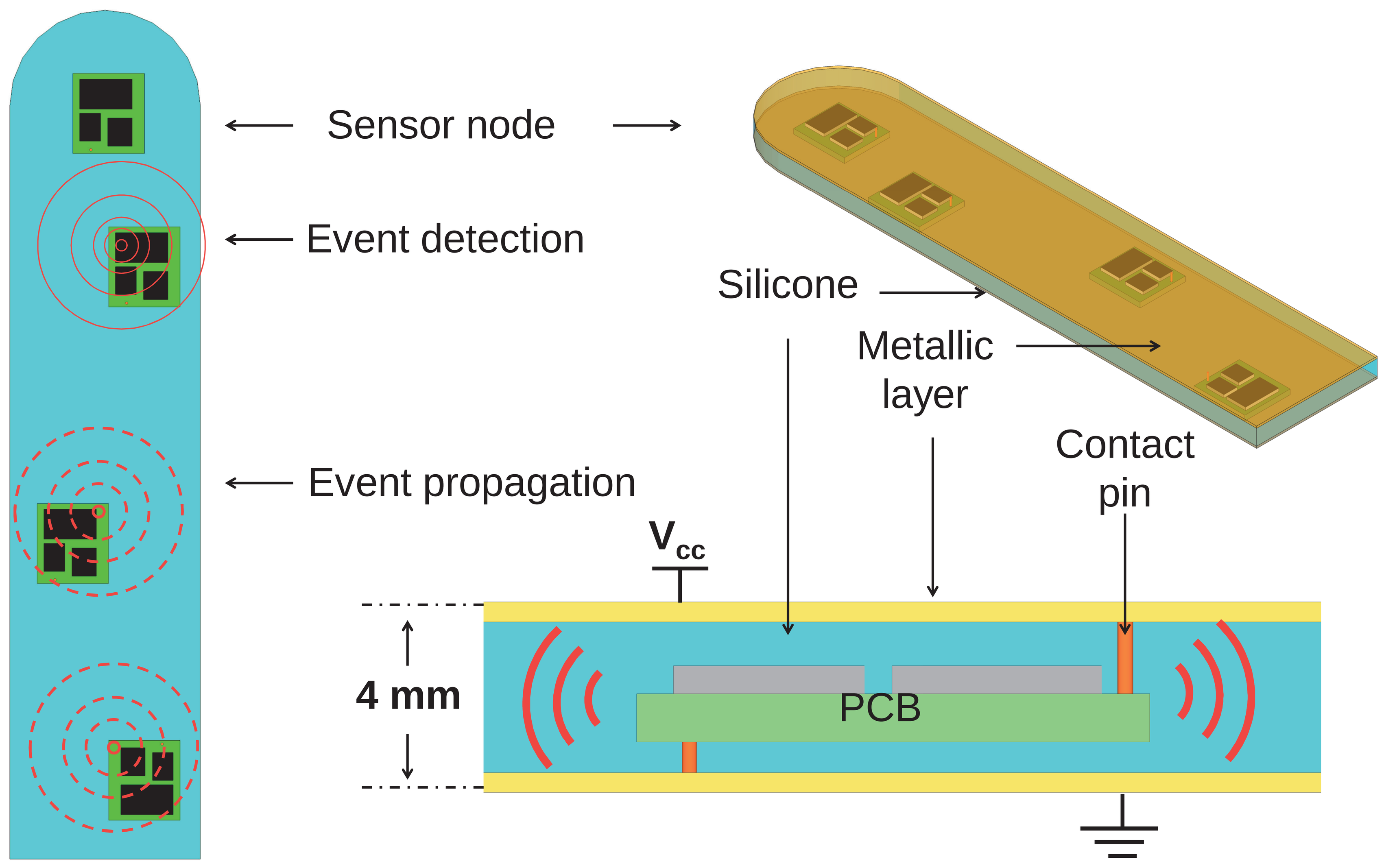
Example of sensing nodes mapped on a hand

Conformal power distribution system

The conformal power distribution system (CPDS) fulfills 3 roles: power each sensor nodes, act as reflective planes for the electromagnetic waves and maintain electromechanical integrity when the finger bends.

- **Example of a sensing finger**

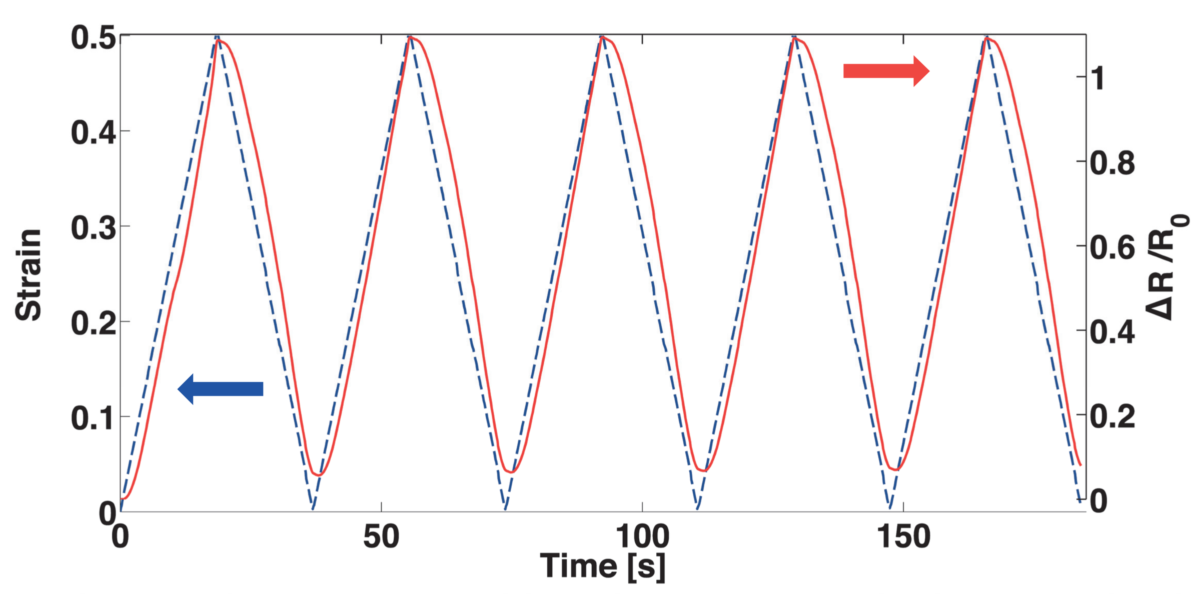
Integrated sensors nodes are distributed inside an elastomeric membrane. A sensor node is composed of one or several pressure sensors, their associated electronics and an antenna.



Top view of a sensing finger — **Cross section of a sensor node integrated in the waveguide**

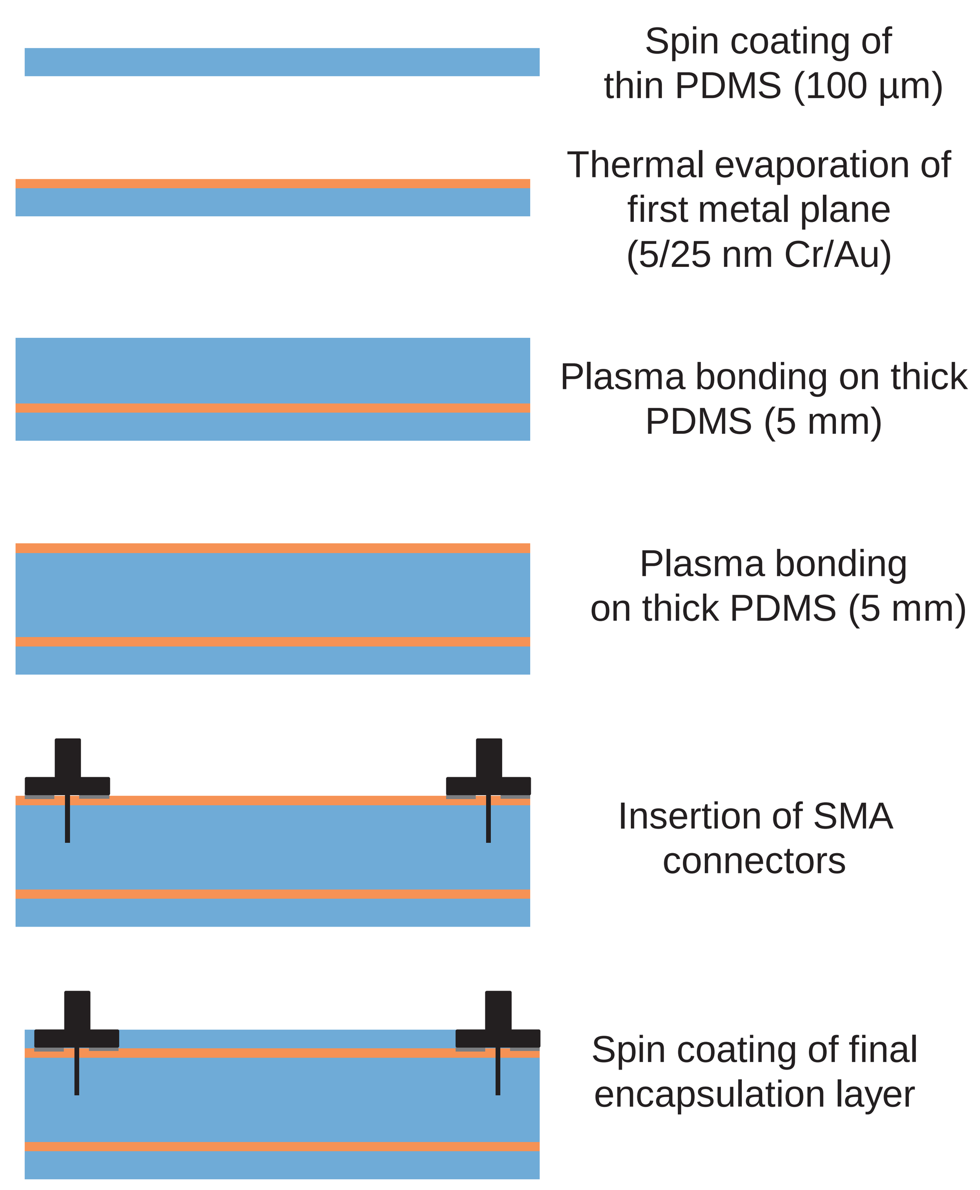
- **Materials for elastic conductors in the CPDS**

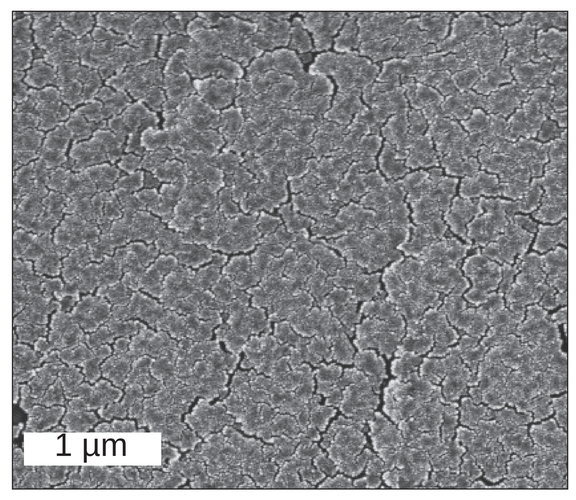
Gold thin films on silicone (PDMS) can be deposited over large area and patterned using shadow masks or standard lithography. They remain conductive under large mechanical strains. The use of soft materials minimizes the stiffness of the layers.



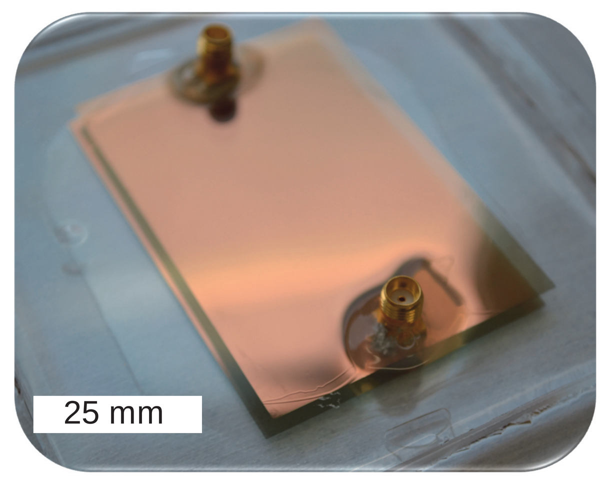
Resistance change of a 6x0.5 mm gold track on PDMS under large mechanical strain.

Fabrication process





SEM image of stretchable gold film on PDMS



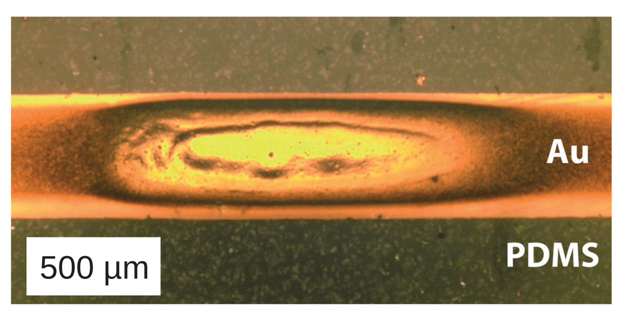
Conformable waveguide structure for propagation tests

Characterization results

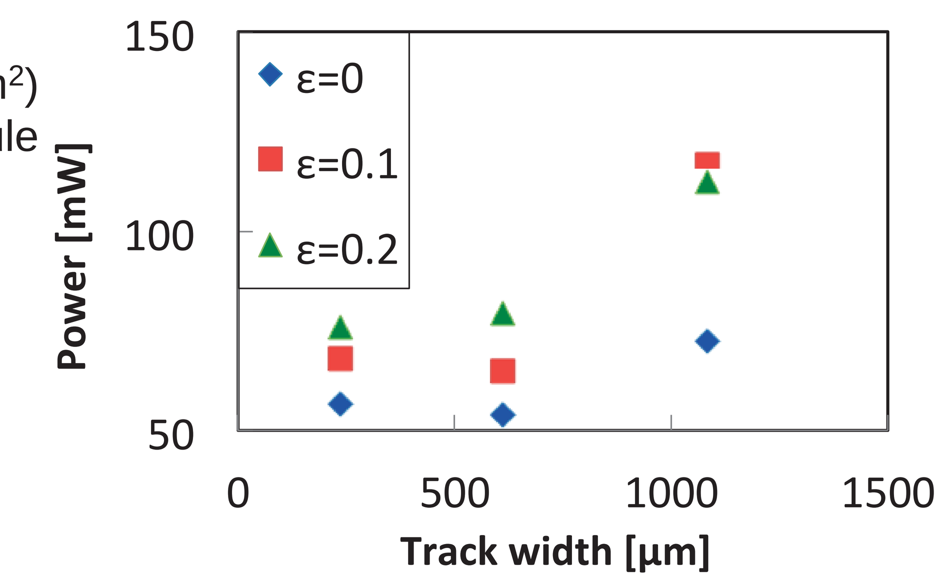
- **Electrical power distribution**

Sheet resistance of stretchable gold thin film is 20-60 Ω/☐ against 0.9 Ω/☐ for standard Au thin films (25 nm).

High current densities (160 kA/cm²) can induce damage due to Joule heating above 100 ° C.

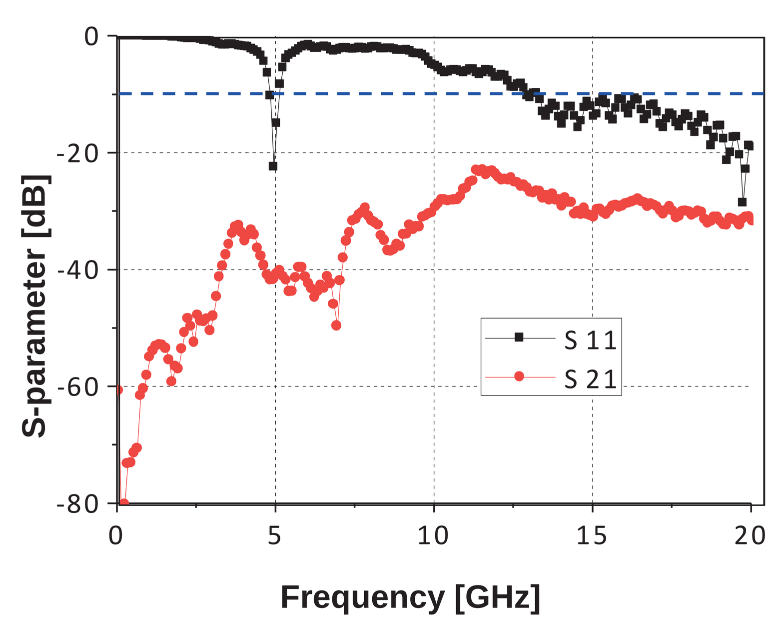


Damage induced by Joule heating

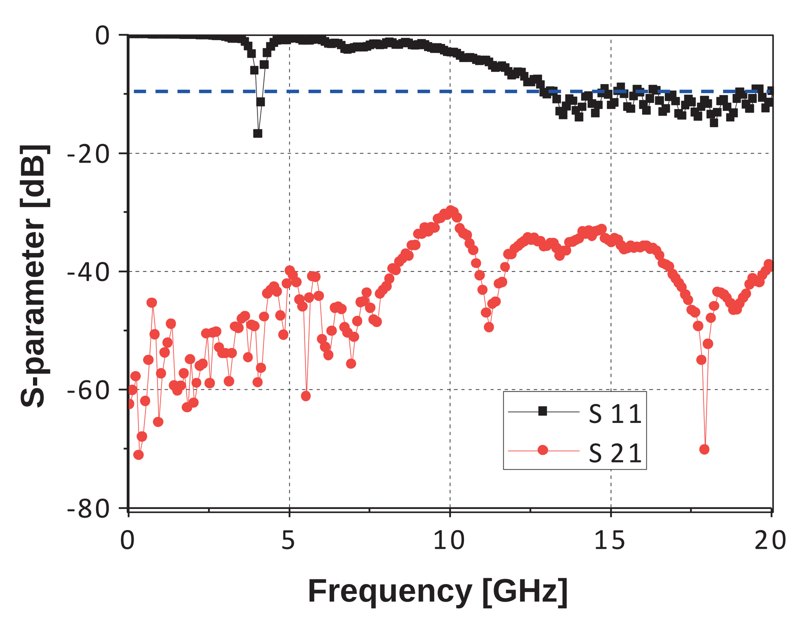


Dissipated power through stretchable gold tracks to reach ε T_{max} = 60° C, as a function of stretch.

- **Electromagnetic waves propagation**



S-parameters for waveguide with top plane non-grounded



S-parameters for waveguide with top plane grounded

Conclusion and future work

- Soft metallic membranes are good candidates to achieve power distribution for a large number of sensors distributed in a skin-like system. Losses in the waveguide seem to be compatible with requirements for radio communication.
- Further experiments will include validation of the powering layer according to total power consumption and validation of the waveguide using integrated antennas.

References

[1] S. P. Lacour, J. Jones, Z. Suo, and S. Wagner, "Design and Performance of Thin Metal Film Interconnects for Skin-Like Electronic Circuits," *IEEE Electron Device Lett.*, vol. 25, no. 4, pp. 179–181, 2004.
[2] C. Antfolk, A. Björkman, S.-O. Frank, F. Sebelius, G. Lundborg, and B. Rosen, "Sensory feedback from a prosthetic hand based on air-mediated pressure from the hand to the forearm skin.," *J. Rehabil. Med.*, vol. 44, no. 8, pp. 702–7, Jul. 2012.