Elastomeric electronic skin acting as a waveguide for wireless sensors integration

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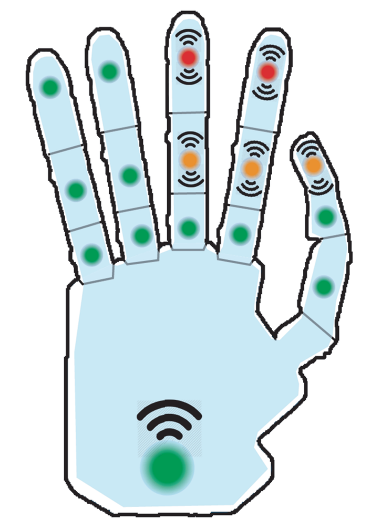
Objectives of the project

- 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.



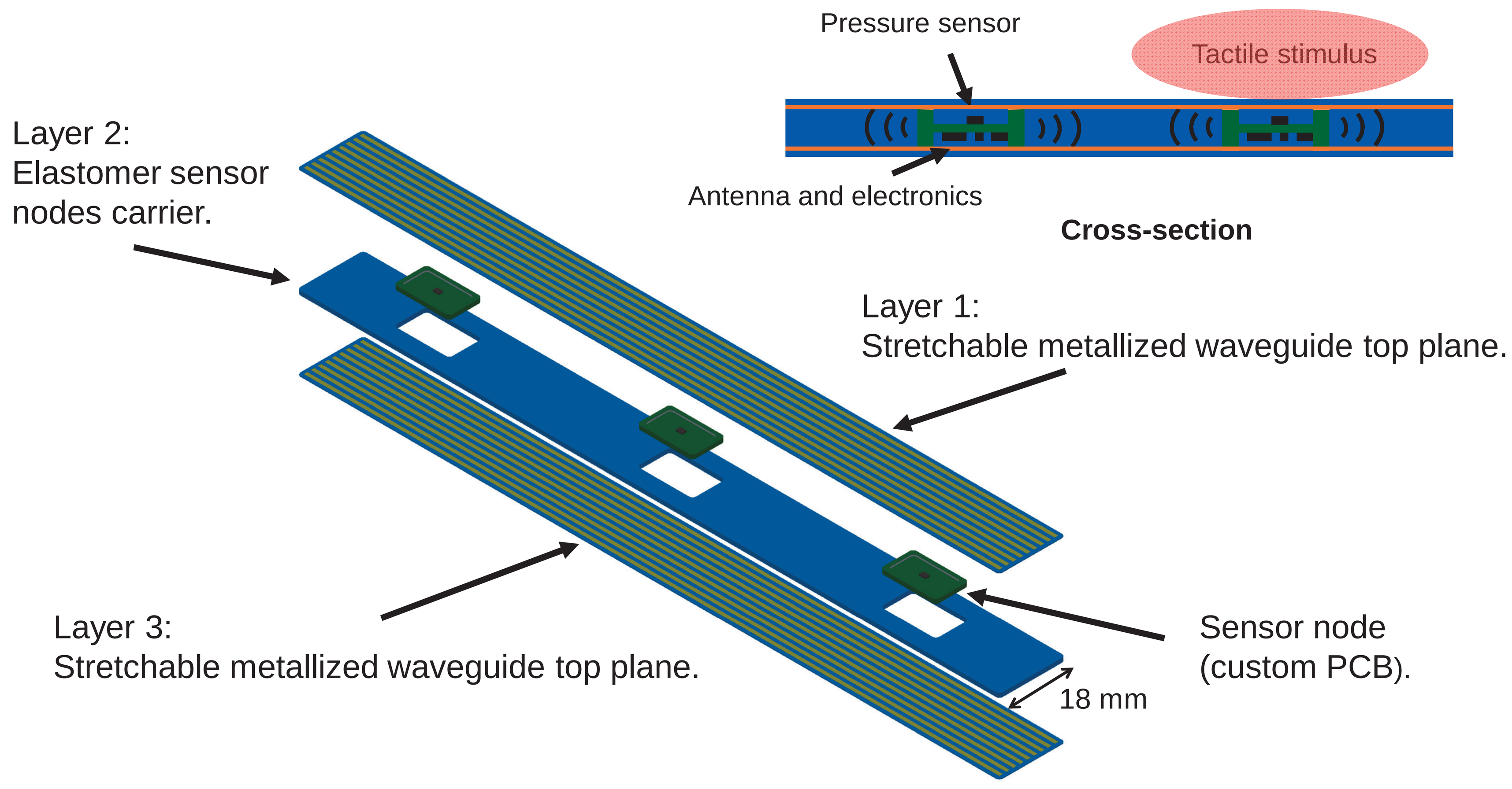
Sensing nodes mapped on a prosthetic hand

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**

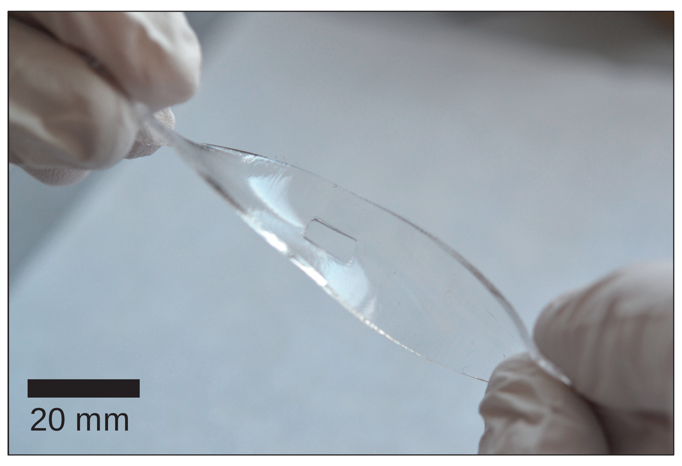
Integrated sensors nodes are distributed inside an elastomeric membrane. A sensor node is composed of one or several pressure sensors, their associated electronics and an antenna.



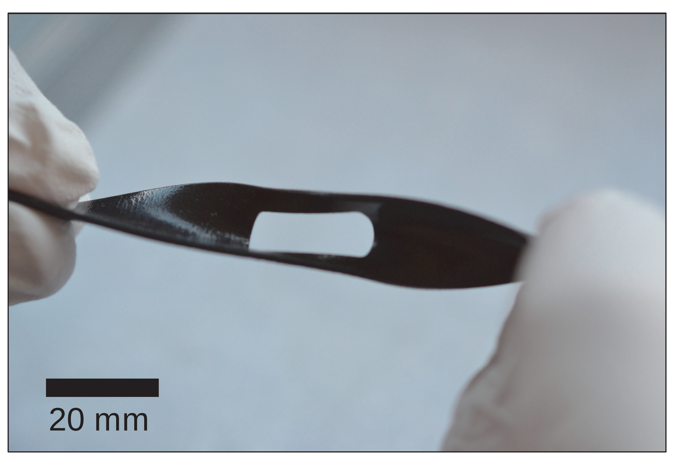
Layers 1, 2 & 3 are in **elastomer**. Total thickness **< 2 mm.**

- **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.

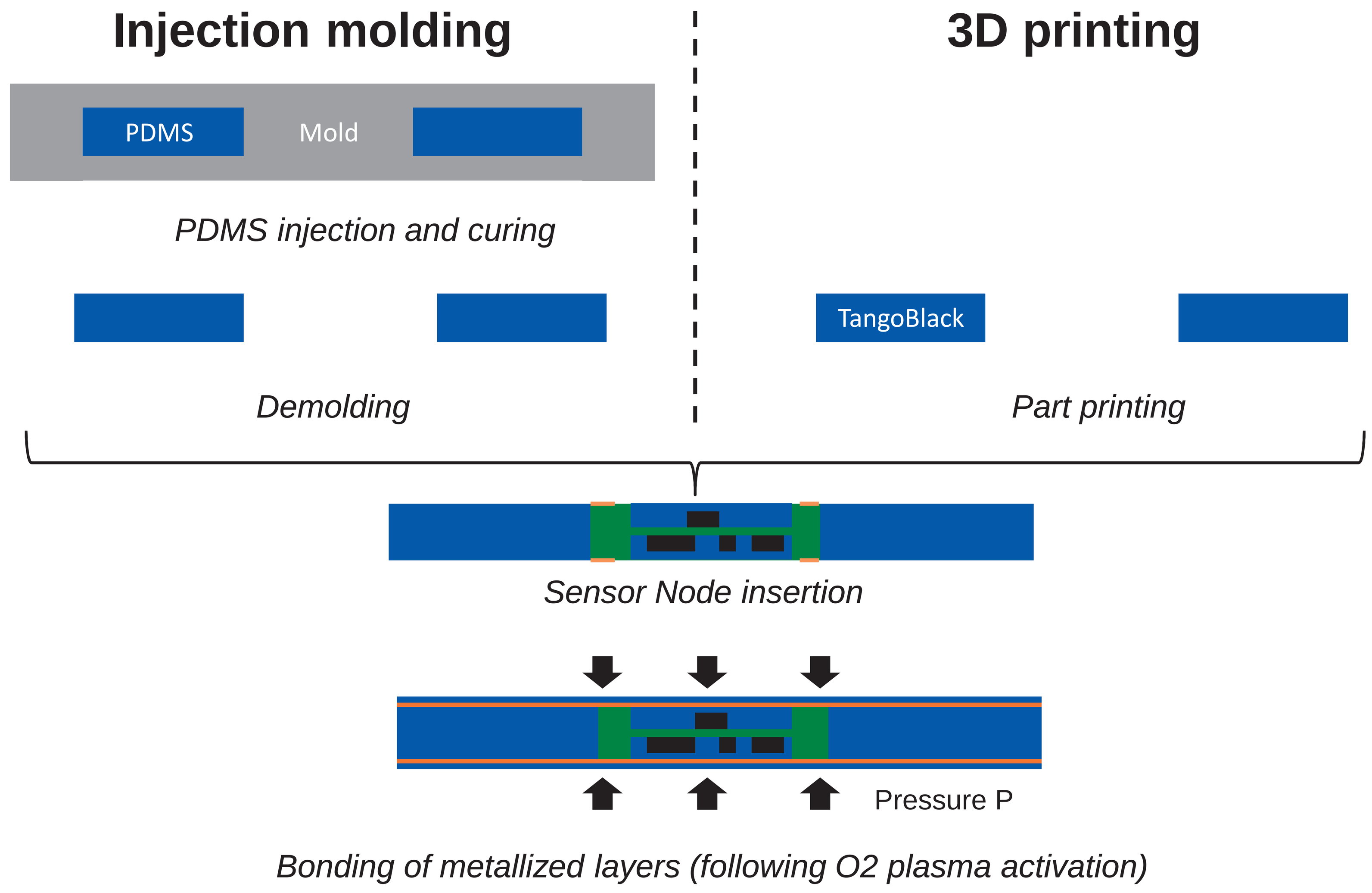


Molded PDMS sample



3D printed TangoBlack sample

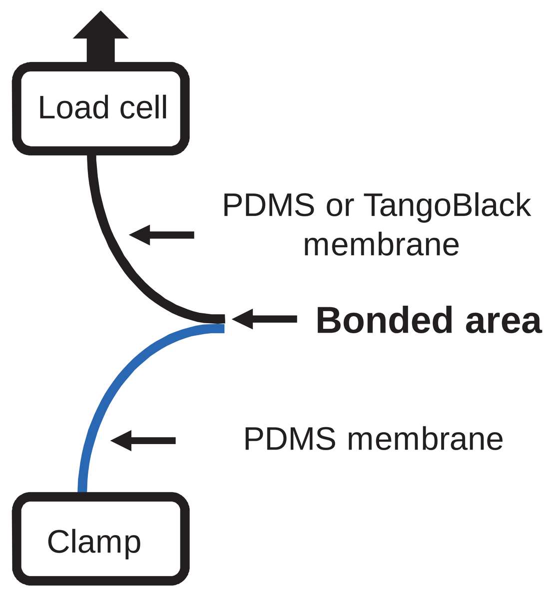
Fabrication process



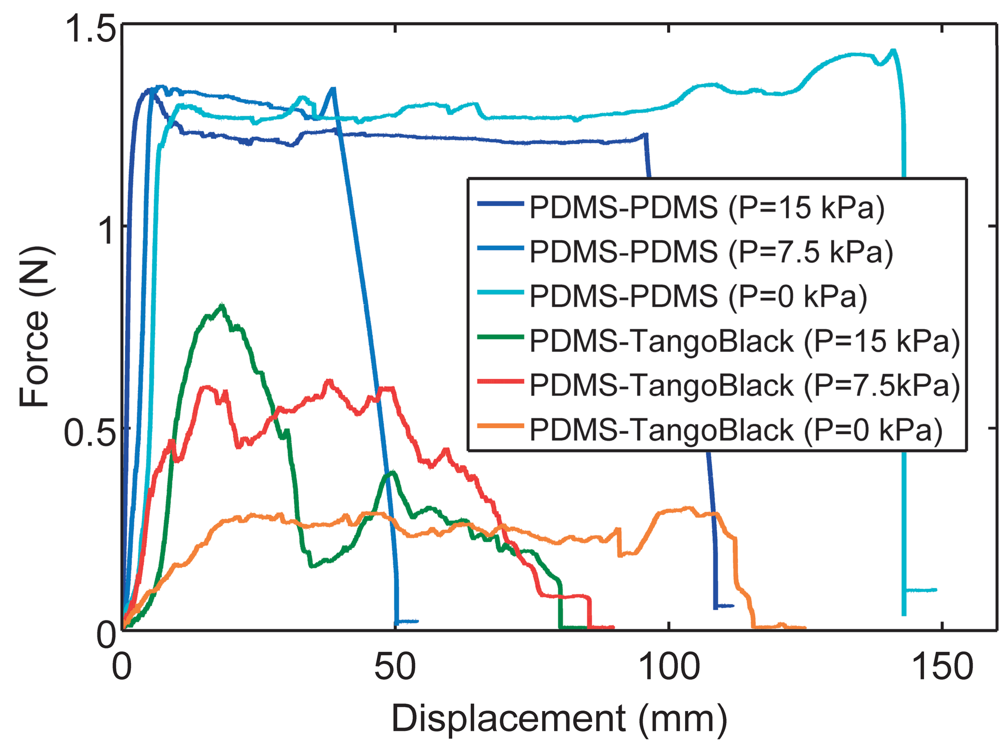
Characterization

- **Bonding force between elastomer layers**

After O_2 plasma activation, bonding force between PDMS and TangoBlack is weaker than the bonding force of PDMS to itself.



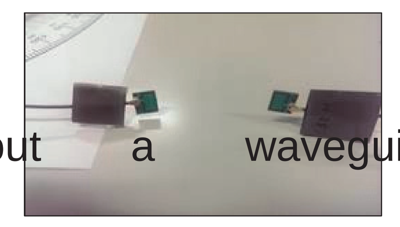
Peel off test setup

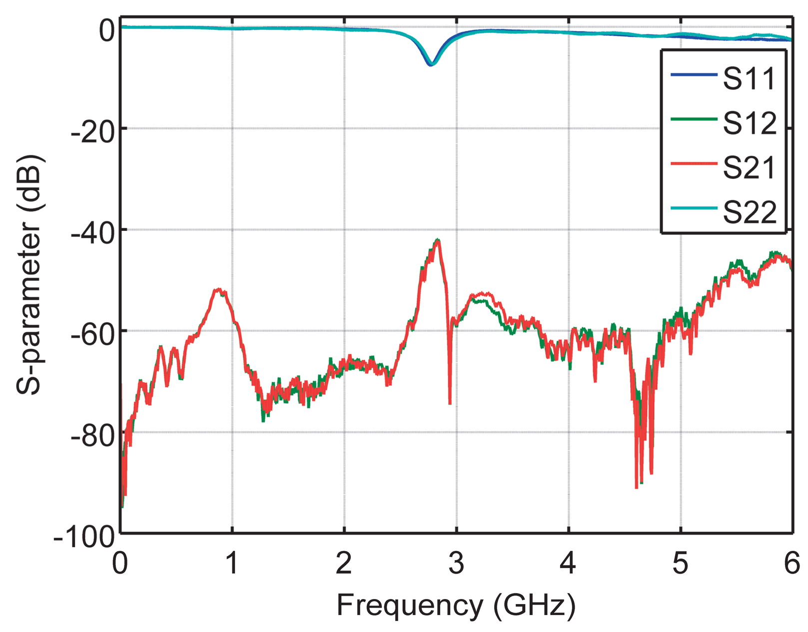


Peel off test results

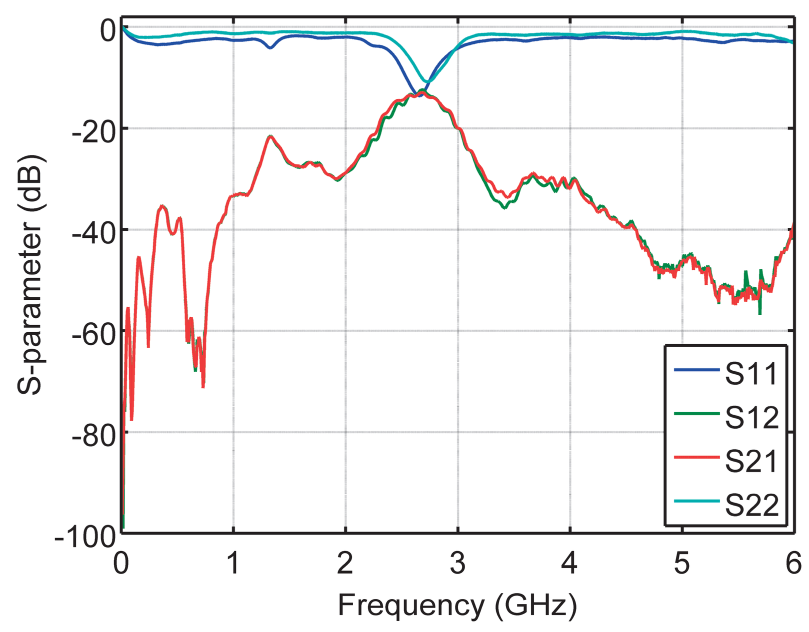
- **Electromagnetic waves propagation**

Scattering parameters of two UHF antennas separated by 5 cm are measured with or without a waveguide. Stretchable metallization reduces losses by 28 dB.





In free space



With the stretchable waveguide

Conclusion and future work

- Elastomer materials can be patterned to enable insertion of wireless sensing nodes in a skin-like system. Incorporating a stretchable waveguide results in a significant reduction of losses for wireless communication.
- Further experiments will include electromechanical testing of the sensor nodes embedded in the skin to assert the robustness of the system.

References

[1] X. Chen, L. Zhang, J.H. Sun, H. Li, and D.F. Cui, "A facile and simple high-performance polydimethylsiloxane casting based on self-polymerization dopamine.", *Journal of Micromechanics and Microengineering*, *24*(9), 095006, 2014

[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.