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Enabling Actuation and Sensing in Organs-on-Chip using Electroactive Polymers

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NETHERLANDS ORGAN ON A CHIP INITIATIVE

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Scan the QR code to watch a video of vSMCs actuated using IPMC in real condition

Organ on chips (OoCs)

• OoCs make use of soft biocompatible substrates, fluid flow, periodic mechanical loading and other dynamic stimuli to help the cultured cell tissues experience an in vivo-like microenvironment [1]

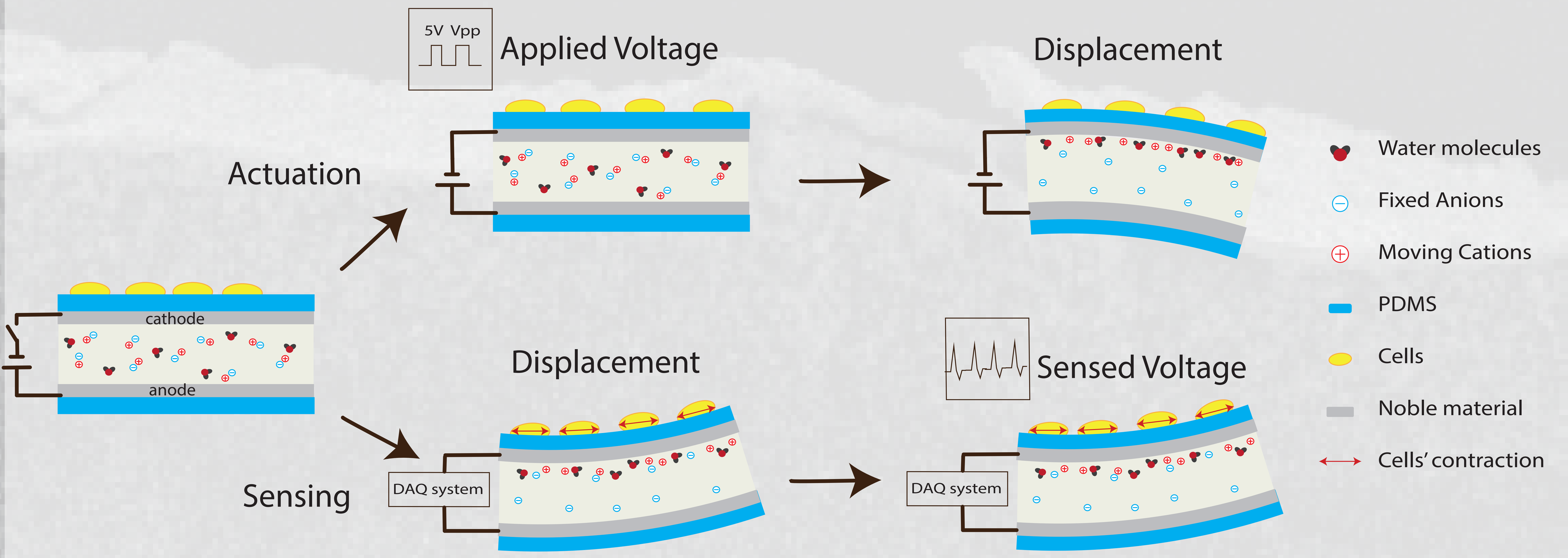
Pneumatic

Pneumatic-based system are widely used, however:
- They are bulky, expensive and non user friendly method [2]
- Barely no sensing
- Non mass manufacturable and hardly scalable for industry

Electroactive

We use Ionic polymer metal composite (IPMC)[3] for the first time in OoC :
- Compact, cheap and easy to use
- Both actuation and real time sensing
- Scalable (clean room compatible)

Working principle



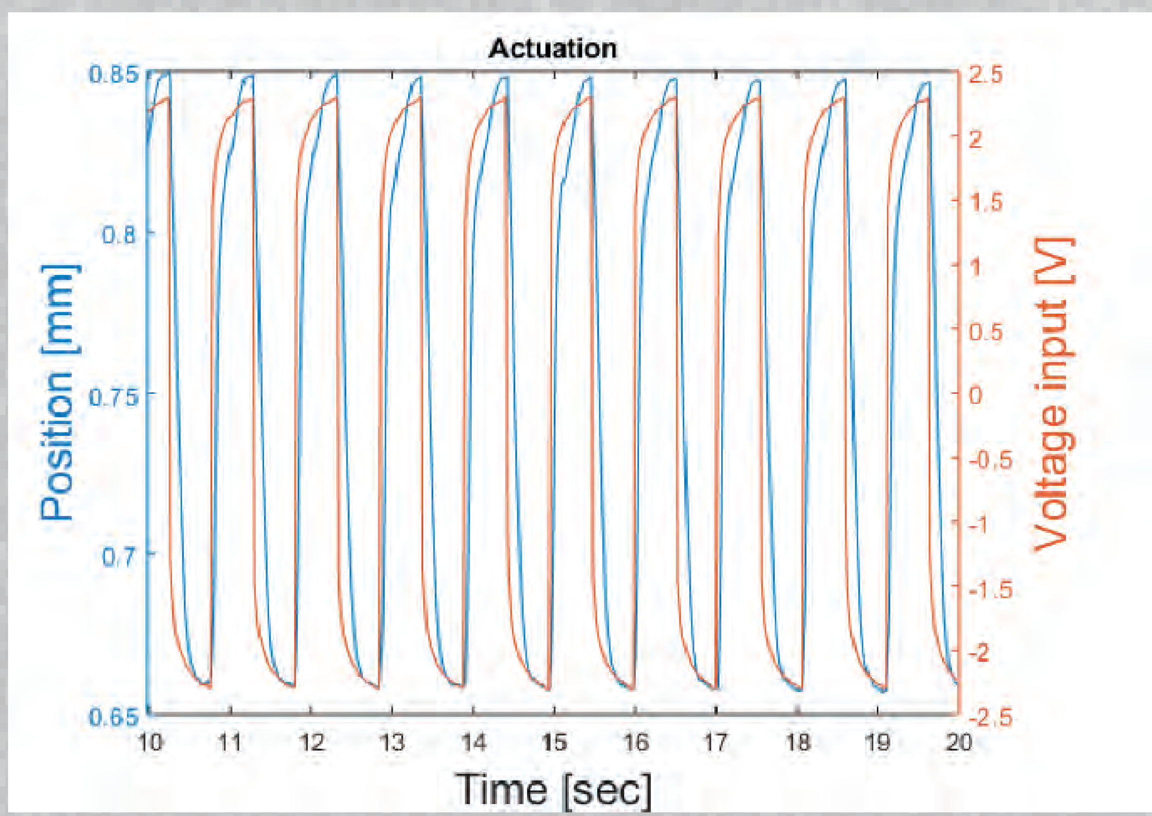
• The polymer backbone is doped with fixed anions, and we are using sodium cations naturally present in the OoC culture medium.

• In the **actuation mode** (top), the voltage applied between the electrodes induces a displacement of the moving cations and therefore the polymer.

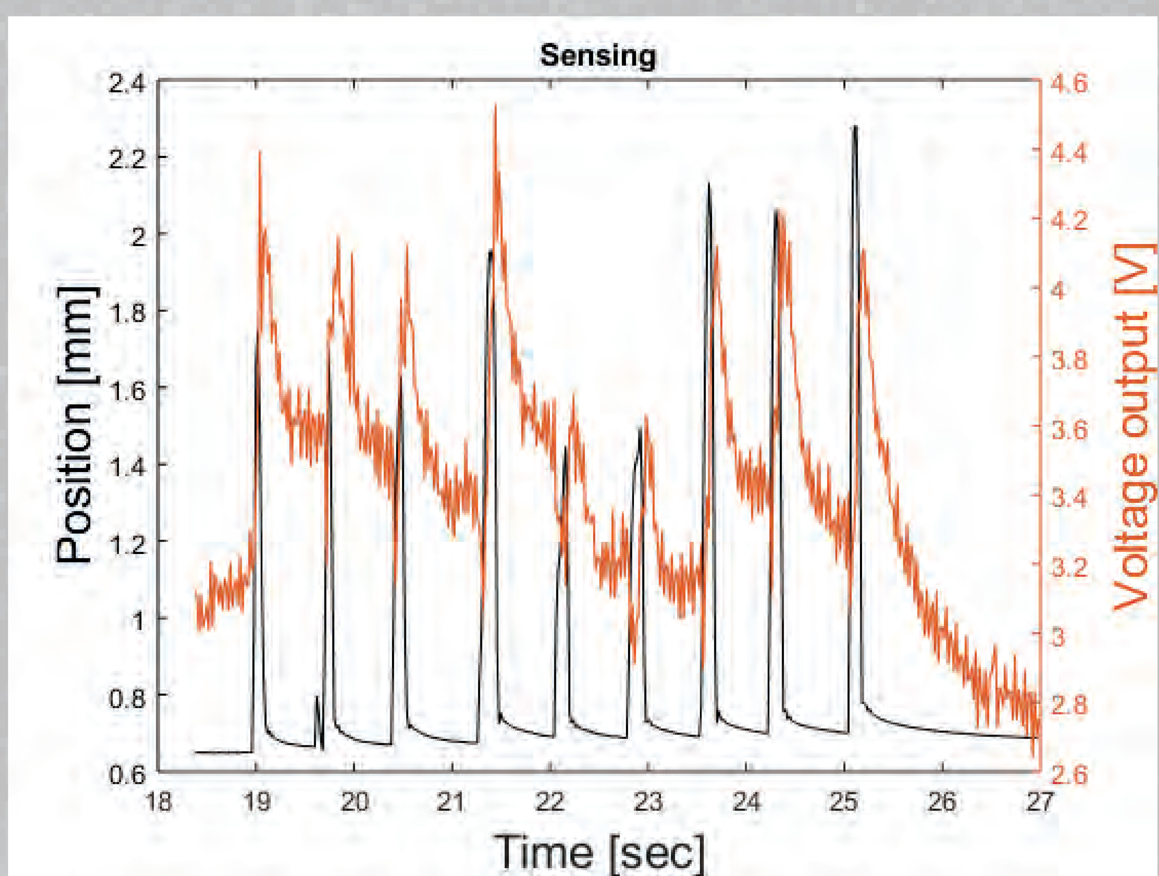
• In the **sensing mode** (bottom), cells contraction deforms the IPMC substrate, triggering cation migration and causing a charge imbalance, measureable as a voltage difference at the electrodes.

Mechanical characterization

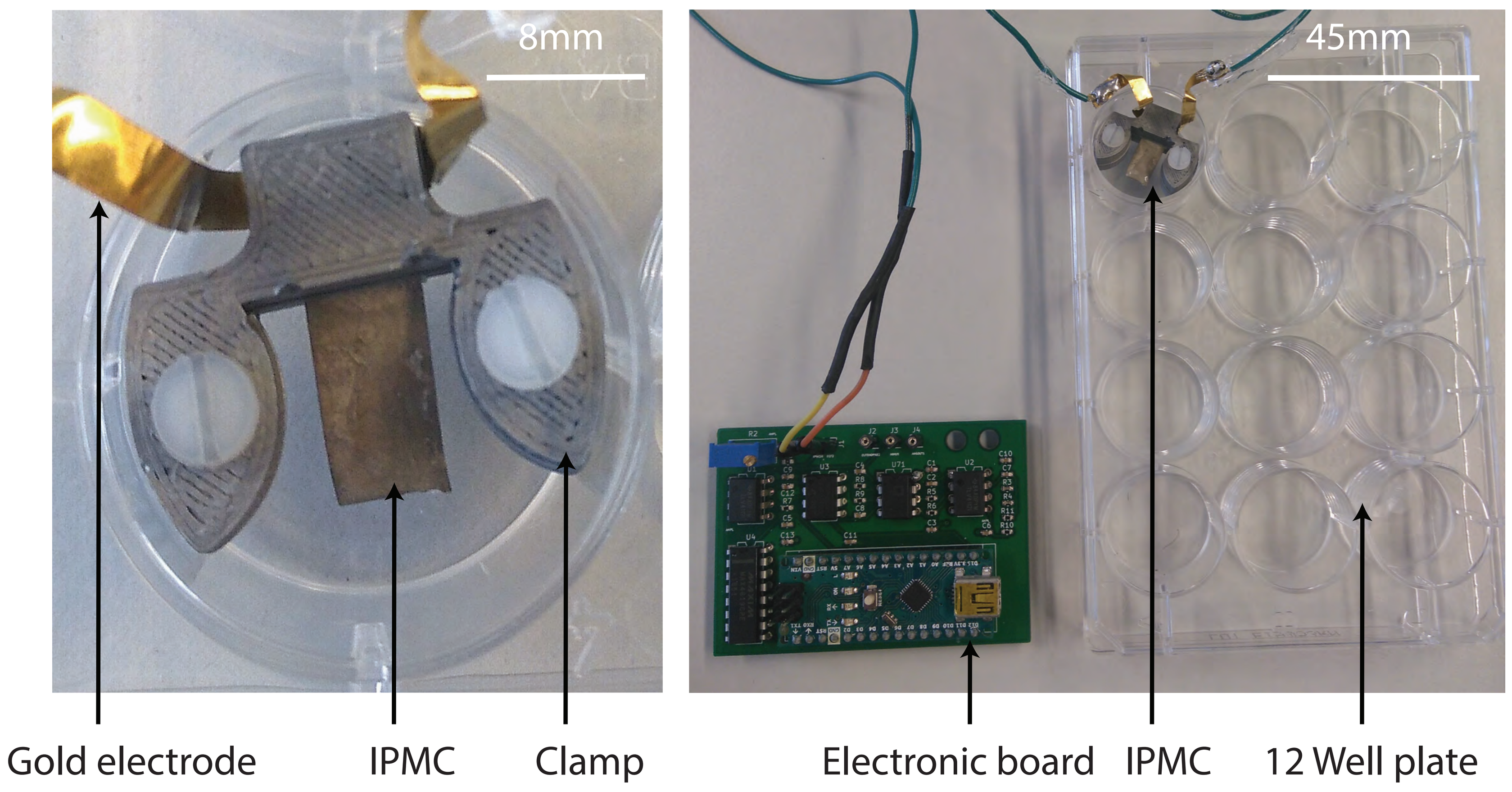
A square wave signal of 1 Hz frequency and 5 Vpp amplitude was used to drive the IPMC motion

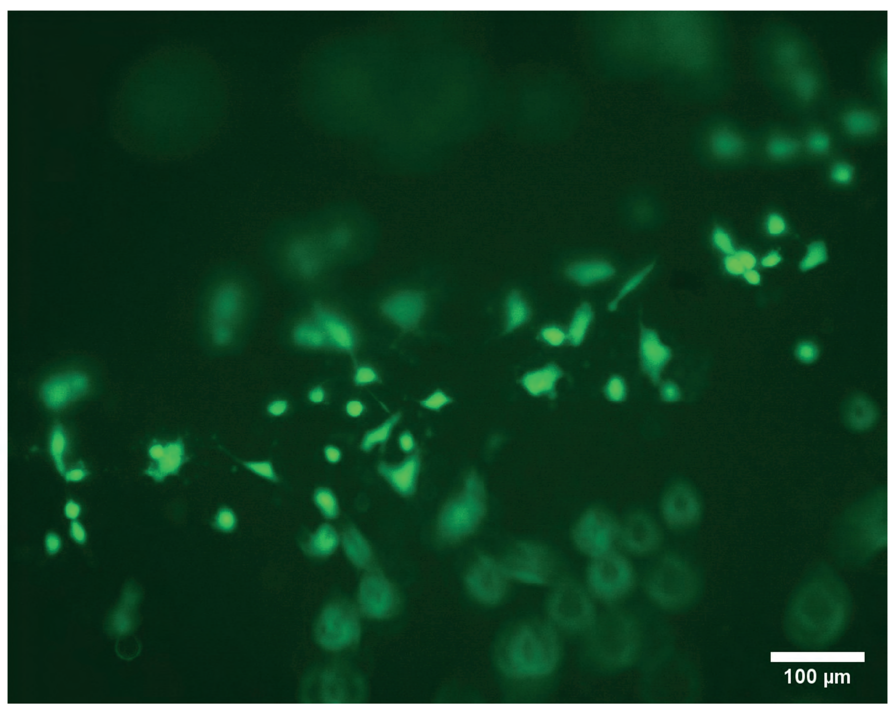


The impulsive and manually induced displacement was recorded using the electronic control board



Proof of concept device





•IPSC Vascular smooth muscles (vSMC) cells have been succesfully cultured and actuated for 2h30.

•Am calcein staining images shows no adverse effects on cells culture after actuation.

References

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[3] M. Shahinpoor, Y. Bar-Cohen, J. O. Simpson, J. Smith, "Ionic Polymer-Metal Composites (IPMCs) as Biomimetic Sensors, Actuators and Artificial Muscles: A Review," *Smart Materials and Structures*, 1998

Conclusion

•Actuation has been succesfully performed for 2h30 with no side effects nor delimination of the human tissue
•0.1 % strain has been achieved during the actutaion mode, close to the strain experienced *in vivo* by vSMCs
•0.72 V/mm sensitivity has been shown on the sensing mode
•Batch fabrication and downscaling will be targetted in the near future
•Actual sensing of the cells' contraction will be reserved for further work