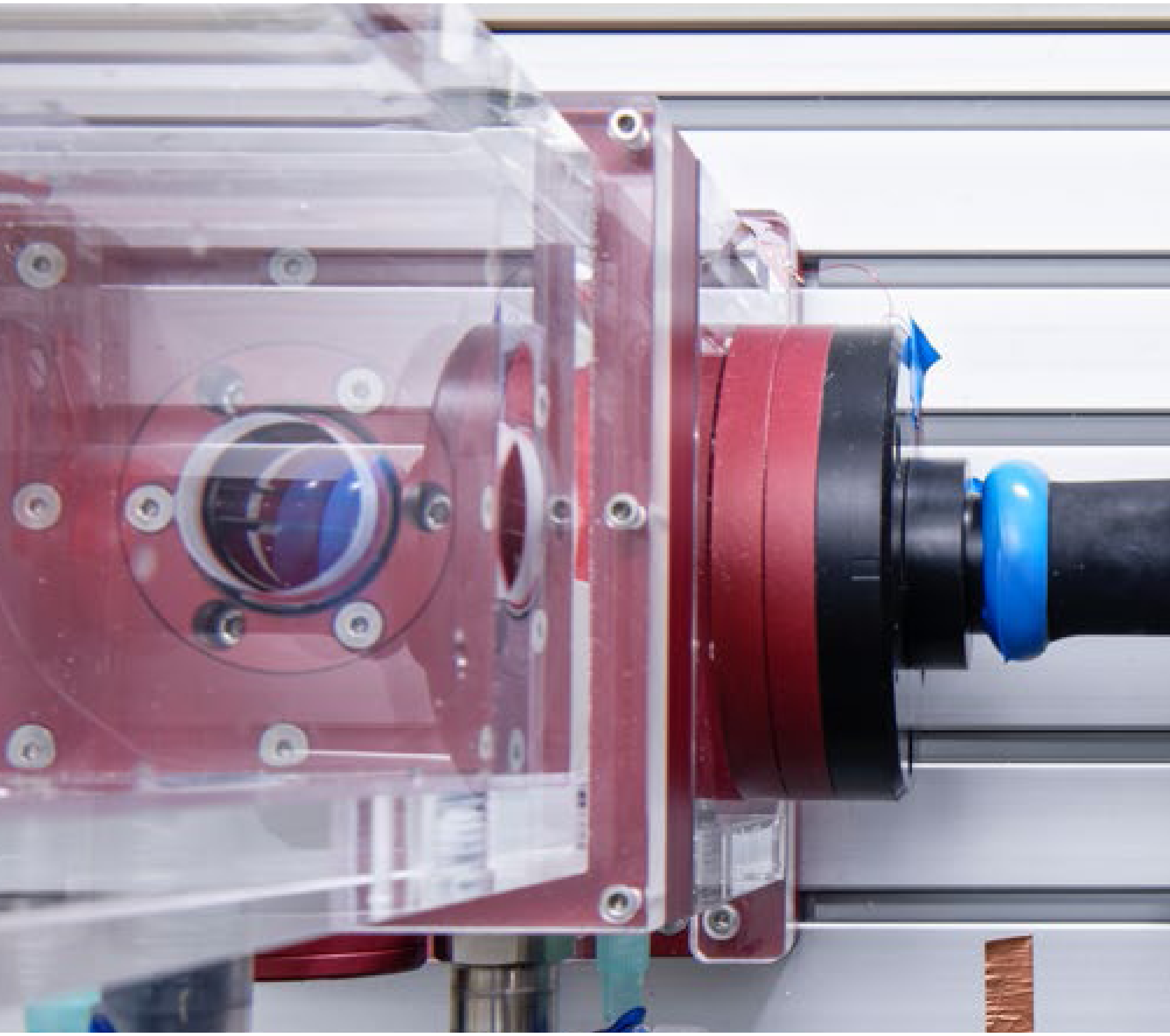

Center for Artificial Muscles

Report 2019

Center
for Artifical
Muscles

Vision

Taking a highly innovative approach for a wide range of applications in various parts of the human body.

Universität Zürich[UZH]

UNIVERSITÄT BERN

Introduction

The Centre for Artificial Muscle's primary goal is to support the human heart by placing a ring (the dielectric elastomer actuator) around the aorta. Two other applications are under progress or will be addressed - an artificial sphincter to help patients suffering either from urinary incontinence or from an underactive bladder, and a flat, activated membrane to restore chewing function and facial expressions.

"Fitting a kind of muscular ring around the aorta is a very creative idea. This ring will offer an additional way to support -rather than replace- heart function. When a weak heart is supported at an early stage, a full recovery is possible in the best case scenario."

Professor Thierry Carrel, who will test the aorta ring in 2021.

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Team

Prof. Yves Perriard (Director)

Morgan Almanza, Alexis Boegli, Jonathan Chavanne, Yoan Civet, Francesco Clavica, Thomas Martinez (Scientists)

Raphael Mottet (PhD candidate)

David Moser, Valentin Mottier (Scientific assistants)

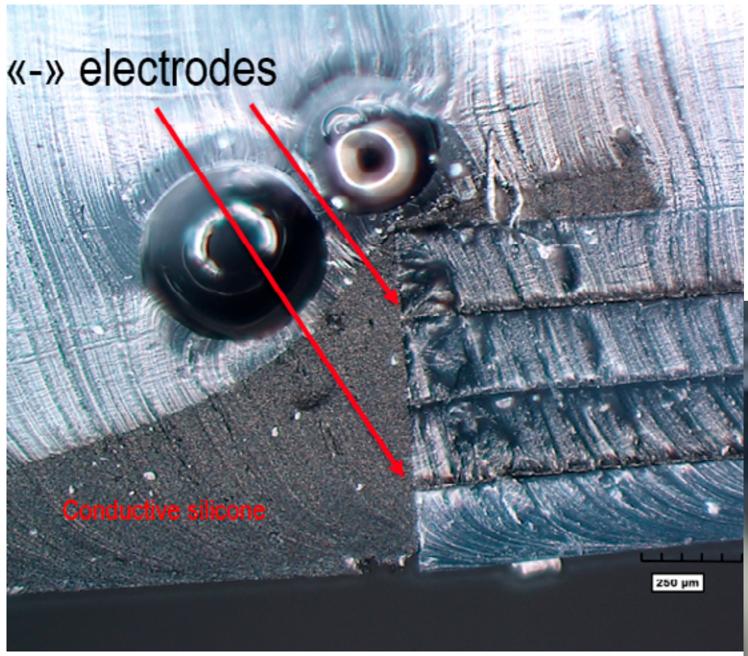
Collaboration partners

Prof. Thierry Carrel, Bern University Hospital

Prof. Nicole Lindenblatt, University Hospital Zürich

Prof. Dominik Obrist, University of Bern

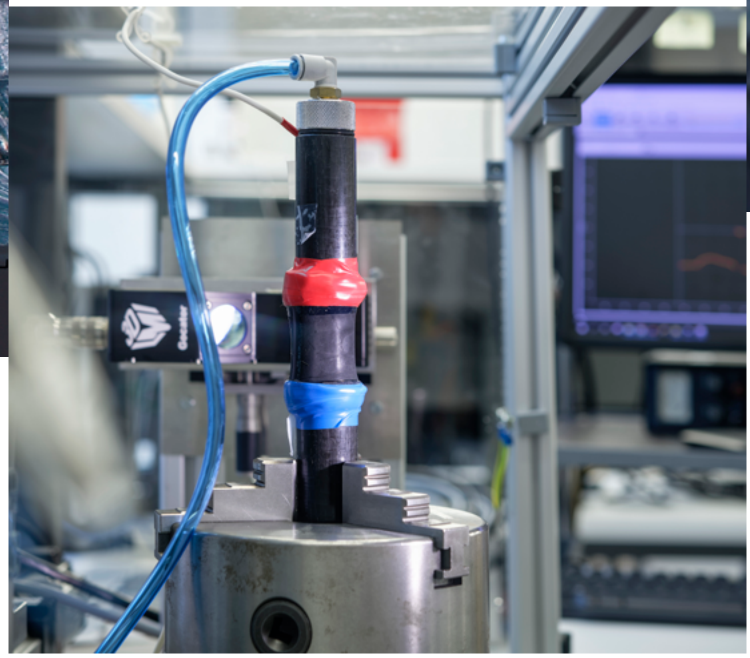
Scientific highlights



DEA Manufacturing

We have established a new process flow to manufacture multilayer actuators starting from the commercial Elastosil film (100 or 200um thick) from Wacker Chemie. We obtained an actuator composed of at least four layers. Thanks to a neat trick (Patent pending CH20190012), we are able to reach the electrical limit of the commercial material for a multilayer actuator.

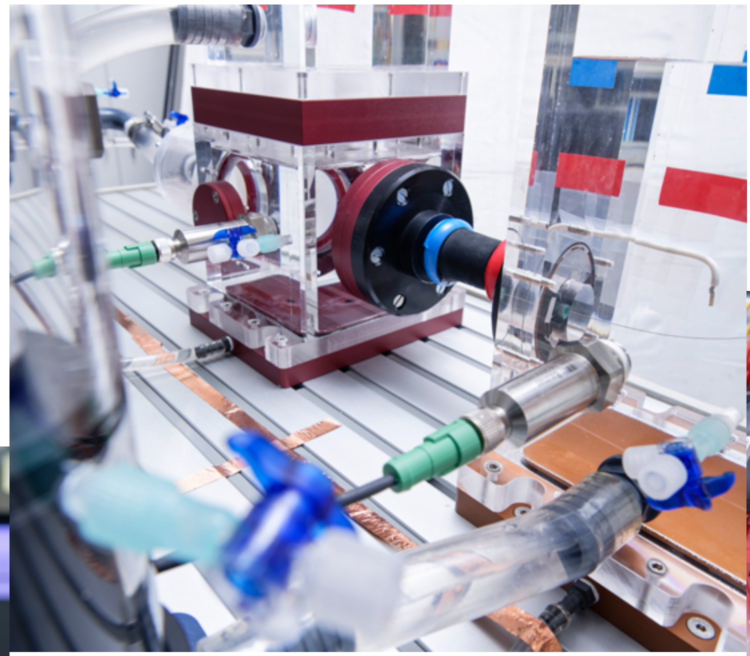
In the meantime, we have started a collaboration with the University of Cergy-Pontoise (LPPI) in France to develop a brand-new material that will allow us to increase the performance (especially in terms of energy density) of the current material by a factor of at least four.



DEAs test and modelling

We have developed an automatic test bench to evaluate and perform intensive tests of our actuator. The preliminary assessments show promising features both in terms of the actuator characteristics and its test bench capability.

We have compared these measurements to our Finite Element Model to validate the latter. We now have a near-predictive model that will be useful to optimize the final actuator.

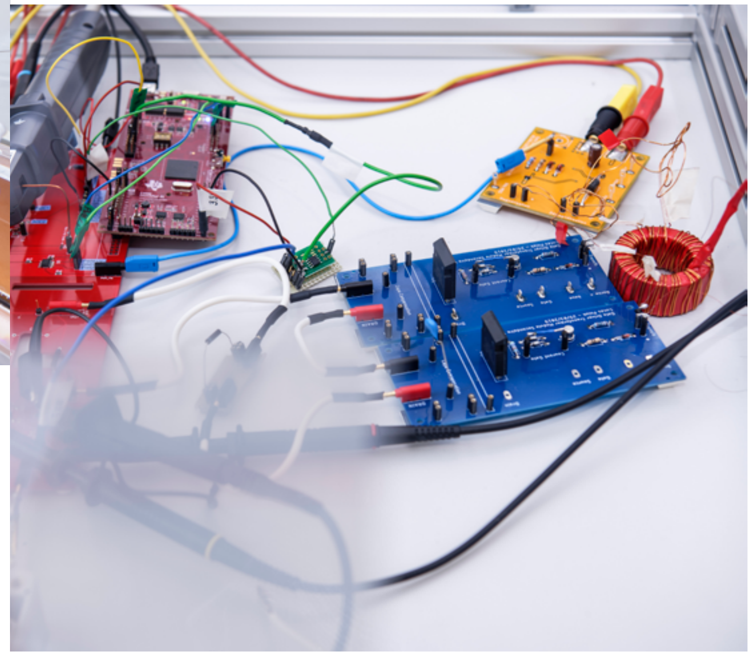


Flowloop and windkessel model

As presented in the 2018 CAM activity report, we have a mock-up Flow loop that imitates the blood circulatory system. We have undertaken our first attempt to plug our actuator on the flowloop.

In parallel, we have established a more accurate, lumped model that is based on the Windkessel model and in which we have integrated our actuator model. This tool will allow us to forecast the blood circulatory system's response according to our actuator activation. The preliminary measurements on the flowloop will allow us to adjust our modified lumped model to match the body's behavior as closely as possible.

The lumped model has also highlighted that one ring might be a good starting device to support the heart. It allows us to modify the pressure after the aortic valve. We have been able to demonstrate that we are capable of modifying the heart's energy or blood flow rate by approximately 10% depending on the way we actuate our device.



Power supply

We already have a custom-made, compact set-up showing the wireless power transfer working on a battery. We have also developed our own electronic system going from 12V to 7kV. This electronic should also allow us to harvest the electrical energy stored in our actuator in order to increase the global efficiency of our system. We have just started to plug the new electronic to our actuator.

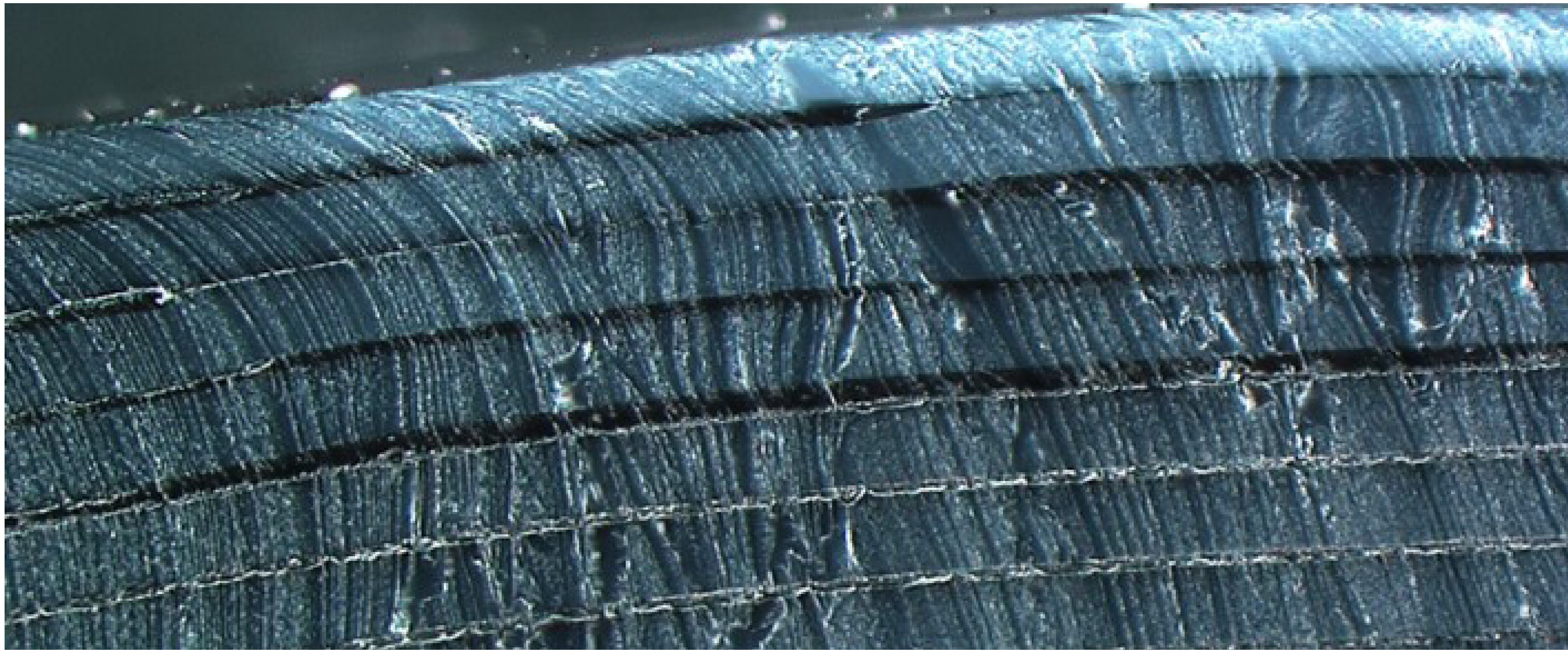
We plan to merge the two electronic subsystems in 2020 resulting in an efficient power supply.

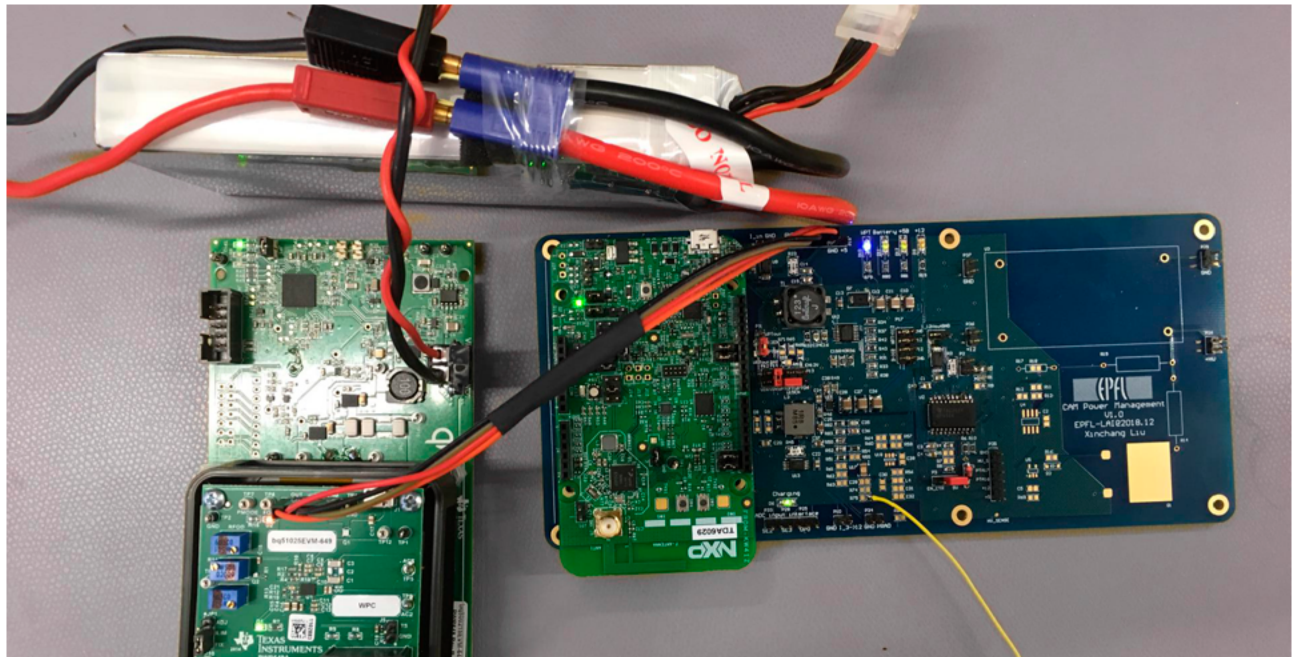
EPFL

Next steps

After two years of exciting and fruitful developments, the road leading to successful clinical tests is drawing ever closer. The team is working intensively on the system's final integration to be ready by late 2020. The following steps are required in order to reach the pre-clinical test phase and fulfill the initial objectives:

- **Model and manufacturing:** Optimized prototype ready to be tested and meeting the clinical requirements
- **Electronics:** Combined electronics, including wireless power transfer and step-up voltage module, from 12V to 8kV
- **Animal trials:** Prepare documentation, including for ethical approval, and the surgery unit in Bern for a first test by the end of 2020





Publications

Invited talks

- EPFL 50th Anniversary, Center for Artificial Muscles, Neuchâtel, September, the 11th 2019

- The Center for Artificial Muscles: a success among many innovative applications of electromagnetism in microtechnology, November the 27th 2019, Zhejiang University, Hangzhou, China

Journals

- Towards the material limit and field concentration smoothing in multilayer dielectric elastomer actuators, Morgan Almanza, Jonathan Chavanne, Yoan Civet, Yves Perriard, Smart Materials and structures, In press

- Ultra High Voltage Switch for Bidirectional DC-DC Converter Driving Dielectric Elastomer Actuator, Lucas Pniak, Morgan Almanza, Yoan Civet, Yves Perriard, Transaction on Power Electronics, In press

Conferences

- Critical Parasitic Elements of Coupled Inductors for Ultra-High Voltage Flyback Converters Used to Drive Capacitive Actuators, Mottet, R. and Almanza, M. and Boegli, A. and Perriard, Y., Proceedings of the 22nd International Conference on Electrical Machines and Systems ICEMS 2019, 2019

- Development of a biologically inspired in-vitro platform for long-term assessment of commercial and innovative ureteral stents, Clavica, F. and Zheng, S. and Carugo, D. and Mosayyebi, A. and Waters, S and Civet, Y. and Perriard, Y. and Obrist, D. and Burkhard, F., Proceedings of the Incontinence: the Engineering Challenge XII, 2019

- Impedance pumping as a non-invasive treatment for underactive bladder? An ex-vivo proof-of-concept-study in porcine bladders, Clavica, F and Roth, J. and Schneider, M. P. and Civet, Y. and Burkhard, F. and Perriard, Y. and Obrist, D., Proceedings of the Incontinence: The Engineering Challenge XII, 2019

- Urine-Contactless Device to Empty Bladders: an Ex-Vivo Proof-of-Concept Study in Porcine Bladders, Clavica, F. and Roth, J. and Schneider, M. P. and Civet, Y. and Burkhard, F. and Perriard, Y. and Obrist, D., Proceedings of the 49th Annual Congress of the International Continence Society, 2019

- Characterization of a radial cylindrical spring using an electromechanical test bench, Mottier, V.; Moser, D.; Chavanne, J.; Civet, Y.; Perriard, Y., 2019 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM), Hong Kong, China, 2019

- High voltage switch for compact bidirectional dc-dc converter driving dielectric electroactive polymer actuators, Lucas Pniak, Morgan Almanza, Raphael Mottet, Yoan Civet, Yves Perriard, Ninth international conference on Electromechanically Active Polymer (EAP) transducers & artificial muscles Dresden, Germany, 2019

- Multi-level high-voltage power supply for DEA application, Lucas Depreux, Lucas Pniak, Morgan Almanza, Yoan Civet, Yves Perriard, 9th international conference on Electromechanically Active Polymer (EAP) transducers & artificial muscles Dresden, Germany, 2019

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- Drastic breakdown field reduction in multilayer DEA, Morgan Almanza, Jonathan Chavanne, Yoan Civet, Yves Perriard, Ninth international conference on Electromechanically Active Polymer (EAP) transducers & artificial muscles Dresden, Germany, 2019

- Towards an ultra-high voltage gain, compact, and energy recovering Flyback DC/DC Converter, Raphaël Mottet, Morgan Almanza, Alexis Boegli, Yves Perriard, Ninth international conference on Electromechanically Active Polymer (EAP) transducers & artificial muscles Dresden, Germany, 2019

- To-Pee or not-to-Pee? A Non-invasive, Urine-Contactless Device to Empty Bladders, Francesco Clavica, Joy Roth, Marc Schneider, Yoan Civet, Yves Perriard, Fiona Burkhard, Dominik Obrist, Swiss Medtech Day 2019 (https://www.visit.medtech-expo.ch/en/), Bern, Switzerland

Thesis

- Cylindrical Dielectric Elastomer Actuator for Cardiac Assist Device, Jonathan Chavanne, 2019

Patent

- Field grading in multilayer elastomer actuator, CH20190001382

- Urinary pumping device with an implantable activation arrangement, EP 19/154102

- External impedance pump for emptying the bladder, CH 00096/19

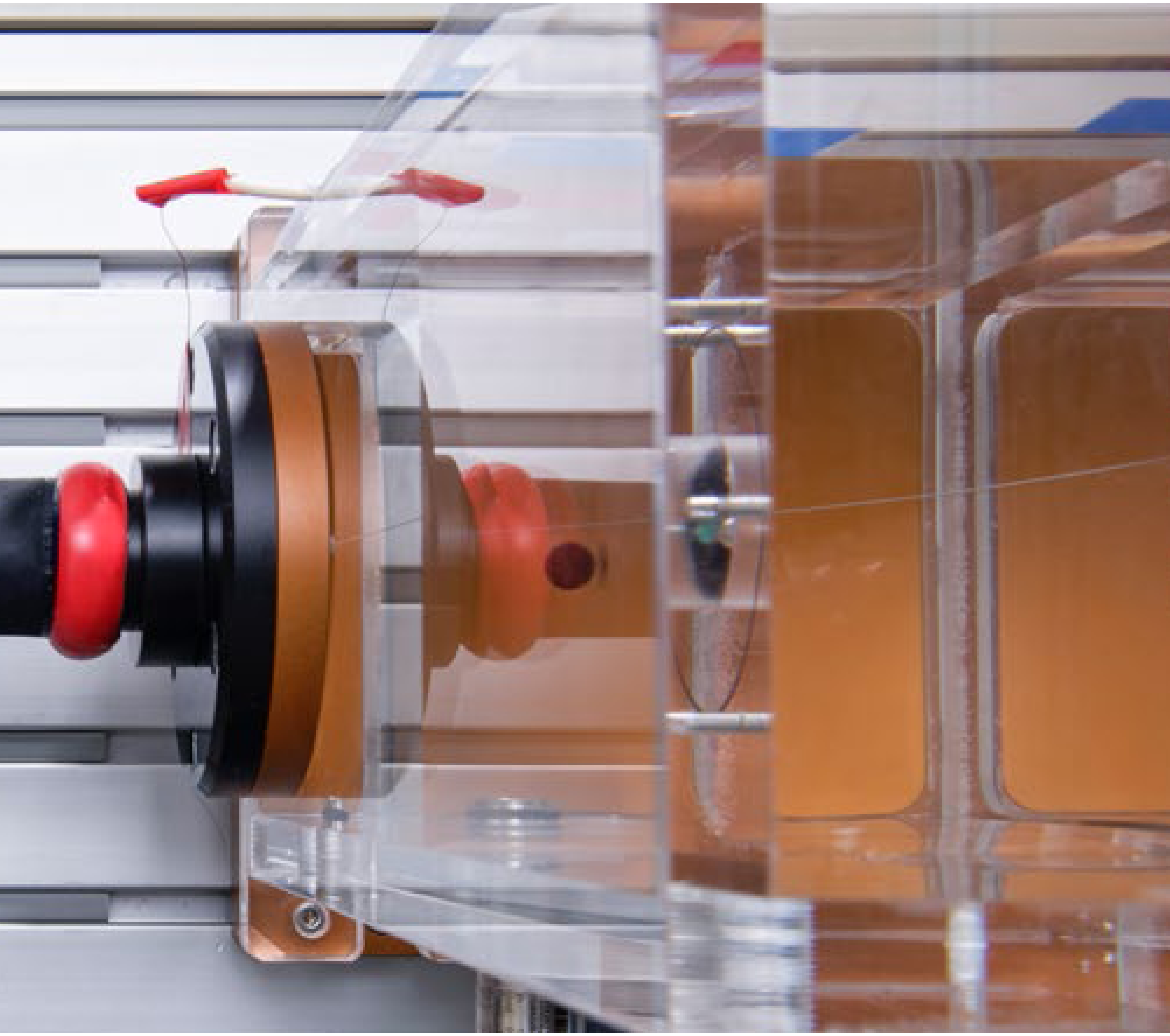
Charlotte Buxhoeveden and Marie Graevenitz, daughters of Carl Siemens.

The Werner Siemens Foundation

"The Werner Siemens Foundation supports groundbreaking projects in the fields of technology [...]. The selected projects in research and education are generally conducted at Universities and higher education institutions [...], key requirements include upholding the highest standards and contributing to solving major problems of our time".

Acknowledgement

The creation of this consortium would not have been possible without the help of the Werner Siemens-Stiftung. The foundation has enabled the new "Center for Artificial Muscles" to establish itself as one of the first international centers for regenerative urology, heart and facial surgery. The work of this Center is of great social importance.



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