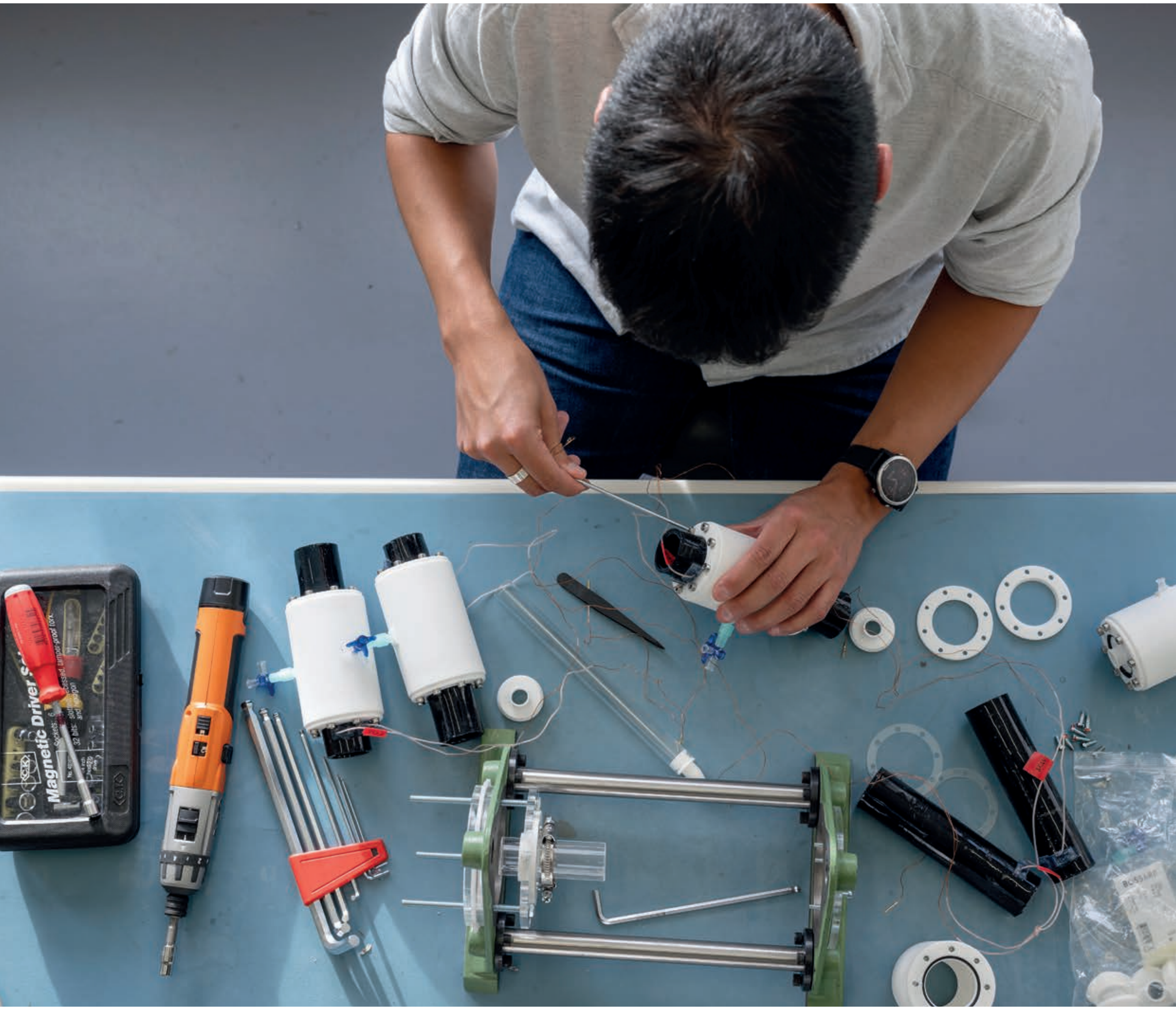
Center for Artificial Muscles

Report 2024



Center
for Artifical
Muscles

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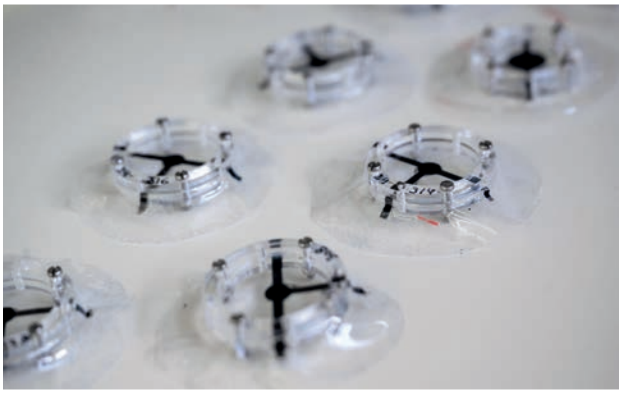
“What a great human adventure to perform and to succeed in creating these new medical devices”

PROF. YVES PERRIARD

Introduction



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Founded in 2018 with the support of the Werner Siemens Foundation, our research center (CAM) focuses on the development of implantable actuators, as well as innovations in key areas of human health, including cardiac assistance, urology, and facial paralysis. Over the past seven years, we have made significant progress in each of these fields, culminating in major breakthroughs in 2024.

This year, we successfully conducted our fourth series of acute tests. What was once a minimal cardiac support system is now evolving into a full-fledged Left Ventricular Assist Device (LVAD), made possible by an innovative pre-stretch system. In the field of facial paralysis, our animal studies have moved beyond hope to reality with the first-ever implantation of artificial muscles on a rat's back, controlled by a nerve. Meanwhile, our research in urology has taken a decisive step forward, as the first bladder cells have been placed on a platform capable of mimicking the organ's natural deformations. This marks the integration of biology as a new and essential component of our center's work. On the other hand, we have manufactured our first DEA based artificial urinary sphincter.

These groundbreaking advancements have been validated by the various committees of the Werner Siemens Foundation, which honored us with a visit during this pivotal seventh year. Through in-depth discussions, we had the opportunity to present our roadmap, reinforcing our commitment to fulfilling the mission entrusted to us: developing solutions that address the real needs of patients.

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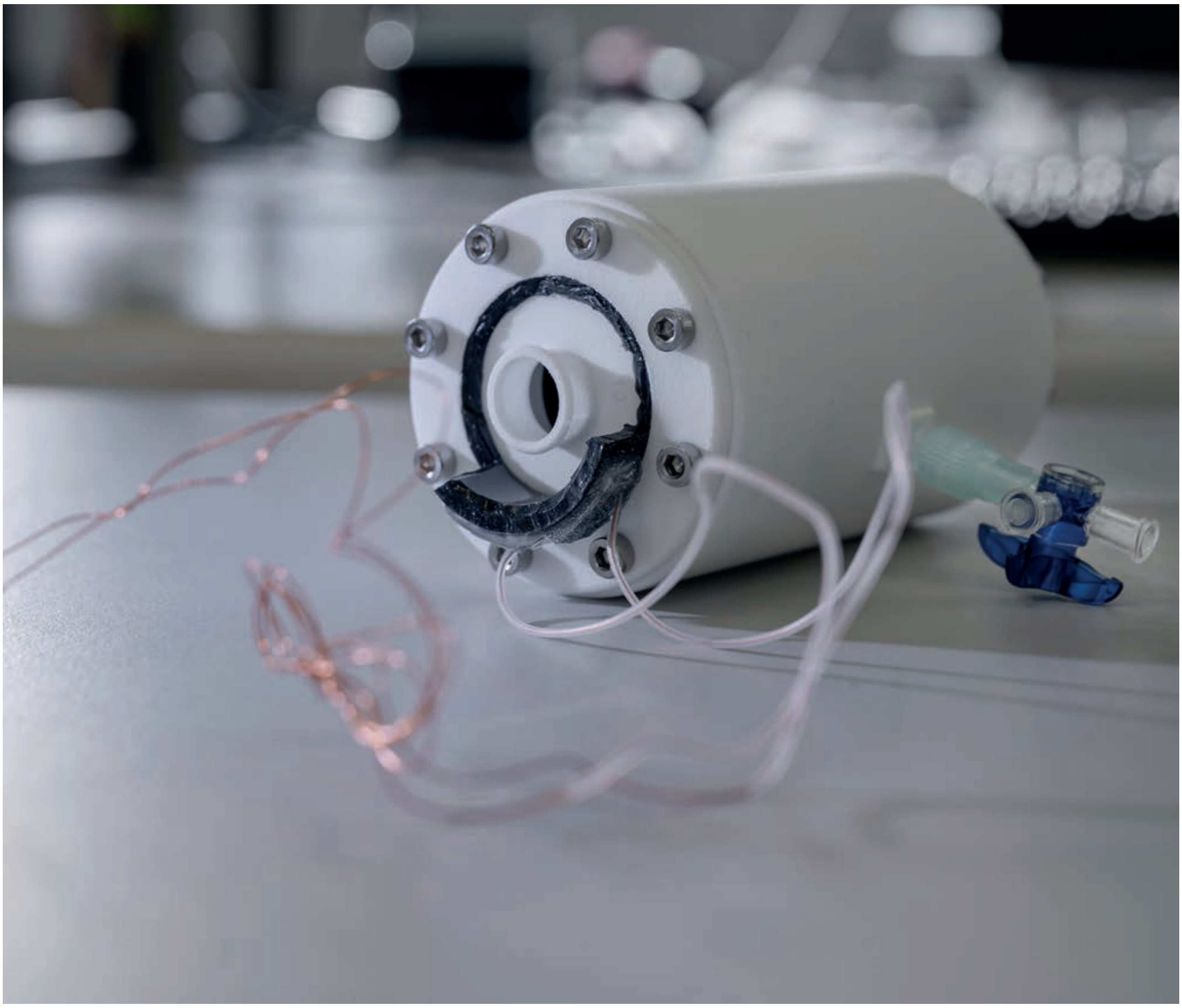
b UNIVERSITÄT BERN

University of Zurich UZH



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Content

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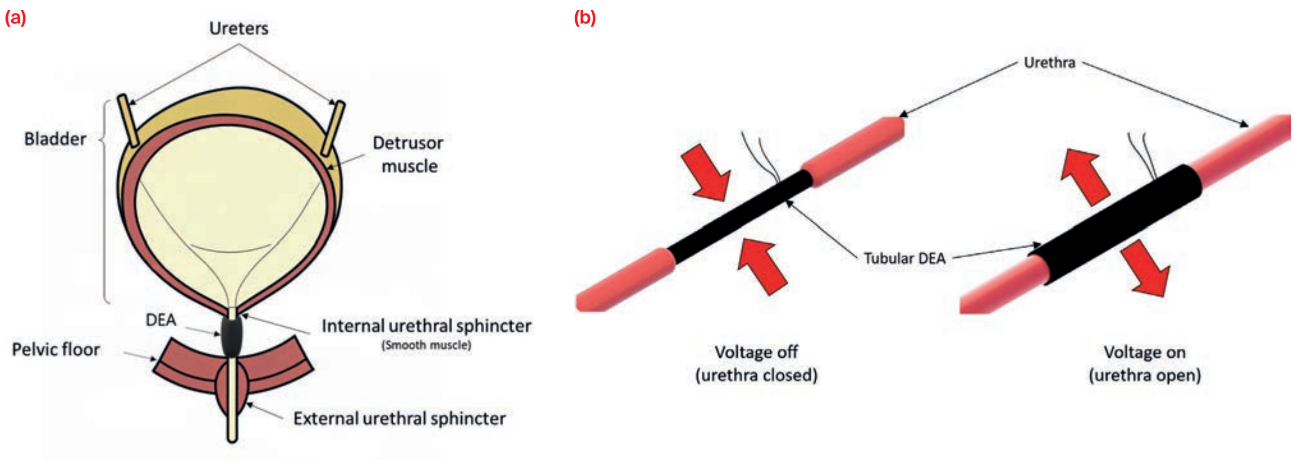
Scientific Highlights

Urology

Artificial Urinary Sphincter (AUS)

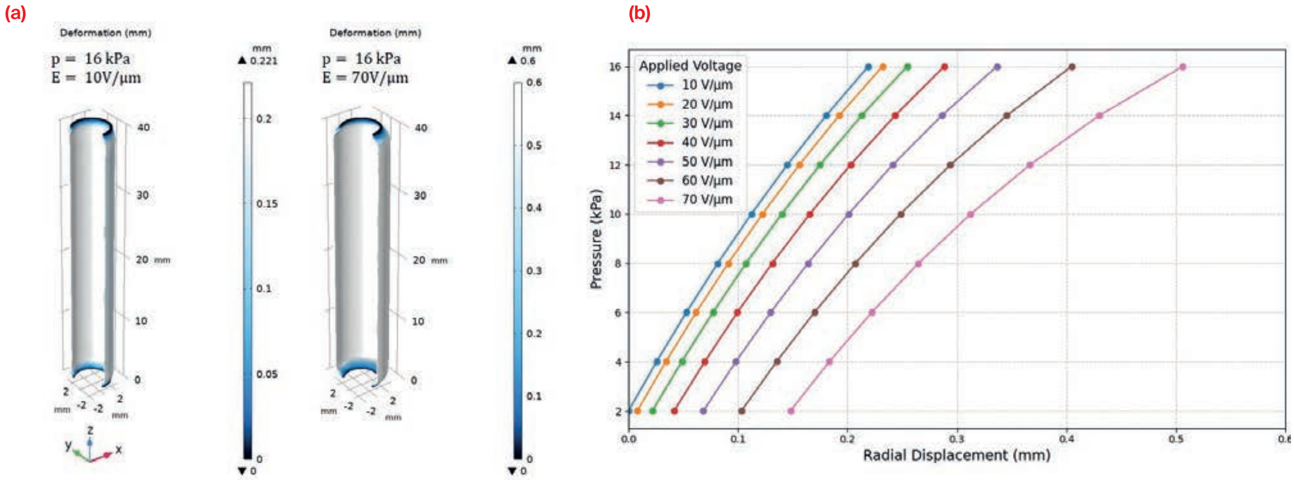
Urinary incontinence (UI), a prevalent manifestation of lower urinary tract symptoms (LUTS), affects over 400 million people worldwide, and its incidence increases with age. UI is characterized by involuntary urine leakage resulting from factors such as aging, medical conditions, or injury. For severe urinary incontinence (SUI), particularly in cases where other treatment options have proven insufficient AUS are considered the gold standard intervention.



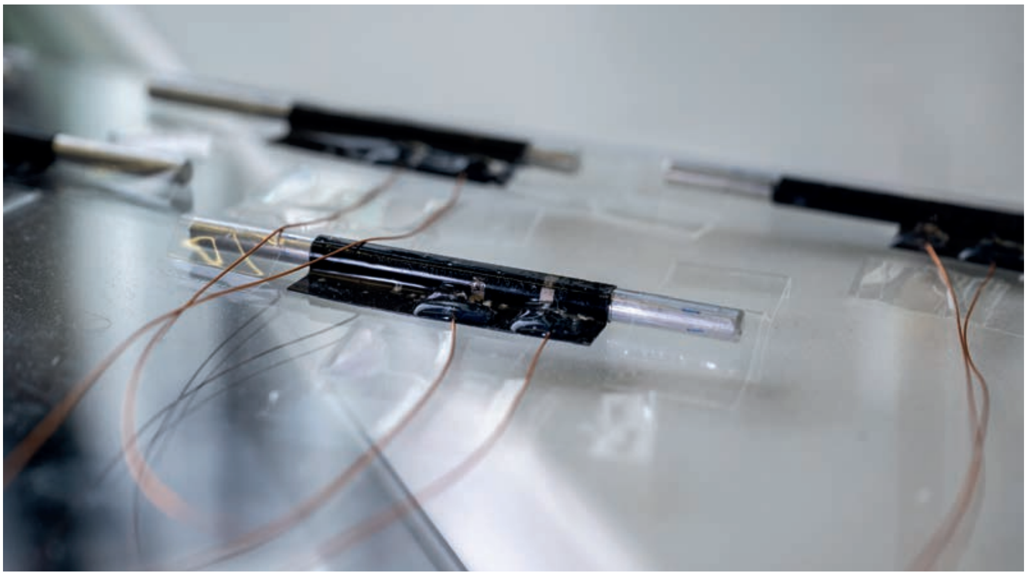
Urinary tract and AUS: Female urinary tract schematic with a DEA wrapped around the urethra **(a)**, DEA based artificial urinary sphincter **(b)**

First DEA based AUS

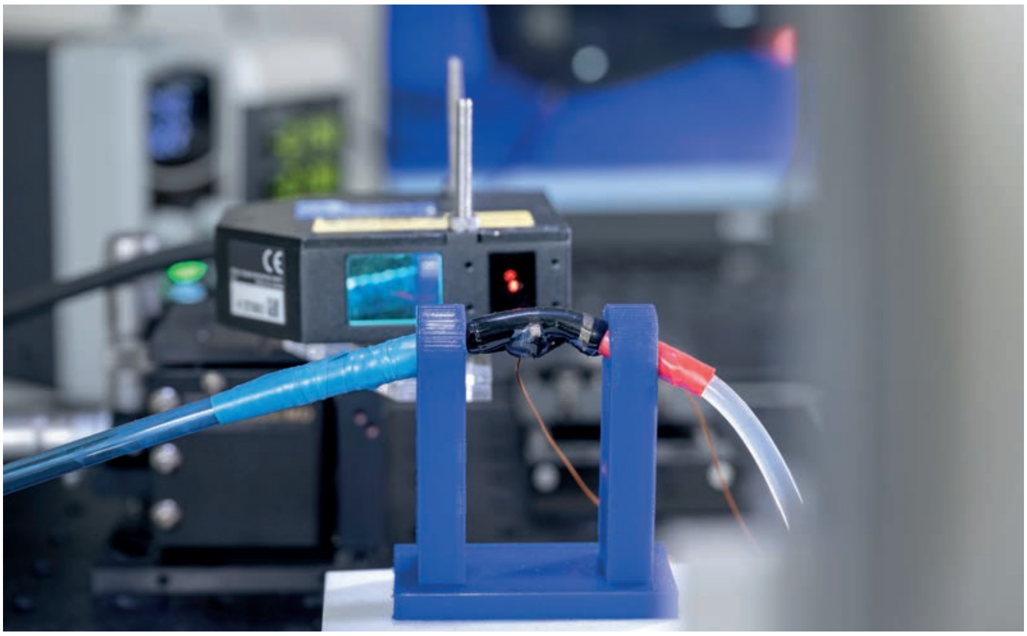
This year, we performed numerical simulations using COMSOL to predict the deformation behavior of the Dielectric Elastomer Actuator (DEA) at the core of our AUS. These simulations were validated through experimental testing, demonstrating strong agreement between predicted and observed deformations. This validation reinforces the reliability of our simulation and provides a solid foundation for further optimization of the AUS design.



Simulation of a tubular DEA deformation under different electrical fields **(a)**, Resulting radial displacement of the DEA as a function of pressure for several electric fields **(b)**

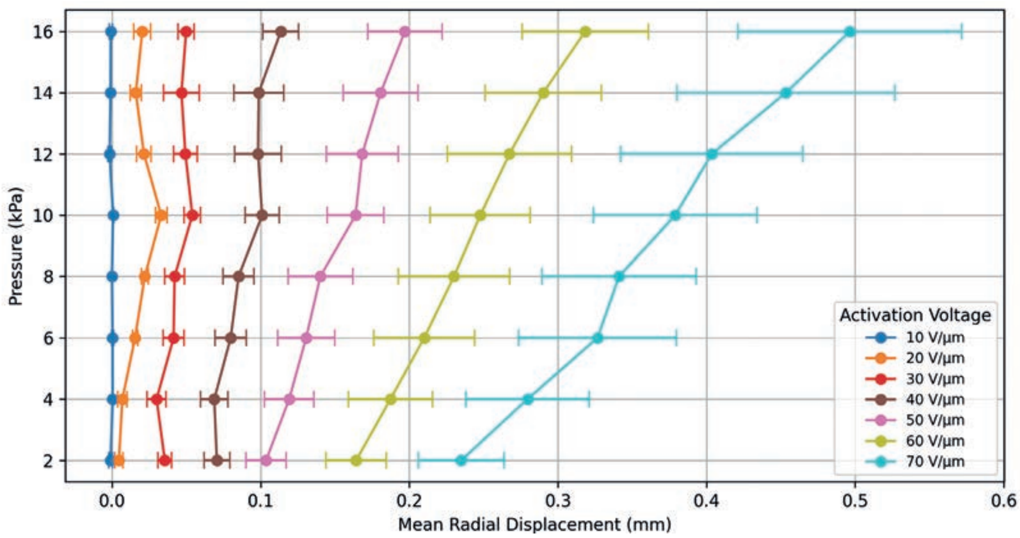


Examples of tubular Dielectric Elastomer Actuator based AUS © WSS, Félix Wey



Experimental setup for the characterization of a tubular artificial urinary sphincter (AUS) based on a Dielectric Elastomer Actuator (DEA) © WSS, Félix Wey

The comparison between experimental data and simulation results confirms that the simulation predicts accurately the DEA's response, with radial displacements of 1 mm diameter opening observed at 70 $V.\mu m^{-1}$ and 16 kPa. These results demonstrate the possibility of using DEAs in artificial urinary sphincter (AUS). The promising results support the advancement of this technology toward a safer and more adaptable AUS solution, with the potential to address the needs in the treatment of urinary incontinence for both female and male patients.



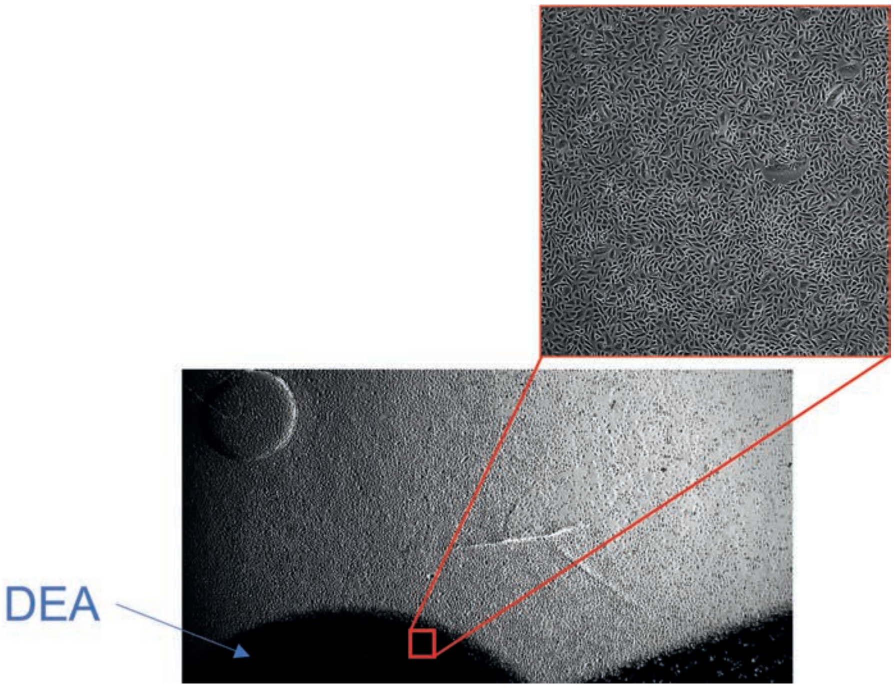
Pressure as a function of mean DEA radial displacement with standard deviation across DEAs for different applied electric fields

Artificial Bio-Bladder

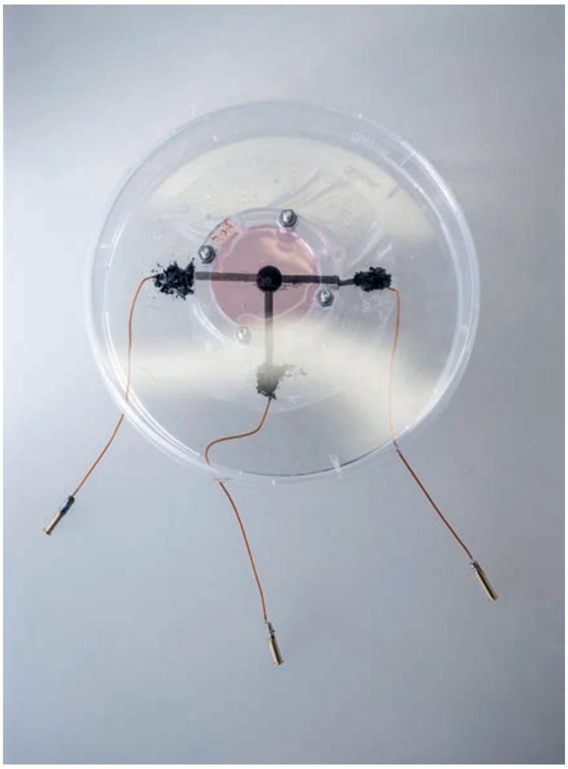
One part of the human body that still raises many scientific questions is the bladder. Researchers use various approaches to get to the bottom of these questions. The most common approach is to use animal models. However, these are often too different from the human body, making it difficult to transfer the findings to the human case. Therefore, an artificial platform (*in vitro* application) should help to solve this problem. The platform consists of a planar DEA deformed by the actuation. The deformation is then used to stretch human cells.

Over the last few years, we have strived to find an optimal actuator that mimics the behavior of the human bladder as realistically as possible and have successfully developed an *in vitro* platform to achieve this. The next step is to demonstrate that our platform is also biologically suitable for the intended application. This involves testing the adhesion of cells to the deformable membrane. Various coatings, such as fibronectin, collagen, gelatin, and others, have been used, and the results are compared.

Additionally, the influence of the electric field, used for the actuation of the DEA on human cells has been examined. Specifically, their viability and any changes in their cell cycles are analyzed. To assess this, a dielectric actuator incapable of deformation is used. After powering, the cells are analyzed using flow cytometry to apply apoptosis assay and cell cycle studies. The results show that cells on the DEA exhibit similar viability whether actuated or not, indicating that DEAs do not induce cell death due to electrical actuation.



TEU-2 cells on Dielectric Elastomer Actuator



Cell medium deposited on planar DEA
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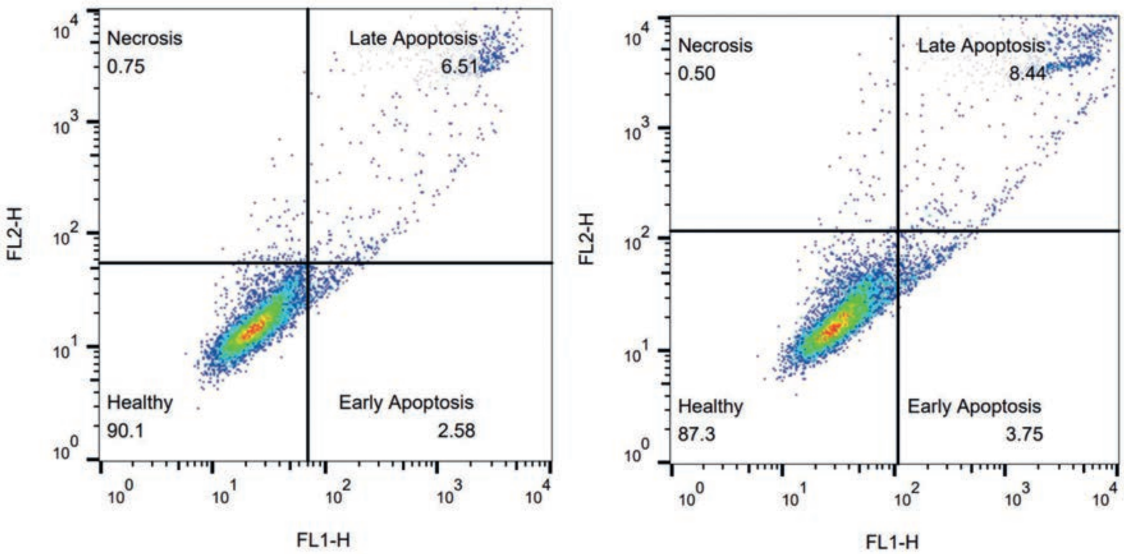


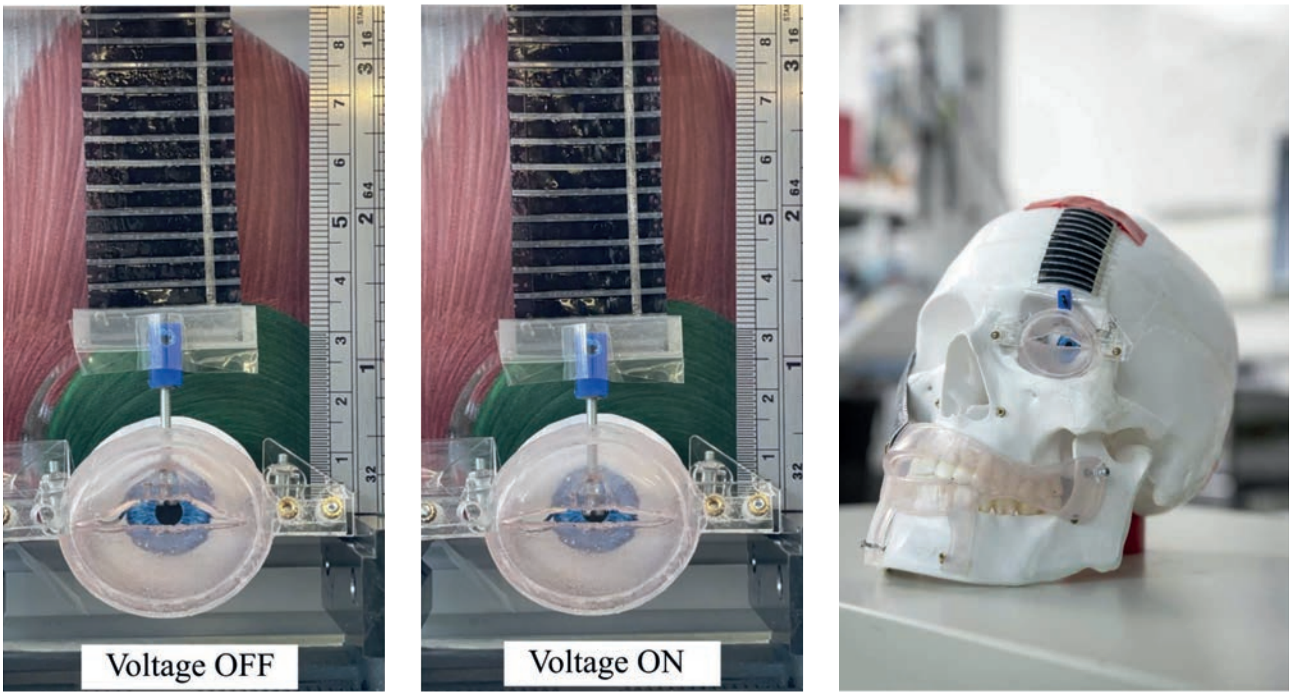
Flow cytometry results: by comparing the non-actuated **(left)** and actuated device **(right)**, no different behavior is shown. More than 87% of cell population remains healthy

Facial Reanimation

Blinking restoration

Facial nerve palsy results in the inability to control facial muscles, including the Orbicularis Oculi, which is the main muscle enabling the blinking action. Blinking is not only important for responding socially to other humans, but also essential for lubricating the cornea. Without lubrication, vision loss or eye infections may occur. Current procedures for patients are not always adequate, and there is a real need for more appropriate solutions.

We are working on a novel design for a prosthesis that enables the restoration of eye-blinking abilities in patients with paralysis. The prosthesis consists of an artificial muscle, namely a Dielectric Elastomer Actuator (DEA), used in conjunction with a bistable negative-rate biasing system (NBS). The prosthesis, along with a realistic and anatomically precise eyelid, is fabricated. The specifications in terms of stroke, force and frequency, including opening and closing time of the eyelid, are reached and a natural blinking movement is achieved, with a resulting displacement of the artificial eyelid of 2.5 mm, showing that the use of a DEA with a NBS is a promising approach for the restoration of blinking in the treatment of facial paralysis.



Operation of the actuator and prosthesis concept design for the restoration of blinking abilities
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Structured implants mimicking the natural muscles

Implementing DEAs that mimic natural muscles has proven difficult, as DEAs provide in-plane expansion when actuated, while natural muscles contract upon stimulation. Multiple solutions can be found in literature, namely stack DEAs and fiber reinforced DEAs. The fibers used for DEAs to achieve contractile motion rely on a fishnet design, where the angle between the fibers, the spacing, the mechanical properties as well as the fiber dimensions can be set by establishing a fiber analytical model. Contraction has only been achieved with DEAs based on acrylic elastomer and pre-stretched with rigid frames, thus making them unsuitable as soft implants.

We introduced the first silicone-based, non-pre-stretched DEAs showing in-plane contractile behavior by embedding such soft structured fiber sheets in the actuators. Fiber-reinforced DEAs were shown to achieve modest contractile strains, particularly with optimal fiber angles between 55° and 65°, enhancing their ability to mimic muscle-like behavior. However, the low contractile strains of silicone-based DEAs indicate that further optimization is needed for real-world applications.

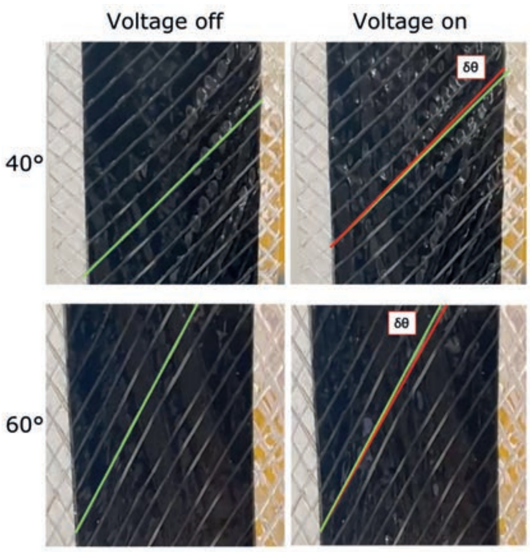
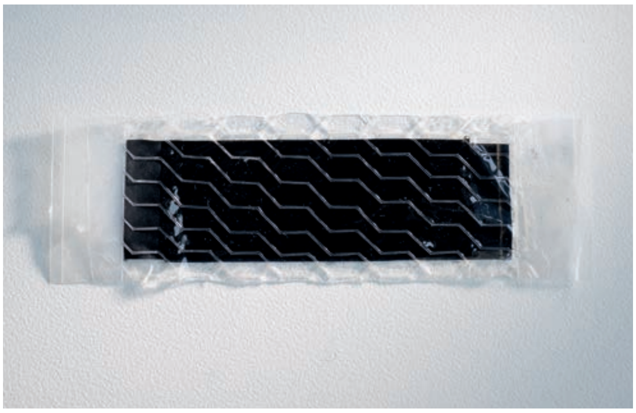


Illustration of the actuation at 7 kV for two fiber orientations highlighting different motions (upward: elongation or downward: contraction)



Optimizing the fibers' architecture could lead to an increase in the contractile strain
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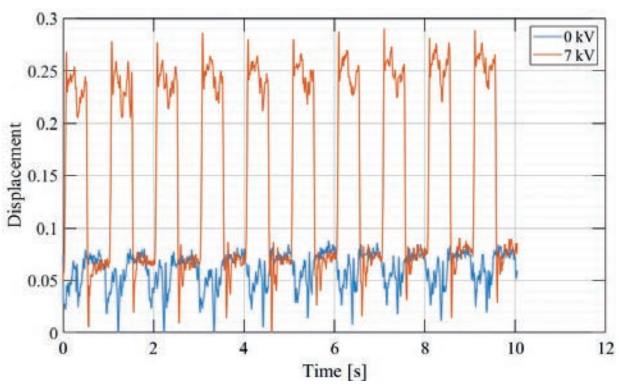
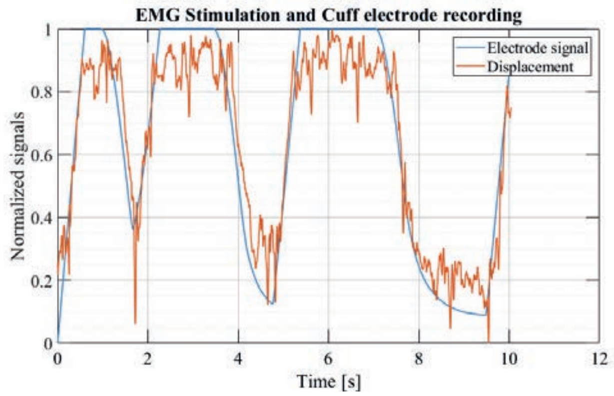
Animal experiments

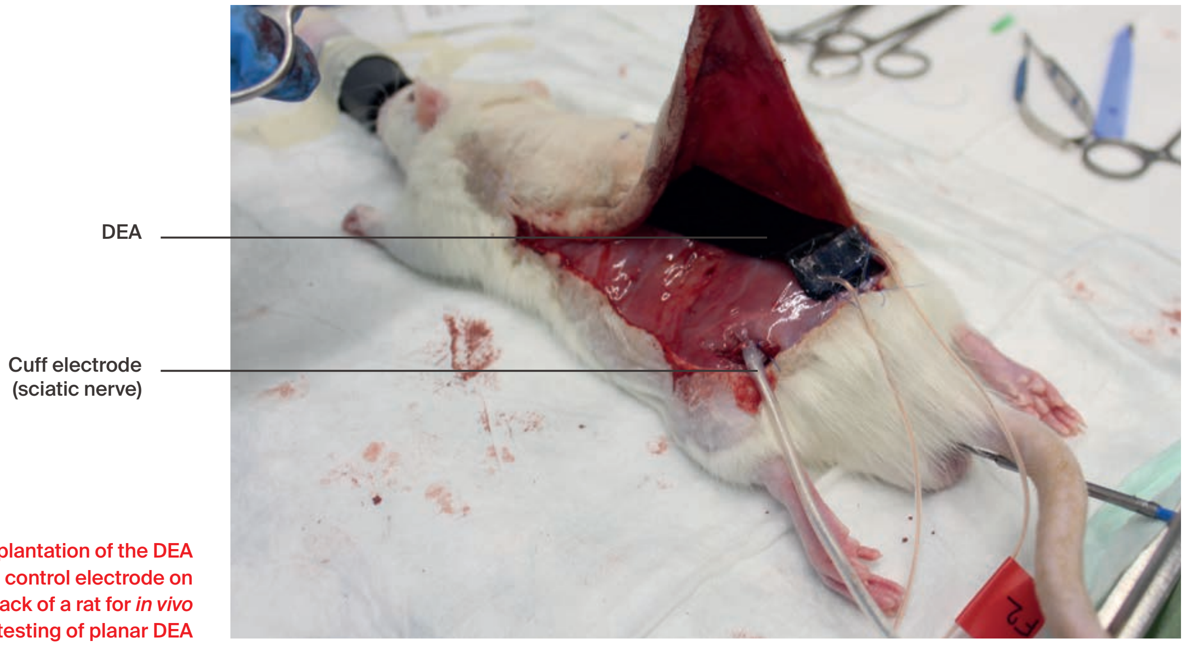
The use of DEAs in living tissues presents new challenges, such as biocompatibility, long-term stability, and the integration of a neural interface to control the actuator. Transitioning from *in vitro* testing to *in vivo* experimentation is a critical step for the restoration of facial movements using DEAs with the aim of less invasive and more effective treatment for facial paralysis. We implanted a planar DEA actuator on the back of a rat. First, we tested the proper functioning of the actuator covered by the skin and measured the resulting displacement of the latter. Then, we evaluated the implantation of cuff electrodes around the nerve, which will be used to trigger movements.



Measured displacement when the DEA is not operated (0 kV) and when a voltage is applied (7 kV) over time



Normalized displacement of the DEA when controlled in real time with a signal recorded from the sciatic nerve. Oscillations come from the breathing of the rat



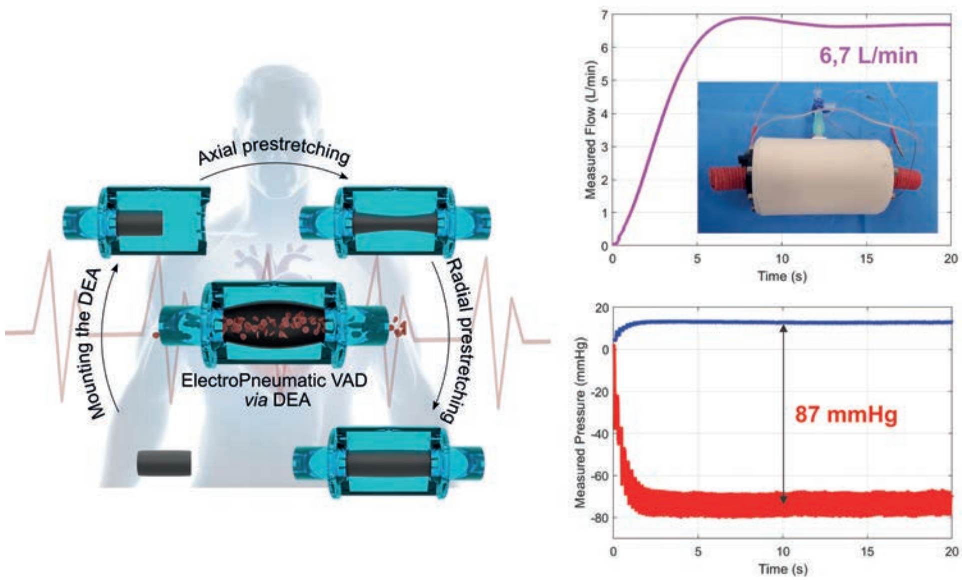
Implantation of the DEA and control electrode on the back of a rat for *in vivo* testing of planar DEA

Mechanical Cardiac support (MCS)

Cardiovascular diseases are a leading cause of mortality worldwide, affecting millions of people each year. In particular, heart failure remains a major challenge, as current treatments are often limited in their ability to fully restore cardiac function. While MCS and heart transplants provide solutions, they come with significant risks and limitations, such as rejection, infection, and the need for lifelong medication. Therefore, there is a growing need to develop soft innovative cardiac assist technologies that are safer, more efficient, and better integrated with the body's natural function.

Vacuum-Enhanced Dielectric Elastomer Device for Cardiac Assistance

The Vacuum-Enhanced Tubular Dielectric Elastomer Actuator Ventricular Assist Device (VAD) represents a novel approach to circulatory support, combining energy efficiency with a soft, adaptable design. Using a multilayer Dielectric Elastomer Actuator within a vacuum-sealed chamber, this device generates pulsatile flow with minimal energy consumption. Optimized through axial pre-stretching and radial biasing, it achieves a flow rate of 6.7 L/min and a pressure head of 87 mmHg at 5 Hz, closely mimicking natural heart function while operating at just 1.6 W. Weighing under 200 grams, this light-weight device offers a promising alternative to conventional motor-driven VADs, which often struggle with bulk and high power demands. Its soft, flexible nature allows for seamless integration with biological tissues, reducing mechanical stress and improving long-term biocompatibility. By bridging the gap between efficiency and adaptability, this dielectric elastomer-based VAD opens new possibilities for next-generation cardiac assist technologies, offering a refined and promising solution for patients with heart failure. Beyond *in vitro* performance, the device was tested *in vivo* in a pig model as both an augmented aorta and a Right Ventricular Assist Device (RVAD), demonstrating its potential to effectively enhance cardiac output.

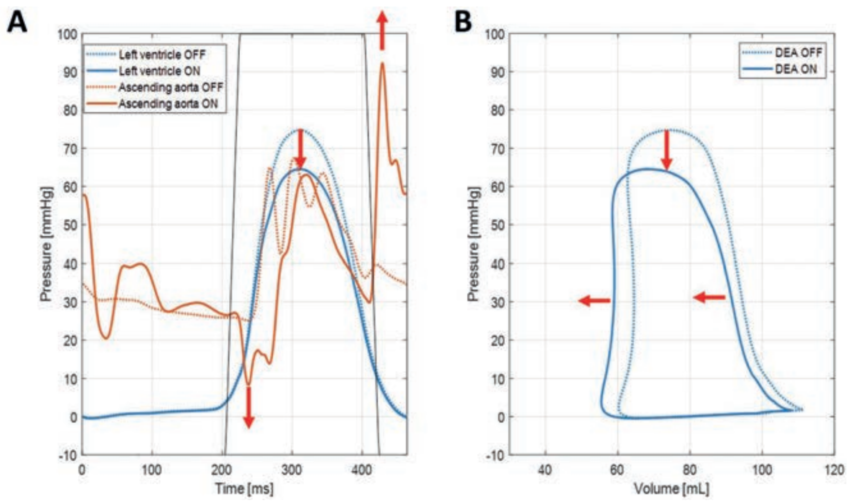


Vacuum-Enhanced Tubular Dielectric Elastomer Actuator Ventricular Assist Device and its performance (Flow and head pressure)

In vivo experiments

Augmented aorta

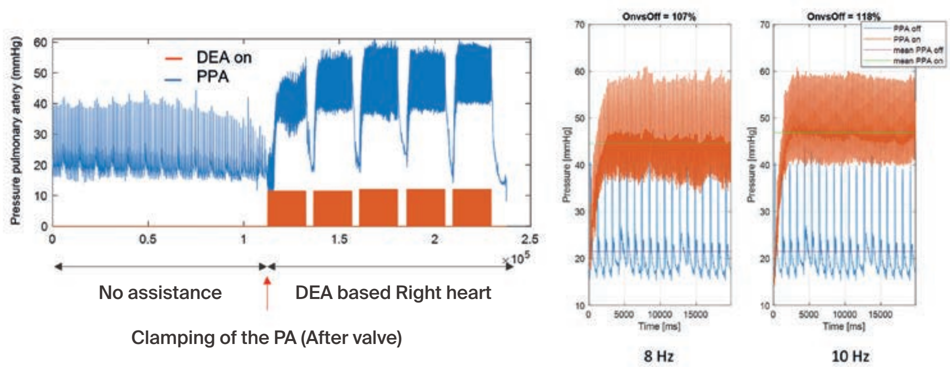
The vacuum-enhanced DEA device was tested *in vivo* in October 2024 (porcine, n=5). The results showed a drastic improvement of the device compared to previous measures from 2022. We were able to reduce the end-diastolic pressure by up to 188% (mean: -131±51.7%, improvement of 14.5x) and increase the early diastolic pressure by up to 58% (mean: 30.1±17.1%, improvement of 5.8x), compared to baseline (DEA turned off) for the best cases. Furthermore, we were able to reduce stroke work (unload the ventricle) by up to 28% (mean: -6.6±9.9%) and increase stroke volume (improve blood flow) by up to 11% (mean: 1.0±4.5%) compared to baseline.



Pressure changes (Left ventricle and aorta) obtained thanks to the vacuum-enhanced DEA **(A)** and pressure-volume (PV) loops of the left ventricle **(B)**. Left shift and decreased height of the PV-loop by the device support indicate unloading of the ventricle.

Right Ventricular Assist Device (RVAD)

In the last animal, the vacuum-enhanced DEA device was tested as an RVAD, positioned between the right atrium and the pulmonary artery using a graft, with one mechanical valve placed before and one after the device. The device was actuated with different frequencies ranging from 1 to 10 Hz, and the pulmonary valve was clamped off to force all blood flow through the device. Despite some problems with the collapsing of the graft, and thereby no or low flow through the device, we were able to increase the pulmonary pressure by up to 118%. This is a promising result, and we believe that by using stiff non-permeable tubes we can achieve comparable flow rates for the RVAD as we have observed *in vitro*.



Pulmonary pressure without or with assistance at different frequencies (Left). Overlapping of pulmonary pressures highlighting an increase (x2) of the mean pressure for a device activated at 8 Hz and 10 Hz (PA and PPA stand for Pulmonary Artery and Pressure Pulmonary Artery respectively)

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Cross-functional developments

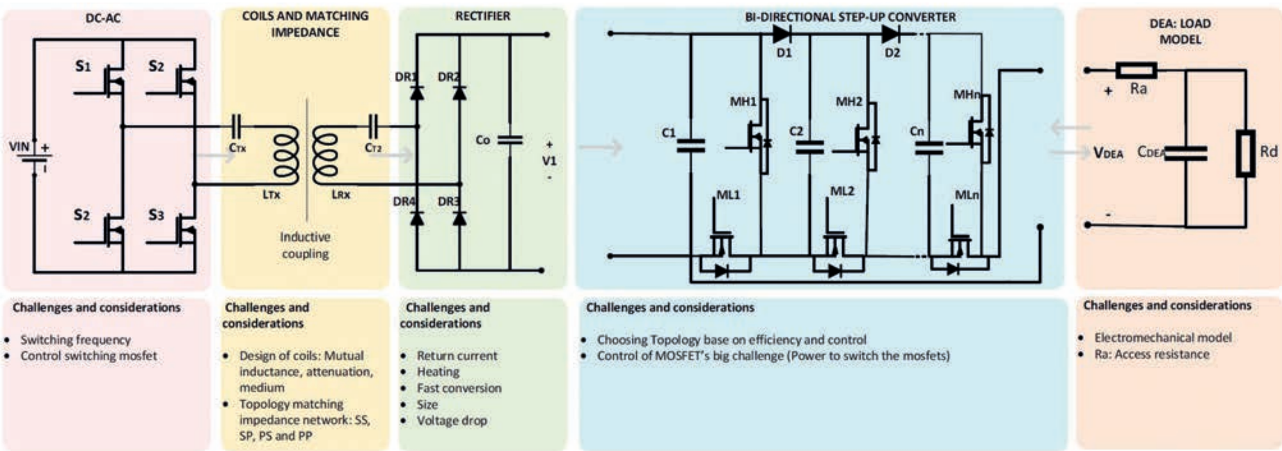
Beyond the three applications mentioned earlier, we are working on the development of a power supply to provide a comprehensive solution for patients. Additionally, we remain at the forefront of technological advancements in manufacturing by exploring various production methods. Lastly, integrated developments within our team are leading to new devices that expand the range of possible applications toward haptic systems for instance.

Powering of a tubular Dielectric Elastomer Actuator

Today, many technologies aim at developing wearable implanted devices capable of powering sensors, actuators, or stimulators to provide optimal solutions for monitoring, prevention, and improving quality of life. However, several challenges must be addressed, including among others, biocompatibility, form factor and efficiency.

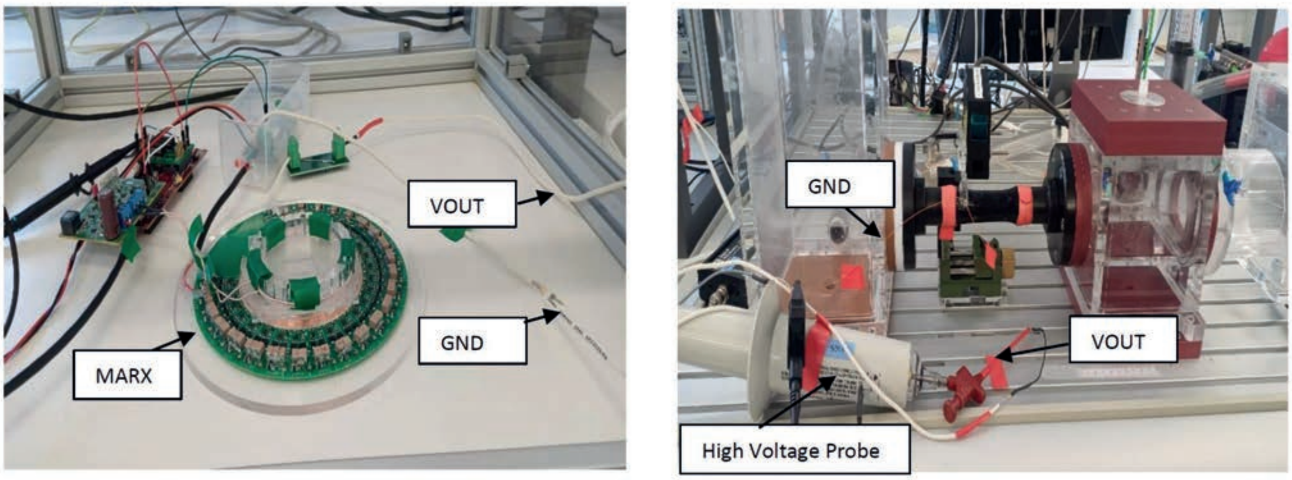
For example, the implementation of cardiac assist devices requires particular attention due to the complexity of the system and the need for reliable power and control. In this context, powering a tubular Dielectric Elastomer Actuator for cardiac assistance demands a strong focus on voltage transfer and energy harvesting.

The following architecture presents an initial idea of the main subsystem required to power the DEA while considering the challenges of a wearable device.



Overview of the architecture for powering dielectric elastomer into the body

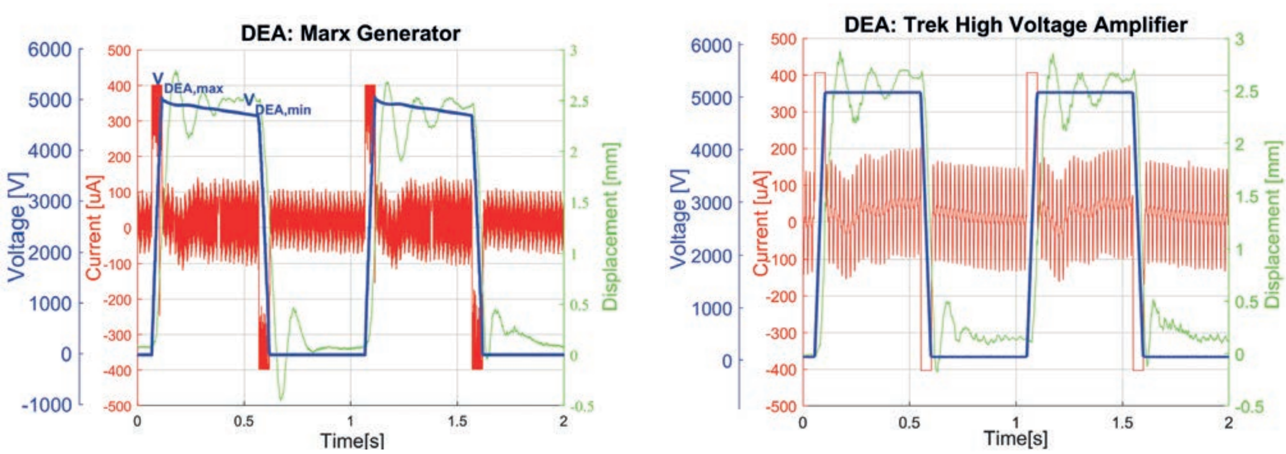
We worked on the implementation of a DC-DC step-up converter (Marx generator) to power the DEA, combined with a wireless power module to control the charge and discharge of the DEA.



Testbench for evaluating the Marx generator as a reliable system for powering DEA

The initial results show some of the advantages and disadvantages of the Marx generator:

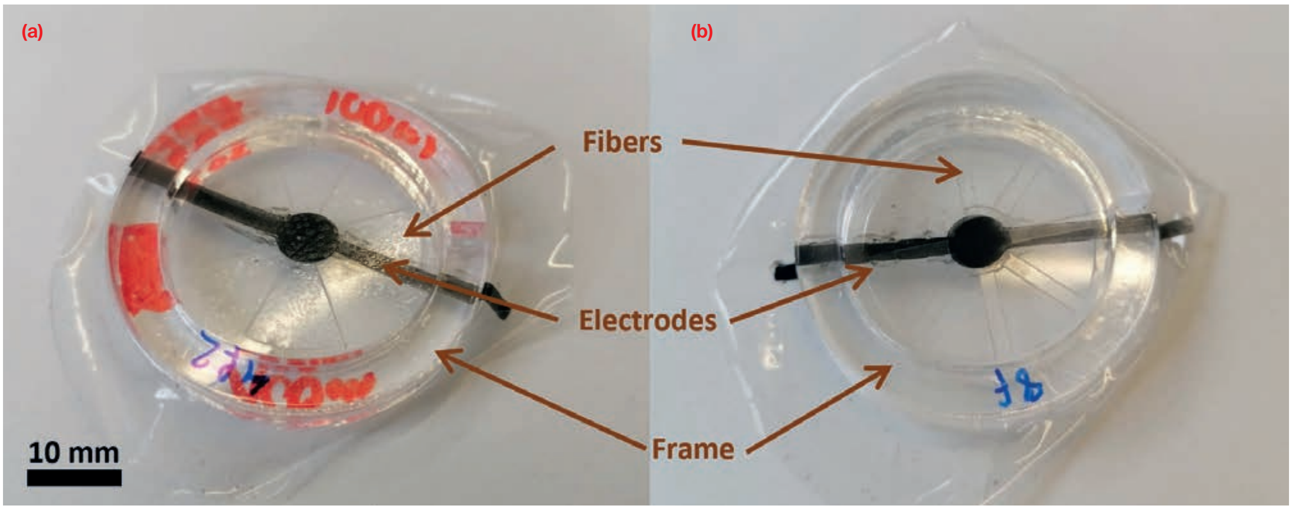
- Smaller form factor for the Marx generator.
- Similar performance in terms of displacements, with approximately 12.5% less displacement in the Marx generator compared to the Trek (Commercial power supply dedicated to laboratory tests).
- Ability to reach high voltage with fast rising and falling times.
- Capability to meet the load requirements to perform the natural motion of the DEA.



Comparison of custom-made high-voltage converter (Marx generator) and commercial high voltage amplifier (Trek 20/20C-HS)

Planar equibiaxial fiber actuators

Dielectric Elastomer Actuators have gained significant attention due to their potential in soft robotics and adaptive structures. However, their performance is often limited by their in-plane strain distribution and limited mechanical stability. To address these challenges, we introduce a novel design utilizing fiber reinforcement. The fiber reinforcement provides enhanced mechanical integrity and improved strain distribution, enabling efficient energy conversion and out-of-plane displacement. Through a combination of analytical and numerical simulations, with experimental validations, we investigated the efficacy of these fiber-reinforced equibiaxial DEAs and characterized their displacement capabilities. A DEA reaching a maximal out-of-plane displacement of 500 µm with a force of 0.18 N has been implemented. In the future, the device could enable different applications, e. g. haptics.



Fabricated DEAs with four **(a)** and eight **(b)** fibers

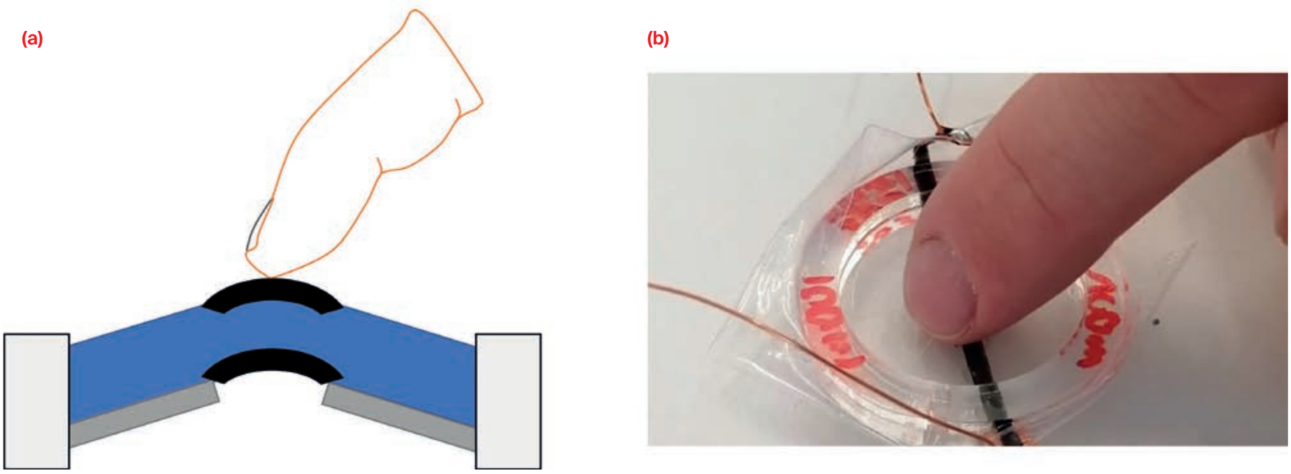


Illustration of an application in haptics. The force resulting from DEA actuation can be felt by a finger placed on the electrode.

New inks

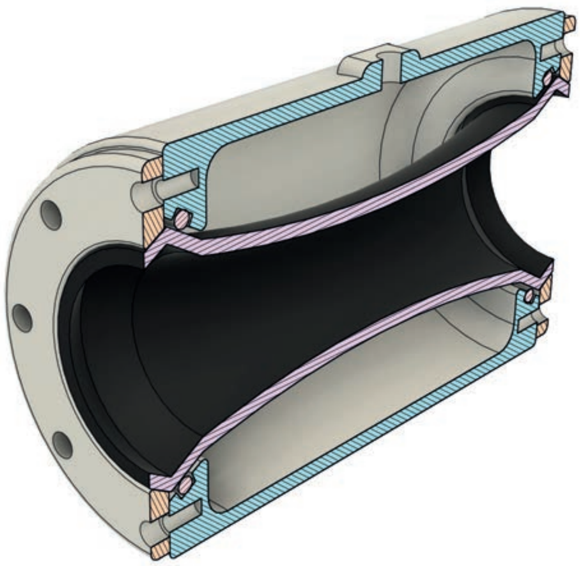
Inkjet printing has now become an integral part of our machine family, and over the past year, we have conducted extensive research into the inks suitable for this process. So far, three inks have demonstrated promising results in terms of deposition and repeatability: carbon ink, PEDOT:PSS and silicone. The first two are conductive inks used for electrode fabrication, while the third serves as a dielectric material. PEDOT:PSS is particularly interesting because of its transparency and conductivity. However, since its extensibility is limited, this property has been enhanced by adding triton x-100.

Mass production of large electrodes

Research has also been conducted on ink deposition using pad printing, with a particular focus on carbon, the primary material for manufacturing our compliant electrodes. In this printing technique, viscosity plays a crucial role in ensuring uniform design transfer. If the ink is too fluid, it will not adhere properly to the pad; if too viscous, the design will not be fully transferred. Using this method, we successfully printed 190-mm-long electrodes, leading to the creation of a functional DEA.

Vacuum

As seen previously, to enhance the capabilities of our cardiac assist device, the use of vacuum outside the DEA seems to hold great promise. So, we had to develop a system that could host our rolled DEA, pre-stretch it and maintain a vacuum, while allowing electrical wires to be connected. The size of the DEA has also been reviewed, with a total of 8 layers, 6 of which are active.



Cross-section view of the vacuum-enhanced cardiac assist device containing a pre-stretched rolled DEA

Next steps

Our research is now entering a crucial phase: translating our work into a medical device capable of assisting the heart. The next milestone will be the initiation of chronic tests in two years. To achieve this, we must optimize the device to make the surgical procedure less invasive. This includes developing a fully integrated control system that encompasses power supply, sensors, and the use of reliable and biocompatible materials.

For patients suffering from facial paralysis, our next steps will focus on improving movement to enable true facial expressions. This progress will be reflected in more pronounced skin movements in our rat models. On the biological front, upcoming tests aim to demonstrate genotypic modifications in cells subjected to cyclic deformation within our platform. Finally, the characterization of the artificial sphincter must provide clear and precise validation of our approach, particularly through more accurate flow rate measurements within the tubular DEA.

As Neil Armstrong once said, “That’s one small step for man, one giant leap for mankind.” In our center, we take many small steps, each one brings us closer to groundbreaking advancements!

Team

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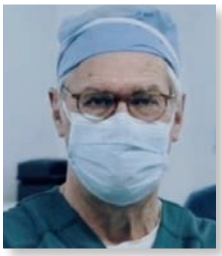
BACK Quentin De Menech, Armando Walter, Francesco Clavica

MIDDLE Purnendu, Stefania Konstantinidi, Maribel Caceres Rivera

FRONT Yoan Civet, Amine Benouhiba, Aline Chappatte-Zürcher, Noé Syfrig, Prof. Yves Perriard

NOT IN THE PHOTO Alexis Boegli, Simon Holzer, Silje Ekroll Jahren, Sedef Kollarik

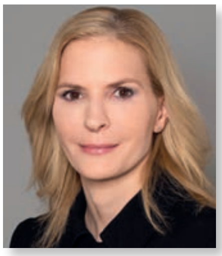
Partners



Prof. THIERRY CARREL, University of Zurich

Thierry Carrel graduated from the University of Bern in 1984. He has then received board certification in General Surgery (1990), Cardiac Surgery (1993) and Vascular Surgery (1999). Following training at the University Hospital in Zurich and fellowships in Hannover, Paris, Helsinki and Baltimore, he was appointed in 1999 at the University Hospital in Bern as Chairman of the Clinic for Cardiovascular Surgery and as a Full Professor at the University until 2020. Between 2006 and 2008, he received the lead ad interim of the Clinic for Cardiac Surgery at the University of Basel. Between 2021 and 2022, he was appointed as a Deputy Director ad interim at the University Hospital of Zürich (Clinic for Cardiac Surgery). He is presently consultant for cardiac surgery at University Hospital Basel, Switzerland.

Since the beginning of his career as a surgeon, he has performed around 12'000 general surgeries and cardiac procedures as a surgeon, teacher, or assistant. He has mentored more than 35 surgeons and 12 professorships in Switzerland and abroad. He is the author and co-author of more than 850 peer-reviewed scientific publications (PubMed registered). In 2013, he received the Da Vinci Award of the European Association for Cardiac Surgery as the best teacher in Europe and in 2015 the honorary title (Dr. h.c.) of the University of Freiburg. In the last 20 years, he conducted numerous medical missions in Russia, Morocco, Uzbekistan and Mongolia. Between 2008 and 2020, he was Associated Editor of the European Journal of Cardio-thoracic Surgery and between 2018 and 2020, he was Member of the Board of Directors of the American Association for Thoracic Surgery.



Prof. NICOLE LINDENBLATT, University of Zurich

Nicole Lindenblatt is a Professor ad Personam for Reconstructive Microsurgery at the University of Zurich and serves as the Deputy Director of the Department of Plastic and Hand Surgery at the University Hospital Zurich. She is also the Director of the Zurich Lymphatic Network of Excellence. Her expertise includes peripheral and central lymphatic surgery, robotic microsurgery, pediatric lymphatic surgery, reconstructive and aesthetic facial and breast surgery, and treatments for facial paralysis.

She has achieved several milestones in her field. In 2021, she conducted the world's first robotic-assisted lymphatic surgery using the Symani® Surgical System. In 2023, she performed the first robotic-assisted central lymphatic reconstruction globally.

Her qualifications include becoming a specialist in General Surgery in 2007 and in Plastic, Reconstructive, and Aesthetic Surgery in 2011. She completed a DAFPRS International Fellowship in Facial Plastic and Reconstructive Surgery and a Fellowship in Lymphatic Surgery in Paris in 2013. Since 2015, she has been instrumental in developing Switzerland's first Lymphatic Surgery Program at the University Hospital Zurich, introducing innovative diagnostics, treatments, and patient-reported outcome measurements (PROMs). Between 2016 and 2018, she earned a European Master's degree in Surgical Oncology, Reconstructive, and Aesthetic Breast Surgery from Universitat Autònoma de Barcelona. In 2017, she held a visiting professorship at Memorial Sloan Kettering Cancer Center in New York.

Prof. DOMINIK OBRIST, University of Bern

Dominik Obrist is Professor of Cardiovascular Engineering at the ARTORG Center for Biomedical Engineering Research of the University of Bern. He holds a degree in mechanical engineering from ETH Zurich and earned his doctoral degree in 2000 at the Department of Applied Mathematics of the University of Washington. From 2000 to 2005, he worked for the supercomputer company Cray Inc. In 2005, Dominik Obrist returned to academia as a senior researcher at the Institute of Fluid Dynamics of ETH Zurich, where he established a research group for biomedical fluid dynamics. He is co-founder of the start-up URODEA, which invented the world's first non-invasive solution for urinary retention. His main research interests include the design of heart valve prostheses and the development of novel technology for the diagnosis and treatment of microvascular diseases.

Prof. FIONA BURKHART, University of Bern

Fiona Burkhard is Associate Professor at the University of Bern and Chair of functional urology, including female urology, incontinence, neuro-urology, urological malformations and bladder reconstruction at the University Hospital of Bern. She has a special interest in functional outcome after continent urinary diversion, especially in women. She is past chair of the EAU guidelines on incontinence and past member of the EAU scientific office and EAU School of Urology. Her research is focused on the application of the development of engineering tools to support the function of the urinary tract in collaboration with ARTORG with the urogenital engineering group and molecular mechanisms of bladder dysfunction using integrated omics, big data and machine learning tools to discover novel diagnostics and therapeutics with the functional urology research group.

Prof. JÜRGEN HÖRER, Technische Universität München

Professor Jürgen Hörer is a clinically active heart surgeon carrying out research in the field of surgical treatment of congenital heart disease and risk evaluation. He is/has been coordinator of several international studies investigating the outcome of surgical treatment of congenital heart disease. After completing his medical school at the University of the Saarland, the University Paris VI and University of Bern, he completed his training in cardiac surgery at the German Heart Center Munich where he was deputy director for the congenital program. From 2015 to 2018, he was the head of the department of congenital heart disease at the Hospital Marie Lannelongue in Paris. In 2018, he was offered the Chair of the newly established congenital and pediatric cardiac surgery at Technical University Munich. He is the director of the department for congenital and pediatric cardiac surgery at the German Heart Center and the head of the division for congenital and pediatric cardiac surgery at the University Hospital of the Ludwig-Maximilians-University in Munich. Jürgen Hörer is a member of numerous organizations, including the European Association for Cardio-thoracic Surgery, the European Congenital Heart Surgeons Association, the World Society for Pediatric and Congenital Heart Surgery, the German Society for Thoracic and Cardiovascular Surgery and the Collège Française de Chirurgie Thoracique et Cardio-Vasculaire.

Dissemination

Invited Talks

Center for Artificial Muscles: Dedicated implant projects for soft robotics, Yves Perriard, *SoRo Health: The future of soft robotics in healthcare*, London, England, February 2024

Implants for soft robotics, Yves Perriard, Tokyo Institute, Japan, August 2024

Journal papers

Breaking the Cardiovascular Flow Barrier for Dielectric Elastomer Actuator-Based Pumping: Design and Characterization, A. Benouhiba, A. Walter, S.E. Jahren, F. Clavica, D. Obrist, Y. Civet and Y. Perriard, *Advanced Engineering Materials. Vol. 27, num. 2, p. 2401306*

The elastic frontier: dielectric elastomer actuators in healthcare technology, A. Benouhiba, S. Holzer, S. Konstantinidi, Y. Civet, Y. Perriard, *Smart Materials and Structures. 2025. Vol. 34, num. 3*

Investigation of buckling instabilities in fiber-reinforced DEAs, S. Konstantinidi, M. Koenigsdorff, T. Martinez, A. Benouhiba, J. Mersch, Y. Civet, G. Gerlach, Y. Perriard, *Composites Science and Technology. 2024. Vol. 258*

Fiber-Reinforced Equibiaxial Dielectric Elastomer Actuator for Out-of-Plane Displacement, S. Holzer, S. Konstantinidi, M. Koenigsdorff, T. Martinez, Y. Civet, Y. Perriard, *Composites Science and Technology. 2024. Vol. 258*

Dielectric elastomer actuator-based valveless pump as Fontan failure assist device: introduction and preliminary study, A. Benouhiba, A. Walter, S.E. Jahren, T. Martinez, F. Clavica, P.P. Heinisch, D. Obrist, Y. Civet and Y. Perriard, *Interdisciplinary Cardiovascular And Thoracic Surgery. 2024. Vol. 38, num. 4, p. ivae041*

Novel para-aortic cardiac assistance using a pre-stretched dielectric elastomer actuator, S.E. Jahren, T. Martinez, A. Walter, F. Clavica, P.P. Heinisch, E. Buffle, M. M. Luedi, J. Hörer, D. Obrist, T. Carrel, Y. Civet, Y. Perriard, *Interdisciplinary CardioVascular and Thoracic Surgery. 2024. P. ivae027*

Conferences

A Dielectric Elastomer based Miniaturized Soft Planar Microactuator, S. Holzer, B. Tiwari, S. Konstantinidi, Y. Civet; Y. Perriard, *ACTUATOR, International Conference and Exhibition on New Actuator Systems and Applications, Wiesbaden, Germany, 2024*

Energy-based modeling and robust position control of a dielectric elastomer cardiac assist device, A. Hammoud, N. Liu, Y. Le Gorrec, Y. Civet; Y. Perriard, *8th IFAC Workshop on Lagrangian and Hamiltonian Methods for Nonlinear Control, Besançon, France, 2024*

Highly anisotropic carbon fiber electrodes for DEAs and their dynamic non-monotonic conductive properties, M. Koenigsdorff, J. Mersch, S. Konstantinidi, Y. Perriard, G. Gerlach, *SPIE Smart Structures + Nondestructive Evaluation, Long Beach, California, USA, 2024*

Inversing the actuation cycle of dielectric elastomer actuators for a facial prosthesis, S. Konstantinidi, Q. De Menech, T. Martinez, P. Germano, A. Boegli, Y. Civet, Y. Perriard, *SPIE Smart Structures + Nondestructive Evaluation, Long Beach, California, USA, 2024*

Frequency response of fiber reinforced DEAs, S. Konstantinidi, M. Koenigsdorff, T. Martinez, Y. Civet, G. Gerlach, Y. Perriard, *SPIE Smart Structures + Nondestructive Evaluation, Long Beach, California, USA, 2024*

Carbon based printed electrodes for DEAs: study of pad, inkjet, and stencil printing, S. Holzer, A. Walter, S. Konstantinidi, T. Martinez, Y. Civet, Y. Perriard, *SPIE Smart Structures + Nondestructive Evaluation, Long Beach, California, USA, 2024*

An artificial urinary sphincter based on dielectric elastomer technology, Q. De Menech, S. Zammouri, S. Konstantinidi, A. Benouhiba, Y. Civet, Y. Perriard, *SPIE Smart Structures + Nondestructive Evaluation, Long Beach, California, USA, 2024*

Characterisation of Polymer Materials for the Development of an Artificial Urethra, Q. De Menech, L. Andre, S. Konstantinidi, A. Benouhiba, T. Martinez, Y. Civet, Y. Perriard, *46 International Conference of the IEEE Engineering in Medicine and Biology Society, Orlando, United States, 2024*

Toward soft cardiac assist devices, A. Benouhiba, S.E. Jahren, T. Martinez, A. Walter, F. Clavica, P.P. Heinisch, D. Obrist, J. Hörer, T. Carrel, Y. Civet, Y. Perriard, *EACTS 2nd Innovation Summit, Paris, France, 2024*

Thank you WSS!

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In 2024, we had the privilege of welcoming both family members and board members of the foundation in April, as well as the foundation's scientific committee in December. It was a tremendous pleasure to host them and showcase the significant progress that has been made since 2018, all thanks to their generous support. Their visit was an opportunity to share the breakthroughs achieved through their contributions, reinforcing the impact of their unwavering commitment, and the roadmap toward full medical devices.

Each guest left with a deep sense of pride, knowing that their remarkable generosity is directly enabling the development of new solutions for patients. The spark of excitement in their eyes and their heartfelt words of encouragement resonated with the entire team, fueling even greater motivation to push the boundaries of current approaches. Their visit was not just a moment of exchange but a powerful reminder of why we strive every day to innovate and address the pressing needs of patients.

We extend our deepest gratitude to them for their continuous support, trust, and belief in our mission. Their generosity is not only transforming research and patient care but also inspiring us to go even further. Without their dedication, none of these achievements would be possible, and we are truly honored to have them by our side on this journey.

We take the opportunity to warmly wish Mr. Gianni Operto (second from left on the picture) all the best for the next chapter of his journey. As Chairman of the Scientific Board, he was there from the very beginning of the CAM adventure. During his visit last year, we learned of his departure from the Foundation, marking the end of an important chapter. Despite his imposing presence—both physically and within the Foundation—Mr. Operto has always shown immense kindness and generosity while never hesitating to challenge us in the best possible way. His wisdom, support, and leadership have left a lasting impact on our work, and we are deeply grateful for everything he has contributed. We sincerely hope he finds great joy and fulfillment in the next stages of his career and personal life, surrounded by his loved ones.

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