# Jun.-Prof. Dr. Philipp Rothemund

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## Research Interests

Functional soft materials have the potential to revolutionize robots and other machines by embodying functions into their hardware, which are currently implemented using sensing and feedback control. My research focuses on functions enabled by static and dynamic nonlinear phenomena of soft materials resulting from mechanical effects, materials behavior, and multiphysics couplings. I study these phenomena with experimental and theoretical tools from mechanics, physics, and materials science and apply the gained knowledge to design robots and autonomous systems with new functions. Applications are bioinspired, lifelike robots, conformable haptic devices, and structures that passively react to and interact with their environment.

## Education

Sep 2012 - Mar 2018 **PhD in Engineering Sciences** (non-graded at Harvard)
Harvard University, Supervisors: Zhigang Suo, George M. Whitesides

Jun 2012 - May 2014 **MS in Engineering Sciences** (GPA 4.00 of 4.00)
Harvard University, Supervisors: Zhigang Suo

Sep 2009 - Jun 2012 **MS in Mechanical Engineering** (with distinction, GPA: 6.00 of 6.00)
ETH Zurich, Supervisors: Edoardo Mazza, Zhigang Suo

Oct 2006 - Aug 2009 **BS in Mechanical Engineering** (with distinction, GPA: 5.81 of 6.00)
ETH Zurich, Supervisor: Paolo Ermanni

Sep 1997 - Jun 2006 **High School Degree** (GPA: 1.4)

## Academic Positions

Sep 2023 - present **Visiting Scientist, Max Planck Institute for Intelligent Systems**
Robotic Materials Department

May 2023 - present **Tenure-Track Junior Professor, University of Stuttgart**
Chair of Functional Soft Robotic Matter
Faculty 7: Engineering Design, Production Engineering and Automotive Engineering

May 2023 - present **International Max Planck Research School for Intelligent Systems**
Faculty member

Sep 2020 - Aug 2023 **Senior Postdoctoral Researcher, Max Planck Institute for Intelligent Systems**
Robotic Materials Department

Key publication: Rothemund P., et al. Shaping the future of robotics through materials innovation. *Nat. Mater.* **20**, 1582 (2021)

Jan 2019 - Aug 2020 **Postdoctoral Research Fellow, University of Colorado Boulder**
Keplinger Research Group, Department of Mechanical Engineering

Key publication: Rothemund P., et al. Dynamics of Electrohydraulic Actuators. *PNAS* **117**, 16207 (2020)

Sep 2018 - Jan 2019 **Lecturer, Universidad Pontificia Comillas**
Escuela Técnica Superior de Ingeniería ICAI

Lecturer for **Multiphysics Simulation**, developed this new master's level class

Jul 2012 - Mar 2018 **Research Assistant, Harvard University**
Suo Group, School of Engineering and Applied Sciences
George M. Whitesides Group, Department of Chemistry and Chemical Biology

Key publication: Rothemund P. et al. A Soft, Bistable Valve for Autonomous Control of Soft Actuators. *Sci. Robot.* **3**, eaar7986 (2018) [*Nature Review Materials* Research Highlight]

## Awards, Scholarships, and Honors

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|---|---|
| Mar 2025 | **Scholarship Program for Postdoctoral Researchers and Junior Professors**, Daimler and Benz Foundation |
| Oct 2024 | **Young Leader Program** at STS Forum in Kyoto, Japan |
| Jun 2023 - | **Member of Junge Akademie** at the German National Academy of Sciences Leopoldina and the Berlin-Brandenburg Academy of Sciences and Humanities<br>**Jun 2024 – Jun 2025** member of the board of Junge Akademie<br>**Jun 2025 – Jun 2026** member of the board and speaker of Junge Akademie |
| Mar 2020 | **PAC Travel Award** (to attend a conference) |
| Jun 2013 | **Chen Fellowship** (for tuition and fees for the first academic year of the Ph.D. program) |
| May 2013 | **Willi Studer Price 2013** (for best master's degree of the year) |
| Mar 2010 | **D-MAVT Bachelor Award** (for best bachelor's degree of the year) |
| Jun 2006 | **DPG Abiturpreis** (for extraordinary physics grades in high school) |

## Teaching Experience

**New Course Development**

***Fundamentals of Soft Robotics* -** This master-level course introduces participants to the fundamental working principles of soft robotic devices, including soft actuators, sensors, and generators. Students will learn the underlying physics of the most important types of soft transducers and basic techniques for modeling their behavior. The class also discusses the advantages and disadvantages of different soft transducer technologies so participants learn the opportunities and limitations of soft robotics in practical applications.

***Multiphysics Simulations* -** Master-level class that teaches the basics of multiphysics finite element simulations. I was responsible for developing and teaching lectures on topics such as linear and nonlinear finite element simulations, continuum and structural mechanics, buckling and modal analysis, explicit and implicit dynamics, heat transfer, and acoustics. The class included the theory of the finite element method as well as hands-on experience using commercial finite element software (ANSYS).

**University of Stuttgart**

| | |
|---|---|
| Ss 25 | **Fundamentals of Soft Robotics** |
| WS 24 | **Mechanik 1 (EE und VIng)** |
| SS 24 | **Fundamentals of Soft Robotics** |
| WS 23 | **Mechanik 1 (EE und VIng)** |

**Before joining the University of Stuttgart**

| | |
|---|---|
| Sep 2018 - Feb 2019 | Lecturer for **Multiphysics Simulations**, Universidad Pontificia Comillas |
| Sep 2015 - Dec 2015 | Teaching fellow for **Engineering Thermodynamics**, Harvard University |
| Jan 2015 - May 2015 | Head teaching fellow for **Introduction to the Mechanics of Solids**, Harvard University |
| Jan 2013 - May 2013 | Teaching fellow for **Introduction to Heat Transfer**, Harvard University |
| Feb 2009 - May 2009 | Teaching assistant for **Dimensioning II**, ETH Zurich |
| Oct 2008 - Dec 2008 | Teaching assistant for **Control Systems I**, ETH Zurich |
| Mar 2008 - May 2008 | Teaching assistant for **Engineering Materials and Production II**, ETH Zurich |
| Oct 2007 - Dec 2007 | Teaching assistant for **Engineering Materials and Production I**, ETH Zurich |

## Advising and Mentoring Experience

**Ph.D. Students**

Dogan Acar — June 2024 -

Svetlana Shachneva — June 2024 -

**M.S. Students**

Malte Hendrikson — Jun 2023 - Nov 2023

Thesis title: Experimental Investigation of Electrostatic Zipping

**At Max Planck Institute for Intelligent Systems**

- Supervised 6 Ph.D. students (informal)

**At University of Colorado, Boulder**

- Supervised 3 Ph.D. students (informal)

- Supervised 1 bachelor's thesis (informal)

**At Harvard University**
- Mentored 1 master student
- Mentored 2 bachelor students

## Leadership and Management Experience

**University of Stuttgart**
Member of faculty council; member of doctoral degree board; external reviewer for a PhD thesis at EPFL Lausanne; involved in writing a proposal for DFG clusters of excellence Bionic Intelligence for Health and Stuttgart Center for Simulation Sciences as participating researcher; representative of the university for the planning of a new building for Cyber Valley.

**Max Planck Institute for Intelligent Systems, Robotic Materials Department**
Led subgroups on modeling and characterization of electrohydraulic HASEL actuators and on developing new materials systems for high-performance soft actuators; coordinated the set-up of the laboratories of the newly founded department, including purchasing lab equipment; involved in planning the renovations of the facilities of the department; responsible for planning the budget of department; representative of the department for the scientific advisory board; involved in planning new building for Cyber Valley; started and organized an institute-wide, weekly talk series and social event (Talk & Talk); department safety officer; evaluator for the International Max Planck Research School for Intelligent Systems and the Max Planck ETH Center for Learning Systems in 2020; reviewer for the Max Planck Institute Grassroots Funding Program in 2020, 2021.

**University of Colorado Boulder, Keplinger Research Group:**
Led subgroups on modeling and characterizing electrohydraulic HASEL actuators.

**Harvard University, Suo Group**
Led an industry collaboration with BASF on using thermoplastic polyurethanes in electroactive noise cancellation devices; was the lab safety officer for 2 years; organized regular social events for the School of Engineering and Applied Sciences; mentored one graduate student.

**Harvard University, George M. Whitesides Group**
Was lab safety officer for 3 years; organized regular social events for the Whitesides group and the Department of Chemistry and Chemical Biology.

## Grant Writing Experience

- Electromechanics of zipping in electrohydraulic artificial muscles (40'000 €), **Daimler and Benz Foundation**, PI: Philipp Rothemund
- Soft Deformation Sensor with High Spatial Resolution Through Impedance Spectroscopy (~182'000 €) **SimTech**, PI: Philipp Rothemund
- Soft Robot Finger with Integrated Proprioceptive Tactile Skin (19'000 €) **MPI-IS Grassroots 2022**, PIs: Philipp Rothemund, Hyosang Lee
- Untethered Soft Robot Enabled by Flexible High-Voltage Drivers and Electro-Hydraulic Continuum Actuators (~455'000 US$) **FlexTech**, PI: Gregory Whiting
- Investigating Tunneling Across Self-Assembled Monolayers Using the Eutectic GaIn Junction (~780'000 US$) **National Science Foundation (USA)**, PI: George M. Whitesides
- Pre-Project Evaluation of Polyurethanes as Electroactive Materials (85'000 US$) **BASF**, PIs: Zhigang Suo, Raymond Neff

## Invited Peer Reviewer

Nature Materials, Advanced Materials, Science Robotics, Nature Communications, Science Advances, ACS Nano, Scientific Reports, Advanced Materials Technologies, Journal of the American Chemical Society, Soft Robotics, Extreme Mechanics Letters, ACS Applied Materials & Interfaces, Frontiers in Robotics and AI, Frontiers in Bioengineering and Biotechnology, Applied Physics Letters, Sensors and Actuators A: Physical, Smart Materials and Structures, IEEE Robotics and Automation Letters, IEEE Transactions on Robotics, IEEE Transactions on Mechatronics, Nonlinear Dynamics, Journal of Fluids and Structures, Robosoft 2020, Robosoft 2022, Robosoft 2024, ICRA 2021, ICRA 2022, Actuators.

## Publication Overview

Citation index: **Google Scholar** https://scholar.google.com/citations?user=O10opkEAAAAJ&hl=en&oi=ao
**Researcher ID** https://publons.com/researcher/3063954/philipp-rothemund/

**[30]** Xu Y., Zhang F., **Rothemund P.**, Keplinger C., Xu Z., Li J. Zheng Q., Zhu J. Soft reconfigurable logic gates with high-frequency electrical switching. *Science Advances* **11**, adx1509 (2025)

**[29]** Milana E., Della Santina C., Gorissen B., Rothemund P. Physical control: A new avenue to achieve intelligence in soft robotics. *Science Robotics* **10**, eadw7660 (2025)

**[28]** Sanchez-Tamayo N., Yoder Z., **Rothemund P.**, Ballardini G., Keplinger C., Kuchenbecker K. J. Cutaneous Electrohydraulic (CUTE) Wearable Devices for Pleasant Broad-Bandwidth Haptic Cues. *Advanced Science* **11**, 2402461 (2024), Inside Front Cover

**[27]** Yoder Z., Rumley E. H., Schmidt, I., **Rothemund P.**, Keplinger C. Hexagonal electrohydraulic modules for rapidly reconfigurable high-speed robots. *Science Robotics* **9**, adl3546 (2024)

**[26]** Bensefelt T., Jyoti Shakya, **Rothemund P.**, Lindström S. B., Piper A., Winkler T. E., Hajian A., Wagberg L., Keplinger C., Hamedi, M.M. Electrochemically controlled hydrogels with electrotunable permeability and uniaxial actuation. *Advanced Materials* **35**, 2303255 (2023)

**[25]** Bensefelt T., **Rothemund P.**, Lee P.S. Ultrafast, high-strain, and strong uniaxial hydrogel actuators from recyclable nanofibril networks. *Advanced Materials* **35**, 2300487 (2023)

**[24]** Rumley E. H*., Preninger D*., Shagan Shomron A., **Rothemund P.**, Hartmann F., Baumgartner M., Kellaris N., Stojanovic A., Yoder Z., Karrer B., Keplinger C., Kaltenbrunner M. Biodegradable Electrohydraulic Actuators for Sustainable Soft Robots. *Science Advances* **9**, eadf5551 (2023) (*equal contribution)

**[23]** **Rothemund P.**, Kim. Y., Heisser R. H., Zhao X., Shepherd R. F., Keplinger C. Shaping the future of robotics through materials innovation. *Nature Materials* **20**, 1582 (2021)

**[22]** Fowler H. E., **Rothemund P**., Keplinger C., White T. J. Liquid Crystal Elastomers with Enhanced Directional Actuation to Electric Fields. *Advanced Materials* **33**, 2103806 (2021)

**[21]** Kirkman S., **Rothemund P.**, Acome E., Keplinger C. Electromechanics of Planar HASEL Actuators. *Extreme Mechanics Letters* **48**, 101408 (2021)

**[20]** Kellaris N., **Rothemund P.**, Zeng Y., Mitchell S. K., Smith G. M., Jayaram, K., Keplinger C. Spider-inspired Electrohydraulic Actuators for Fast, Soft-Actuated Joints. *Advanced Science* **8**, 2100916 (2021)

**[19]** Li Y.*, Root S. E.*, Belding, L., Park J., Rawson J., Yoon H. J., Baghbanzadeh M., **Rothemund P.**, Whitesides G. M. Characterizing Chelation at Surfaces by Charge Tunneling. *Journal of the American Chemical Society* **143**, 5967 (2021) (*equal contribution)

**[18]** **Rothemund P.**, Kellaris N.*, Mitchell S. K.*, Acome, E.*, Keplinger C. HASEL Artificial Muscles for a New Generation of Lifelike Robots—Recent Progress and Future Opportunities. *Advanced Materials* **33**, 2003375 (2021) (*equal contribution), Frontispiece

**[17]** **Rothemund P.†**, Kirkman S., Keplinger C.† Dynamics of Electrohydraulic Soft Actuators. *Proceedings of the National Academy of Sciences of the United States of America* **117**, 16207 (2020) (**†corresponding author**)

**[16]** Wang X., Mitchell S. K., Rumley E. H., **Rothemund P.**, Keplinger C. High-Strain Peano-HASEL Actuators. *Advanced Functional Materials* **30**, 1908821 (2020)

**[15]** **Rothemund P.**, Kellaris N., Keplinger C. How Inhomogeneous Zipping Increases the Force Output of Peano-HASEL Actuators. *Extreme Mechanics Letters* 31, 100542 (2019)

**[14]** Luo K.*, **Rothemund P.***, Whitesides G. M., Suo Z. Soft Kink Valves. *Journal of the Mechanics and Physics of Solids* **131**, 230 (2019) (***equal contribution**)

**[13]** Preston D. J., Jiang H. J., Sanchez V., **Rothemund P.**, Rawson J., Nemitz M. P., Lee W.-K., Suo Z., Walsh C. J., Whitesides G. M. A Soft Ring Oscillator. *Science Robotics* **4**, eaaw5496 (2019)

**[12]** Kellaris N., Gopaluni Venkata V., **Rothemund P.**, Keplinger C. An Analytical Model for the Design of Peano-HASEL Actuators with Drastically Improved Performance. *Extreme Mechanics Letters* **29**, 100449 (2019)

**[11]** Preston D. J., **Rothemund P.**, Jiang H. J.*, Nemitz M. P.*, Rawson J., Suo Z., Whitesides G. M. Digital Logic for Soft Devices. *Proceedings of the National Academy of Sciences of the United States of America* **116**, 7750 (2019) (*equal contribution)

**[10]** Cafferty B. J.*, Campbell V. E.*, **Rothemund P.**, Preston D. J., Ainla A., Fulleringer N., Diaz A. C., Fuentes A. E., Sameoto D., Lewis J. A., Whitesides G. M. Fabricating 3D Structures by Combining 2D Printing and Relaxation of Strain. *Advanced Materials Technologies* **4**, 1800299 (2019) (*equal contribution)

**[9]** **Rothemund P.**, Morelle X. P., Jia K., Whitesides G. M., Suo Z. A Transparent Membrane for Active Noise Cancelation. *Advanced Functional Materials* **28**, 1800653 (2018)

**[8]** **Rothemund P.**, Ainla A., Belding L., Preston D. J., Kurihara S., Suo Z., Whitesides G. M. A Soft, Bistable Valve for Autonomous Control of Soft Actuators. *Science Robotics* **3**, eaar7986 (2018).

**[7]** Belding L., Baytekin B., Baytekin H. T., **Rothemund P.**, Verma M. S., Nemiroski A., Sameoto D., Grzybowski B. A., Whitesides G. M. Slit Tubes for Semisoft Pneumatic Actuators. *Advanced Materials* **30**, 1704446 (2018)

**[6]** **Rothemund P.**, Bowers C. M., Suo Z., Whitesides G. M. Influence of the Contact Area on the Current Density across Molecular Tunneling Junctions Measured with EGaIn Top-Electrodes. *Chemistry of Materials* **30**, 129 (2018)

**[5]** Baghbanzadeh M.*, Bowers C. M.*, Rappoport D., Zaba T., Yuan L., Kang K., Liao K.-C., Gonidec M., **Rothemund P.**, Cyganik P., Aspuru-Guzik A., Whitesides G. M. Anomalously Rapid Tunneling: Charge Transport across Self-Assembled Monolayers of Oligo(ethylene glycol). *Journal of the American Chemical Society* **139**, 7624 (2017) (*equal contribution)

**[4]** Hamedi M. M.*, Campbell V. E.*, **Rothemund P.**, Güder F., Christodouleas D. C., Bloch J.-F., Whitesides G. M. Electrically Activated Paper Actuators. *Advanced Functional Materials* **26**, 2446 (2016) (*equal contribution), Inside Front Cover

**[3]** Illeperuma W. R. K., **Rothemund P.**, Suo Z., Vlassak J. J. Fire-resistant Hydrogel-fabric Laminates: A Simple Concept that may Save Lives. *ACS Applied Materials & Interfaces* **8**, 2071 (2016)

**[2]** Keplinger C.*, Sun J.-Y.*, Foo C. C., **Rothemund P.**, Whitesides G. M., Suo Z. Stretchable, Transparent, Ionic Conductors. *Science* **341**, 984 (2013) (*equal contribution)

**[1]** Schmidt A., **Rothemund P.**, Mazza E. Multiaxial Deformation and Failure of Acrylic Elastomer Membranes. *Sensors and Actuators A: Physical* **174**, 133 (2012)

## Talks

### Invited Talks

**[12]** IEEE RAS EMBS 10th International Conference on Biomedical Robotics and Biomechatronics (BioRob 2024), Heidelberg, Germany, September 2024: HASEL artificial muscles for the next generation of lifelike robots

**[11]** 11th International Conference on Soft Transducers and Electromechanically Active Polymers, Bristol, UK, June 2023: Electromechanical Modeling of Electrohydraulic HASEL Actuators

**[10]** 2023 IEEE International Conference on Robotics and Automation (ICRA), Workshop *Soft Robotics: Fusing Function with Structure*, London, UK, June 2023: Bistable elements for the embodied control of fluid flow in soft robots

**[9]** IEEE International Conference on Soft Robotics (Robosoft) 2023, Workshop *Mechanical and Fluidic Control of Untethered Soft Robots*, Singapore, April 2023: Control of fluid-flow in soft robots with bistable elements

**[8]** AIRS in the AIR, Shenzhen Institute of Artificial Intelligence and Robotics, Online, September 2022, **Keynote talk:** Physics of Hydraulically Amplified Self-Healing Electrostatic Actuators

**[7]** EUROMECH Colloquium on Mechanics of Soft Active Polymers, Southampton, UK, August 2022: Electromechanical modeling of hydraulically amplified self-healing electrostatic actuators

**[6]** TU Dresden, Chair of Microsystems, Seminar, Germany, June 2022: Electromechanics of hydraulically amplified self-healing electrostatic actuators

**[5]** Intelligent Machines? – Self-organized Nonlinear Dynamics of Machines across Scales (Intema 2022), Dresden, Germany, June 2022: Quasistatic and dynamic behavior of electrohydraulic HASEL actuators

**[4]** IEEE International Conference on Soft Robotics (Robosoft) 2022, Workshop *New Directions for Simplified Control of Soft Robots*, Edinburgh, UK, April 2022: Soft Bistable Valves for Pressure-Based Feedback Control of Pneumatic Soft Robots

**[3]** Imperial College London and London Centre for Nanotechnology, Online, November 2021: Mechanisms of Electrohydraulic Actuation in HASEL actuators

**[2]** Queen Mary University of London, Engineering Seminar, Online, May 2021: Physics of Electrohydraulic Actuation in HASEL Actuators

**[1]** Step Anywhere, Online, March 2021: Hasel Artificial Muscles for a New Generation of Lifelike Robots

**Conference Contributions**

**[5]** EuroEAP, Online Forum, June 2021: Spider-inspired Electrohydraulic Soft-actuated Joints [Lightning talk & Poster presentation]

**[4]** SPIE Smart Structures/NDE, Electroactive Polymer Actuators and Devices (EAPAD) XXIII, Online forum, March 2021: Dynamics of Electrohydraulic HASEL Actuators [Oral presentation]

**[3]** Gordon Research Conference: Robotics, Ventura, CA, USA, January 2020: Fundamentals of the Electromechanics of HASEL Actuators [Poster presentation]

**[2]** 2019 SES Technical Meeting, St Louis, MO, USA, October 2019: How Inhomogeneous Zipping Increases the Force Output of Peano-HASEL Actuators [Oral presentation]

**[1]** SPIE Smart Structures/NDE, Electroactive Polymer Actuators and Devices (EAPAD) XVI, San Diego, CA, USA, March 2014: Durability of Dielectric Elastomer Actuators Made with Ionic Conductors [Oral presentation]

## Patents

**[1]** Keplinger C. M., Mitchell S. K., Kellaris N. A., **Rothemund P.**, Composite Layering of Hydraulically Amplified Self-Healing Electrostatic Transducers. U.S. Patent Application No. 17/436455. Status: Pending

## Professional Service for Journals, Conferences, and Funding Agencies

⇒ Peer reviewer for an extensive list of journals, see page 3.

**[9]** Schweizer Nationalfond (SNF)
**Review of grant proposal 2025**

**[8]** 8th IEEE – RAS International Conference on Soft Robotics (Robosoft 2025), Workshop *Soft Robotic Actuation and Sensing Based on Functional Materials*, Lausanne, Switzerland, April 2025
**Workshop co-organizer**

**[7]** Twelfth Conference of the European Society for Electromechanically Active Polymer Transducers & Artificial Muscles, Stuttgart, Germany, June 2024
**Conference Chair**

**[6]** Smart Materials and Structures
**Guest Editor, Special issue for EuroEAP 2024**
**Guest Editor, Special issue for EuroEAP 2023**

**[5]** Frontiers in Robotics and AI
**Associate Editor 2022-present**
**Review Editor 2021-2022**

**[4]** European Research Council (ERC)
**Reviewer of ERC starting grant proposal 2022**

**[3]** European Society for Electromechanically Active Polymer Transducers & Artificial Muscles
**Chair of conference committee 2024-present**
**Member of conference committee 2022-2024**

**[2]** Shaping the Future of Robotics through Materials Innovation, Kreuth, Germany, June 2022
**Conference Chair**

**[1]** German-Israeli Foundation for Scientific Research and Development (GIF)
**Review of grant proposal 2021**

## Skills, Activities, Interests

- **Languages:** German (native), English (fluent), Spanish (good) , French (basic), Latin (basic)
- **Public outreach:** Spoke at ***Nerd Nite Boulder*** (Event at a local bar during which researchers present their work to the public); Helped hosting ***TEDx Adventures*** in the Keplinger Research Group at CU Boulder; helped hosting Girl's Day 2023 at the Max Planck Institute for Intelligent Systems; explained research to the general public in scientific **TV shows** broadcasted in South America, and Germany and France.
- **Rock climbing, chess, hiking**