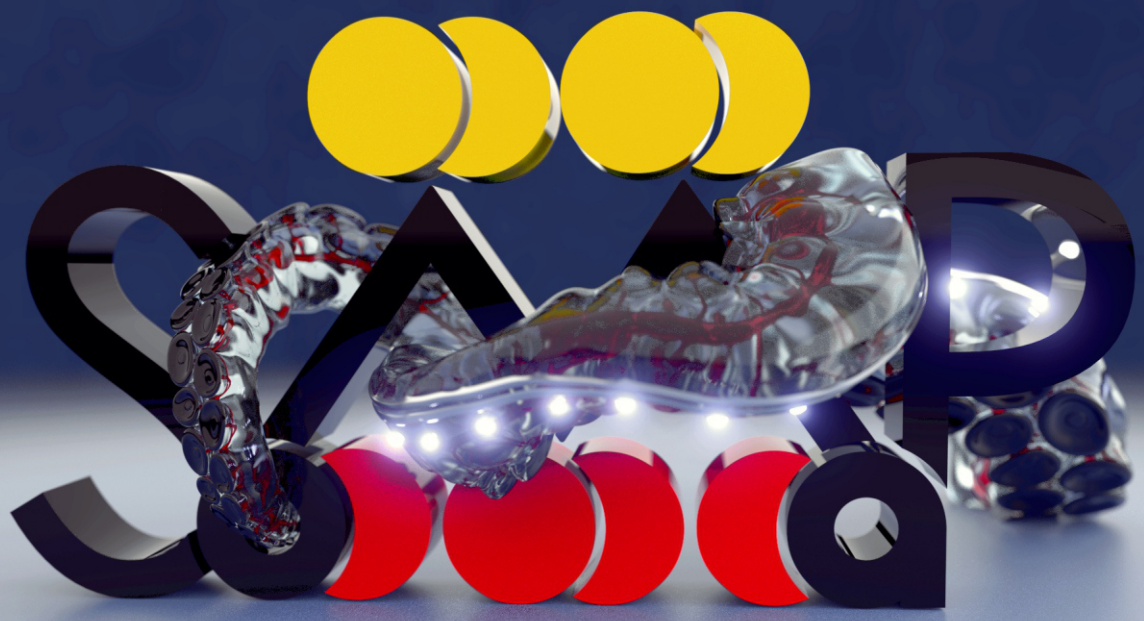
SOFT MATTER PHYSICS



BACHELOR AND MASTER THESIS PROGRAM 2021

JOHANNES KEPLER UNIVERSITY LINZ

SOFT MATTER PHYSICS

OUR DEPARTMENT

ARE YOU INTERESTED IN WORKING ON A PROJECT?

WHAT ARE WE DOING, WHO ARE WE LOOKING FOR?

At the department of Soft Matter Physics we work on interdisciplinary research projects, covering activities from diverse subfields including physics, material science, electronics, and chemical engineering. Therefore we welcome physicists, chemists, electrical engineers, and polymer engineers to conclude a Bachelor- or Master thesis at our department.

HOW TO GET IN TOUCH WITH US?

If you are interested in working on a Bachelor- or Masters project, or if you want to know more about our current research topics, write us an Email or just stop by and visit us at the department. You can either contact Prof. Martin Kaltenbrunner or one of our post-docs and PHD students for additional information.

WHAT RESEARCH PROJECTS ARE AVAILABLE?

The topic of your thesis will be oriented along our current research aims. In this thesis-program we list some project descriptions to give you an idea of how your project might look like. However, since we like to promote the creativity of our students, your thesis is not restricted to our descriptions. Therefore **there are always projects available**, which are not listed in this program. Contact us and we will find a suitable project for you.

JOHANNES KEPLER UNIVERSITY LINZ

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JOHANNES KEPLER UNIVERSITY LINZ

ULTRALIGHTWEIGHT SOLAR CELL ENCAPSULATION

BACHELOR THESIS | BEGINNING: ANYTIME

PROJECT DESCRIPTION

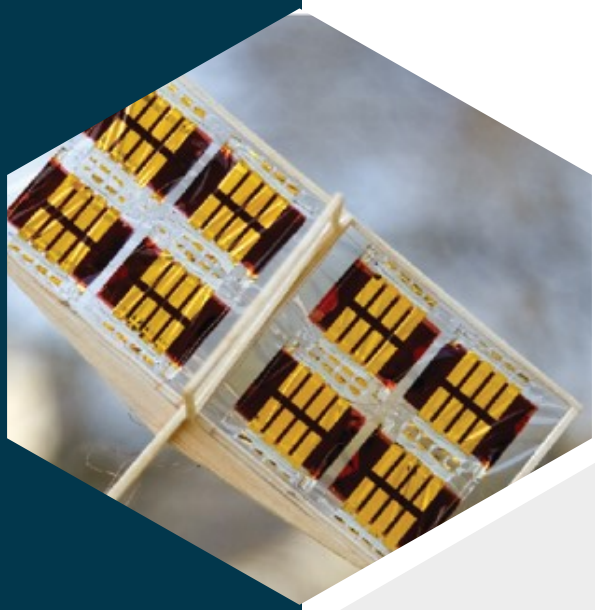
SOLAR CELLS • FLEXIBLE MATERIALS • MATERIALS RESEARCH• SUSTAINABILITY

Creating efficient, lightweight, and sustainable power sources is a challenging task that benefits multiple fields of application e.g. wearable devices, robotics, and aerospace. While state-of-the-practice solar cells are suitable for providing power in large grid form factor, they are often bulky, heavy, energy intensive and expensive to fabricate. One of the most rapidly advancing thin film solar cell technologies, metal halide perovskite, offers a possibility to fabricate next generation photovoltaics with easy and low cost fabrication methods on ultralightweight and flexible substrates (down to 1.5 µm thick). The aim of this project is to research and implement a proper encapsulation material for these devices that will extend their operational lifetime and expand their area of application.

This work offers an introduction to the world of photovoltaics, focusing on long term effects and environmental stability. Furthermore, it will allow to explore connection to a number of other applications (robotics, wearabes, etc.) which require lightweight power sources and that are currently researched at the institute.

Working on this thesis will include:

- Research and selection of commercially available materials suitable for ultraflexible solar cell encapsulation
- Fabrication, encapsulation, and stability testing of ultraflexible solar cells under various environmental stresses (increased temperature, humidity, mechanical stress, etc.)



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LIGHT EMISSION FOR ELECTRONIC SKINS

BACHELOR THESIS | BEGINNING: ANYTIME

PROJECT DESCRIPTION

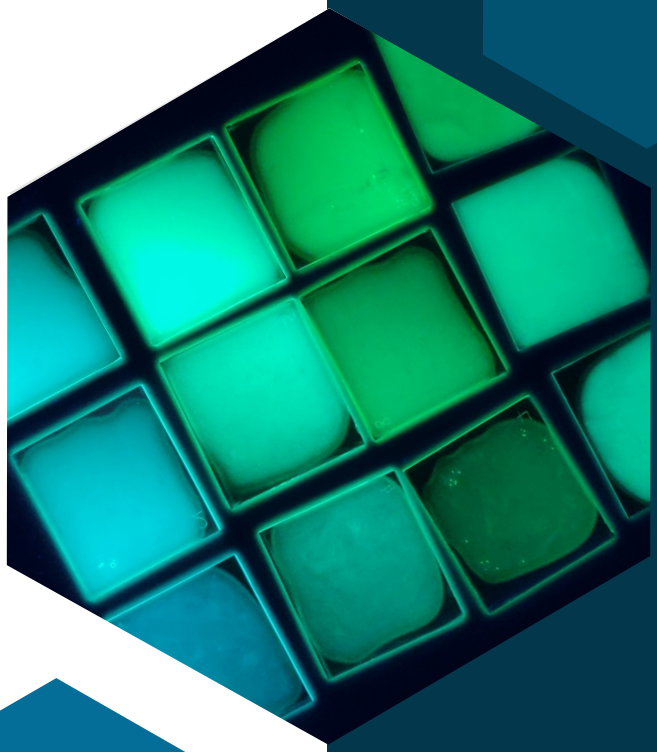
LEDS• FLEXIBLE MATERIALS • PEROVSKITES• E-SKINS

Electronic skin is a nature inspired large area network of electronic devices that allows for various sensing and information transfer, similarly to human skin. Light emitting devices directly built into electronic skin allow for enhanced human-machine interaction and further greatly benefit the progress of soft robotics, wearable electronics, prosthetics, and health monitoring. While common LEDs have been already adapted for deformable substrates, the technology utilizing Alternating Current Electroluminescence (ACEL) is the only inherently flexible and stretchable alternative with a very simple fabrication process. The aim of this project is to combine recently developed high performance light emitting compounds called metal halide perovskites with soft and deformable substrates in order to develop new and better electroluminescent skin technology .

The project offers a wonderful opportunity to learn and utilize both physics and chemistry techniques for an exciting cutting-edge science and engineering application. Bachelor students can contribute to any of the parts of the project (*e.g. material development, device preparation, various types of testing, etc.)*

Working on this thesis will include:

- Preparation and characterization of quantum dot—polymer composite materials (photoluminescence/absorption/ stress-strain testing , etc..).
- Fabrication and testing of flexible/ stretchable ACEL devices,



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DEVELOPMENT AND IMPLEMENTATION OF A TEST-BENCH SYSTEM FOR THIN FILM SOLAR CELLS

BACHELOR THESIS | BEGINNING: ANYTIME

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PROJECT DESCRIPTION

SOLAR CELLS • CHARACTERIZATION MEASUREMENTS • SOFTWARE DEVELOPMENT

In recent years, photovoltaics (PV) became one of the fastest-growing energy technologies globally. The need for highly efficient solar energy harvesting has become increasingly urgent for reasons of climate change mitigation. Besides the commercially available crystalline silicon solar cells, thin-film solar cells based on metal halide perovskites (PSCs) have attracted intensive attention because of their rapid progress on power conversion efficiency (PCE), low-cost materials, and simple solution fabrication processes. The fast development pace and great efficiency improvements require reliable prototyping and testing methods to stay competitive. A very time-consuming processing step is hereby the standardized characterization and evaluation of the individual solar cells. The aim of this thesis is to design and develop a test-bench to fully characterize and evaluate multiple solar cells at a time. The architecture of the desired test system is based on the implementation of three parts: the mechanical design, the electrical, and the control & evaluation software.

This work offers a wonderful opportunity to gain hands-on experience in both physics and chemistry experimental techniques.

Working on this thesis will include:

- Literature research on thin-film PVs and standardized solar cell characterization methods
- Design and fabrication of a solar cell test-bench including the development of the corresponding software (Python)
- Fabrication of flexible perovskite thin-film solar cells

JOHANNES KEPLER UNIVERSITY LINZ

UP-SCALING FABRICATION METHODS FOR A NEW PHOTOVOLTAIC TECHNOLOGY

BACHELOR THESIS | BEGINNING: ANYTIME

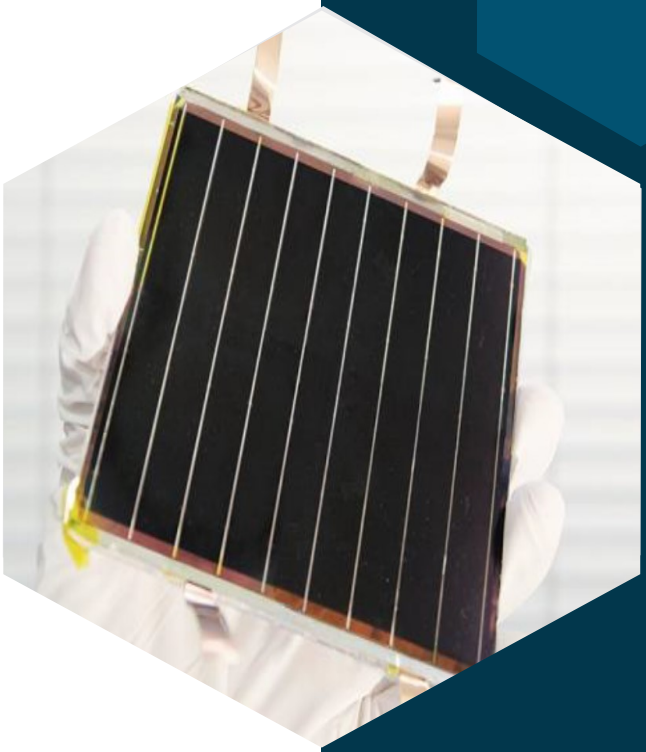
PROJECT DESCRIPTION

SOLAR CELLS • ENERGY CONVERSION• PEROVSKITES• UP-SCALING

In a world affected by climate change, renewable energy sources are paramount for sustainable future development. However, most commercial solar cells are currently based on silicon, involving a complex, energy intensive, and expensive fabrication process. To address these issues, a new photovoltaic technology - based on perovskite crystals – has emerged due to its cheap, low-energy fabrication process and high performance.

Unfortunately, most of the best performing solar cells are still produced using labscale fabrication methods like spin-coating. Such methods cannot be used to create large-area photovoltaics that would be necessary to move this technology from the laboratory to a useable product.

The aim of this thesis is to develop a scalable fabrication procedure that yields a similar performance to currently available methods by using the blade coating technique. All tasks of the project are on a basic level suitable for bachelor students.



Working on this thesis will include:

- Literature research on perovskite solar cells and their current fabrication methods.
- Fabrication of perovskite solar cells.
- Analysis of device performance and material properties, measurements of the light-harvesting efficiency, absorption, and photoluminescence.
- Design of a blade coating method.

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CARBON BLACK BASED STRETCHABLE CONDUCTORS FOR SURGICAL SIMULATORS

BACHELOR THESIS | BEGINNING: ANYTIME

PROJECT DESCRIPTION

STRETCHABLE CONDUCTORS • MATERIALS RESEARCH • SENSOR SKINS

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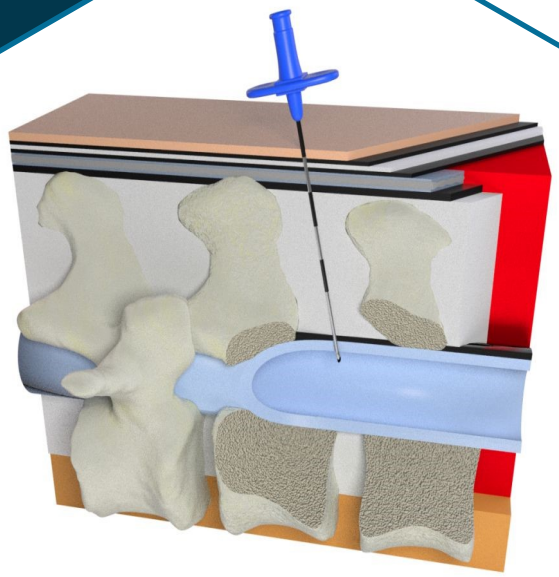
In the last decades, developments in medicine such as new surgical techniques have transformed healthcare treatment around the world. Yet, surgical techniques are mostly limited by the practical experience of the surgeon. Repetitive training is crucial to increase the success rate, especially for surgeries with a high risk of permanent damage. Training on human specimens or on patients under supervision can be minimized by the use of surgical simulators. Therefore, the development of surgical simulators that precisely mimic the body's anatomy and haptics are a promising path towards complication free medical procedures. Here, we propose an electrically conductive material, which has the same stiffness and friction as human tissue. This material can be used to locate a needle tip during an anaesthesia surgery. Via detection through several layers the trainee gets feedback on the needle position in real time and information on the success of the simulated surgery.



The sensing material mainly consists of carbon black (conductive carbon) and an elastomer. The aim of this thesis is the characterization and understanding of the electrical properties of the material and the optimization of the sensor material fabrication.

Working on this project requires interest in fabrication of conductive carbon-black elastomer sheets and rapid prototyping (3D printing) of molds. All tasks of the project are on a basic level suitable for bachelor students.

Working on this thesis will include:

- Literature research on conduction mechanism of carbon black- elastomer matrixes
- Fabrication of electrically conductive elastomer sheets
- Rapid prototyping of molds
- Characterization of electrical and mechanical properties

3D-PRINTED SOFT ROBOTICS

BACHELOR THESIS | BEGINNING: ANYTIME

PROJECT DESCRIPTION

SOFT ROBOTICS • 3D-PRINTING • MATERIALS RESEARCH • RAPID PROTOTYPING

Soft robots are promising candidates to fulfill the evermore complex tasks in various fields through their highly adaptive, soft structure. Yet, the assembly of such a robot usually involves many different steps and is limited to different molding techniques. In prototyping processes, 3D-printing technologies are already commonly used since they reduce the production steps dramatically.

We are currently developing a multi-material 3D-printer to print functional, untethered soft robots, made of gelatin and liquid metal. To increase the geometrical complexity of a print, a structure is needed to carry overhanging features.

Two Bachelor Theses are available on this project.

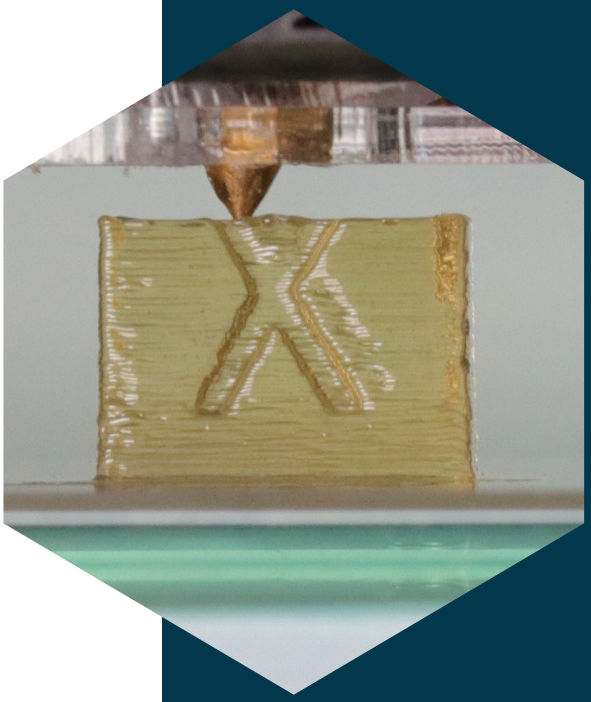
Working on thesis A will include:

- finding a suitable, extrudable material that is compatible with gelatin and easily removeable after print
- Characterization of the materials properties
- Incorporation into the existing extrusion mechanism
- Tuning the printer properties for good printing results

Working on thesis B will include:

- Synthetisizing liquid metal compounds from an existing recipes
- finding the correct printing parameters for printability
- produceing a sensor with printed liquid metal lines on a gelatin substrate

We are looking for motivated students with good basic technical skills and an interest for 3D printing.



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JOHANNES KEPLER UNIVERSITY LINZ

PERMEABLE AND CONFORMABLE SENSOR GRIDS FOR HEALTHCARE

BACHELOR THESIS | BEGINNING: ANYTIME

PROJECT DESCRIPTION

SOFT ROBOTICS • BIODEGRADABILITY • SMART HYDROGEL • RAPID PROTOTYPING

In this Bachelor's Thesis, thin film sensor points for pressure, humidity and temperature are connected by stretchable wires into a conformable sensor grid. This can then be applied to complex, 3d-printed surfaces or embedded in flexible polymer foam cushoins and mattresses.

We are looking for a candidate with good basic technical skills and a preference for practical work in the laboratory. This thesis is offered in collaboration with the spin-off company sendance GmbH."

Working on this thesis will include:

- Characterization of thin film sensors
- Fabrication of stretchable connecting wires
- Fabrication of small sensor grids
- Readout and characterization of sensor grids

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