Internship Opportunity in Cutting-Edge
3D Manufacturing

3D MATTER
MADE TO ORDER

Background:

The Cluster of Excellence 3D Matter Made to Order (3DMM2O), a joint initiative of Karlsruhe Institute of Technology (KIT) and Heidelberg University, is revolutionizing **3D Additive Manufacturing**. The main task of the Cluster is to take 3D Additive Manufacturing to the next level.

This technology is reshaping industries by enabling rapid prototyping, cost-effective customization, and innovative material production.

Join us to be part of a transformative movement in **next-generation manufacturing**. Funded by the **German Excellence Strategy, Carl Zeiss Foundation, and Helmholtz Association**.

Opportunities for the summer 2025 include work on different topics:

- ✓ Repurposing Sustainable Feedstocks as Inks for 3D Printed Materials
- ✓ Novel Push-Pull Chromophore Design Concepts for Electro-Optic Modulators
- ✓ Direct Laser Writing of Microscale Biohybrid Actuators
- ✓ Controlling Human Stem Cells Using 3D Printed Metamaterials
- ✓ Design of Optics for Solar Cells using 3D Printing

General Guidelines:

Applicants should have a background in science/engineering and a strong desire for interdisciplinary and collaborative research in Germany. All interns will be supervised by Cluster professors and young researchers. The degree of supervision will depend on the lab and the intern.

Duration: Internships will have a minimum length of eight weeks. Priority will be given to those able to stay for up to 10 weeks.

Start/end date: Exact dates will be determined based on the applicants´ and supervisors´ timelines.

Internship funding: Limited funding (travel costs and a living stipend) can be applied for from the Cluster; it is strongly recommended to apply for additional funding through MCS-Funded Independent Internships Outside the U.S.

Applications: Prospective candidates are requested to submit the following materials by **February 15, 2025 at 10 am EST**:

- ✓ CV
- ✓ Cover letter (1-page limit)
- ✓ BSc Transcripts

Please send the complete application documents to graduateschool@3dmm2o.de with the subject line: Internship program Summer 2025: [First Name] [Last Name] [Internship project]

If there are any scientific questions, you can reach out to the contact persons in the adds; for all organizational questions you can reach out to Stefanie Peer.

Internship offers:

[2025_01] Repurposing Sustainable Feedstocks as Inks for 3D Printed Materials

Requirements: background in chemistry / materials science / or related subjects

Location/Contact: Institute of Molecular Systems Engineering and Advanced Materials, Heidelberg University, Prof. Dr. Eva Blasco and team

Further information: see page 3

[2025_02] Novel Push-Pull Chromophore Design Concepts for Electro-Optic Modulators

Requirements: background in chemistry, interest in improving analytics data (nuclear magnetic resonance spectroscopy, mass spectroscopy, UV/VIS spectroscopy etc.) and other working techniques like working under inert gas

Location/Contact: Institute of Organic Chemistry (IOC), Karlsruhe Institute of Technology, Masis Sirim

Further information: see page 4

[2025_03] Direct Laser Writing of Microscale Biohybrid Actuators

Requirements: Background in biology / biomedical engineering / material sciences, basic knowledge of biomaterials and cell culture

Location/Contact: Institute of Molecular Systems Engineering and Advanced Materials, Heidelberg University, Krishna Ramesh

Further information: see page 6

[2025_04] Controlling Human Stem Cells Using 3D Printed Metamaterials

Requirements: Basic knowledge in chemistry /biology / or physics (first year BSc level). The content can be adjusted according to the training background.

Location/Contact: Physical Chemistry of Biosystems, Heidelberg University, Natalie Munding & Prof. Motomu Tanaka

[2025_05] Design of Optics for Solar Cells using 3D Printing

Requirements: Background in electromagnetics simulations of metamaterials; excellent problem-solving skills and ability to work independently; good communication skills, both written and verbal

Location/Contact: Institute for Nanotechnology, Karlsruhe Institute of Technology, Dr. Maryna Meretska

Repurposing sustainable feedstocks as inks for 3D printed materials

Time frame: June-September 2025, 6 - 9 weeks (preferably 9 weeks)

Requirements/knowledge of the applicants: chemistry / materials science / or related subjects

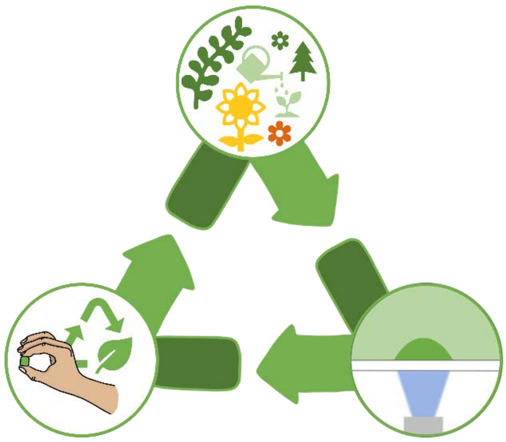
Location: Heidelberg University, Institute for Molecular Systems Engineering and Advanced Materials

Supervision: Prof. Dr. Eva Blasco and team

https://www.imseam.uni-heidelberg.de/en/research-groups/blasco-group

Short description: Advanced manufacturing technologies, particularly 3D printing, rely heavily on plastic materials. However, despite its importance, the widespread use of plastic has led to significant environmental concerns, particularly regarding waste management, pollution, carbon emissions and resource depletion. In this context, research in biobased and biodegradable polymer materials from non-petrochemical resources has become an even more urgent task. The main advantage of using biobased polymers relies on the saving on greenhouse gas emissions: It is estimated that substituting almost 70 % of current polymers with biobased ones would save up to 316 million tons of CO_2-equivalent annually.[1]

The aim of this project is to bring 3D printing to the next level by considering sustainability.[2-3] Renewable, biobased feedstocks, would be used to develop new printing materials (also called inks) that can be applied in cutting-edge 3D printing technologies using light. Ideally, the 3D printed materials will biodegrade after use. Thus, the proposed project is comprised of three components: 1) *design and synthesis of biobased inks for 3D printing*; *2) 3D printing and characterization of materials,* and *3) biodegradability studies*.



References:

1. T. Zink, R. Geyer and R. Startz, *Journal of Industrial Ecology*, 2018, **22**, 314.
2. C. Vazquez-Martel, L. Florido Martins, E. Genthner, C. Almeida, A. Martel Quintana, M. Bastmeyer, J. L. Gómez Pinchetti, E. Blasco, *Adv. Mater.* 2024, 36, 2402786.
3. P. Klee, C. Vazquez-Martel, L. Florido-Martins, E. Blasco. *ACS Appl. Polym. Mater.* 2024, 6, 1, 935–942

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Time frame: May to July 2025

General topics: organic electronics, silicon photonics, next-gen computing, molecular engineering

Novel Push-Pull Chromophore Design Concepts for Electro-Optic Modulators

This year it is expected that 175 zettabytes of data will be created, captured, or replicated worldwide – that is an increase of 430% compared to 33 zettabytes in 2018.[1] This surge is particularly driven by cloud computing, the Internet of Things, 5G, telecommunications, and artificial intelligence, leading to the rapid expansion of data centers and their demands.[2-3] It is also predicted that by 2025, data centers will account for 20% of global electricity consumption.[4] Notably, the cooling system of data centers contributes approximately 40% to their operating temperature maintenance.[5] To achieve more sustainable data centers with excellent performance, it is essential to develop highly efficient, thermally stable and durable electro-optical (EO) modulators as key components in optical transceivers. Organic nonlinear optical materials combined with silicon photonics in so-called Silicon-Organic-Hybrid (SOH) modulators hold the greatest potential due to their high EO coefficients (r_{33}), good processability, and low cost.[6]

The EO activity of organic materials is derived from second-order nonlinear optics. The associated EO effect, the POCKELS effect, causes a linear change in the refractive index of the material under an applied DC field. Due to the resulting phase shift of the penetrating light beam, its phase can be modulated. By variation of constructive and destructive interference, information can be transformed from the electronic domain to the photonic ("on" and "off" as a binary code).

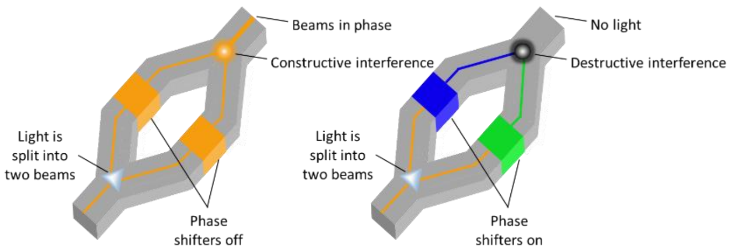

Figure 1: Illustration of an EO modulator with phase shifters on (left) and off (right).

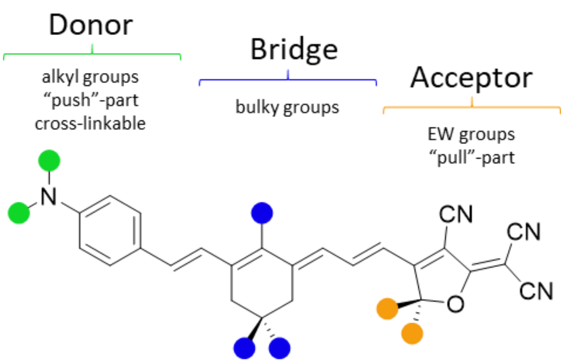

Figure 2: General structure of a push-pull chromophore for EO application.

In general, organic EO materials consist of donor and acceptor groups linked by a conjugated spacer. The most important properties of the chromophores are their hyperpolarizability and a non-centrosymmetric orientation. Further important properties are thermal, photochemical and long term EO allignment stability.[7] In order to improve the performance in the modulator the chromophores can be immobilized by embedding or introducing the chromophores to a polymer via photocrosslinking.

Various concepts of crosslinking in a non-centrosymmetric and aligned manner are possible and under investigation.

The aim of this project will be to synthesize new crosslinkable chromophores and characterize them regarding their photochemical properties as well as their efficiency in modulators. The chromophores will be tested on a silicon chip to show close to application utilization and performance. Besides organic synthesis, you will improve your improve your evaluation of analytical data (nuclear magnetic resonance spectroscopy, mass spectroscopy, UV/VIS spectroscopy etc.) and also other working techniques like working under inert gas.

[1] D. Reinsel, J. Gantz, J. Rydning, International Data Corporation (IDC), The Digitization of the World From Edge to Core, **2018**. [2] S. Feng, S. Wu, W. Zhang, F. Liu, J. Wang, Molecules **2024**, 29. [3] F. Ullah, N. Deng, F. Qiu, PhotoniX **2021**, 2. [4] N. Jones, Nature **2018**, 561, 163 - 166. [5] J. Ni, X. Bai, Renewable and Sustainable Energy Reviews **2017**, 67, 625-640. [6] P. Wang, H. Zhang, X. You, C. Zhao, S. Bo, J. Zhang, Y. Ao, M. Li, Dyes and Pigments **2024**, 224. [7] W. Freude, A. Kotz, H. Kholeif, A. Schwarzenberger, A. Kuzmin, C. Eschenbaum, A. Mertens, S. Sarwar, P. Erk, S. Bräse, C. Koos, IEEE Journal of Selected Topics in Quantum Electronics **2024**, 30, 1-22.

Summer Internship, AG Selhuber-Unkel

Project: Direct Laser Writing of Microscale Biohybrid Actuators

Contact: Krishna Ramesh, krishna.ramesh@mtl.maxplanckschools.de

This internship will focus on engineering structural properties of novel materials for controlling muscle cell differentiation. The internship will be hosted in the Selhuber-Unkel group at the Institute for Molecular Systems Engineering and Advanced Materials (IMSEAM) at Heidelberg University.

Duration: 3 months, June – September 2025

This project combines direct-laser writing by two-photon polymerization (DLW-2PP) with bioprinting to precisely engineer multi-material microtube structures containing skeletal muscle cells, to create biohybrid microactuator models. We aim to achieve structural geometry-driven differentiation and alignment of myotubes in 3D by encapsulating muscle cells within a gelatin-based hydrogel ink and 3D-printing cell-laden microtubes. Accordingly, the impact of 2PP-DLW on cell orientation and differentiation inside the printed microtubes will be studied. Following this, the biohybrid actuators can be stimulated to induce actuation. Such bio-actuator systems would be extremely useful for soft robotic applications which require natural muscle-like movements for complex tasks like movement or gripping.

The student will work on culturing skeletal muscle cells and assist in 3D-bioprinting. Following this, the student will employ confocal microscopy to follow the growth and differentiation of myotubes in the printed structures, and quantify cell alignment and muscle beating behavior.

Requirements: Background in biology/biomedical engineering/material sciences, basic knowledge of biomaterials and cell culture