Fraunhofer
ISC

Annual Report 2022/23

BIO

ANNUAL REPORT

Welcome

Dear friends and partners of ISC,

This year, our annual report comes after a very exciting event. On 8 May 2023, we celebrated the opening of the Fraunhofer Biotechnology site in Würzburg. Thanks to co-financing from the European Union, the Federal Republic of Germany, and the Free State of Bavaria, we were able to completely renovate the listed building of the former University Eye Hospital, which had been vacant for decades and which dates back to 1901. The result is a building entirely dedicated to research with state-of-the-art bio labs and office space for staff from the Fraunhofer Translational Center for Regenerative Therapies of the ISC as well as the Project Center for Stem Cell Process Engineering, which is jointly operated by Fraunhofer IBMT and ISC. To celebrate this success, we have decided to make bio-related research a focus of this year's report.

An ongoing concern for Fraunhofer ISC is researching and developing more sustainable products and processes. Sustainability plays an important role in all ISC research areas. From resource conservation and multifunctional materials, through to the use of renewable raw materials, the switch to aqueous processes and non-critical starting materials, decarbonization, resource and energy efficient processes, and the smart recovery and reuse of functional materials, Fraunhofer ISC is contributing significantly to making future production more sustainable. Internally, our new sustainability management has provided additional impetus to continue pursuing sustainability in all aspects of our work.

The last few years have made the vulnerability of our economy and not least our society extremely clear. When confronted with these challenges, it is imperative that we join forces to work towards greater resilience. We can do this by consistently using our own sustainable resources and cooperating closely at the European level to better mitigate energy and supply bottlenecks or to prevent them altogether. As an institute, we were also affected last year by the rise in energy prices and the subsequent uncertainty in terms of planning experienced by our industrial customers – something which was also reflected in our budget. I would like to take this opportunity to express my sincere thanks to all employees who, despite these constraints, continued to demonstrate tremendous commitment in their work to ensure that projects emerged successful; that sustainable research was implemented; and that we continued to develop new ideas and innovations to secure a future worth living.

Key to creating this future is the speed at which we are able to generate and advance innovations. Fraunhofer ISC plays a crucial role in accelerating material innovations and developing them for economical and environmentally friendly production. Evidence of this is our research into the digitization of material development and manufacturing processes and into the use of artificial intelligence for finding and validating new material compositions for glass development, functional coatings, particle technology, biomaterials, batteries, and high-temp materials. For research like this, our digitization group – which was established a few years ago at the Center Smart Materials and Adaptive Systems – is on hand to provide all departments with the support they need to implement their projects.

As ever, I would like to express my heartfelt gratitude to all friends, sponsors, and partners of Fraunhofer ISC. The trust you place in us and the demands you place on us are constant incentives for us to continue using our research to find the best possible solutions to global issues.

Yours sincerely,

Gerhard Sextl

Contents

Find out more online at
www.isc.fraunhofer.de/annual-report

A clean and sustainable future starts with materials

The Fraunhofer-Gesellschaft has set itself the goal of researching and working towards climate neutrality by 2030. With this goal, the FhG hopes to support and make its contribution to the German Federal Government's aim to achieve climate neutrality, the European Green Deal, and the Paris Agreement. The agenda for 2030 lays the foundation for future measures and for global economic progress which fosters social justice and respects the earth's ecological limits. At the heart of this agenda lie the 17 Sustainable Development Goals (SDGs).

Our motivations

Fraunhofer ISC fully supports the German Federal Government's climate goals through its research and is committed to making a significant contribution to enabling the transformation to a sustainable and climate-neutral future.

The Fraunhofer-Gesellschaft has set itself the target of cutting 55 percent of its emissions by 2030 and is working hard to achieve this goal through the Fraunhofer Climate Neutral 2030 initiative.

At Fraunhofer ISC, we measure our work against these challenges and actively participate in finding solutions to them. As Europe's leading center for materials-based research and development, we understand that we have a responsibility to create a better, cleaner, and fairer world.

Fraunhofer ISC is committed to sustainability through its interdisciplinary research, including at the Fraunhofer Translational Center for Regenerative Therapies TLC-RT and the Fraunhofer R&D Center for Electromobility Bavaria FCEB.

Our mission: We have made it our mission to develop notable materials and process-based solutions for tackling the major global challenges posed by climate change, environmental pollution, the excessive consumption of resources, the energy transition, an aging population, and growing urbanization.

Our commitments

At the Fraunhofer Institute for Silicate Research ISC, we strive for the greatest possible transparency, both internally and externally, and aim to report comprehensively and honestly on our contribution to sustainability. We are currently developing a sustainability strategy and reviewing our processes and structures. With a team of 400 employees, we are working to facilitate and advance the ecological, economic, and social aspects of sustainability within our research projects and administrative activities.

With the support of our stakeholders, we will prepare a materiality analysis and will present the results in our upcoming sustainability report. The purpose of this report is to look critically at the status quo, to carry out self-reflection, and to develop improvement measures. Our engagement is focused on the impact of climate change on our institute and on the influence of our research portfolio.

Through an energy management system, we want to achieve targeted improvements and be more efficient and economical in our use of energy. This will involve setting targets for reducing our energy consumption. Many measures, such as moving to LED in office buildings, optimizing building services supply systems, adjusting IT patch management, and energy-saving tips are already being gradually implemented. By switching to green electricity, we are also doing our part for the energy transition.

In addition, we are measuring our greenhouse gas emissions according to the Greenhouse Gas (GHG) Protocol. Work is already underway with this, and we have collected activity data for the 2021 reference year. The next step involves identifying gaps in this data and any potential challenges. The goal is to improve data for recording purposes so as to be able to continue monitoring our emissions in a consistent manner.

We believe it important to encourage a change in thinking to protect not only nature but also people, and we want to bring employees, customers, and research partners with us on this journey.

The ISC strives to support employees both in terms of their daily work and in terms of using sustainable mobility. Since 2019, the Fraunhofer-Gesellschaft has been expanding charging infrastructure at its sites throughout Germany. We have around 480 charging points and a portion of these are also available to external users. Moreover, since October 2021, the charging infrastructure set up under the LamA – Charging at Work project has also been available at the ISC for use by employees, visitors, and the general public.

Incentives to switch to more climate-friendly modes of transport will also soon be derived based on a survey investigating employee commuting behavior.

Fraunhofer ISC aims to inspire and encourage its employees to commit to sustainability both at work and in their private lives. We work together to identify potential opportunities for promoting sustainability and supporting the United Nations' 2030 Agenda and 17 Sustainable Development Goals (SDGs). Our research projects in the fields of energy, the environment, and health are crucial ways in which we contribute to achieving these goals.

The preamble to the 2030 Agenda identifies 5 core messages that act as guiding principles for the 17 SDGs. These are known as the 5Ps and stand for: people, planet, prosperity, peace, and partnership.

Our research demonstrates our particular commitment to the second core message of »protecting the planet« – limiting climate change and preserving natural life-support systems. To help us fulfil this commitment, we focus on a large number of important and forward-looking technologies, that we successfully implement in a variety of applications. In doing so, we seek to find resource-saving and waste-minimizing solutions for almost all technical applications.

Our principles and values

Since 2016, sustainability has been firmly anchored in the Fraunhofer-Gesellschaft's mission statement and is a strong motive for everything we do. "Through our research we contribute to the sustainable development of an ecologically sound environment, and an economically successful and balanced world. We are strongly committed to this responsibility." In 2017, the Fraunhofer-Gesellschaft also joined the United Nations Global Compact (UNGC), thereby voluntarily committing itself to upholding and promoting 10 universal principles in the areas of human rights, labor standards, environmental protection, and anti-corruption.

In 2009, the Fraunhofer Sustainability Network was founded – dedicated to identifying, unlocking, and advancing the potential for sustainability within the Fraunhofer-Gesellschaft. Fraunhofer ISC was one of the first members, with 21 institutes now belonging to the network.

Fraunhofer ISC realizes that every action has an impact on the environment and is dedicated to using its knowledge and actions to help promote sustainable development. This is a form of development that meets the needs of present generations whilst ensuring future generations have the possibility of meeting their needs too. This goal is central to our research.

Diversity and equal opportunities

The Fraunhofer-Gesellschaft supports equal opportunity measures and actively pursues diversity management. "This includes equal participation and development – regardless of ethnicity, gender, religion, ideology, disability, age, or sexual identity."

Equal Opportunity Officers have been appointed at each institute to support employes. At the ISC, this has been the case for well over 10 years. Equal Opportunity Officers from across the different institutes are well connected and work together to provide this support.

The ISC has put in place various options to ensure family and career can go hand-in-hand. Employees benefit, for example, from flexible hours and workplace set-ups, workshops on the topic of work-life balance, and consulting and support services provided by the (Fraunhofer-wide) pme family service.

Ensuring equal professional opportunities – regardless of gender – is a clear objective for the Fraunhofer-Gesellschaft and will secure innovation, team intelligence, and scientific excellence in the long term. To help achieve this objective, the TALENTA career program makes an important contribution to increasing the proportion of women in management positions.

Percentage of women

The Fraunhofer-Gesellschaft wants to increase the proportion of female employees across all areas of the organization. At Fraunhofer ISC, we are pursuing this goal very ambitiously. Here, we are well ahead of the target of 31.1 percent, with female employees making up 33.6 percent (Q4, 2022) of the workforce.

In 2022, the proportion of female managers was 12.1 percent. For this reason, in summer 2023, Fraunhofer ISC will be launching a project as part of the Fraunhofer Diversity Program. The aim of this project is to promote female scientists and increase the proportion of women in specialist and managerial positions.

Sustainability and applied research

It is also our own scientific and economic interests that encourage us to pursue sustainability. In this sense, our goal is to be able to use resources and materials reasonably and for as long as possible so as to support sustainable development. The institute is working to develop innovative functional materials and technologies for more sustainable products that use fewer resources, and to bring about significant contributions to solving major global issues and future challenges. One example of this is developing new, more reliable ways of testing pharmacological and cosmetic active ingredients which can help accelerate the development of therapies and care products in the future.

In particular, and due to global developments, recycling valuable raw materials contained in products and materials and the search for sustainable alternatives are becoming increasingly important. Changing demands relating to primary resources, availability issues, and the replacement of critical or environmentally hazardous substances have resulted in new guidelines that affect, for example, the energy and mobility transition. Fraunhofer ISC sees great potential here in terms of using sustainable material and process development to further resource and energy optimization.

The institute's greatest impact in terms of sustainability is achieved through its research.

We are committed to consistently applying our expertise in the field of innovative materials management to challenges involving resource conservation and sustainability. At Fraunhofer ISC, we have an extensive skills and research portfolio that supports the transition from fossil-resource-based value creation to a sustainable materials cycle.

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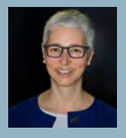

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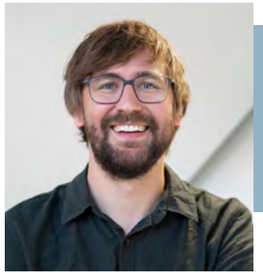

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PROJECTS

»AutoProNano« – international cooperation for in vitro and in vivo diagnostics

The French/German AutoProNano collaborative project is working on developing an automated process for the production of nanoparticles for advanced diagnostics. Through the collaborative efforts of French and German partners, the project aims to drive forward innovative technology for in vitro and in vivo diagnostics.

Biofunctionalized nanodiagnostics and therapeutics are predicted to play a truly revolutionary role in the future fight against major diseases such as cancer. In biomedicine too, demand is growing for functional nanoparticles with special optical or magnetic properties, as well as with bio-functional surfaces for antigen detection and drug loading.

However, these nanoparticles must meet strict requirements in order to be approved as medical products. A key challenge is to ensure that the desired properties of the nanoparticles can be reliably reproduced. This requires a robust and precise production process that meets international standards and is scalable, cost-effective, and constantly controllable so as to guarantee outstanding quality.

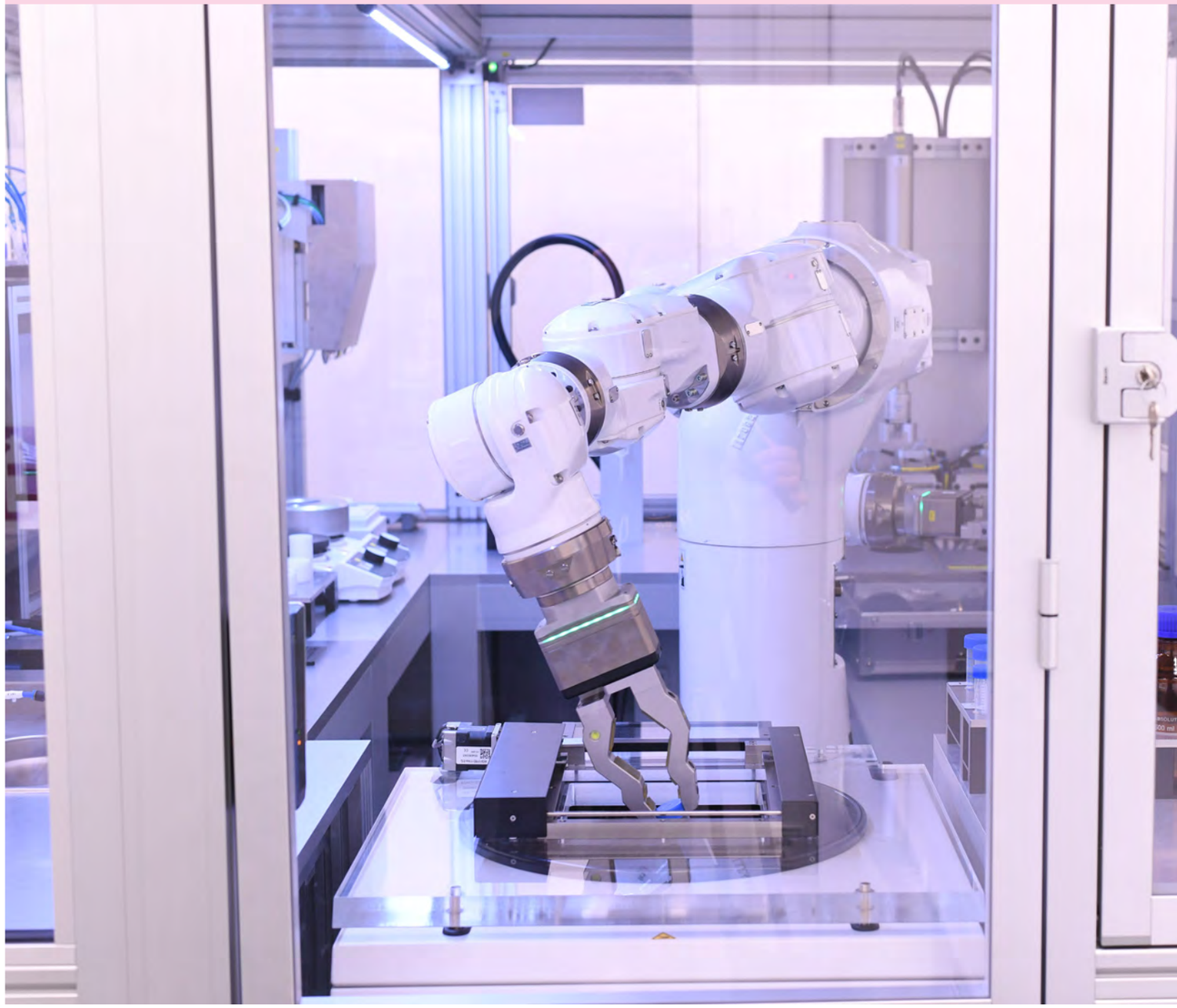
As part of the French/German AutoProNano collaborative project, the Balingen-based plant manufacturer, Goldfuß engineering GmbH, is working with other German partners including nanoPET Pharma GmbH, the Fraunhofer Institute for Silicate Research ISC, and the Institute of Medical Engineering at the Technical University of Applied Sciences Würzburg-Schweinfurt (THWS) in addition to the French companies Cordouan Technologies and Poly-Dtech to develop an adaptable automation process for the production and analysis of diagnostically relevant nanoparticle systems.

The aim of the project is to establish a flexible, robotic process for the automated production and characterization of diagnostic nanoparticles for in vitro and in vivo diagnostics.

Fraunhofer ISC and Goldfuß engineering have already developed the basic principle of a robotic platform for the automated production of nanoparticles as part of the joint APRONA project funded by the German Federal Ministry of Education and Research (BMBF). Within the framework of AutoProNano, this platform is now being further developed in order to carry out essential synthesis processes automatically. This will ensure standardized product properties and allow relevant quality requirements to be taken into account as early on as the development phase.

Total funding for the French/German collaborative AutoProNano project is 1.5 million euros. German partners receive their funding under the German Federal Ministry for Economic Affairs and Climate Action's (BMWK) Central Innovation Program for SMEs (ZIM), while French partners are supported by Bpifrance. The result is international collaboration that is making a significant step towards both state-of-the-art diagnostics and securing medical progress.

The AutoProNano project was launched as part of the smart analytics cooperation network. This international initiative has been receiving funding from the Central Innovation Program for SMEs (ZIM) of the German Federal Ministry for Economic Affairs and Climate Action (BMWK) since May 2020. This funding aims to help advance developments in the region and beyond. The coordinator for the German side is BioRegio STERN Management GmbH.



Goal 3 and 9

This project is contributing to the crucial area of improving healthcare. In the future fight against major diseases such as cancer, biofunctionalized nanodiagnostics are predicted to play a revolutionary role. The project also falls within efforts to achieve Goal 9 since innovations – such as the automated production of nanoparticles – are essential to modern industry and infrastructure.

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»CoSiMa®« – an innovative anti-aging face mask for stimulating connective tissue formation

The CoSiMa project demonstrates just what collaboration between the Fraunhofer Institute for Silicate Research ISC and the cosmetics industry can lead to. Alongside their project partner, B-COS GmbH, a team of researchers from the Biomaterials Department have developed an anti-aging face mask that releases orthosilicic acid. This project has not only led to an extensive amount of new know-how in the field of sol-gel processes, but plans are also underway to bring the mask to market.

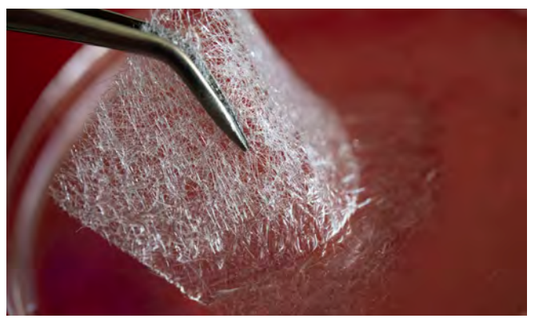
Orthosilicic acid (OKS) stimulates collagen production in the dermis. In contrast to standard cosmetic products, which plump up unwanted wrinkles in the skin with only a short-term effect, OKS is able to fill out wrinkles with longer-lasting impact. This also stimulates the body's own connective tissue formation, which generally reduces wrinkle formation. The research team from the Fraunhofer Institute for Silicate Research ISC in collaboration with their project partner decided to make use of precisely this effect. The aim of the CoSiMa project is to develop a face mask which, when it comes into contact with an activation solution, dissolves, within a short application period, into orthosilicic acid without leaving behind any residue. This is then absorbed into the skin, achieving an anti-ageing effect.

In vitro testing proves OKS can be absorbed into the skin

After two and a half years of working on CoSiMa, the team was able to successfully complete the project in November 2022 and develop a promising demo version of the face mask. The demo mask consists of two components: a silica gel fiber fleece and an activation solution. The mask can be massaged into the skin within a time frame of three to five minutes and leaves virtually no residue. The team were able to prove that the orthosilicic acid is indeed absorbed into the upper layer of the skin. Whether the desired skin generation also occurs is still being dermatologically tested.

Silica gel fiber fleece as a basis

For the basis of the mask, the researchers resorted to a silica gel fiber fleece, which has been approved as a medical device for the regeneration of chronic wounds since 2010. However, with a face mask, the hydrolysis of the water-soluble OKS needs to happen at a somewhat faster rate than is necessary in the treatment of chronic wounds. Therefore, to vary the silica-gel fleece matrix, the synthesis and process parameters were modified, and the effects produced by adding different substances tested.



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One challenge here was to enable dissolution at exactly the right time. The researchers succeeded in finding a combination of storage stability and activation trigger that dissolves the silica gel mask within the desired time to such an extent that the mask can be massaged gently into the skin. The research team discovered that the addition of lipophilic components – in the case of the demo mask, this component was sunflower oil – causes the silica gel materials to dissolve more quickly, allowing the mask to be more easily massaged into the skin. Overall, the project contributed to a significant expansion of know-how in the field of sol-gel-based materials.

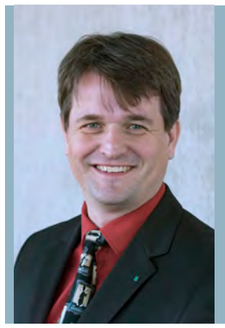
Plans to bring the mask to market

This project was the first time that the Biomaterials Department at Fraunhofer ISC had been involved in the development of materials for cosmetic products and this initial partnership with the cosmetics industry will pave the way for new collaborations between Fraunhofer ISC and the cosmetics sector in the future. Fraunhofer ISC and B-COS believe the chances of turning the mask into a marketable product are good. For this to happen, the mask still needs to be tested at a recognized test institute for skin care products. Further discussions and plans to bring the product to market are currently underway.

Goal 12

Among other things, Goal 12 focusses on promoting resource and energy efficiency, reducing waste, and encouraging reuse and recycling. With this project, we are working in partnership to develop a bioproduct that degrades completely when used.

12 RESPONSIBLE CONSUMPTION AND PRODUCTION



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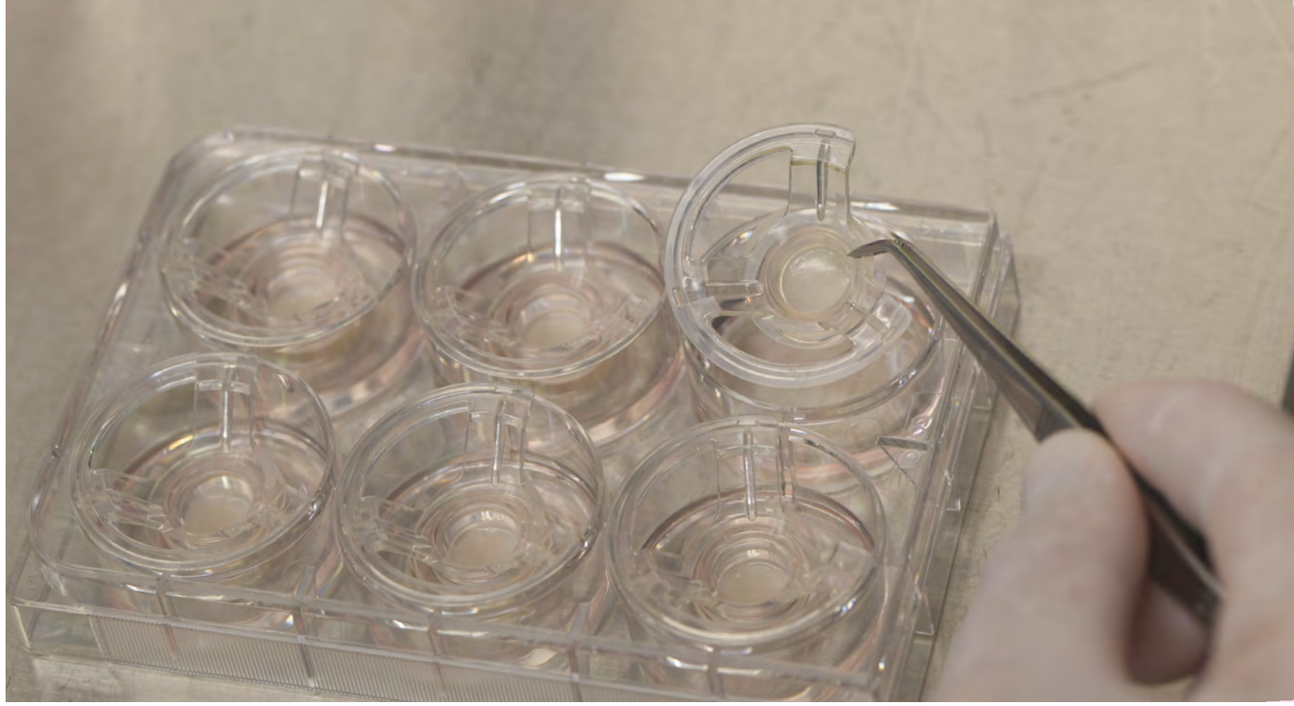
»SAPs4Tissues« – human tissue models with customized biomaterials

Human tissue models instead of animal experiments? What is an already possible solution within some areas still faces major hurdles when used within more complex contexts and applications. A joint project carried out by the Max Planck Institute for Polymer Research, Mainz, and the Translational Center for Regenerative Therapies at the Fraunhofer Institute for Silicate Research ISC, Würzburg, is developing scientific bases and biomaterials for the standardized production of valid tissue models.

Modern medicine is becoming increasingly reliant on three-dimensional human tissue models during preclinical drug development. This is not only because, on an ethical level, these models are less problematic than animal testing, but also because, on a scientific level, they often constitute a more meaningful alternative. However, in order to be used for testing the risk and efficacy of drugs, these model systems must be as close as possible to human tissue in terms of morphology and functionality.

This is precisely where the SAPs4Tissue project comes in. With the help of ordered molecular protein building blocks – so-called peptide nanofibrils (SAPs) – and in combination with biological polymers, the physiological environmental conditions of the cell can be simulated. Human cells see, so to speak, their »natural environment« – known as the extracellular matrix – which is a soft biopolymer matrix surrounding them. In addition, the molecular building blocks are provided with chemical groups that enable the material properties to be specifically influenced with the aid of external signals, such as light or pH value. Researchers are hoping to use the resulting scaffold structure to transform human cells into specialized cells and to grow these as functional tissues such as the intestine.

This is made possible by methods known as tissue engineering – an interdisciplinary field of work that takes the principles from engineering and life science and applies them to targeted tissue cultivation. The project will also systematically investigate the relationships between molecular signature, three-dimensional structure, and tissue-specific function.

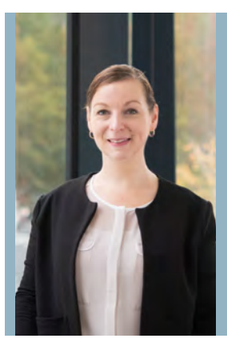


The project leaders, Dr. Christopher Synatschke, Dr. Tanja Weil (MPI Polymer Research), Dr. Marco Metzger, and Dr. Daniela Zdzieblo (Fraunhofer ISC) are confident that by bringing together the core competencies of biomaterials, stem cell biology, and tissue engineering, they will be able to produce a completely new class of scaffold structures that will enable the standardized construction of different human tissues. The success of this work would not only further boost core research into tissue and disease engineering but would also have a significant socio-economic impact by providing an alternative to animal testing, as well as more effective preclinical testing methods. This would have a direct impact on healthcare system costs.

The SAPs4Tissue project is funded by the Fraunhofer-Gesellschaft and the Max Planck Society.

Goal 3

SDG 3 aims primarily at improving health and ensuring healthy lives for all. SAPs4Tissues, if successful, would have a significant socio-economic impact by providing an alternative to animal testing, as well as developing more effective preclinical testing methods. This would ultimately have a direct impact on healthcare system costs.



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»TraumaCare« – first aid for severely bleeding wounds

Providing care for severely injured people is a significant challenge in civilian settings. Carrying out the same care during military operations means having to face the additional challenges of enemy fire, long travel times and distances, and inadequate supply. Yet, first aid has a decisive impact on the injured person's chance of survival. Within the scope of the TraumaCare research project, Fraunhofer ISC is working alongside the German Armed Forces Hospital in Ulm to develop a solution that will enable first responders to treat severely bleeding wounds whilst they wait for professional medical care to become available.

Administering quick and effective first aid in areas of military conflict, in crisis situations such as terrorist attacks, and following accidents and disasters often constitutes a major challenge. Severely bleeding wounds, in particular, represent an acute threat to the survival of those affected. Uncontrollable bleeding often means that victims die at the place of injury before they are able to be treated in hospital. The TraumaCare project was launched with the aim of finding solutions to help better manage these life-threatening situations. The project is dedicated to the development of an easily applicable wound paste that first responders can use to stop bleeding and close the wound until professional surgical care can be administered in a medical center.

Current methods used by first responders to treat severely bleeding wounds include mechanical ligatures, hemostatic dressings (dressings that stop the flow of blood), and tissue adhesives. However, these treatments have their limitations in terms of applicability and the potential risk of additional tissue damage. TraumaCare is therefore working on finding an approach that will overcome these disadvantages.

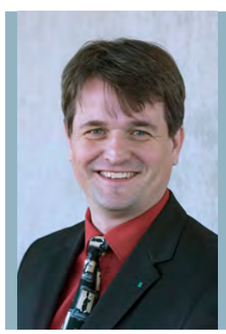
The TraumaCare concept is based on three individual components. Firstly, fibers are used to mechanically strengthen the material. Secondly, a swellable component is employed that is able to fill the entire shape of the wound and generate counterpressure and, finally, a bonding component ensures that the overall material hardens into a stable closure.

In a proof-of-principle experiment, the developed material was tested on a cannulated pig hind leg. For this, the arterial system of the leg was flushed with a phosphate-buffered saline solution. Once the research team had used a stabbing tool to cause an injury, they applied the three-component material. After briefly and gently pressing the paste onto the wound, it quickly hardened, successfully closing the wound. The material could then be easily removed without affecting the intact arterial system.

Based on these promising results, the TraumaCare team plans to continue the project in the form of TraumaCare II, beginning in 2024 and running for two years. This next step will focus on developing an applicator to enable easy handling and transport of the material. In addition, standard operating procedures (SOPs) for material production will be drafted and suitable sterilization, packaging, and storage methods identified. The goal is to obtain approval as a medical product so that the first-aid wound paste can be applied in medical practice.

Goal 9 and 17

Focused on finding materials that support emergency medical care, the project is pursuing further goals for sustainable use. To achieve this, knowledge and expertise are pooled with the aim of finding innovative solutions to challenges in this field.



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»SUSI« – on the way to autonomous hiPSC culture

Research on human induced pluripotent stem cells (hiPSCs) holds great potential for the development of cell therapies, drugs, and disease research. Although hiPSCs are cultivated in a laboratory using adult cells, they demonstrate a high level of similarity to embryonic stem cells. However, producing large quantities of hiPSCs remains a challenge. To help overcome this, researchers at the Fraunhofer Institute for Silicate Research ISC have developed a bioreactor that enables automated long-term cultivation of hiPSCs.

Research on hiPSCs is one of the fastest growing areas in biology. Reprogramming connective tissue cells – which can be obtained relatively easily from adults – entails far fewer ethical issues than the use of embryonic stem cells. At the same time, the use of hiPSCs could also increase availability and comparability. Nevertheless, so far, it has been difficult to provide these reprogrammed cells in sufficient quantity and quality.

Bioreactor enables long-term cultivation

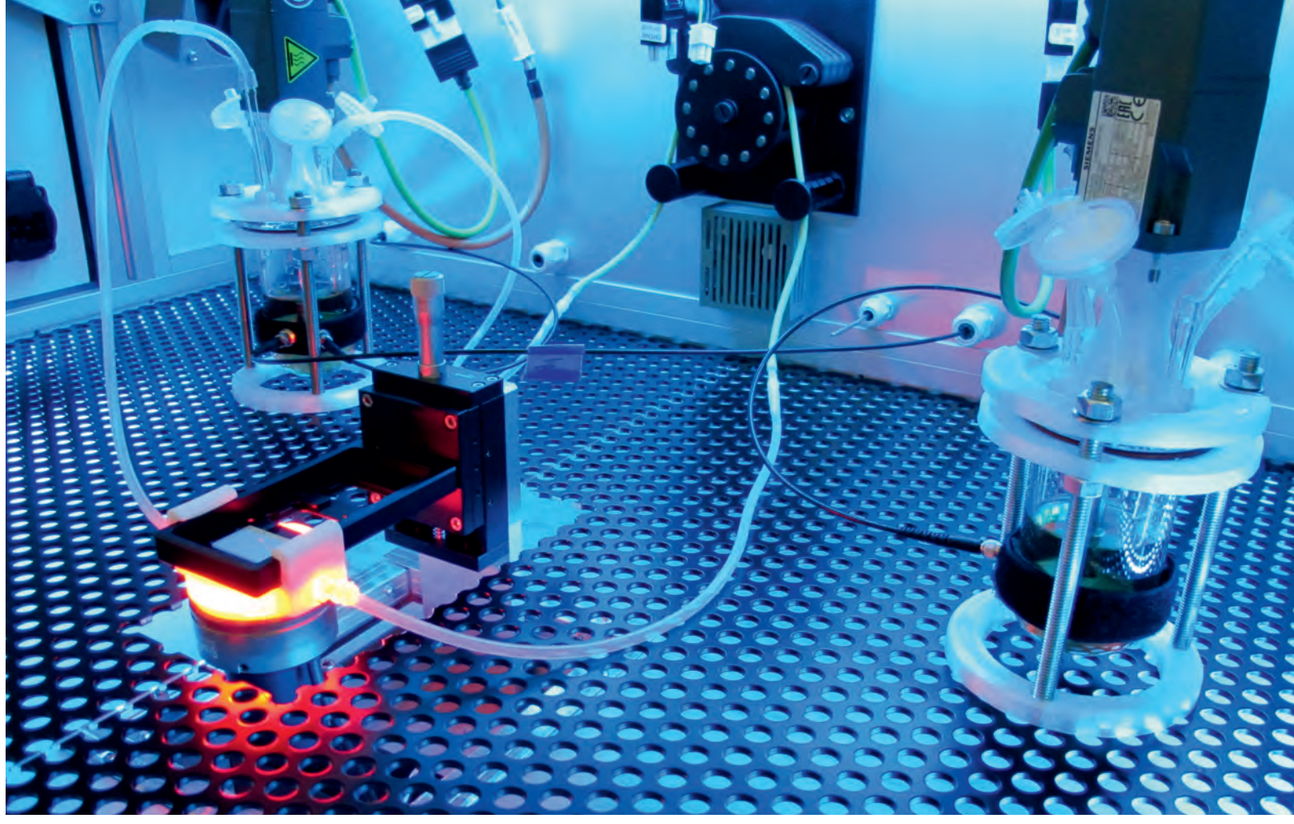
Novel solutions for the cultivation of hiPSCs are needed both to meet the growing demand and to enable standardized production in larger numbers. To respond to this demand, a team of researchers at the Fraunhofer Institute for Silicate Research ISC has developed a dynamic incubator and suspension bioreactor suitable for the long-term cultivation of hiPSCs. A fluid circuit, enabled by an interconnection of four valves, transports all liquid solutions required for the processes into a sterile environment. This allows for the fully automated propagation of hiPSCs and also minimizes the impact of human interactions.

Development of new cell therapies and drugs

The data obtained from the project has enabled the system to be adapted so that various differentiations from these cultures are also possible. As such, SUSI is contributing to the advancement of hiPSC technology. This technology will provide access to many human in vitro models for developing new cell therapies and drugs.

Goal 3 and 9

In medicine, innovative research methods play an important role in the development of drugs and also in new approaches to cell therapy. This is exactly what the SUSI project is doing – developing a solution to enable the production of the required amount of high-quality cells.



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TIGERSHARK
SCIENCE

»TigerShark Science« – skin organoids derived from human stem cells as an alternative to animal testing

Animal testing has long been an integral part of medical and pharmaceutical research, but there are increasing concerns about this method, and not just ethical ones. The start-up project TigerShark Science has set itself the task of advancing alternatives to animal testing for use in the pharmaceutical and cosmetics industries. To this end, the project has successfully developed a skin organoid from human stem cells that could replace animal testing in the future.

Organoids are small cell aggregates cultivated in a laboratory that are used to realistically replicate organs. They make it possible to study the physiological processes of human organs under controlled conditions and thus have the potential to make an important contribution to medical and pharmaceutical research. The research team at TigerShark Science has now succeeded in developing a skin model that is able to generate almost all structures of human skin and consequently represents a realistic skin model – a significant advancement in this field.

Cultivating fully functional artificial skin with nerves, vessels, and hair

TigerShark Science's skin model is developed from programmed hiPS cells and forms complex structures such as hairs and nerves.

Based on a tissue engineering approach, miniature three-dimensional versions of human skin are produced in vitro. This not only makes the model suitable for a wide range of applications, it also brings with it a further benefit. Instead of using animal collagen, the matrix is produced by the human cells themselves. The skin model will primarily be used for research into diseases, and it will also be possible to produce skin disease models in vitro that imitate, for example, skin cancer or skin fibrosis, in order to study disease progression, the impact of drugs, and organ development.

An alternative to animal testing

For a number of years now, animal testing for cosmetic products has been banned in the EU and is only permitted for fully justified medical purposes. The use of in vitro test systems, therefore, should be able not only to eliminate ethical concerns, but also to meet legal requirements and pave the way for advanced research.

Further, animal experiments are often expensive and time-consuming. With human cell cultures, researchers are able to achieve faster and more precise results. In many cases, these results are also more transferable to humans. Accordingly, TigerShark's human stem cell skin organoid constitutes groundbreaking technology that has the potential to revolutionize research.

A spin-off of the start-up is planned for next year

Amelie Reigl, Dr. Dieter Groneberg, and Dr. Florian Gröber-Becker were able to win over the AHEAD jury with their start-up idea and are now in phase two of the program. This marked an important milestone for TigerShark who is now ready to take the next step. The team is working on a spin-off of the start-up and bringing the technology for growing human skin to market. Since complex skin models are not yet available on the market, the spin-off has tremendous potential.

Dieter Groneberg

Amelie Reigl

Dr. Florian Groeber-Becker

What is the AHEAD program?

AHEAD is the central platform linking the Fraunhofer-Gesellschaft and the national and international start-up scene. As one of the leading technology transfer programs in Europe, AHEAD supports a new generation of deep tech entrepreneurs and connects them with experts, mentors, and funders. Research teams can apply with their project idea. If successful, they receive extensive support from AHEAD.

Fraunhofer AHEAD Empowering Hightech Ventures

Goal 3 and 8

Promoting entrepreneurship, creativity, and innovation is one of the sub-targets of SDG 8. In the case of TigerShark Science, the start-up project combines economic innovations with innovative medical research and alternatives to animal testing for use in the pharmaceutical and cosmetics industries.

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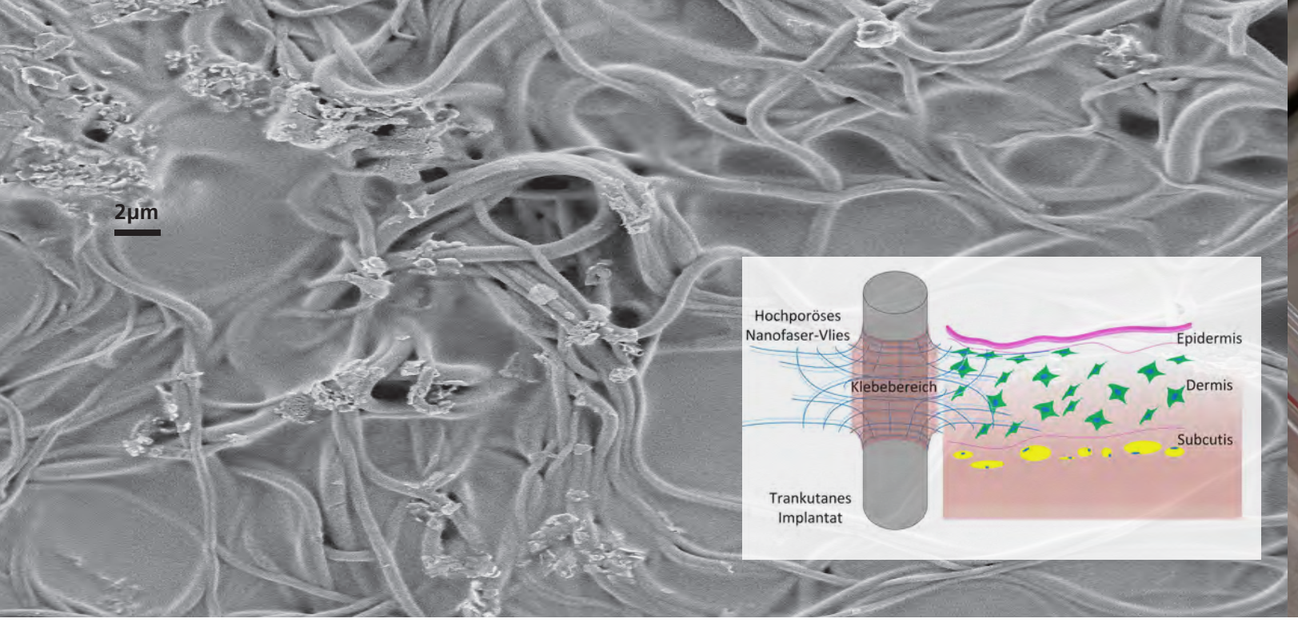
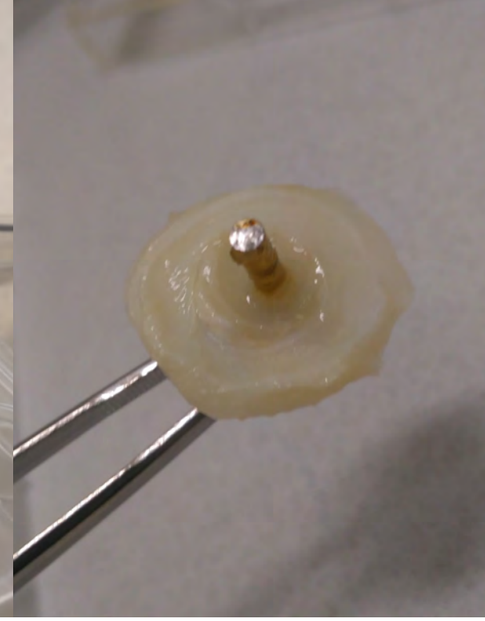




»TOPS« – minimizing the risk of infection in endo-exo prostheses using a fiber fleece

Researchers at Fraunhofer ISC have developed a novel fiber fleece that can create a covalent bond between the skin and the metal base of endo-exo prostheses. This minimizes the risk of infection and prevents permanent wounds. Future projects will further optimize the bonding and adapt the fiber fleece for use in different applications.

Amputationen stellen für Betroffene einen erheblichen Ein-
Amputations significantly lower patients' quality of life. The »standard« means of compensating for loss of function are socket-guided prostheses, which are usually held in position by means of straps, static friction, or vacuum suspension. However, despite technological advances in this area, users are still experiencing problems. Skin irritations or a non-physiological movement sequence can be reasons as to why it is ultimately easier for the user to refrain from walking or standing up. So-called transcutaneous osseointegrated prosthesis systems (TOPS) can provide alternatives to this conventional technology. With these endo-exo prostheses, a stable metal base is firmly implanted in the body, with the prosthesis being attached from the outside. In other words, endo-exo prostheses literally pass through the skin.

Minimizing the risk of infection currently associated with endo-exo prostheses

For people with leg amputations, endo-exo prostheses have many advantages. No sweating, less skin irritation, and no slipping or complicated donning. Instead, these type of protheses offer improved freedom of movement, better perception, and greater power transmission. This results in a higher quality of life, especially for active and sporty patients. However, they also have a major disadvantage. Since the skin is unable to fully attach to the metal after the metal base has been surgically attached, an open gap remains between the skin and the metal base. This permanent wound must be carefully cared for on an ongoing basis and carries a constant risk of infection. Researchers at the Translational Center for Regenerative Therapies have found a solution to this problem. By means of modified fiber fleeces developed at the Fraunhofer ISC, it may be possible to avoid these permanent wounds in the future.

Preclinical tests have been successful

In collaboration with the German Armed Forces Hospital in Berlin, the biomimetic fiber fleece that had already been developed at ISC was adapted and a covalent bond to the implant was developed.

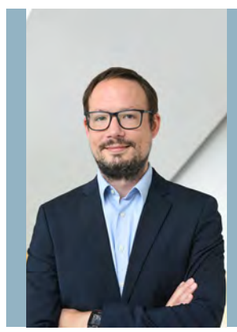
On the one hand, this fleece promotes the long-term ingrowth of skin cells and, on the other hand, enables a firm connection to the metal. Initial tests on in vitro skin models showed very good colonization of the fiber material with skin cells and the formation of an epidermis over the fleece that serves as a barrier against pathogens. Preclinical in vivo tests have now also been successfully carried out. The planning stages confirm the compatibility of the fleece with tissue and the immune system. As a prerequisite for clinical translation, further in vivo studies investigating the efficacy of the entire transcutaneous in vivo implant are required.

Looking forward to future projects

A follow-up project is already underway. The BARTIM project (Biohybrid Bacterial Barriers for Transcutaneous Implants) seeks to further optimize the covalent bonds and test their applicability to different materials. For example, they could also be used in the catheterization of paraplegics, cardiac support systems, or external fixators. The research team's aim is to increase the chances for clinical translation by ensuring the broadest possible applicability.

Goal 3 and 17

Health and well-being are crucial for a long life. Further research in the field of regenerative medicine plays a decisive role in this. When it comes to the projects above, this is achieved by means of collaboration and local partnerships.



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»ScarCare« – A bioresorbable membrane for healing internal and external wounds

Chronic wounds are a major burden, both for patients and for the healthcare system. Researchers at the Fraunhofer Translational Center for Regenerative Therapies TLC-RT have developed a membrane that represents a big step forward in chronic wound treatment. This is because the membrane continues to allow nutrients to pass through, which is fundamental to ensuring wounds heal.

Once a wound has become chronic, treatment can become a protracted challenge. People with impaired wound healing, such as diabetic patients, are particularly affected. A non-healing wound on the foot often leads to limited mobility, which significantly reduces quality of life and, in the worst case, may lead to amputation.

A solution is now in sight that will help treat chronic wounds. Researchers from TLC-RT at the Fraunhofer Institute for Silicate Research ISC and the Fraunhofer Institute for Toxicology and Experimental Medicine ITEM have developed a membrane that could be used to heal internal and external wounds. The team has produced an electrospun membrane from the bioresorbable silica gel Renacer® that is neither toxic to cells nor genotoxic. This novel matrix mimics fibrous structures found in connective tissue and is completely biodegradable.

The starting point for this development was a fiber fleece that had already been approved for the treatment of chronic wounds. This fleece dissolves during the healing process and is completely dissolved after 6 to 8 weeks.

Researchers have now modified its structure so that it mimics the fibrous structures of connective tissue and is therefore well accepted by the body's own cells.

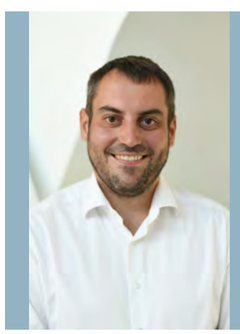
To do this, the research team reduced the diameter of the fibers by a factor of more than 50, so that the fibers now have a diameter of less than one micrometer. Using the electrospinning method, the team has succeeded in spinning a silica-gel sol into a close-meshed silica-gel membrane.

While the original fiber fleece made of 50 µm thick fibers is inserted externally into a chronic wound, the thinner fiber fleece is also suitable for intraoperative applications. A typical application would be to use the fiber fleece to cover filler material used for bone defects in the jaw in order to accelerate wound healing. In principle, the membrane can be bonded in the body with biodegradable adhesives.

What distinguishes the Renacer® membrane from conventional products is that the open-mesh membrane enables nutrient transport, whilst still preventing cell passage. The tissue is therefore adequately supplied, and the body can remove metabolic products. In addition, it is possible to integrate active ingredients into the membrane that will then be released as the fleece gradually dissolves.

Goal 3, 9 and 13

Development of biocompatible materials that do not pollute the environment and medical technology that improves health and enhances people's quality of life. It is likely that the innovative, scientific research that emerges from this project will be able to be used in a whole host of applications.



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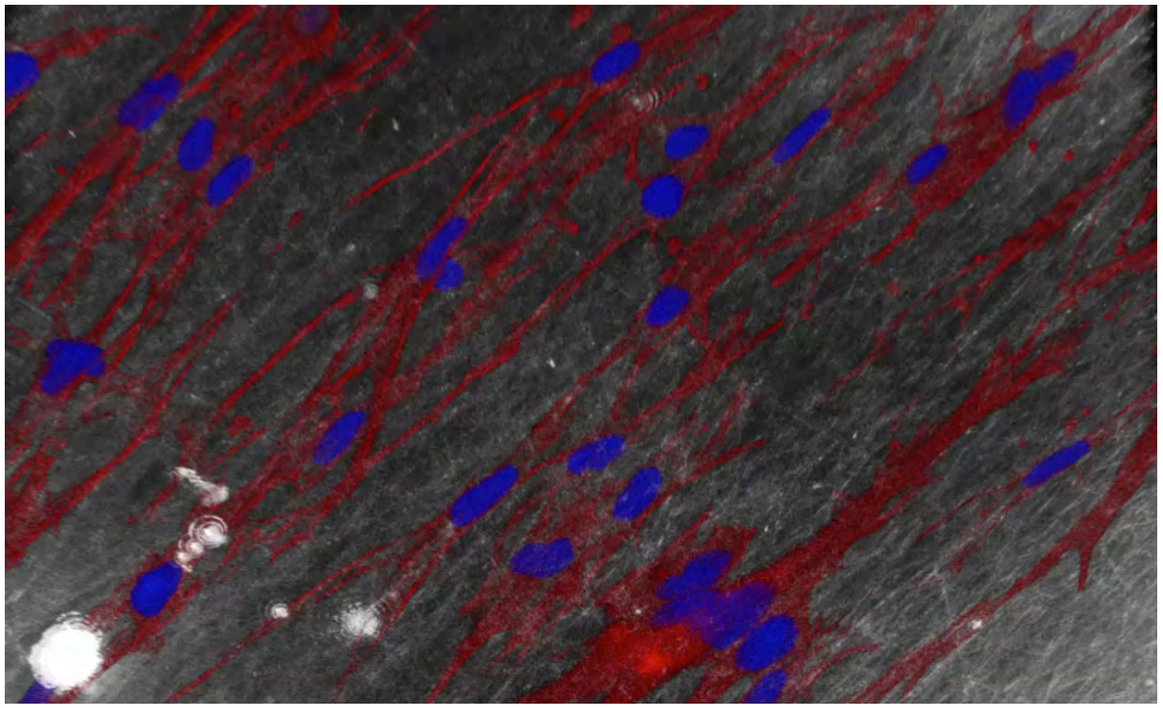

»INN-PRESSME« – an EU project promoting open innovation with bio-based solutions

The EU project INN-PRESSME is breaking new ground to pave the way towards a more sustainable future for European companies. The Fraunhofer Institute for Silicate Research ISC is part of the EU-wide consortium and is supporting the project by developing biodegradable and environmentally compatible coating solutions.

The transition to a sustainable and green economy is a critical component of the »European Green Deal«. One project at the forefront of this ambitious effort is INN-PRESSME, a joint project bringing together 27 partners from across nine European countries. The project aims to develop solutions to replace fossil-based plastics with bio-based materials throughout production chains in various different industrial sectors. Of these sectors, the project is focusing particularly on packaging, consumer goods, and energy and transport.

Access to innovation platforms

The driving force behind INN-PRESSME is the Open Innovation Test Bed (OITB). This innovation platform is a one-stop shop granting companies access to shared pilot facilities operated by ten European partners. In addition, it also provides the services needed to develop, test, and upscale bio-based materials in industrial settings. The overarching purpose is to promote recyclable and biodegradable product solutions, from validation in the laboratory right through to prototype development.

Use cases illustrate how well the materials perform

The project is centered around a total of nine real-life use cases from the three industrial sectors mentioned above – packaging, consumer goods, and energy and transport.

These are intended to demonstrate the performance of the innovative materials, which are set to be made available at the end of the project with TRL 7*. Fraunhofer ISC is involved with six of these use cases covering all three sectors and brings its expertise on the subject of coating with and from bio-based materials. The use cases the Fraunhofer team is working on range from a paper-based cosmetic tube to interior components for the automotive sector and sustainable Styrofoam substitutes for sports equipment. The specific developments in these areas are very broad and also of interest for many other areas of application.

INN-PRESSME is an ambitious endeavor to drive forward the transformation towards a more resource-efficient economy through the principle of open innovation. The project has been running since January 1, 2021, and will continue until January 31, 2025, with the clear goal of bringing solutions to market and preparing European companies for a sustainable future.

**TRL = Technology Readiness Level – a measure of the technological maturity of a development.*

Goal 7, 12 and 13

Within the framework of the EU Green Deal, this project sets an example for cooperation and promotes a real circular economy. The ISC is contributing by providing know-how relating to bio-based coatings and thus is helping to strengthen a sustainable European economy within the packaging, energy, and transport sectors.

The 3 main application areas

PACKAGING

ENERGY & TRANSPORT

CONSUMER GOODS

The INN-PRESSME project and its goals

INN-PRESSME (full name: »Open innovation ecosystem for sustainable plant-based nano-enabled biomaterials deployment for packaging, energy/transportation and consumer goods«) is a wide-ranging project launched by the European Green Deal that aims to create a sustainable and green European economy. First established in 2021, the project brings together 27 partners from nine different European countries and is coordinated by VTT. It is funded by the European Union's Horizon 2020 program.

INN PRESSME
Open Innovation Test Bed

www.inn-pressme.eu

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»NewHype« – eliminating microplastics on farmland

Farmers and gardeners often use mulch films to increase crop yields and regulate soil moisture. The problem with this is that the petroleum-based material used for mulch films is not biodegradable. As a result, at the end of a season, a lot of effort needs to be put in to collect the film residues as leaving them would cause pollution to the soil. Within the scope of the NewHype project, Fraunhofer researchers are working with European partners to develop sustainable, biodegradable mulch papers with a protective hybrid coating.

The residues of films made from petroleum-based polymers – especially polyethylene – remain in the soil for several decades. Since they are not biodegradable, they accumulate there and pollute the land. Although they are collected at the end of the season, this requires a lot of work and is not usually entirely successful. When the film residues decompose into microplastics, they may eventually enter the food chain. In response to this and within the framework of the NewHype project, a team of researchers at the Fraunhofer Institute for Silicate Research ISC in Würzburg, together with research and industry partners from Germany, Finland, and Norway, has developed biodegradable, sustainable alternatives.

When it comes to finding an environmentally friendly substitute for the large films, there is an important condition that must be fulfilled – any replacement must be both cost-effective and easy to mass produce.

Biodegradable paper as an alternative to plastic films

For the development of sustainable films, the project partners opted for cellulose-based paper. This has the advantage of being able to decompose quickly without leaving residues. However, this also means it decomposes too quickly to be used directly. Accordingly, a protective functional coating made of ORMOCER®s was designed to stabilize the paper and slow down the decomposition process so that the films are able to withstand rain for longer than just a few downpours and can be more easily spread or applied by vehicle. The ORMOCER® class of materials was developed at Fraunhofer ISC more than 30 years ago and offers chemical and mechanical stability due to the hybrid inorganic-organic character of the materials. The mulch paper has been designed to remain stable for the length of a three to six-month growing season, after which it decomposes completely. Initial tests have proved that coating the paper massively increases its wet tenacity, making it more stable than its uncoated counterpart.

Goal15

This project involves the development of a sustainable alternative to existing mulch films in agriculture. Together with European partners, Fraunhofer ISC is developing sustainable, biodegradable mulch papers with a protective hybrid coating that will be able to replace the plastic films that are currently used.

A composting test also showed that the coated material degrades more slowly, but, crucially, does still decompose.

Novel hybrid mulch paper

In addition to this stabilizing functional coating, the project partners are also working on a completely new hybrid mulch paper made from functionalized nanocellulose with ORMOCER® bonding. What makes this paper special is the fact that it will not require any additional coating and – thanks to its biodegradability – could be simply plowed into the soil after use, just like the coated mulch paper.

Fraunhofer ISC is responsible for the coordination, administration, and management of the entire NewHype joint project. Thanks to its many years of experience and expertise in the field of coating development, the institute is also responsible for the development, modification, and characterization of the hybrid coating materials – the ORMOCER® class of materials – and for combining these with the cellulose-based base materials.

More information about the project at:

www.newhype-project.com

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»CircEl-Paper« – recyclable paper-based electronics

Billions of tons of electronic waste are generated in the EU every year. Adopting a novel approach, the EU project CircEl-Paper could improve the recycling process for electronics to make it more sustainable in the future

Elektronik, die im herkömmlichen Papierrecyclingverfahren Electronics that can be disposed of using the conventional paper recycling process and even recycled – is this something within the realms of possibility? This is the aim behind the EU CircEl-Paper project. To achieve this, functional printed circuit boards are being developed using paper technology. This approach, which enables a sustainable circular economy for electronics, has been arousing the interest of researchers for several years. Now, within the framework of a large complementary consortium, it is being investigated for use with complex devices for the first time.

Disposing of electronic waste in the same way as wastepaper

Although recycling is already well established within the EU, there are still considerable deficits when it comes to recycling electronic waste. Since printed circuit boards (PCBs) consist of many different materials, recycling these fully is both highly complex and expensive. The recycling process for wastepaper, on the other hand, has proven itself and is well accepted by consumers. To increase the recycling rate of electronic components, the most promising route is therefore the paper recycling one.

The CircEl-Paper project wants to find out whether and how this can be achieved without compromising the performance of the electronics involved.

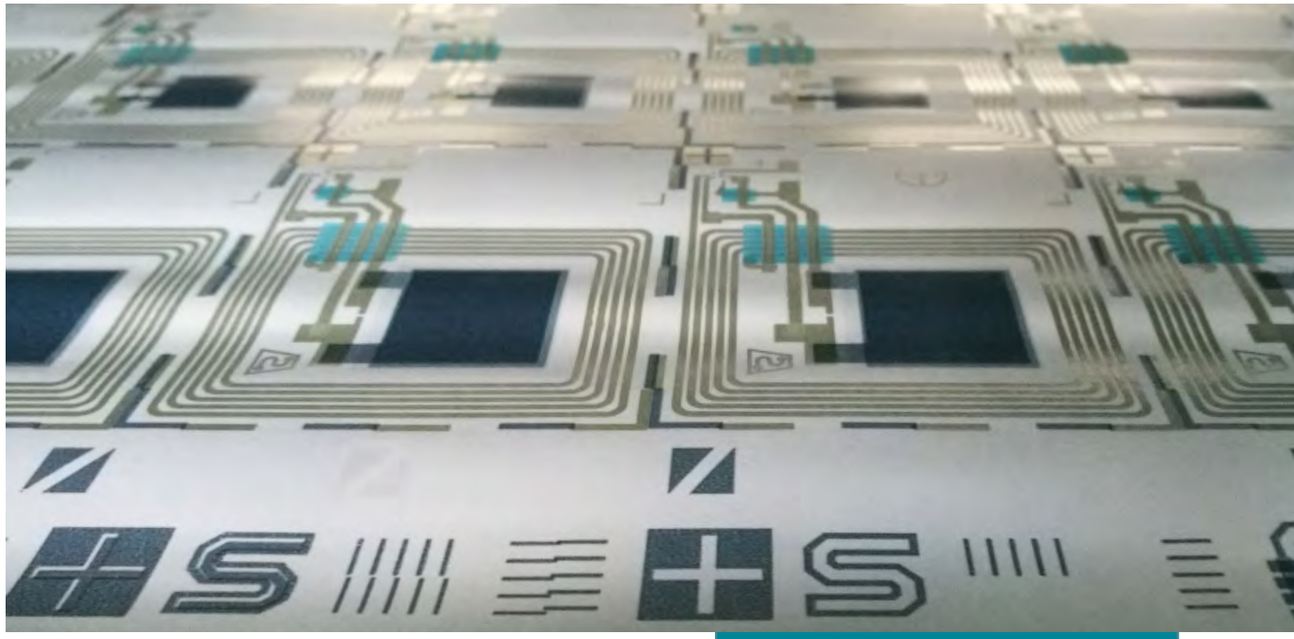
An important step on the way to recyclable printed circuit boards is replacing the usual glass fiber/polymer composite material FR4 with a paper substrate. This would mean a reduction in CO2 equivalents of up to 60 percent – a real achievement in terms of ecological footprint. In order to move PCB technology into the circular economy, each step of the process is being investigated.

In addition, alternative approaches are being developed that increase the proportion of materials that are recyclable, bio-based, based on secondary raw materials, or at least harmless to the environment, and that allow a higher integration density than is currently possible.

A wide range of applications in medicine, logistics, and consumer electronics

Three use cases from the fields of medicine, logistics, and consumer electronics demonstrate the areas in which paper-based electronics can be applied. A medical sensor for measuring glucose levels on the skin; packaging with an integrated time temperature indicator (TTI); and greeting cards that play music all exemplify the technology's performance and adaptability.

The international consortium that has been working on the project since September 2022 covers the entire value chain. Under the leadership of the Fraunhofer Institute for Silicate Research ISC, a total of eight research and industry partners are working to implement the project.



Goal 13

This project looks at how the recycling process for electronics could be made more sustainable in the future. The approach being investigated would mean a reduction of CO2 equivalents by up to 60 percent – a real achievement in terms of environmental footprint and a clear contribution to protecting the climate.

More information about the project at: :

www.circelpaper.eu

CircEl·Paper

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»BIG-MAP« – a paradigm shift in European battery innovation

Batteries will play a crucial role in the transition to a zero-emission economy. The EU's BIG-MAP project is accelerating the development of batteries by changing the way in which they are invented. This is set to enable future sustainable and ultra-high-performance batteries to be developed ten times faster than is possible today. With an automated synthesis system, the Fraunhofer Institute for Silicate Research ISC is helping to reinvent the way we invent batteries..

Demand for efficient and environmentally friendly batteries is growing rapidly throughout the world, and Europe wants to play a leading role in this. This is why the EU's BIG-MAP project has set itself the ambitious task not only of accelerating the development of sustainable and high-performance batteries by a factor of ten, but also of securing a radical paradigm shift in European battery innovation. While there were no uniform standards for battery research prior to the project, the central concern of BIG-MAP is to standardize and ensure consistency across battery research and development throughout Europe.

To make this project a reality, the Fraunhofer Institute for Silicate Research ISC is contributing its expertise in chemical analysis, robotics, and digitization. At its core is an automated synthesis system for organic cathode materials, which is being developed at the R&D Center for Electromobility. With the help of machine learning algorithms, the synthesis robot can access synthesis instructions – i.e. a set of recipes for cathode materials – from the European research network and evaluate them at the molecular level. The corresponding process factors such as temperature, mixing times, and other parameters are then automatically optimized and carried out. As a result, the approach enables faster and more precise material development.

The system consists of various components that are able to communicate with each other. This is particularly important to ensure that all components work together smoothly. By integrating suitable commercially available products, the robotic system is modular and reproducible. In addition, the research team has also developed its own solutions for special chemical steps, such as automated »liquid extraction", in collaboration with the University of Copenhagen (ITU) and integrated these into the system. Whereas previously, this process had to be carried out manually, now, a robot is in charge.

Thanks to its success, the project, which has already been running for three years, has been extended by a further six months, and plans for a follow-up project are already underway. This is where yet another benefit of the modular design of the synthesis system will really come to light, with its flexibility meaning it can be adapted for other processes too. This also renders the system an extremely attractive prospect for future research projects on topics such as battery recycling. By combining artificial intelligence with autonomous synthesis robotics, the BIG-MAP project is well on its way to ushering in a new era in battery research.

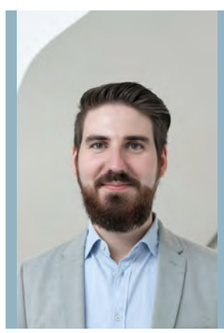
The EU's BATTERY 2030+ research initiative

BIG-MAP is part of BATTERY 2030+, a large-scale European research initiative aimed at developing greener and safer batteries in Europe with improved performance, increased storage capacity, and longer lifetimes. It is part of the European Commission's €272 million funding initiative to improve and accelerate battery research and production. Seven research projects are currently being launched under the umbrella of Battery 2030+.

For more information, please visit www.battery2030.eu/battery2030/projects/big-map/

Goal 7, 9 and 13

This major EU project focusses on storing energy extremely efficiently, including sustainable and cost-effective production, so that in the future it will be profitable to store electricity from the sun and wind in batteries. This is not just about producing the next generation of batteries, but also about providing a new, efficient, and quick way of finding novel solutions by combining existing knowledge, digital modeling, artificial intelligence, and human researchers.



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You will find the complete Annual Report on the Internet at https://www.isc.fraunhofer.de/jahresbericht

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