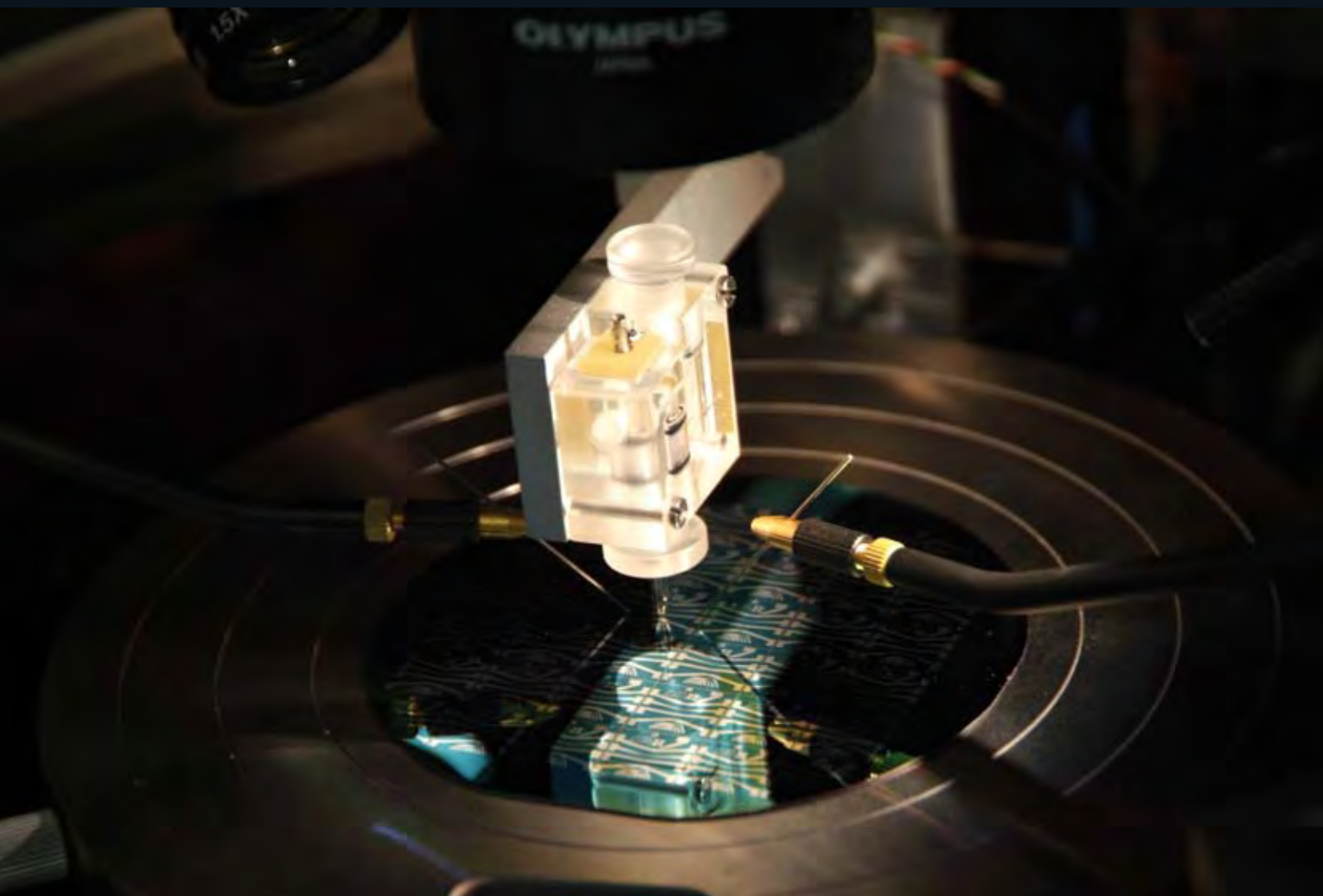
FH AACHEN
UNIVERSITY OF APPLIED SCIENCES

5. Graduiertentagung
5th Graduate Symposium
15. November 2012



5. Graduiertentagung der FH Aachen 15. November 2012

5th Graduate Symposium FH Aachen – University of Applied Sciences November 15th, 2012

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Vorwort / *Preface*

In diesem Jahr stellen unsere Doktorandinnen und Doktoranden zum fünften Mal im Rahmen der Graduiertentagung ihre wissenschaftlichen Arbeiten aus den verschiedenen Fachdisziplinen vor.

Wie im vorangegangenen Jahr werden – neben den Posterpräsentationen zu den verschiedenen, an unserer Hochschule bearbeiteten wissenschaftlichen Fragestellungen – Vorträge von Doktorandinnen und Doktoranden zu hören sein, die ihre Promotionsarbeiten bald abschließen werden. Das Programm wird abgerundet mit einem praxisnahen Gastvortrag eines Unternehmers. Mit diesem Format möchten wir an die Erfolge der letzten Jahre anknüpfen und wiederum eine Plattform zum Austausch über die unterschiedlichen wissenschaftlichen Themen zwischen den Mitgliedern der Hochschule und unseren Gästen bieten.

Die Arbeit des Graduiertenkollegs hat sich im vergangenen Jahr weiter verstetigt. Die Graduierten werden innerhalb der Hochschule zunehmend wahrgenommen, sie vertreten ihre Belange in den forschungsrelevanten Gremien der Hochschule und werben erfolgreich interne Forschungsförderungsmittel ein. Wir unterstützen unsere Nachwuchswissenschaftlerinnen und Nachwuchswissenschaftler aber nicht nur in ihrer fachlichen, sondern auch in ihrer persönlichen Weiterentwicklung. Der Schwerpunkt unseres diesjährigen Doktorandentrainings liegt deshalb auf den Schlüsselqualifikationen, den sog. „Soft Skills“ bzw. „Transferable Skills“. Der Erfolg in dem vom Ministerium für Wissenschaft und Forschung des Landes Nordrhein-Westfalen ausgeschriebenen Programm „Forschungskooperation Uni & FH“, in dem wir gemeinsam mit der RWTH Aachen in den nächsten Jahren kooperativ Doktoranden ausbilden können, zeigt, dass wir hier auf dem richtigen Weg sind.

Die diesjährige Graduiertentagung bietet unseren Promovierenden wiederum die Möglichkeit, ihre wissenschaftlichen Arbeitsergebnisse im intensiven Dialog mit ihren Kolleginnen und Kollegen sowie den geladenen Gästen zu diskutieren. Herrn Dr. Christian Jacobi, Geschäftsführer der agiplan GmbH, konnten wir in diesem Jahr als Gastreferenten gewinnen. Er wird über seine Erfahrungen im Bereich der Logistikplanung von morgen berichten – seien Sie also gespannt!

Wir freuen uns auf einen interessanten Tag gemeinsam mit Ihnen und sind sicher, dass Sie mit Ihrem Beitrag auch in diesem Jahr die wissenschaftliche Landschaft der FH Aachen bereichern werden.

Oktober 2012

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Curriculum Vitae

Ausbildung

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Effects of salts, nitric oxide donors and ATP on protein unfolding and aggregation

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Protein activity regulation by small molecules provides a rapid, flexible and fine-tunable tool of metabolic control and is known to be a key event in cellular signaling pathways. However, biophysical mechanisms of interactions between proteins and low-molecular messengers are poorly understood and studied so far. The effects of small solutes on protein behavior can be studied for instance by examining changes of protein secondary structure, of protein hydrodynamic radius or as well of protein thermal aggregation.

This study aimed at investigating aspects of the impact of the nitric oxide donor spermine NONOate, of adenosine-5'-triphosphate (ATP) and of sodium/potassium on the dynamics of thermal unfolding and aggregation of human hemoglobin (Hb). The effect of those molecules on thermal behavior of Hb was examined by two techniques; 1) The dynamic light scattering technique (DLS) provided data on the protein´s aggregation behavior, and 2) the circular dichroism spectrometry (CD) addressed predominantly molecular unfolding events. Measurements were carried out in the temperature range between 25°C and 70°C.

Major obtained results were:

1) Irrespectively of the Na+/K+-environment, Hb's unfolding temperature was persistently decreased by spermine NONOate and systematically increased by ATP and
2) mutual effects of ATP and NO were strongly influenced by particular buffer ionic compositions.

Moreover, the presence of potassium facilitated a partial unfolding of Hb alpha-helical structures even at room temperature. The obtained data might shed more light on molecular mechanisms involved in the regulation of protein activity by small solutes.

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High temperature moving bed heat exchanger for thermal storage in granular material

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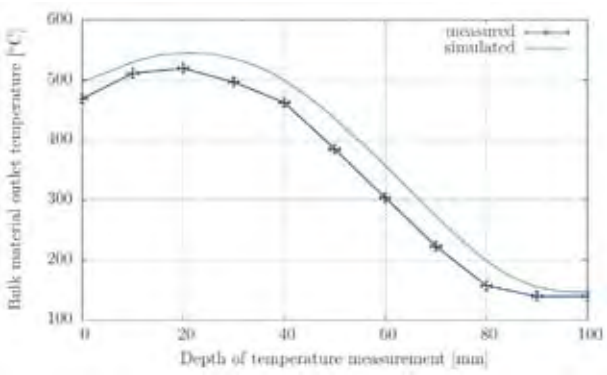
This Abstract summarizes research activities that analyse the thermodynamic behaviour of an Air-Sand Heat Exchanger, developed by Solar-Institut Jülich (SIJ) and the German Aerospace Centre (DLR). The numerical 3-D model, new results and a model validation of this particular cross-flow heat exchanger are presented. The simulation was validated with a new 15 kW prototype unit. Ansys, including Ansys-CFX, is used as modelling and simulation platform. Validation is made by a new test rig system. The geometry of numerical model is equal to the inner geometry of the test rig. Furthermore, the 3-D geometry between the air entrance and exit cross section area are considered and simulated within the new numerical model (fig. 1, above). The bulk material is modelled by a porous solid medium without structural dynamic interaction between fluid and solid phase. A constant velocity is imprinted on the bulk velocity field. Material parameter, e.g. permeability, porosity and bulk density, were gained on the one hand from literature and on the other hand from measured results. Thus all thermodynamic medium properties depend on temperature. For bulk material the pressure drop model from Ergun&Forchheimer is used. This model parameters are permeability, porosity, Sauter diameter and Forchheimer coefficient. The parameters for the material quarz sand were validated and fitted with measured values of a separate pressure drop test rig. Additionally a material library was also gained for bulk material with 1-2 mm diameter, i.e. for basalt and spherical ceramic balls.

Validation was made with the 15 kW test facility shown in fig. 1 (below). A quartz glass plate is installed for analysing the bulk flow behaviour and temperature profile inside the heat exchanger, near the pane. Thus the temperature profile can be visualised with an infrared camera. Pressure drop validation shows an accuracy of ± 2 %. In fig. 2 (left) the result of the simulated air streamlines through the MBHE are shown. Inside the HE the air uses a larger cross section area than the filter walls on the inlet and outlet.

Fig. 1 | 3-D model of MBHE (above), test facility (below)



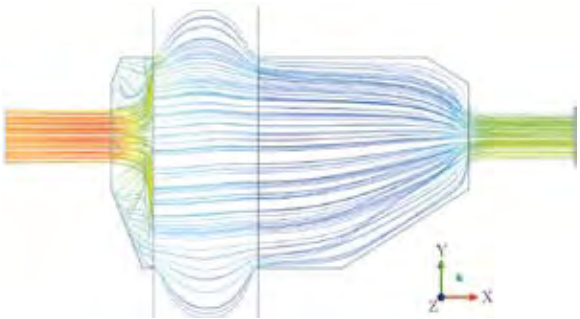


Fig. 2 | Sand outlet temperature profile (left),
Air streamline through heat exchanger (right)

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Smoothed finite element method applied to 3D models of tissues

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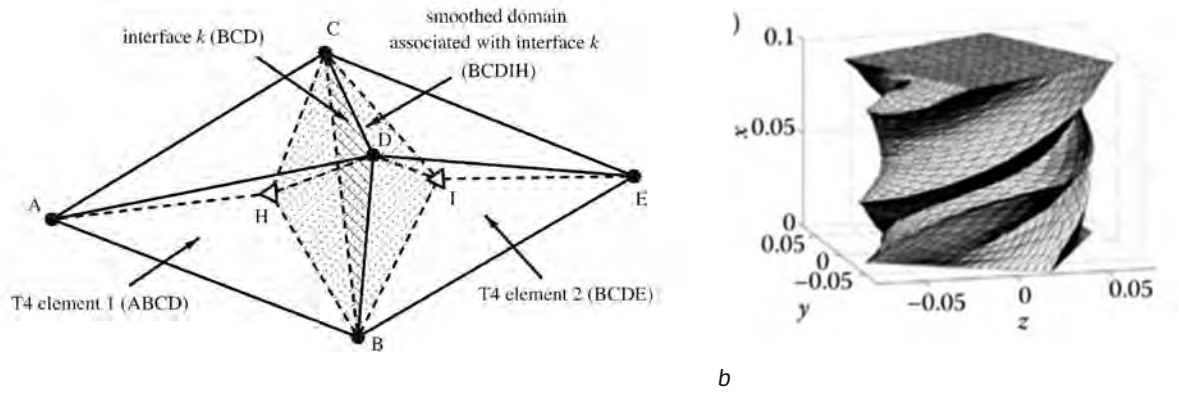
This research presents a Face-based Smoothed Finite Element Method (FS-FEM) for 3D models implemented in a large open source software program for biomedical applications. Simulation of biological soft tissue using standard Finite Element Method (FEM) is always a challenge topic due to its shortcomings such as overly stiff behavior, poor stress solution, and volumetric locking in the nearly incompressible cases. Thus, FS-FEM is developed to overcome these difficulties, resulting in more accurate solutions. Soft tissues normally have complicated geometrical models, and hence the 3D domains are properly discretized by using four-node tetrahedral element (T4). In this study FS-FEM-T4 is used to smooth the strain field at the common face between two T4 elements[1]. This leads to the softer system stiffness matrix computed using smoothed strains for the same mesh. Therefore, the numerical results presented demonstrate that the efficiency and properties of FS-FEM-T4 for physically and geometrically non-linear 3D problems are much improved compared to FEM-T4. In addition, no additional DOFs are used, and the results are much better than those of FEM-T4, without much increase in computational efforts. In conclusion, FE-FEM-T4 is a suitable method for simulations of soft tissues in biomedical applications.



a *b*

Fig. 1 | a) Smoothing 3D domain with T4 element[1] b) FS-FEM solving distorted mesh[1]

[1] G.R. Liu and T.T. Nguyen. Smoothed Finite Element Methods. CRC Press, 2010

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The Impact of biochemical and biomechanical properties of human fetal membranes linked to preterm premature rupture during pregnancy

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Human fetal membranes hold the amniotic fluid and protect the developing fetus from outside influences. When the membranes rupture amniotic fluid drains off and birth is initiated. When the membranes rupture before onset of labour, it is called premature rupture of membranes (PROM). If a PROM occurs before achievement of the 37th week of gestation, then it is preterm premature rupture of membranes (PPROM). PPROM is critical because it leads in 30-40% of all cases to a preterm birth. Preterm births in turn are crucial, because the neonatal death rate is substantially due to premature infants.

The aim of this study is to find the influence of biochemical-biomechanical properties of human fetal membranes linked to PPROM and preterm birth. These findings shall then form the basis to build a probe which will examine fetal membranes in vivo to give a prediction about the risk of an upcoming PPROM during pregnancy.

According to our results, there was a positive correlation between the collagen content and the maximal bursting pressure of fetal membranes in vitro. It looks that collagen is the major determinant for the stability of fetal membranes. As the effect of the collagen of the fetal membranes was believed very important in the stability of this tissue, the future goal was to determine it in vivo by a new non-invasive probe. This probe to follow the patients will contain an autofluorescence measuring module (see Fig. 1) to quantify collagen fibers.

Furthermore, our in vitro measurements showed that tissues with higher water and hyaluronan content are less stable. The literature says that towards the end of pregnancy hyaluronan is embedded into the fetal membranes causing water retention making the tissue gelatinous. This may cause the disturbance of cross-linkage of the collagens, ending with decreased tissue stability. Besides, as the thickness of the fetal membranes could be changed by an increase of hyaluronan and water, the probe for in vivo measurements was planned to contain an Optical Coherence Tomography (OCT) unit to determine the thickness of the fetal membranes. Simultaneously the tissue can be deformed by an air pulse to measure the stress-strain behaviour. The change in deformation might then give information about the internal pressure.

Altogether, the in vivo data will be obtained could then give a risk profile of an upcoming PPROM.

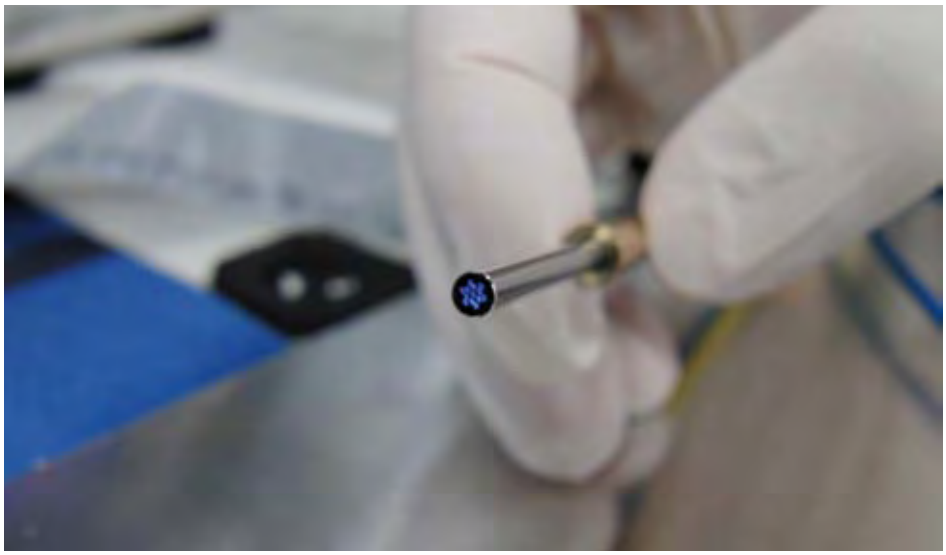

Fig. 1 | Probe for in vivo measurements with autofluorescence detection unit for collagen measurements.

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Modelling and simulation of cardiac tissue

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The Laboratory of Cell Biophysics developed a device called CellDrum™ used to determine tension in cell tissue by inflation of a cell-seeded membrane. Within the project Cardiakytos we model and simulate those bulge experiments for further mechanical investigation of the cell tissues (usually cardiac tissue) and for investigation of changes in the material response of the tissue if it is under drugs or medication. Using the Finite Element Method we represent the circular membrane and the attached cardiac tissue as a so-called plate or shell model, Fig. 1. The membrane is assumed to be governed by a so-called Neo-Hookean hyperelastic material law[1]. A very common approach to model cardiac tissue is to divide the stress T into a passive part T_p and an active part T_a. The passive part can be modelled as hyperelastic whereas the active part is the stress related to contraction of the muscle cells and has to take into account ion concentrations, ion fluxes, stretches, etc.[2].

The material parameters of the constitutive laws can either be determined by fitting of the results of bulge experiments done in the CellDrum™ or have to be measured as accurate as possible, like for instance minimum and maximum inner Calcium concentration, Fig. 2.

Those models and the simulations shall give further insights in the mechanical behaviour and properties of the membrane and the tissue. Further we want to predict the response of the tissue when medication is used to stimulate or relax the muscle cells.

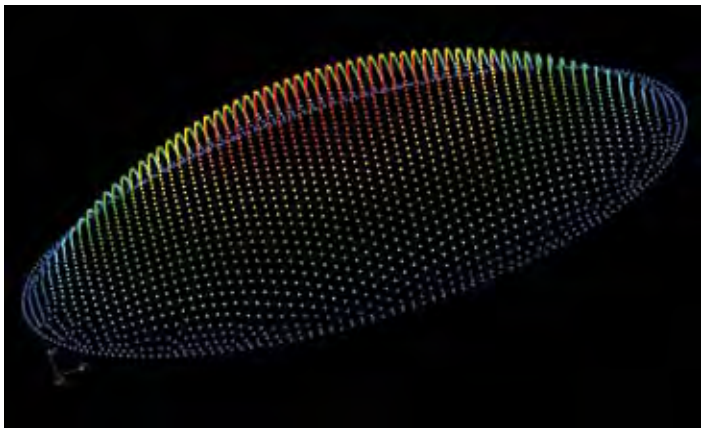

Fig. 1 | The simulated deflection we got from the inflation of a cell-seeded membrane with a certain pressure p is shown. Corresponding experiments lead to pressure-deflection curves that have been used for material parameter fitting. Having the simulation results further mechanical quantities like stress and strain can be computed easily.

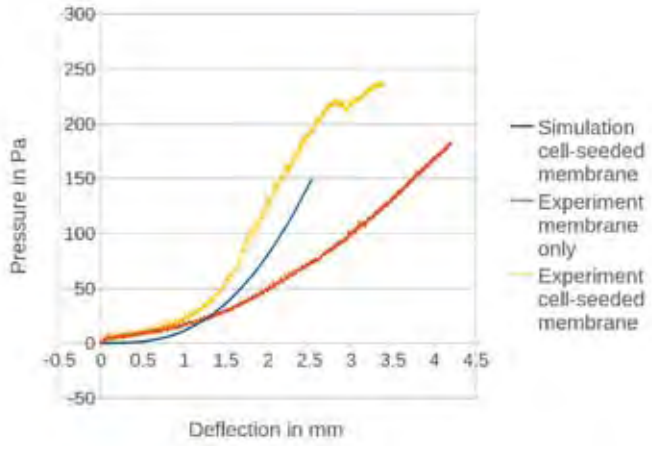

Fig. 2 | The diagram shows pressure-deflection curves. The red and yellow curves are examples for experimental curves that are used to fit material parameters. Those parameters can be used in simulations. The blue curve shows a computational pressure deflection curve that fits the related yellow experimental curve. Despite some known shortcomings in the modelling the simulation error is relatively small.

[1] G.A. Holzapfel: Nonlinear Solid Mechanics: A continuum approach for engineering, John Wiley & Sons, Ltd, 2000.
[2] P.J. Hunter, A.D. MCCulloch, H.E.D.J. ter Keurs: Modelling the mechanical properties of cardiac muscle, Progress in Biophysics & Molecular Biology 69, 289-331, 1998.

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Mapping of real life processes to automate workflows using the WS-HumanTask standard

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Complex processes are often modeled as workflows. A workflow consists of several tasks which can depend on each other. Each task describes an atomic piece of work. Workflows are illustrated as directed graphs with tasks as nodes and dependencies as edges [see Figure 1]. Control flow patterns are used to route the execution of the individual tasks on the base of decisions.

The ubiquity of IT-based solutions enables users to automate their processes. To do this, the users compose predefined software components, i.e. tasks and control flow patterns, to model a particular workflow. Thereafter, they submit the so modeled workflow to workflow management software that automates its execution based on the dependencies and the progress of the individual tasks.

Workflows attempt to include as many automate tasks as possible, however some tasks can only be offered without full automation, and i.e. they require some kind of human interaction. An integration of human tasks into workflows is therefore common. Examples are bio-medicine applications which require human interaction in the loop flow control and human involved adaptations in predefined image processing. Some of these human tasks like the configuration can be made once before the start of the workflow but others like control the convergence of results are real interactions during the runtime of the workflow. Therefore, interactive tasks have to be considered during the workflow modeling.

The HiX4AGWS project deals with many aspects of the integration of human tasks into workflows. The project provides an own implementation of the WS-HumanTask standard which was developed by IBM, SAP, Oracle and others to integrate human interactions consistently into workflows. The HiX4AGWS implementation has the benefit that it is not limited to one specific workflow management software but can be connected to arbitrary ones instead. Since user authentication is out of scope of the WS-HumanTask specification, the project provides an authentication framework which provides interfaces for arbitrary WS-HumanTask implementations and supports an easily integration into existing security domains. One crucial requirement during the execution of workflows is the validation of the generated results and the traceability of the experiments execution path. The HiX4AGWS provenance framework fulfils this requirement by collecting and preparing the required data during workflow runtime.

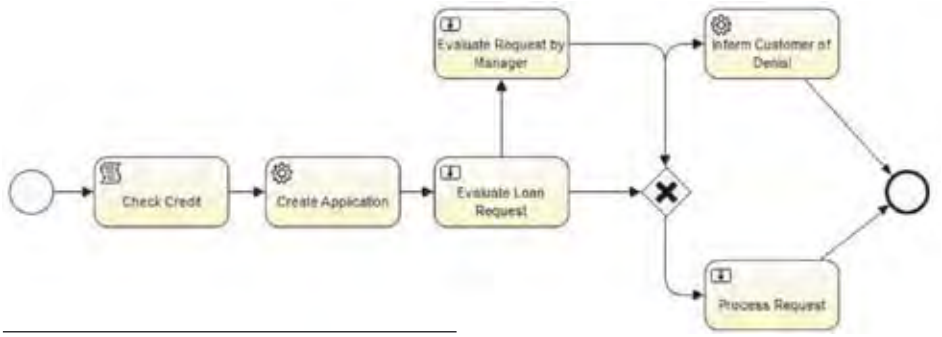

Fig. 1 | Example workflow with six tasks and one "exclusive choice" control flow element. Three tasks are automated and three tasks are human interactions.

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Name des Projektes | *Name of the project*	Entwicklung eines zellulären dreidimensionalen Herzmuskelmodells und Charakterisierung seiner Inotropie für die funktionellen Medikamenten- und Toxinforschung
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Betreuender Professor an der Universität | *Professor attending to the University*	Prof. Dr. Matthias Epple
Projektpartner | *Project Partner*	> Axiogenesis AG > Hitec Zang GmbH > FH Aachen, Fachbereich Maschinenbau und Mechatronik > RWTH Aachen, Institut für Pharmakologie und Toxikologie

Measurement of the contractile forces of autonomously beating cardiomyocytes

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Cardiovascular diseases are the main cause of death worldwide. While the development of a single drug costs approximately 1,000,000,000 €, modern technologies from the fields of personalized medicine rise hope for the development of customized substances and substance combinations in the near future. Both strategies may gain profit from the possibility of testing potential inotropic (contraction force modulating) pharmaceuticals and combinations of pharmaceuticals under in-vitro conditions for their influence on the contractile force of cardiomyocytes.

The aim of this work is the development of an artificial, three-dimensional model of the heart muscle for the measurement of the contractile forces of autonomously beating cardiomyocytes for functional drug and toxin research. It is based on the CellDrum system which was developed at the Institute of Bioengineering at the University of Applied Sciences Aachen. In brief, the CellDrum is a cell culture system in which adherent cells are cultured on an ultra-flexible silicone membrane. By application of pneumatic pressure and simultaneous measurement of the deflection and the applied pressure, the cellular tension can instantaneously be calculated. In previous studies, the feasibility of the CellDrum system was successfully demonstrated with various cell types including fibroblasts, endothelial cells and myocytes. In addition, the flexibility of the culture substrate provides the possibility to simulate various physiological and pathological tensile conditions. Thus, the system can serve as a model for several cardiovascular diseases like hypertonia and cardiomyopathy.

First experiments with cellular monolayers of autonomously beating cardiomyocytes showed the high resolution of the CellDrum system (see figure 1). In a next step, drugs with known effects on the contractility of cardiomyocytes will be tested. In order to improve the model in aspect to the physiological parameters – especially regarding the mechanical environment – a method for the covalent adhesion of cell seeded collagen matrices to the silicone membrane was developed at early stage of this work. These 3D constructs provide an environment for the cells in which the effect of new drugs can be tested at almost natural physiological and pathological conditions.

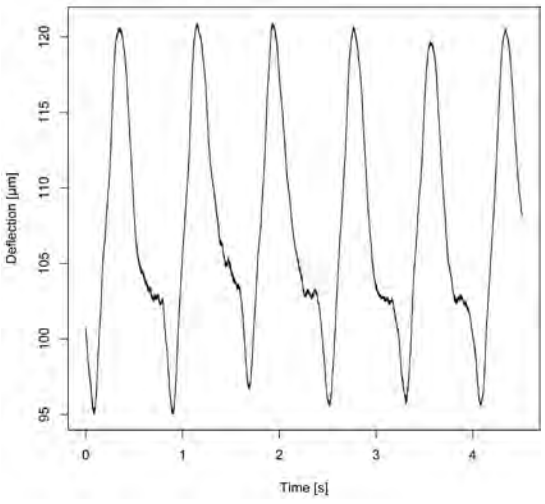

Fig. 2 | Measured signal of autonomously beating cardiomyocytes recorded with the CellDrum system

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Name des Projektes | *Name of the project*	EMSiG – Entwicklung eines Multisensorsystems in Siliziumtechnik zur Beurteilung der Gärbiologie eines Anaerobfermenters in der Flüssigphase
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Investigation of a bi-functional sensor chip for the detection of dissolved hydrogen in biogas reactors

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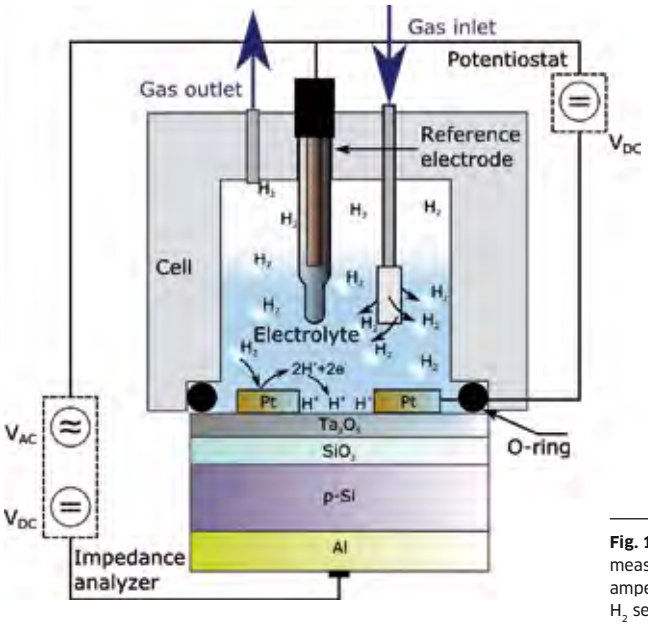
Hydrogen is becoming increasingly important as a process parameter in various technological areas. One example is biogas, where dissolved hydrogen (H_2) represents one of the key parameters for process control. Real-time and reliable monitoring of the biogas process enhance process performance for better economy of the biogas plants and can improve process stability and thus, avoid expensive and time-consuming digester breakdowns.

In this work, a new Si-based combined bi-functional chemosensor capable for simultaneous amperometric/field-effect monitoring of the concentration of dissolved H_2 has been developed (1 a). The combination of two different transducer principles for the detection of the same parameter might allow a more accurate, selective and reliable measurement of dissolved H_2. The feasibility of the approach has been demonstrated by simultaneous amperometric/field-effect measurements of dissolved H_2 concentrations in electrolyte solutions. Both, the amperometric and the field-effect transducer show linear response behaviour in the H_2 concentration range from 0.1 to 3 % v/v with a slope of 198.4 ± 13.7 nA% v/v and 14.9 ± 0.5 mV/% v/v (Fig. 1b).

a



b

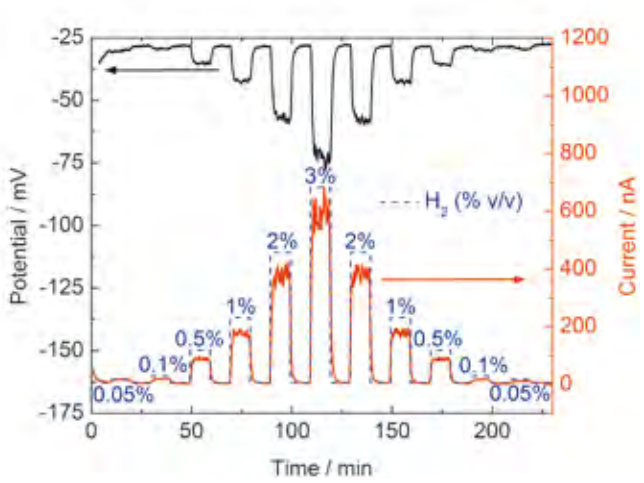


Fig. 1 | Schematic structure and measurement set-up of the bi-functional amperometric field-effect dissolved H_2 sensor (a) and simultaneous amperometric/field-effect detection of dissolved H_2 in the concentration range from 0.05 to 3% v/v.

Acknowledgements | The authors would like to thank the Bundesministerium für Bildung und Forschung (BMBF, Germany) for financial support of this project ("EMSiG").

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Adaption and optimization of the Dry-Low-NO_X-Micromix-Application with high energy densities using hydrogen and hydrogen-rich syngases

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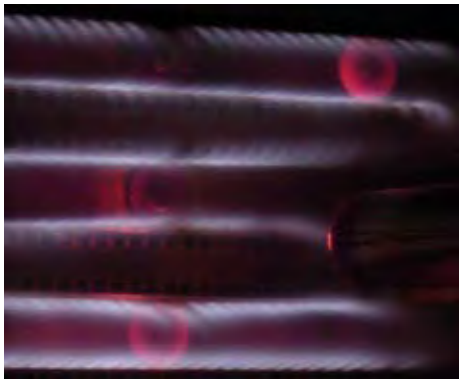
The research and development of renewable energy sources is driven by the need to reduce greenhose gas emissions. Especially the reduction of CO_2 and NO_x is of great importance since forced by the European emission trading system from 2013 on. For future scenarios, hydrogen combustion systems can play an important role when hydrogen is produced by renewable and sustainable energy like wind- or solar-power and stored for combustion in industrial gas turbine applications. When hydrogen is burned with air in gas turbines no CO_2 emissions occur but NO_x emissions arise.

Against the background of secure and low NO_x combustion of hydrogen the Dry-Low-NO_x-Micromix burning principle is developed for years at Aachen University of Applied Sciences and was first invented for the use in aircraft jet engines to significantly reduce NO_x-emissions. Previous research activities proved the significant NO_x reduction ability of the Micromix principle based on cross-flow mixing of air and gaseous hydrogen burning in multiple miniaturized diffusion-type flames (Fig. 1a) with the advantage of inherent safety against flash back.

Current research work intends to increase the energy density of the Micromix application for the use in stationary high-power generation gas turbines in combination with hydrogen and hydrogen-rich IGCC-syngas fuel. Those fuels are composed of hydrogen, carbon-monoxides and hydro-carbons and are an outcome from carbon capture power plant technologies. To adapt the Micromix principle to increased energy density and syngas fuel it is necessary to conduct a deep analysis of the key design hydrogen and syngas combustion chamber parameters influencing the formation of emissions at high-power density applications and experimentally and numerically investigate the combustion characteristics by means of Micromix test burner applications (Fig. 1b).

a



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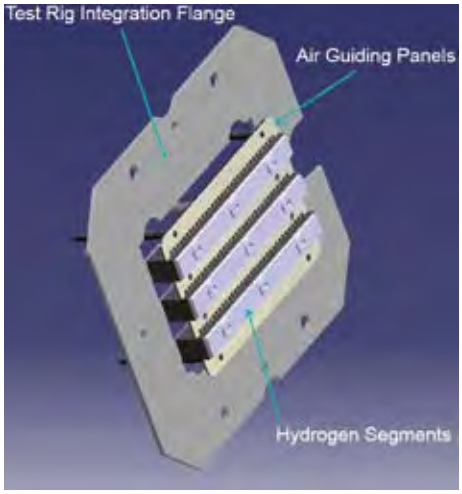

Fig. 1 | (a) Micromix Test Burner Application (b) Micromix Combustor

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Partner University	RWTH Aachen, Institut für Allgemeine Mechanik, IAM
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Project Partner	> Imperia GmbH > TU Braunschweig > RWTH Aachen (IAM)

“Intelligent Car Body”: a design approach for construction of a virtual car body for small sized batch production

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With increase in demands for special purpose vehicles such as electric vehicles, small series production is gaining more importance in automotive industry. However, due to restricted amount of information available about the structural performance targets in the concept design phase of the vehicle, its design goes through multiple optimization loops. This in turn increases the development time and cost, which is a major disadvantage for small series vehicle manufacturers.

The present design approach, “Intelligent Car Body (ICB)”, aims at reducing these problems, although not completely eliminating them, by integrating “Structural Intelligence or Knowledgebase” in the car body design process. Crash simulations performed on full vehicles and its components are extensively used here to set up this knowledgebase.

The ICB approach is based on the space frame construction concept and focuses mainly on the crush - crash loads imposed on the car body. It targets to implement “Structural Intelligence” mainly for two tasks in the car body design process, namely, to define the performance targets for the desired car body during various crash scenarios and to develop an analytical design tool which can design the car body components to match these predefined targets. In order to facilitate the process of target definition a benchmark is developed which summarizes typical values of energy absorbed, load distribution paths during crash scenarios and hence provides a basis for the target definition. The analytical design tool under development is also validated by performing various numerical simulations of car body relevant components for crush and crash loads.

The ICB approach connects various steps in the car body design process in a logical order and integrates “Knowledgebase” to guide the design at each of these steps. The “Intelligence” developed will be validated for an electric car “ec2go” currently under development.

Fig. 1 | "Intelligent Car Body" Approach

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Monitoring of aseptic sterilisation processes by means of a multi-sensor system

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Aseptic carton packages are nowadays available for a variety of foods such as milk, fruit juices or soups. An effective sterilisation of the packaging material is of high importance with the intension to avoid product recontamination by pathogenic microorganisms and to attain a longer shelf life of the product to be filled. The food processing industry is making use of microbiological challenge tests in order to ensure safe packaging processes.

Within the frame of this work, different types of sensors have been evaluated on their response on the influencing factors of the sterilisation by hydrogen peroxide (H_2O_2) vapour, namely the H_2O_2 concentration, temperature, flow rate and humidity. Further, it is a well-known phenomenon that the inhibition of microbiological growth by H_2O_2 is not a direct result of its oxidative properties in its molecular state, but the consequence of the activity of other strongly oxidant, chemical species derived from it. In fact, hydrogen peroxide is an excellent source of singlet oxygen, superoxide radicals (O_2•) and hydroxyl radicals (OH•) that are highly reactive and very toxic for microorganisms. Regarding the sensory examination of the sterilisation process, it is therefore of primary interest to chose sensors of such kind that exhibit a certain sensitivity to the latter mentioned species. Metal oxide (MOX) semiconductor sensors, like the tin oxide (SnO_2) or tungsten oxide (WO_3) sensor have shown to be excellent candidates for the detection of oxidising and reducing species. However, they are not very specific. On the other hand, doping of the MOX by additives (x), that catalytically enhance surface reactions, may affect the selectivity to certain species. Further, calorimetric type of sensors may be used to selectively monitor the H_2O_2 concentration during the sterilisation process. Beyond that, an electrochemical type of sensor, more precisely a lambda probe has been implemented in order to specifically detect oxygen, which is apparent from the decomposition process of H_2O_2.

It could be shown, that the influencing factors of the sterilisation by H_2O_2 vapour equally affect the response of the gas sensors in test. Comparative studies with microbiological probes did confirm this.

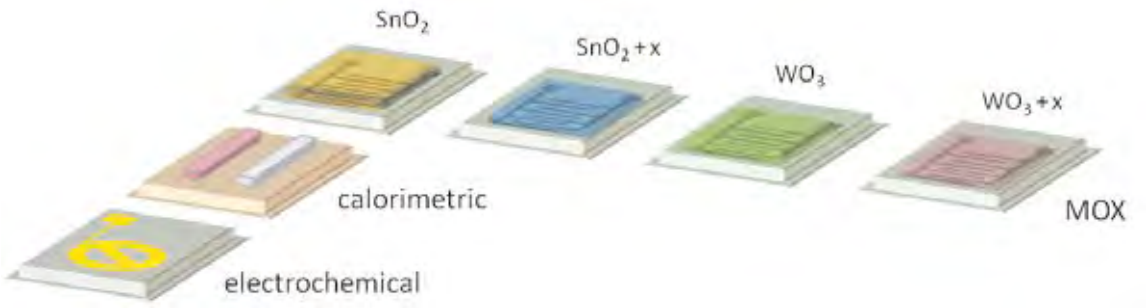

Fig. 1 | Schematic of the different sensor types used to characterise aseptic sterilisation processes employing hydrogen peroxide vapour.

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Key studies on soluble oxygen-tolerant [NiFe]-hydrogenase, an intricate and invaluable catalyst

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Hydrogenases are highly sophisticated metalloenzymes, which catalyze the reversible cleavage of molecular hydrogen (H_2) into protons and electrons. They can be subdivided into three convergently evolved classes, which differ in the composition of their active site. Even among one class, these enzymes show enormous variability towards their oxygen and carbon monoxide stability, turnover rate and their distinct maturation route required to attain catalytic activity. The so-called bidirectional [NiFe]-hydrogenases display a heterogenous group of catalysts which were brought to attention for their unique characteristics, particularly their ability to perform hydrogen oxidation even under air. These oxygen-tolerant hydrogenases are silver-bullets for the biotechnological industry, especially those which couple hydrogen oxidation with the production of reducing equivalents like NADH. An oxygen-tolerant hydrogenase is a clean catalyst which might be produced, purified and even applied under air. In this manner, industrial catalyses which rely on the recycling of reducing equivalents for the product formation to proceed may be driven simply by streaming hydrogen through the reaction vessel without the need for anaerobiosis and without producing any waste products. Furthermore, by genetic engineering, these enzymes might be connected in vivo to synthesis routes of solvents or alternative fuels, where production is driven by creation of an intracellular NADH surplus. A second application field is the use of these enzymes in enzymatic fuel cells, where an oxygen-tolerant hydrogenase is immobilized on a graphite anode, cleaving hydrogen. The protons and electrons thus formed are used by a second, cathode immobilized enzyme (laccase) to reduce oxygen to water, leaving no waste products and creating an electrical current.

The most advanced hydrogenase in terms of oxygen stability is the soluble hydrogenase (SH, fig. 1) from the "Knallgas" bacterium Cupriavidus necator (Cn). The SH mainly serves as an electron sink producing NADH from H_2 needed for energy conservation and CO_2 fixation on demand. In the present study, we examined and optimized the production and isolation of this enzyme. A screening for optimal growth conditions in terms of hydrogenase yield maximization was successfully performed. Cn was subsequently cultivated under these optimized conditions and the cells were used for isolation studies of the SH. Ensuring careful and mild chromatographic steps, the enzyme was purified aerobically in its hexameric form and exhibited high catalytic activity. Stability under air and the catalytic function were consistent with literature and illustrated the SH as a highly stable and promising multimeric catalyst.

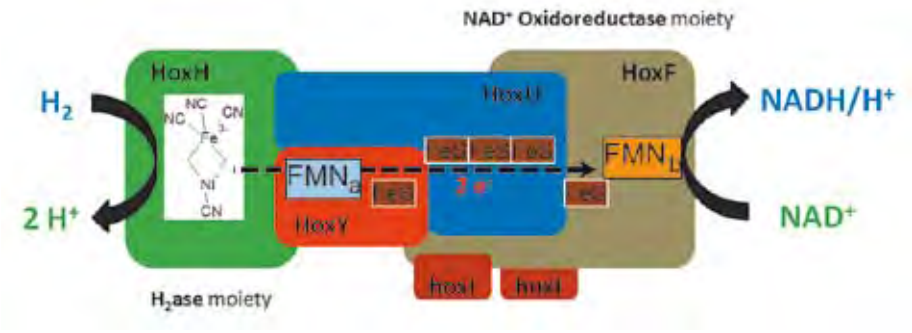

Fig. 1 | Cartoon of the SH with its two distinct modules: the hydrogenase moiety (HoxYH) and the NAD⁺ oxidoreductase moiety ($HoxFUI_2$)

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GPUFaserVis – GPU based visualization of nerve fibres from polarized light imaging

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In order to improve the understanding of healthy and diseased human brain, it is essential to understand its function and to understand the connections of different brain regions by a huge network of nerve fibre tracts.

Nerve fibres have a diameter of 5-20µm, so a high resolution procedure is needed to made fibre tracts visible. The polarized light imaging (PLI) detects fibre structures below 100µm in post-mortem brains.

PLI use the birefringence property of the sheath that surrounds the nerve fibres. This property persists even in post mortem brains. The procedure, which is done by our project partners from Research Centre Jülich, will be described below.

After removal of the brain, it is frozen. By Cryostat Microtome it is cut into 100µm thin layers. For each section, a digital colour image of the frozen block is taken (Blockface Image). The brain sections are then illuminated in a specially constructed apparatus with polarized light (figure 1). By the birefringence property of the sheath, the polarized light is changed depending on the fibre orientation. Using a CCD camera, the polarization effects are considered (figure 2, at the back). Via suitable measurements, the spatial orientation of the white matter can be estimated (Fibre Orientation Map (FOM), figure 2, in front). From the FOM, the nerve fibre tracts can be reconstructed using tractography.

In the GPUFaserVis project, appropriate data structures and algorithms have been developed to visualize the variety of data in 3D. The special challenge here is to obtain the real-time interactivity in the visualization. This was achieved using modern GPU technology and parallel programing. Among others, we have implemented the following visualizations: A visualization of the 3D Blockface Images (figure 3), a visualization of the vector field of the FOM, a combined visualization of anatomy and reconstructed fibre tracts (figure 4), a range of visualization techniques for the reconstructed fibre tracts (figure 5, fibre tracts visualized with tubes).

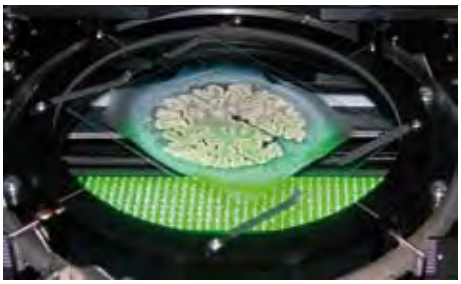

Fig. 1

Fig. 2

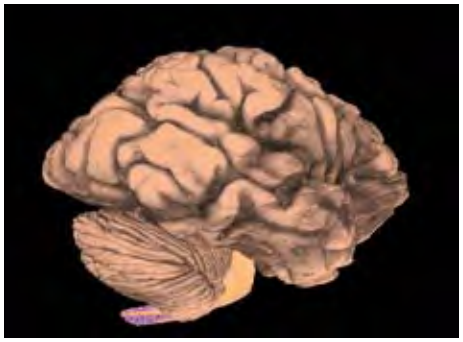

Fig. 3

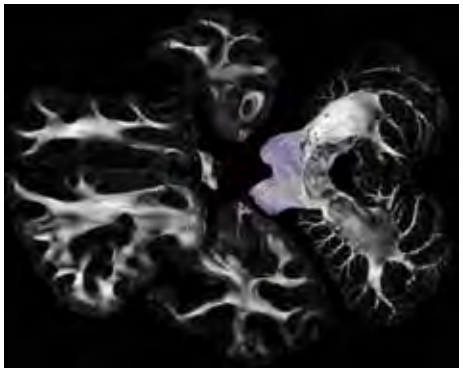

Fig. 4

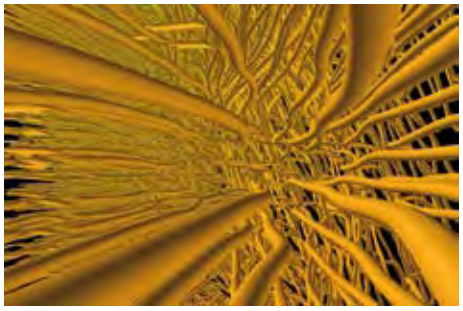

Fig. 5

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PT BioChip – A sensor concept for real-time monitoring of degradation process of biodegradable polymers

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Biodegradable polymers play a major role in today's research. Their nature to disappear in a biological environment has led to a great interest in these materials ranging from packaging industry to medical healthcare. Especially for the latter field, these polymers have to meet strict demands. Beside the fact that they should neither contain nor produce harmful substances during degradation, their degradation kinetics need to be well-adapted to the requirements of the application. Since manipulating the degradation kinetics (e.g., by modifying the chemical composition of the device) is not a straight-forward procedure, a large number of studies accompanies the adaption of the degradation kinetics.

In general, there is a lack of techniques for in vitro and real-time monitoring of the degradation process. For this purpose, a sensor concept is designed (see Fig. 1) enabling on-line monitoring of the degradation process as well as the surrounding medium in respect of pH, ionic strength and temperature, which also affects the degradation process[1]. The chip focuses on on-line and in situ monitoring of the degradation process by means of impedimetric measurement techniques and can help to improve the throughput of studies on degradation kinetics.

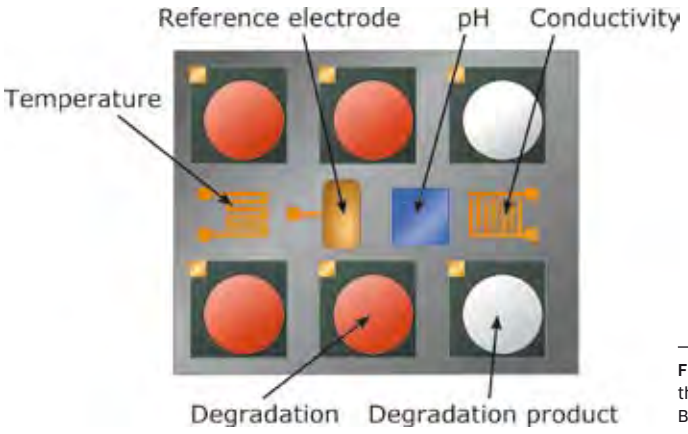

Fig. 1 | Schematic of the polymer-testing BioChip (PT BioChip).

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Development of a tubular bioreactor system for the generation of biohybrids

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Objective: Tissue Engineering as a multidisciplinary field of science is used to study in-vitro models, as well as to generate organ transplants. Therefore, it shows a high effectiveness in consequence of its constant quality. These standardized models and transplants are strongly depending on standardized conditions, where scaffold materials take a central role. In combination with autologous cells it is possible to engineer biohybrids, that are superior compared to allografts. This project deals with the development of an automatized bioreactor system, in order to generate a ureteral replacement out of an engineered scaffold and primary cells of the genitourinary system. Additionally, a seamless tubular collagen scaffold is supposed to compensate medical postoperative problems, like restriction, stone formation excessive mucous production.

Materials and methods: An automatized bioreactor system is developed on the base of an engineered collagen scaffold (OPTIMAIX) for the cultivation of primary smooth muscle- and urothelial cells. The Matricel GmbH, Herzogenrath, provided these seamless tubular matrices. An incubating system ensures the optimal support of the cells and is built around the UREPLACE bioreactor. Primary smooth muscle- and urothelial cells were isolated from porcine urinary bladders, which were obtained from an abattoir. In addition to theses primary cells, established cell lines were applied on the collagen scaffold in the automatized bioreactor system. The cultivation process was observed and controlled on a developed user surface. Subsequently, the biohybrids were analyzed by histological methods.

Results: The separation of the UREPLCE bioreactor and the sensors and actuators of the incubating system shows advantages in the handling. Standard conditions for the temperature and CO_2-concentration were achieved by means of measurement and control technology. Short-term cultivation periods of primary porcine smooth muscle- and urothelial cells and NIH-3T3-fibroblasts show a homogeneous circular distribution of the cells on the collagen matrix. It can be shown that cells penetrate the interconnected pores into the inner matrix of the sponge like material.

Conclusion: The automatized bioreactor system, in combination with the tubular scaffold material, shows a high potential for the generation of tubular tissue equivalents. Nevertheless, further investigations have to be done on elongated cultivation periods with the focus on a confluent matrix.

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Process classification for producing companies

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MIND-Energy Sustainable energy supply for producing companies

Background

Today, companies strongly depend on fossil fuels besides electrical power to keep their production running. Facing the rising demand of fossil fuels in emerging countries, it is assumed that in about 20 years in Germany oil and gas due to low availability and high prices only can be used to a very limited extent for production processes and space heating. The alternative use of electric energy is partially physically impossible, thermodynamically ineffective or too expensive.
Companies must make strategic decisions in the near future, which energy sources are suitable for them and their processes.

Objectives and methodology of the research project

The aim of the study MIND-Energy is to enable companies to select a sustainable energy system, suitable for them and to blueprint their strategic plan over the next 10-20 years. For this purpose, a software-based methodology is developed. Using that, the company is able to check which forms of renewable energy and energy storages are suitable for their production process and their location. Furthermore, they can estimate the costs associated with the conversion of the energy system. The energetic, technical and economic potential of all available renewable energy carriers can be determined and the matching conversion technology can be chosen.
Result of the study will be a catalogue of structures and methods with that, while maintaining the production outcome and comfort for companies in Germany, with much less energy use and the use of regionally available renewable energy carriers, companies can ideally become energy autarkic. Hence, securing operation of the plant by innovative strategies for future energy supply, time and cost plans for the coming years, and -if necessary by contracts- secure locally available fuels and storages are possible.

State of the study

To investigate the energy consumption of a company, besides the water and energy consumption of the complete plant, the production processes inside the plant must be known in great detail. Therefore a database of so called “Part-Processes “and “Elementary Processes” is generated, based on the methods of LCA (Life Cycle Analysis). Using this database and recombining these elementary processes like “cutting” or “crushing” to the complete process, the technologically minimal energy demand of the production process can be determined. Based on this information process cascading and inclusion of renewables is evaluated.

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Optimization for elasto-plastic structures under shakedown conditions

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Optimization in structural and continuum mechanics is a relatively new but extremely rapidly expanding research field, which has interesting theoretical implication in mathematics, mechanics, multiphysics and computer science, but has also important practical applications by the manufacturing (in particular, car and aerospace) industries, and is likely to have a significant role in micro and nanotechnologies.

There is always a need for improvement of products and processes. That is why we have to use design optimization. Design optimization is a rational finding of a design that is the best of all possible designs for a chosen objective and a given set of geometrical and behavioral constraints. Our work will build up and solve the problems of optimal 2D structures that are made of an elastoplastic material and are exposed to cyclic loads. The objective will be defined by limit and shakedown analysis which allows the simultaneous optimization for all load histories.

Fig. 1 + 2 | Industrial examples in Airbus

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Light-addressable potentiometric sensors and their application for the determination of the metabolic activity of bacteria

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The light-addressable potentiometric sensor (LAPS) is a semiconductor-based chemical sensor with the advantage to detect chemical species on the sensor surface in a spatially resolved manner (Fig. 1a). This can be used to determine the concentration of multiple species, perform chemical images (Fig. 1b) or analyse the metabolic activity of microorganisms. The spatial resolution is achieved by focused and modulated light sources. We developed different LAPS set-ups utilising different light sources to achieve a high spatial resolution (about 200 µm) or fast measurements (5 images per second).

One of these LAPS set-ups is used to determine the metabolic activity of the bacteria *E. coli* by measuring their acidification. With this, it is possible to get information about the "welfare" of the organisms and information about the nutrient concentrations inside the media. By measuring in solution from a biogas digester, this kind of biosensors can be used to investigate the status of the anaerobic digestion.

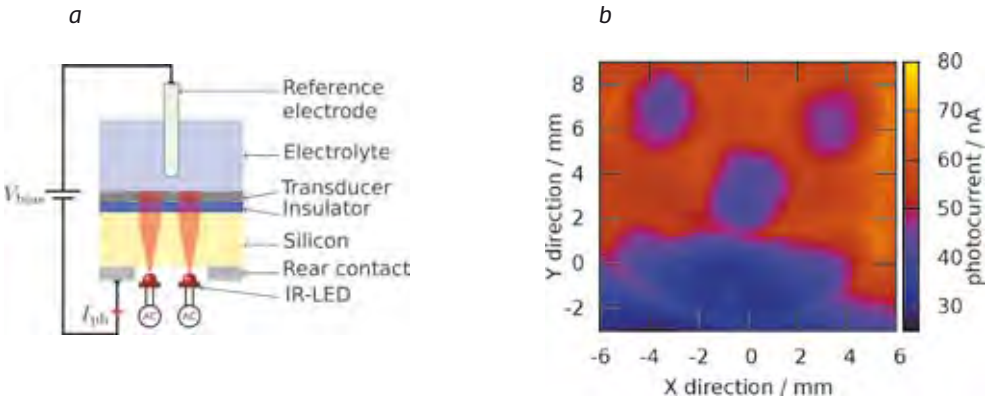

Fig. 1 | Principle of a LAPS (a) and a chemical image (b)

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