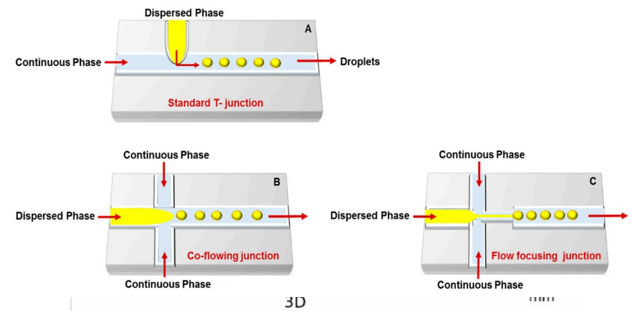
Digital Microfluidics
Analysis of a T–Junction

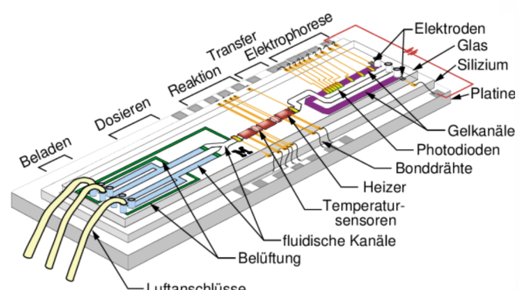
Fluid flow in microchannels can be utilized for manifold applications, e.g.: Lab-On-A-Chip, micromixers, study of transport phenomena, etc.
T-junctions are often used for example for drug delivery, where microdroplets need to be generated with specific properties. A continuous phase C cuts off a dispersive droplet phase D.

Tasks

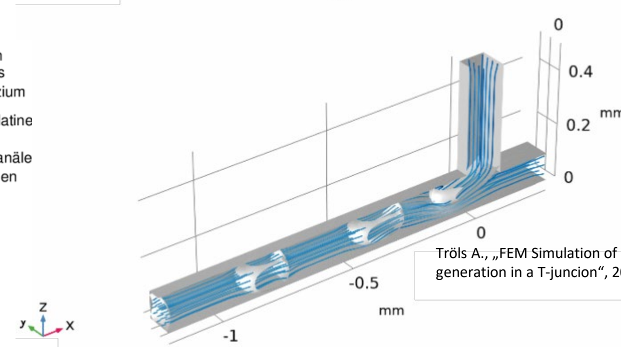
- Review of microchannel theory and important microfluidic key figures
- Select optimal type of T-junction and define control parameters
- Automation of setup via Matlab / Python
- Verification of the given droplet parameters
- Perform simple microfluidic tasks with resulting droplets

Damiati et. Al., Microfluidic Devices for Drug Delivery Systems and Drug Screening , MDPI, Genes, 2018





Müller R., „Mikrofluidik auf der Basis von CVD-Diamant “, 2007,



Tröls A., „FEM Simulation of droplet generation in a T-juncion“, 2023

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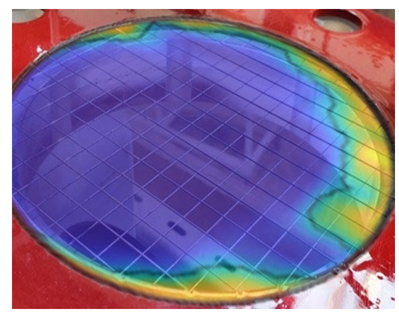
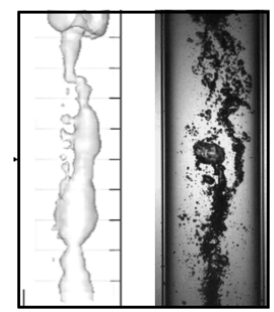
Flow rate measurement of multiphase mixtures based on tomographic sensor data

Currently there is a trend to apply tomography to investigate flow in pipes, where fast processes may occur (e.g. multiphase flow, chemical reactions in vessels). Flow rate measurement of multiphase mixtures is very challenging. Tomographic sensor data can be explored for this task. Therefore at our institute the following points provide the possible scope of a Bachelor-/ Master Thesis.

Tasks

- Review of measurement techniques for flow determination
- Study and implementation of two-dimensional cross-correlation Technique for tomographic data
- Development of data processing and parameter extraction algorithms
- System performance testing and evaluation based on synthetic and experimental data





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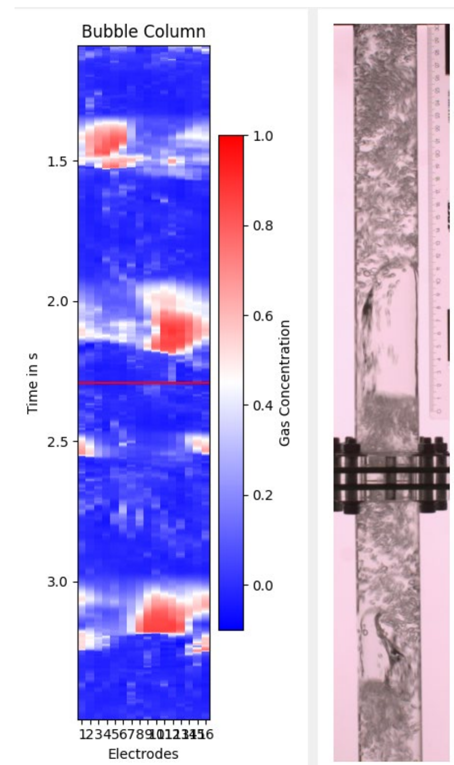
Further development of a multi-electrode conductance sensor (MECS) to determine air bubble velocities

A multi-electrode conductance sensor (MECS) was developed to validate a computational fluid dynamics (CFD) simulation of gas-liquid flows in pipes. The MECS measures changes in conductivity in the vicinity of its electrodes and thus deduces the presence of air bubbles. In order to be able to draw conclusions about the speed of the air bubbles, the sensor is to be extended by a further measurement level.



Tasks

- Review of conductive multi-phase flow measurements
- Extend/Modify the existing circuit
- Test the modified sensor on an experimental setup and gather measurements
- Write an algorithm to determine the velocity of detected air bubbles (cross-correlation)

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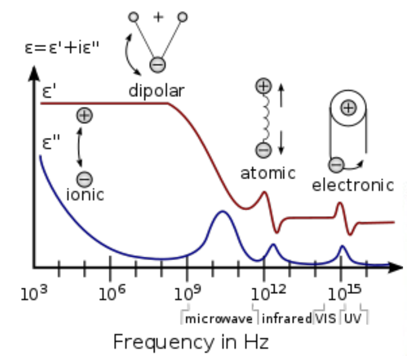
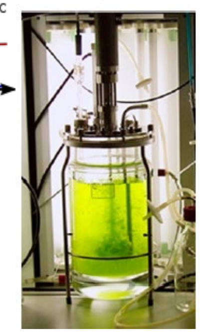
Combined electrical and optical probe for the investigation of colloidal systems

Colloidal systems are commonly found in the chemical industry and consist of a continuous high volume phase (usually a liquid) and a dispersed phase (such as droplets, gas bubbles, or suspended solids). For a detailed characterization of such systems, the combination of dielectric and optical spectroscopy seems to be sought. However, as a new technology, such combined measurement systems require the design, development and testing of dedicated sensors and measurement circuits. The depth and scope of the work will be tailored as a BSc or MSc thesis.

Tasks

- Review of dielectric and optical spectroscopy of colloidal systems
- Design and implementation of dielectric spectroscopy probe
- Design and implementation of optical spectroscopy probe
- Combination of both systems in a single probe
- Testing for a chosen application such as crystallization, liquid-liquid extraction, multiphase flow.





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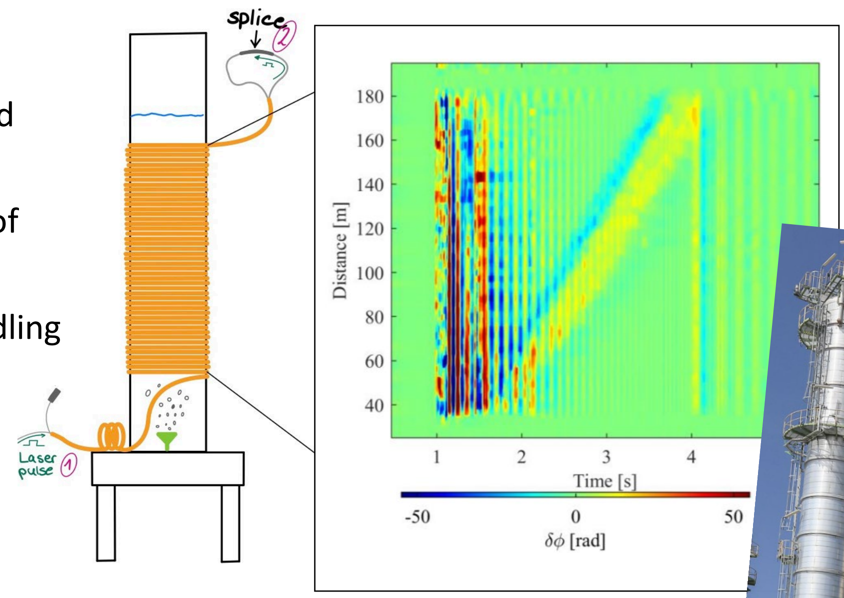
Application of distributed fiber-optic sensor for monitoring Bubble Column Reactors

Distributed Acoustic Sensing (DAS) based on optical fibers has become popular due to its non-invasive nature and high spatial resolution. Its application to bubble column reactors, a key piece of equipment in the process industry, opens up new approaches to monitoring these complex systems. Currently, pressure and temperature are commonly measured in such large scale plants, limiting the possibility of modern energy saving process control. We aim to investigate the use of DAS in such chemical reactors, which will open up new and improved ways of monitoring chemical processes.

Tasks

- Modelling of the measurement chain and column processes
- Design and implementation of measurement series for targeted localization of vibration sources in the column
- Spatial visualization of measurement data and reconstruction of vibration propagation within the column
- (Master Thesis only) Optimizing DAS parameters and data handling with Matlab/Python



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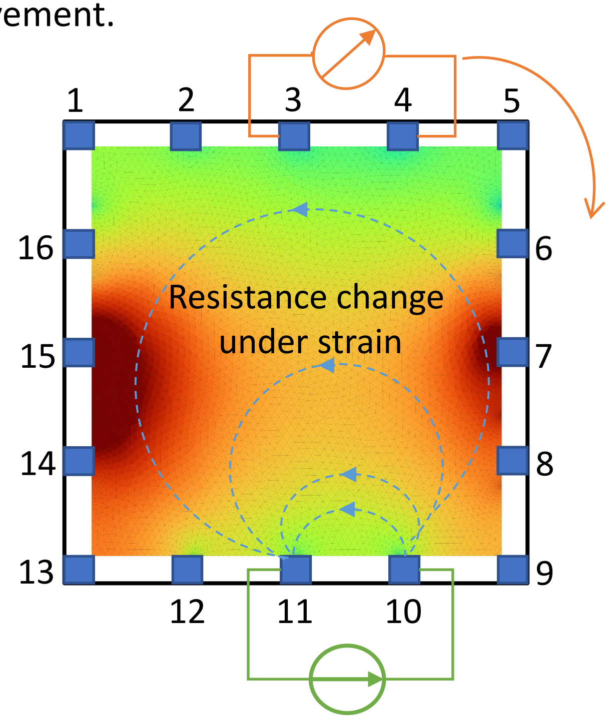
Spatially-resolved strain measurement with conductive elastomers for soft robotics

Imperceptible sensors are one of the key areas of research for wearable sensors in textiles or soft robots. In recent years, a number of highly conformable and compliant sensors have been introduced. However, many of them optimize for sensitivity without addressing the other essential dimensions of sensor quality: specificity and stability. In particular, stability in dynamic scenarios is often neglected and consequently some piezoresistive phenomena in polymeric materials are not fully understood. Spatially resolved techniques such as electrical impedance tomography or matrix-based sensors are promising avenues for improvement.

Tasks

- Implementation of combined digital image correlation and spatially-resolved impedance measurement system under varying strain
- Measurement of the impedance-strain properties of conductive elastomers under dynamic loading conditions
- Combination and evaluation of the spatially-resolved strain and impedance data
- Analysis of interrelation between conductive elastomer properties and strain-impedance behavior



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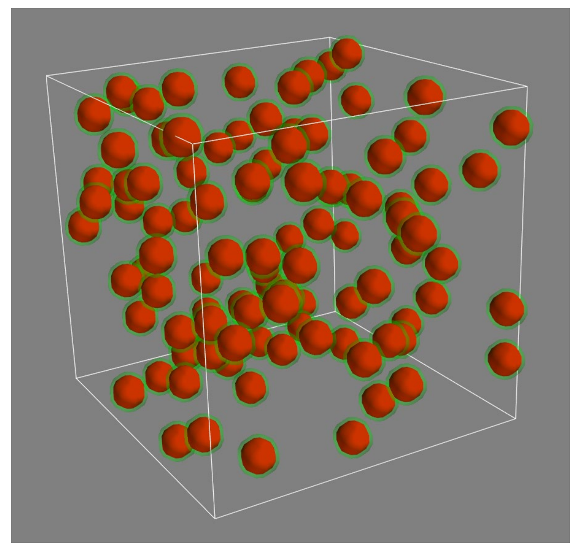
Particle-based modeling of electro-mechanical properties of carbon-filled elastomers

Conductive elastomers, which are based on carbon particles as fillers are an emerging field of research. Possible applications range from soft robots and artificial muscles to electrodes for electromyography. But especially the stability in dynamic scenarios is often neglected and consequently some piezoresistive phenomena in polymeric materials are not fully understood. Models that incorporate both the electrical connection and disconnection mechanisms between particles in the conductive network as well as the visco-elastic properties of the elastomer can drastically improve our understanding of dynamic piezoresistive phenomena.

Tasks

- Development of 3D percolation model with particle-particle interactions in Python
- Implementation of visco-elastic matrix properties for dynamic loading scenarios
- Visualization of 3D conductive network
- Verification of developed model and validation based on existing experimental data sets



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