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Master Thesis topics for summer semester 2021
(Research Institute for Microsystem Technology, https://www.hs-furtwangen.de/en/research/research-institutes/institute-for-microsystems-technology/)

Topics related to medical and health care:

I Topics embedded in running research projects
(special conditions and ressources as third party fundings are available, these topics can be linked to additional assistant jobs, non-disclosure agreements may have to be considered)

1. Dynamic fibre coupling using MOEMS system

At HFU an active focusing system has been developed. The main component for this purpose is a MOEMS devices developed at HFU using a reflective membrane (micromirror device) which is electrostatically actuated in such a way that an almost perfect parabolic surface is obtained. The bending of the surface can be adjusted by the applied voltage (typically up to 200 V). Within this thesis this device should be used for an active coupling system which allows to couple light into the fibre ("on") or to suppress coupling into a fibre ("off", e.g. 40-60 dB between "on" and "off" for multimode fibre). A µC-based electronic control system has to be designed using the coupled light as input for driving voltage for appropriate focusing. Besides coupling efficiency the dynamic performance has to be determined and compared to simulation results.

In this thesis, specifically, the dynamic behaviour should be investigated using FEM, given devices and to be built-up set-ups

- Understanding of MOEMS device (practical testing)
- Optical set-up for fibre coupling of a laserdiode into a multimode fibre
- Control electronic to find automatically optimal coupling conditions
- Test-set-up for dynamic characterisation (optical set-up)
- Learning COMSOL multiphysics
- Modal analysis of device (based on previous models)
- Comparison simulation and experiments
- Modelling of frequency dependence
- documentation

Literature
U. Mescheder, M. Freudenreich, S. Somogyi, C. Estan: Distortion optimized Focusing Mirror Device with Large Aperture: Journal: SENSORS AND ACTUATORS A: PHYSICAL Vol. 130-131, 2006, p. 20-27]
W. Kronast, U. Mescheder, B. Müller, R. Huster: Development of a focusing micromirror device with in-plane stress relief structure in SOI technology. Proc. SPIE 8616, MOEMS and Miniaturized Systems XII, 86160Z (March 13, 2013), San Francisco, 2013
W. Kronast, U. Mescheder, B. Müller, R. Huster: Entwicklung einer Stressausgleichsstruktur für span-nungsarme aktive Membranspiegel in SOI Technologie. In: GMM ; VDI/VDE-IT (Hrsg.): MikroSystem-Technik Kongress 2013, 880 Seiten, CD-ROM, ISBN 978-3-8007-3555-6, S. 432-435
W. Kronast, U. Mescheder, B. Müller, R. Huster: Development of a focusing micromirror device with an in-plane stress relief structure in silicon-on-insulator technology. J. Micro/Nanolith. MEMS MOEMS. 13(1), 011112 (Jan 21, 2014), ISSN 1932-5150, doi:10.1117/1.JMM.13.1.011112, 10 Seiten
U. Mescheder, M. Lootze, K. Aljasem, Evaluation and Optimization of a MOEMS Active Focusing Device, *Micromachines* 2021, *12*(2), 172; https://doi.org/10.3390/mi12020172
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2. Tactile display for finger position detection in Braille reader systems

Braille displays [1]) are important tools to help blind or visually handicapped people to read and write data.
In this project a new concept for sensing the finger position, to identify the “reading finger” of the reading person in order to control “cursor” setting during reading automatically has to be investigated. The thesis is embedded within an ongoing third party funded project and is done in cooperation with the company Helptech GmbH.
As a first experimental set-up a capacitive display allowing to distinguish “touch” of a finger and approaching of a finger (forceless) to the display by using the “self or stray capacitance effect [2] for a PCAP (“projected capacitance”) based sensing and a read out circuit using an Arduino board with an open source “test kit”” [3] has been built up at the HFU and is available for first functioal tests of the PCAP principle.

In this thesis, a FEM model should be developed using the Comsol AC/DC module [4]. Two different schemes should be modelled: the mutual capacitance and the stray capacitance priniciple (Fig. 1)

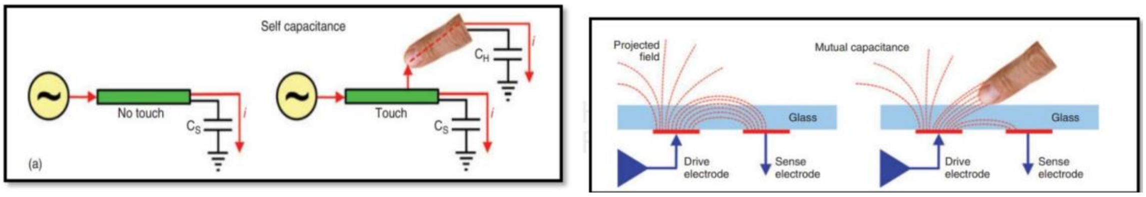

Fig 1:left: self capacitance scheme with two electrode layers separated by a flexible material, right mutual capacitance scheme with drive and sense electrode within the same layer [2].

Based on the results an optimized set-up should be built up and characterized.

Tasks:

- Literature research about touch displays (principles, set-ups, materials)
- Testing available set-up experimentally
- Building a model in COMSOL multiphysics, modelling of expected output signals
- Design of optimized PCAP for Braille display
- microfabrication of optimized PCAO for test set-up
- Connection to adjusted Arduino board using test kit and characterization of optimized tactile display
- Documentation and presentation

Literature:
[1] https://helptech.de/en/products/braille-displays-and-note-takers/braille-keyboards
[2] G. Walker, "Touch Displays", *Handbook of Digital Imaging*, pp. 1-65, 2015, Wiley Online Library, 10.1002/9781118798706.hdi067
[3] Narjes Pourjafarian , Anusha Withana , Joseph A. Paradiso , Jürgen Steimle, Multi-Touch Kit: A Do-It-Yourself Technique for Capacitive Multi-Touch Sensing Using a Commodity Microcontroller, UIST ’19, October 20-23, 2019, New Orleans, LA, USA. Copyright is held by the author/owner(s). ACM ISBN 978-1-4503-6816-2/19/10. http://dx.doi.org/10.1145/3332165.3347895
[4] https://www.comsol.de/video/modeling-capacitive-and-resistive-devices-with-a-multiscale-approach

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3. Grayscale lithography for fabrication of 3D structures using negative photoresist with direct writing laser (DWL 66FS) device (

Negative resist?

Direct writing laser enables the maskless exposure of the CAD layout design on the wafers coated with photoresists. The laser intensity of the DWL device can be modulated to expose the photoresist with variable depth of exposures; thereby, enabling the grayscale exposure (3D) of the photoresists. This technique has been successfully investigated in case of positive photoresists (i.e. the exposed regions are dissolved in developer), however it is still vaguely investigated in case of negative photoresists (i.e. the exposed regions remain during the development). Therefore, in this thesis work, the applicability and feasibility of grayscale exposure of negative photoresist has to be investigated.

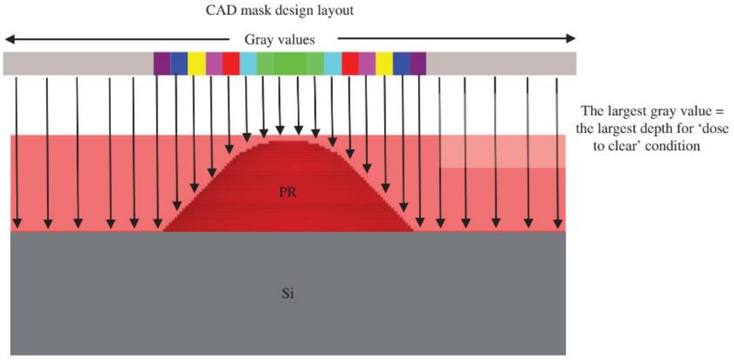

Figure 1: Schematic showing the concept of gray scale lithography using direct writing laser.

Schematic of grayscale lithography in case of positive photoresist, in case of negative photoresist the reversed is expected, the exposed region would remain during development and the unexposed photoresist would dissolve, so a microchannel is expected in the dark red region in the above schematic.

The tasks involved in the thesis work:

1. Literature study involving the grayscale lithography especially those with negative photoresists.
2. Training with the Heidelberg Instruments DWL66FS device (direct writing lithography device)
3. Selection of the negative photoresists
4. Design of the CAD layout
5. Test exposures and development
6. Characterization of the exposed photoresists
7. Documentation

Literature:

[1] F. Lima, I. Khazi, U. Mescheder, A. Tungal, U. Muthaih: Fabrication of 3D microstructures using grayscale lithography, Advanced Optical Technologies: vol:8, iss:3, 2019 (in Press)

[2] Isman Khazi, Ulrich Mescheder, Uma Muthaih: 3D free forms in c-Si via grayscale lithography and RIE, Microelectronic Engineering Volume 193, 5 June 2018, Pages 34-40

[3] Uma Muthiah, Isman Khazi, Ulrich Mescheder: 3D Structuring of Silicon using Grayscale Technology, Proceedings Mikrosystemtechnik Kongress, Munich 2017

[4] F. Lima, A. Tungal, I. Khazi, U. Mescheder: Galvanisch aus 3D-Fotolack-Strukturen abgeformte metallische 3DFreiformen, Proceedings Mikrosystemtechnik Kongress, Munich 2017

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4. Investigation of porous polydimethylsiloxane (PPDMS) for sensor applications

Polymeric membranes are widely used in various sensor applications. Porous materials offer a significantly larger surface area for sensor applications. In this work a simple and inexpensive method to produce porous polymeric structures and membranes is investigated. Porous PDMS (PPDMS) structures could be fabricated by printing or targeted removal of material from polydimethylsiloxane (PDMS). Sugar cubes can be used as template and filled with PDMS. The sugar can be selectively dissolved to produce porous PDMS Structures or membranes. In addition, the pores of the porous PDMS structure can be filled with conductive metals, such as Galinstan, to create a 3D sensor cube for resistive or capacitive sensor applications.

The tasks involved in the thesis work:

1. Literature study about the fabrication possibilities of the porous PDMS layer
2. Fabrication of porous PDMS layers and membranes using sugar template
3. Characterization of the porous PDMS layers and membranes
4. Surface functionalization of the porous 3D structures using Galinstan
5. Characterization of the 3D sensor cube or membrane for resistive or capacitive sensor applications
6. Documentation

Literature:

[1] F. Seokyong Song, Dahl-Young Khang, M. Joon Kim, Jeong-Eun Park, Hong H. Lee, Asymmetric porous thin film preparation by controlled solvent absorption using PDMS, Journal of Membrane Science 305 (2007) 5–12
[2] Lei Li, Zeyi Xiaob, Shujuan Tan, Liang Pu, Zhibing Zhang, Composite PDMS membrane with high flux for the separation of organics from water by pervaporation, Journal of Membrane Science 243 (2004) 177–187
[3] Marcin Juchniewicz, Dorota Stadnik, Krzysztof Biesiada, Andrzej Olszyna,
Michał Chudy, Zbigniew Brzózka, Artur Dybko, Porous crosslinked PDMS-microchannels coatings, Sensors and Actuators B 126 (2007) 68–72

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5. Creation of a model for testing wireless energy transmission

Introduction:
Active implants like pacemakers or cochlear implants are well established and widely spread in therapeutic medicine. A critical factor in the development of active implants is and has always been the energy supply and data transfer. While some implants with low energy demand use a fully implanted battery solution, this is not applicable for implants with higher energy demand. For those implants, energy transfer from outside the body to the implant must be accomplished to ensure a stable operation of the implant. While there are many reasons to use wireless energy and power transfer, strict regulations for energy transfer into the human body limit options and must be considered when designing an energy transfer system. The effects of energy transfer on surrounding biological tissue must be kept at a minimum and the feasibility of the energy transfer has to be studied and documented before an implant is approved and certified.
Aim:
In this project, the requirements for a medical implant are identified by a broad literature review. Based on the results of the literature review, a test setup for wireless energy transfer for medical implants is developed. The evaluation of implant feasibility for specific requirements (e.g. heating of tissue etc.) must be considered in the test setup.
Tasks:

- Literature research (requirements energy transfer into human body and already established models)
- Develop list of requirements for specific model
- Design model based on determined properties and requirements
- Manufacturing of designed model

Literature:
[1] Finkenzeller, K. (2010): RFID Handbook. Fundamentals and applications in contactless smart cards and identification cards, radio frequency identification and near-field communication. 3rd ed. Chichester, West Sussex: John Wiley & Sons.
[2] Nikita, Konstantina S. (Ed.) (2014): Handbook of biomedical telemetry. Institute of Electrical and Electronics Engineers. Hoboken New Jersey: John Wiley & Sons Inc.
[3] Sun, Tianjia; Xie, Xiang; Wang, Zhihua (2013): Wireless Power Transfer for Medical Microsystems. New York, NY: Springer.

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