1. MOTIVATION & INTRODUCTION

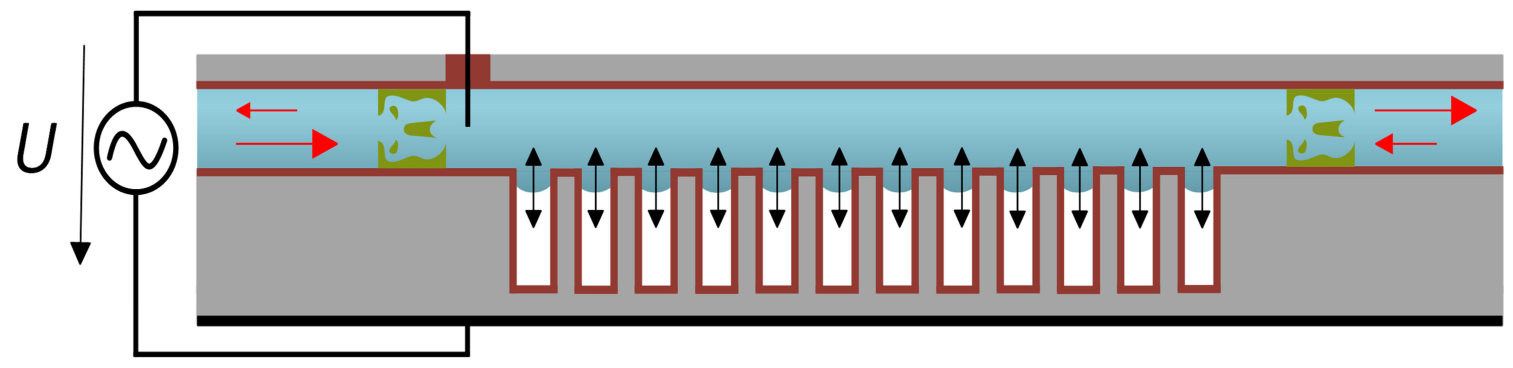


Fig. 1: Schematic view of the EWOD-driven micropump.

Micropumps have a **wide range of applications**, e.g., in medical technology, environmental analysis or lab-on-a-chip applications. In all these applications, **robust** and **easy-to-integrate** micropumps are desirable. The Electrowetting-On-Dielectrics-effect (**EWOD effect**) can be used to design a **micropump without any moving components,** which meets these requirements [1]. The project **objective** is the modelling, fabrication and characterization of this micropump.

Function principle:

A large number of **microcavities** are created within a silicon wafer. The surface of this cavities is **hydrophobized** to prevent the pumping liquid from entering the cavity. By applying an alternating voltage, the **wetting properties can be varied**, and thus, the liquid partially enters the cavities **periodically**. The resulting volume stroke can be rectified using **passive** microfluidic **Tesla valves.**

2. FABRICATION

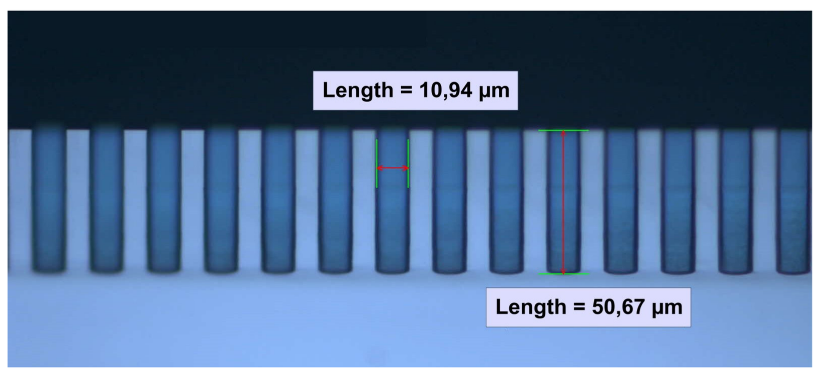


***Fig. 2:** Microcavities etched in a silicon substrate using DRIE.*

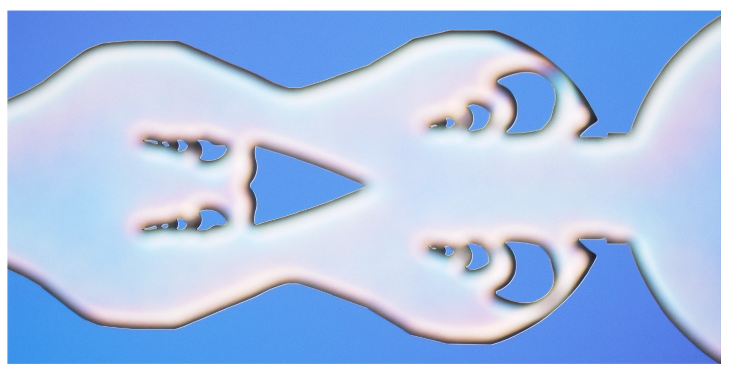


***Fig. 3:** Etched passive Tesla valve. The fluidic resistance differs strongly for the two flow directions.*

The manufacturing process is based on **conventional** fabrication methods of **microsystems technology (MEMS)**. This enables a cost-effective and sustainable production. The structures are etched utilizing an optimized **deep reactive ion etching** (**DRIE**) **process**. The **lid** contains the **pump chamber** as well as the **Tesla valves** and the **microcavities** are placed inside of the **base**. **The base and the lid** are bonded utilizing a dry-film resist**.** The **hydrophobization** of the cavities is done using **Teflon™** to prevent the liquid from entering in the cavities. [2]

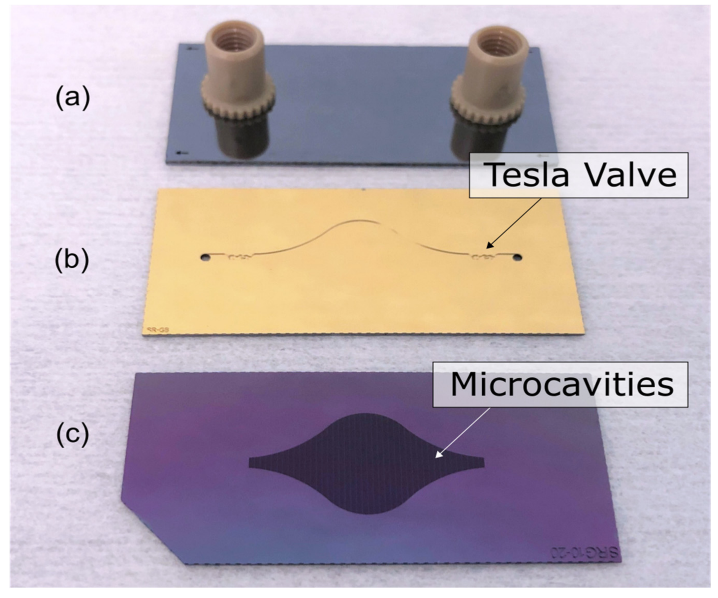
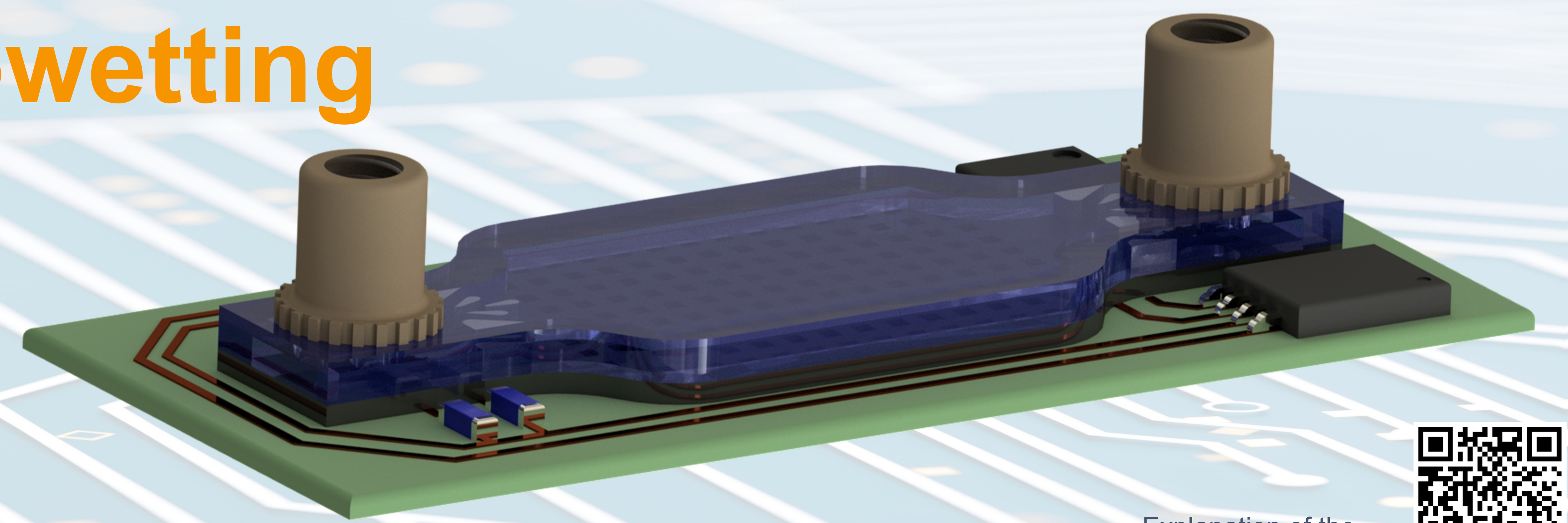


***Fig. 4:** (a) Fully assembled micropump; (b) Pump chamber and Tesla valves; (c) Base of the pump with microcavities*

E-PunCh – Electrowetting Pump On a Chip

Sebastian Bohm, Hai Binh Phi, Lars Dittrich, Erich Runge



Explanation of the micropump in a video:

3. SIMULATIONS

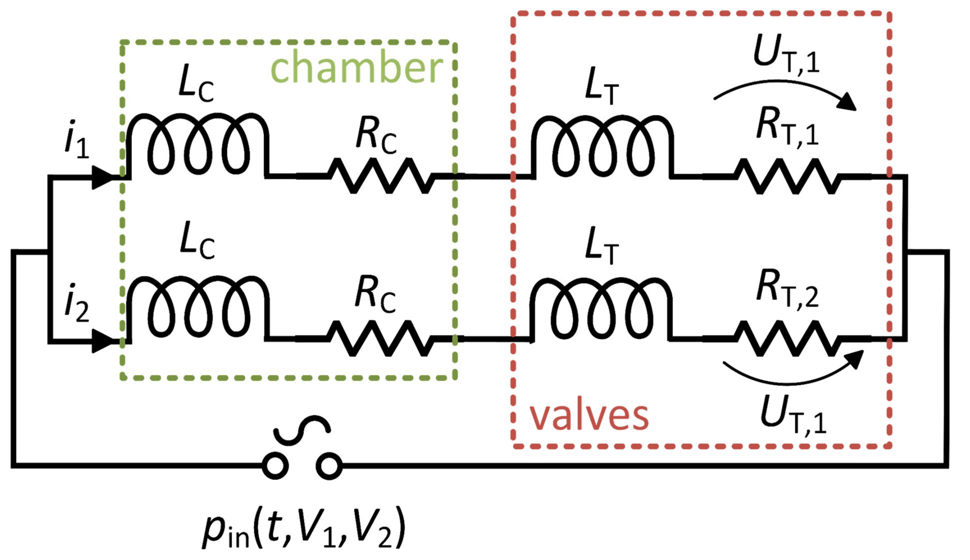


***Fig. 4:** Fluidic equivalent circuit model of the micropump.*

The description of the micropump is done with the help of a **fluidic equivalent circuit model**. The result is an **efficient** and **straightforward** calculation [3]. In addition, this simulation method allows the pump design to be **adapted** to the **target application.**

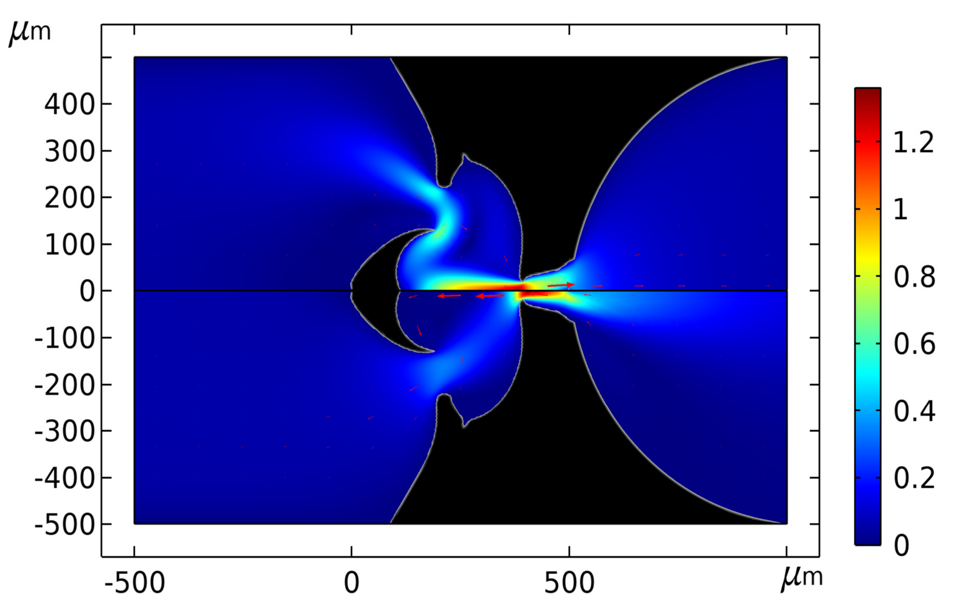


***Fig. 5:** Calculated material distribution together with the flow profiles during the optimization.*

One particular challenge is the design of efficient valve geometries. To find nearly optimal geometries of the Tesla valves, a self-developed **topological optimization** algorithm is used. This optimization algorithm finds **near-optimal** valve geometries **by itself,** leading to very efficient valve designs.

4. CHARACTERIZATIONS

Characterization involves the fluidic measurement of the **pump** and **valve performance**. The Valve performance is determined by the flow rate-dependent **diodicity (pressure difference ratio)** and the pump performance is determined by a **frequency-** and **voltage-dependent flow rate.** Two **measuring setups** were developed for the **characterization**. [4]

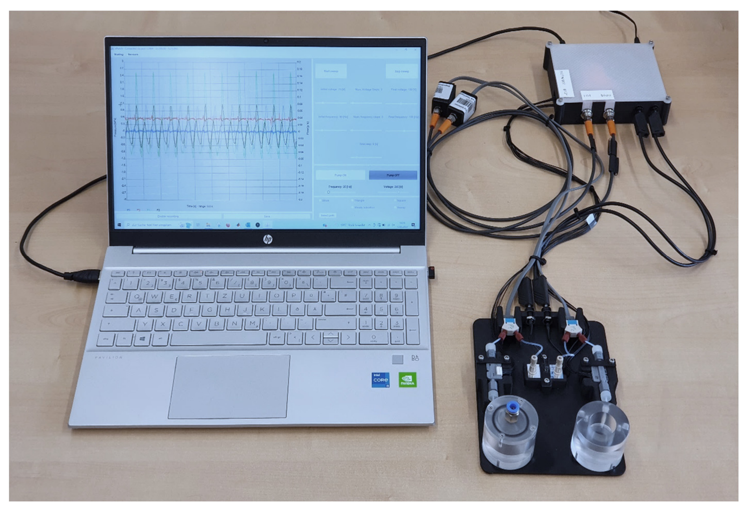


***Fig. 6:** Experimental setup for the measurement of the pump performance.*

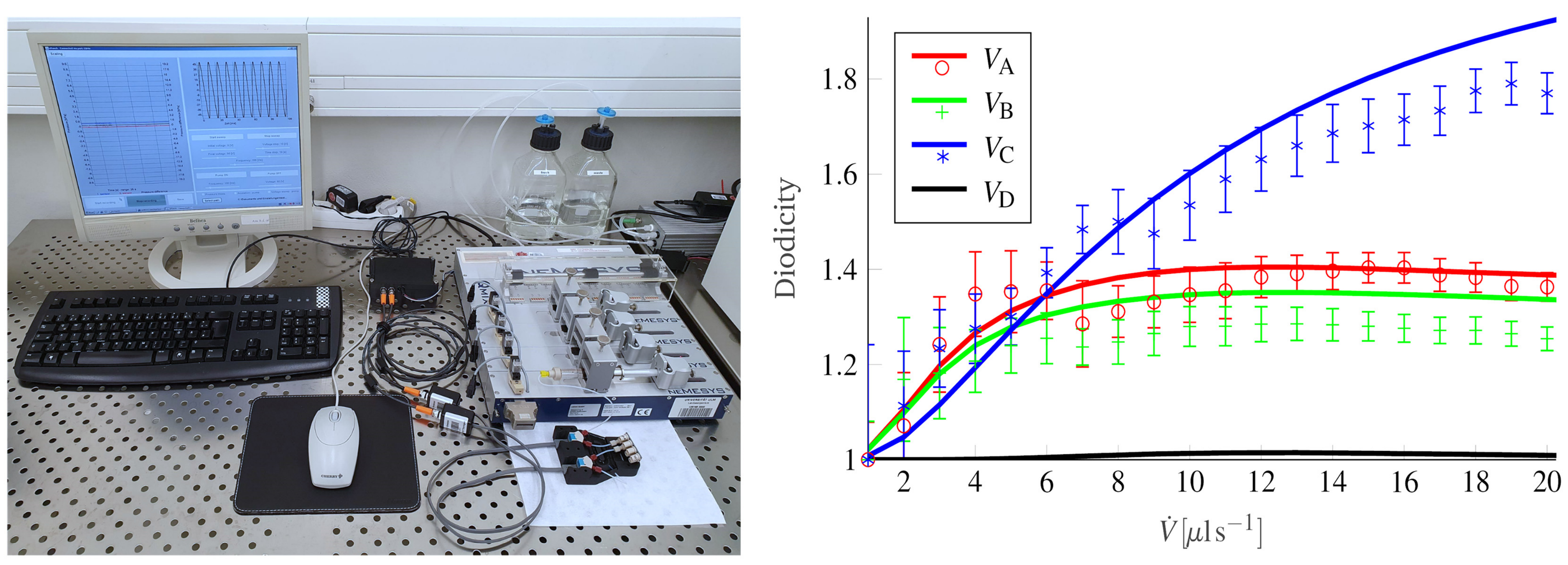


***Fig. 7:** (left) Experimental setup for the measurement of the performance of a Tesla valve. (right) Comparison between the measured and simulated diodicities (higher is better). Black curve shows performance of a state-of-the-art valve.*

References:

[1] Hoffmann, M., Dittrich, L., Bertko, M., Mikropumpe zur Erzeugung einer Fluidströmung, patent DE 11 2011 104 467 B4 (2012)

[2] Phi, H. B., Bohm, S., Runge, E., Strehle S., Dittrich, L., Wafer-level fabrication of an EWOD-driven micropump, MST-Kongress, Ludwigsburg (2021)

[3] Bohm, S., Dittrich, L., Runge, E., Three-dimensional time resolved fluid mechanics simulation of an EWOD-driven micropump, COMSOL Conference Europe (2020)

[4] Bohm, S., Dittrich, L., Runge, E., Modellierung, Fertigung und Erprobung einer neuartigen EWOD betriebenen Mikropumpe, MST-Kongress, Berlin (2019)

Contact:
Sebastian Bohm
sebastian.bohm@tu-ilmenau.de
Fachgebiet Theoretische Physik I
Technische Universität Ilmenau
www.tu-ilmenau.de

Please vote for the poster online!

For more information visit:

Funding:
ZIM Zentrales Innovationsprogramm Mittelstand
Gefördert durch: Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages

Project partners: KOMPASS PIONEERING SENSOR SOLUTIONS; 5microns microsystem professionals