Department of Applied Sciences
Course of study Biochemical Engineering, M.Sc.

TECHNISCHE HOCHSCHULE LÜBECK

Abstract of the Master Thesis

„Simulation and manufacturing of microfluidic channels for optical blood analysis“

The mobOx POCT device enables blood gas analysis through optical and chemical measurement. mobOx needs an evenly and fast filling microfluidic testchip, that works under harsh conditions like temperature deviation. The mobOx device needs a cheap and disposable Lab-on-a-chip microfluidic device, which is inserted through a slot in the front. Microfluidic devices transport very small amounts of liquid, resulting in cost efficient and portable blood testing devices. Blood in the testchip is driven by a passive pump principle, due to its simplicity.

In this thesis a temperature testing device is designed, manufactured, and programmed. The manufacturing process was optimized during prelimenary tests, where an assembly guide and merging device were manufactured. The temperature testing device was used to test two designs between 10°C and 40°C where the best filling time was 29 s at 40°C with a blood HCT of 0.6. A mathematical analysis using the electric circuit analogy was carried out, where the blood viscosity was modeled with vicosity-curve fitting methods using literature data. The experimentation revealed that the shear-rate within the testchip must be below <1 s^{-1} because the filling time increased by reducing the temperature, indicating a predominant effect of blood viscosity onto the flow time. The contact angle between PVOH and PMMA was determined using a digital microscope. According to the calculation, a microchannel width <1 mm increases velocity per microchannel exponentially, thus a multichannel testchip design was simulated against a single channel design. The simulation was carried out in Ansys Fluent using the VOF model, having blood as a non-Newtonian fluid and air as a Newtonian fluid. The simulation revealed that the multichannel design had a high pressure drop in the measurement window, leading to a flow stop. The calculation revealed that the multichannel designs filling time improves by around 5 % opposing to the single channel design. This effect was caused by the exponential increase in hydrodynamic resistance R_h by the length L and the reduced width w of the microchannel. During preliminary experimentation, multichannel designs with a microchannel <1 mm performed poorly, having blocked channels and poor filling time. Incorporating manufacturing cost, a single microchannel design is recommended, having a plausible filling time below 15 s under an operating temperature above 30 °C.

Author:	Karan Iqbal Singh Grewal
First Assessor:	Prof. Dr. Stefan Müller
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