Concept development and prototyping of a flow cell for blood preparation with acoustophoresis

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Introduction

- Light scattering affects the concentration determination of dissolved blood components by absorption spectroscopy.
- Acoustophoresis is investigated to separate blood plasma and blood cells.
- A flow cell was designed and manufactured to analyze the separation process with acoustophoresis.

Theory

- Acoustophoresis utilises the different acoustic properties of blood cells, fluids and flow cell materials.
- Straight and plane channel walls are needed for good acoustic reflection.
- A high acoustic impedance of the flow cell material is necessary to achieve a standing acoustic wave inside the flow channel.
- Acoustic Radiation Force (ARF) causes movement of particles depending on their acoustic density in an acoustic standing wave.
- Glass accomplishes all specifications like acoustic impedance and optical transparency.

Tab. 1 – Density, speed of sound and characteristic acoustic impedance of selected materials [1]

	Density/ kg m^{-3}	Speed of sound/ m s^{-1}	Characteristic acoustic impedance/ 10^6 kg m^{-2} s
Silicon	2331	8490	19.79
Steel – stainless 347	7890	5790	45.68
Aluminium	2700	6420	17.33
Borosilicate glass	2230	5647	12.59
Polymethyl methacrylate (PMMA)	1150	2590	2.98
H_2O (25°C)	997	1497	1.49

Design

- Dimensions of the main channel are 1 mm width and 1 mm hight for accurate acoustic standing waves with a frequency of 1.6 MHz.
- Channel structure needs to be divided into three sections for separation of blood plasma and cells.
- Main channel is divided into one channel in the middle with a width of 500 µm and two channels with a width of 250 µm.
- Inlet on the bottom and outlet on top of flow cell to avoid air bubbles.

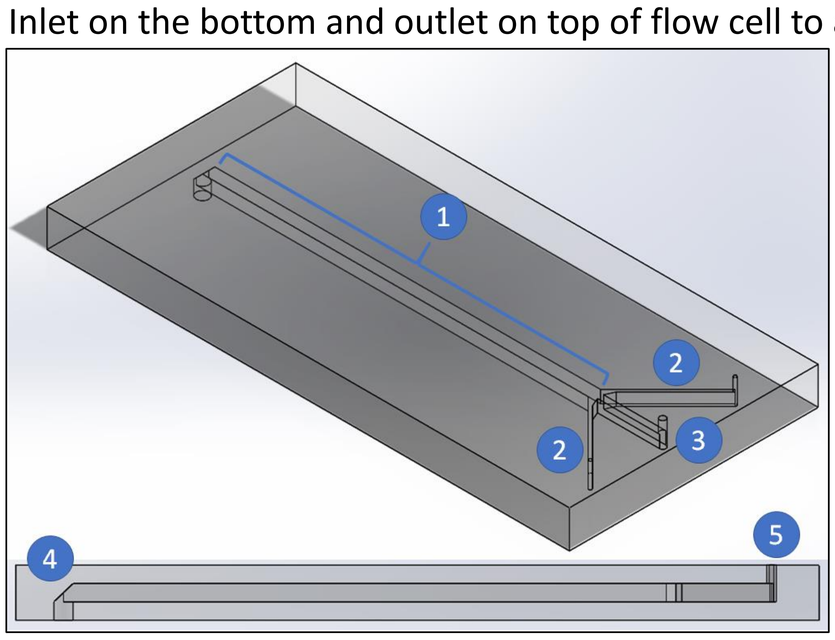

Fig. 1 – Design of flow cell; Isometric View: 1 main channel, 2 side channels, 3 middle channel outlet
Front view: 4 inlet on bottom, 5 outlets on top

Results

- Selective Laser-induced Etching (SLE) was used as manufacturing process for the flow cell.
- Flow cell was built out of quartz glass EN08 for optical transparency and high acoustic impedance.
- Secondary advantages of glass are biocompatibility and mechanical stability.
- Channel walls have a maximum deviation of the width by ± 9 µm in the main channel.

Outlook

- Blood flow characteristics and separation efficiency during acoustophoresis should be further investigated with shown flow cell.

Flow Cell

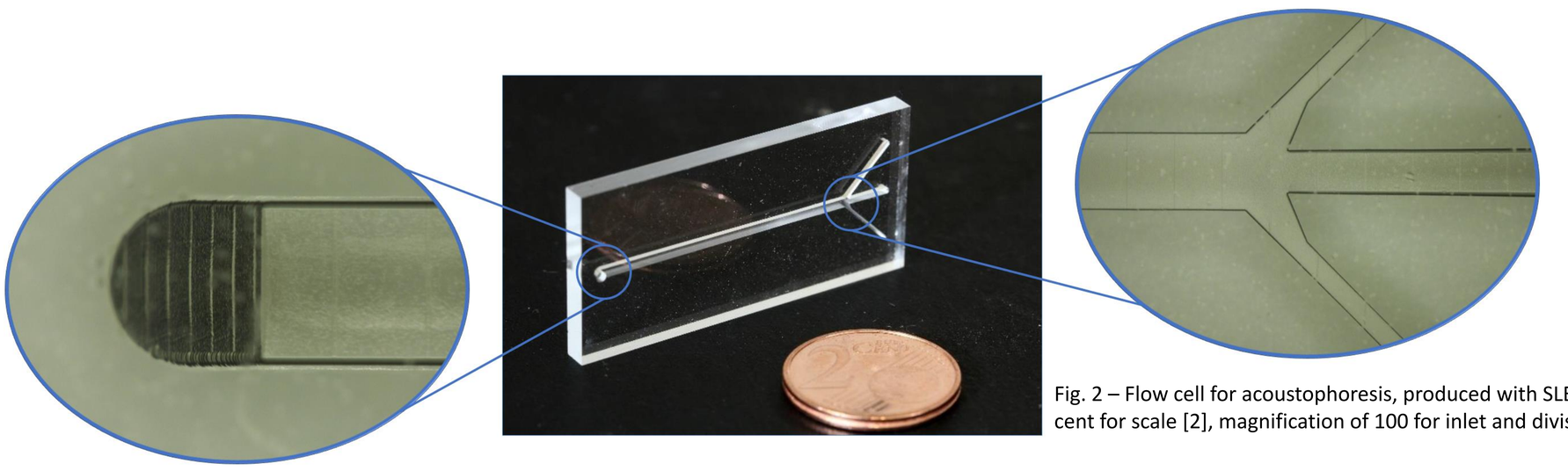

Fig. 2 – Flow cell for acoustophoresis, produced with SLE with two Euro cent for scale [2], magnification of 100 for inlet and division section.

References

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