Microfluidic system with integrated electrodes

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The field of microfluidics includes the handling, manipulation and detection of small volumes of liquids. In this work, a PDMS-based microfluidic system with integrated Au-microelectrodes was designed, manufactured and tested. The demonstrator has been used to analyze the mixing behaviour of two liquids and the flow speed by impedance spectroscopy.

Motivation

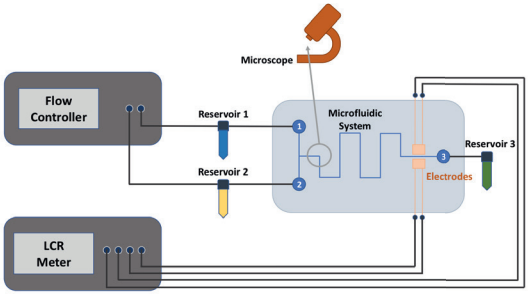
Microfluidics is a rather recent and promising branch of microsystems technology. One application field, for example, is biomedical engineering. The goal of this work is to build, as demonstrator, a multilayer PDMS-based micro-mixer with integrated Au-electrodes for analysis of liquid properties by impedance spectroscopy.

Approach

During a preliminary study, several designs for a passive micromixer have been evaluated. For manufacturing the microfluidic devices, established manufacturing processes based on UV-lithography and wet chemistry were used under clean room conditions. Figure 1 shows the experimental setup, including the actual microsystem, flow controller for the transport of the liquids and an LCR meter for impedance spectroscopy. Mixing behaviour has been evaluated by using ink-colored water and inspection by an optical microscope. As test liquids for impedance spectroscopy, citric acids with different concentrations have been used.

Experimental details

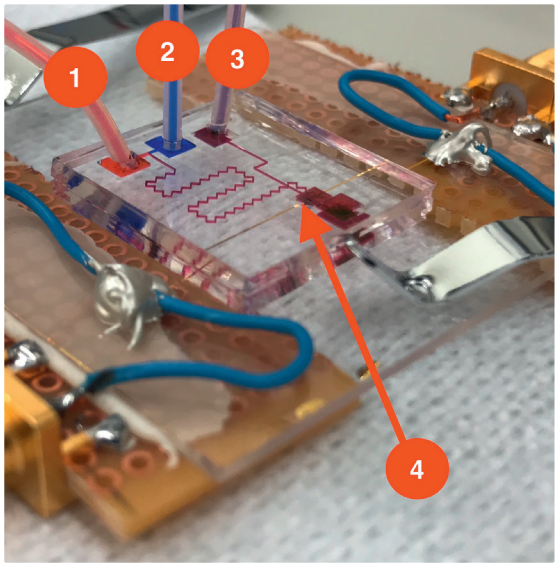
The flow controller is equipped with a PID controller, whose parameter values were optimized before the measurements, so that the flow rate does not deviate by more than ± 5 µL/min. The developed demonstrator shown in figure 2, is built up by two PDMS layers and is bonded on a glass substrate with Au microelectrodes. It has two inlets and one outlet for the liquids. The layers have been designed modularly, such that single layers can be easily used to build-up more complex systems with more than two layers. The impedance spectroscopy measurements were recorded and evaluated in Matlab.



Setup of the whole system

Results and Outlook

A two-layer microfluidic system was manufactured and tested. Optimal channel geometries, widths and lengths for efficient mixing could be successfully established. As one result of the experiments, it was determined that channel widths < 130 µm are not suited for a stable and reproducible flow behaviour. Additional experiments have shown that the mixing behaviour and the flow velocity can be measured by impedance spectroscopy. For further research it would be interesting to evaluate, whether the metallic electrodes could be replaced, using the conductive polymer PEDOT:PSS and if the same measurement precision can be achieved.



Two-Layer microfluidic system demonstrator, (1) & (2) Fluid Inlets, (3) Fluid Outlet, (4) Au Electrodes

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