Introduction

This presentation deals with the design and first results obtained with dedicated chip-based devices for rapid mixing of solutions for the study of chemical reactions and the electrochemical separation of mixtures using mid-IR synchrotron radiation. The developed micromixer allows highly reproducible and fast mixing of two or three liquids in micro-channels. Due to the small overall dimensions of the channels (10-15 µm) the diffusion distance is short which results in fast diffusion based mixing. Following the equation HO=CTE, it is required for complete mixing. L, characteristic diffusion length, D, Diffusion constant) reduction of L, as made possible by the chip design and the use of synchronisation (small measuring spot) allows to increase the time resolution to a maximum. The chemical reactions can then be followed off-chip in real time. A second advantage resulting from the miniaturisation is the reduction of sample volume required for measurement. The combination of the small measuring spot with the chip design makes this development a promising tool for the study of many different biochemical systems.

Furthermore, we introduce infrared spectrometry as a novel molecule specific detection technique in chip based capillary electrophoresis (CE). A CE microchip with mid-IR detection has been designed which allows to separate mixtures of inorganic species or proteins with high resolution and sensitivity. 

Adhesive wafer bonding with SU-8

SU-8 has been used for wafer bonding by different groups, for full-wafer bonding as well as for bonding between SU-8 structures to form closed cavities [5]. Because of the fact that SU-8 is not fully crosslinked after UV exposure and post-exposure bake, a bond can be formed between corresponding SU-8 structures or between SU-8 structures and other materials. If the two wafers are pressed against each other and a stream of was introduced in the central inlet and the other two inlets were used for the introduction of . The initial flow rate was a stream of was introduced in the central inlet and the other two inlets were used for the introduction of . The initial flow rate was

Three streams of liquid are injected by means of a syringe pump. These streams merge in the mixing point and the reactants are mixed by horizontal diffusion while the chemical reaction takes place. This reaction is investigated by time resolved FTIR-spectroscopy.

Micromixer for FTIR-spectroscopy

The mixing device is used for the investigation of chemical reactions by time resolved FTIR-spectroscopy [1, 2]. It combines an IR-transparent flow-through-cell with in-situ mixing of two reactants, i.e. the IR-beam passes directly the mixing chamber.

Improved bonding method

This improved waferbonding method combines exposed (hard) and unexposed (soft) SU-8. The latter is thermoplastic and even flows and closes gaps due to capillary forces. At temperatures above 120 °C it is crosslinked. Consequently one can say that unexposed SU-8 behaves similar to thermally curing epoxy adhesive.

Preparation of the wafer

View of the SU8 wafer ready for bonding

Bondeing procedure

1. Alignment of the wafers
2. The channel of the wafer is evacuated
3. The wafers are brought into contact and a contact force is applied
4. The temperature of the top and bottom heaters is ramped up to 150 °C with 5 °C / min
5. The temperature of 150 °C is maintained for one hour
6. The temperature of the top and bottom heaters is ramped down to room temperature

Experimental setup

The performance of the cell was tested by filling it with H2O (green) and D2O (blue) successively. Spectra were recorded using a 20 µm aperture in the same plane in the mixer channel.

- H2O - D2O Proton Exchange
- Preliminary results of the monitoring of the proton exchange reaction that takes place between H2O and D2O. For the experiment, a stream of H2O was introduced in the central inlet and the other two were used for the introduction of D2O. The initial flow rate was set at 10 µL/min and then the flow was stopped and spectra corresponding to the formation of HDO were recorded.

Synchrotron IR Monitoring of Chemical Events in Microfluidic Devices

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CE on a chip

The advantages of CE are even more pronounced when CE on a chip is used, where the separation is achieved directly in the chip. Especially the separations are much faster so a high sample throughput can be achieved. The use of FT-IR as a detection limit in CE [4] on a chip allows to detect specific molecular features like the secondary structure of a protein and is therefore a suitable complementary method to standard detection methods.

Experimental setup

Picture of the CE chip with all connections (standard FIA connectors) and the two electrodes (left and right in the form).

Protein mobility in a CaF2 CE chip

3-D plot of myoglobin, with the amide I band (1649 cm-1), indicating that the protein has an alpha structure. The peak broad around 1460 cm-1 corresponds to the amide II band (N-H) and the increasing HDO absorption due to the proton exchange that takes place with the medium (D2O) during the separation process.

Protein identification

Comparison between ATR spectrum and the spectrum obtained with the chip confirming the right identification of the protein and the equality of both methods.

References


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