

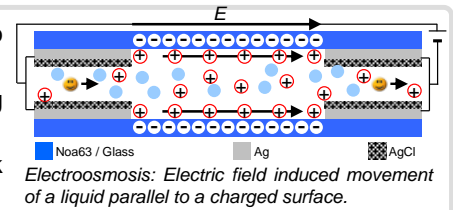
# Deposition and Structuring of Ag/AgCl Electrodes inside a closed Polymeric Microfluidic System for Electroosmotic Pumping

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## Introduction

- In microfluidics, electroosmotic (eo) pumps provide a unique solution to electrically propel liquids
- Ag/AgCl electrodes: during pumping the electrochemical reaction transforms Ag into AgCl and v.v. rather than creating electrolyzed gas bubbles
- Polymer vacuum casting & electroless Ag/AgCl flow deposition provides a quick & cheap alternative to standard silicon micromachining

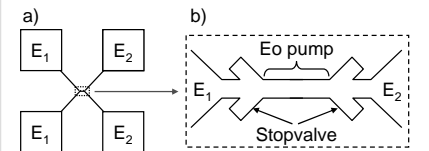


## Experiments and Results

### Design

#### Layout $\mu$ -fluidic system

- Focus on a better understanding of the fabrication process & eo pump actuation



Layout of the a) symmetric  $\mu$ -fluidic system and b) detail of the eo pump and the electrodes ( $E_1$  &  $E_2$ ) including stopvalves for microfluidic structuring

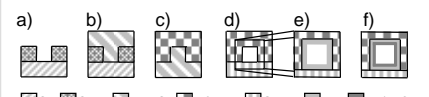
### Processflow

#### Polymer casting of $\mu$ -fluidic system<sup>1</sup>

- SU8: high resist thickness ➔ a)
- PDMS: no stiction to SU8 & NOA63 ➔ b)
- NOA63: hydrophilic  $\mu$ -fluidic system ➔ c)
- Glass: fluorescent microscopy ➔ d)

#### Electroless Ag/AgCl flow deposition

- Ag: Tollens' solution ➔ e)
- Structuring: microfluidic stopvalves ➔ e)
- AgCl: sodium hypochloride ➔ f)

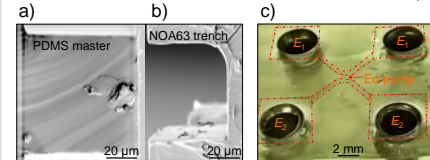


Processflow: a) - c) polymer casting, d) glass capping and e), f) electroless electrode deposition.

### Fabrication Results

#### Polymer vacuum casting

- Good transfer of shape ➔ a), b)
- Cross-section ( $55 \mu\text{m} \times 65 \mu\text{m}$ ) ➔ b)
- Facilitated electrical & fluidical connection with Cord End terminals ➔ c)



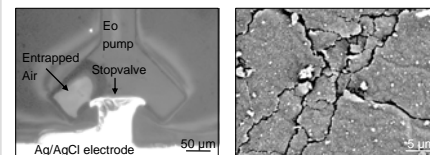
SEM image of the casted a) PDMS master and b) NOA63 trench. c) OM image of the complete microfluidic system with Cord End terminals.

#### Electroless flow deposition

- Improved process & deposition control
- Deposition of thick electrodes

#### Ag/AgCl electrode

- Successful deposition & structuring ➔ a)
- To avoid cracks, limit AgCl transformation to 20% of initial Ag layer thickness ➔ b)

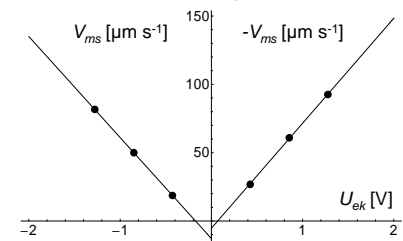


a) OM image of filled eo pump and the deposited & structured Ag/AgCl electrode. b) SEM image of stress induced AgCl electrode cracking.

### Electroosmotic pumping

#### Flow measurement

- Solution: 10 mmol KCl, pH 10
- Fluorescently labeled microspheres
- Microsphere speed  $v_{ms}$  measurement



Average microsphere speed  $v_{ms}$  measured within the eo pump as a function of the voltage  $U_{ek}$  drop over the eo pump.

#### Electrokinetic microsphere velocity

- Electrophoretic<sup>2</sup>:  $-108 \mu\text{m s}^{-1} \text{V}^{-1}$
- Electroosmotic:  $39 \mu\text{m s}^{-1} \text{V}^{-1}$

#### Electroosmotic pump rate:

**$0.12 \text{ nl s}^{-1} \text{V}^{-1}$**

#### Additional observations

- Similar slope for negative and positive applied voltages
- Slight voltage offset of 0.12 V for eo pumping
- Hydrostatic induced velocity  $7 \mu\text{m s}^{-1}$  equals filling level difference of  $6 \mu\text{m}$

## Summary

#### Polymeric $\mu$ -fluidic system with integrated Ag AgCl electrodes

- Vacuum casting, hydrophilic capillary, cross-section ( $55 \mu\text{m} \times 65 \mu\text{m}$ )
- Flow electroless deposition and microfluidic stopvalve structuring

#### Electroosmotic pump

- Pump rate:  $0.12 \text{ nl s}^{-1} \text{V}^{-1}$  at low actuation voltages -2 V to 2 V

## Acknowledgements / References

#### Support in fabrication and funding

- Dimes Cleanroom facilities, Delft University of Technology
- DCMM, Delft Centre for Mechatronics and Microsystems

<sup>1</sup>Dupont et al., 2010, *Microelectronic Engineering*, **87**.

<sup>2</sup>Behrens et al., 2000, *Langmuir*, **16**.

