ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Fabrication of polymer micro-devices based on organic sacrificial pastes

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Outline

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- Introduction
- Process
- Formulation of the sacrificial paste
- Applications: microfluidics
- Conclusion

Introduction

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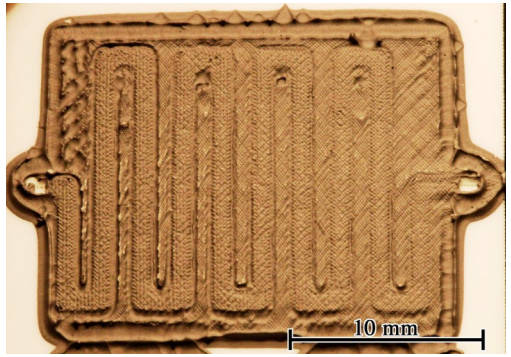
- Fabrication of polymer fluidic and mechanical devices

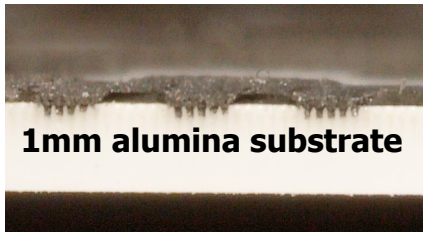
→ **biocompatibility**

- Structures defined by sacrificial pastes based on evaporable compounds

→ **formulation** of the pastes



Microchannels covered with silicone-graphite



Cross-section of microchannels

Process: principle

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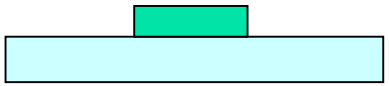
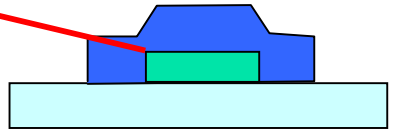
1) screen-printing of the sacrificial paste

Viscosity

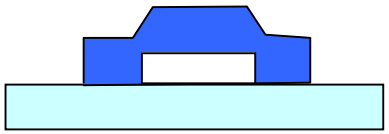


2) overprinting with ethyl-cellulose or silicone resin

Potential interactions between
sacrificial material and overlayer



3) sublimation of sacrificial layer at 150°C



Process: requirements and solutions

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- **Viscosity**: high importance regarding screen-printing process
  - Use of solvents mixes based on cyclohexanol (easily evaporable compound with high viscosity)
- Processable pastes -> **homogeneity**
  - Dissolution of plastic crystals followed by precipitation and cooling under agitation-> fine-grained suspensions
- **Drying** properly (well-defined structures) at moderate temperatures (<100°C)
  - Adapted solvent mixes

Formulation of the sacrificial paste

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- Investigation focused here on polyols

Code	CAS	Name	Source	M.P. [°C]	B.P [°C]
NPG	126-30-7	Neopentyl glycol	Sigma-Aldrich	130	207
TME	77-85-0	Trimethylolethane	Sigma-Aldrich	200	293
DMHD	110-03-2	2,5-dimethyl-2,5 hexanediol	Sigma-Aldrich	86	214

-> Solid at room temperature, good sublimation ability

Formulation of the sacrificial paste

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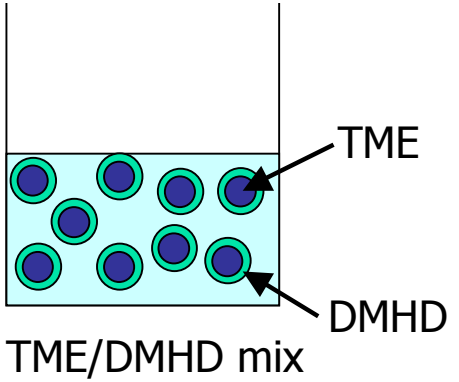
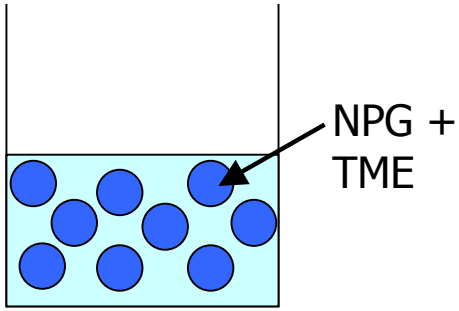
- Components:
  - TME/DMHD mix
  - TME/NPG mix
- Roles:
  - TME = sublimable material
    - Suspension
  - DMHD/NPG = « waxy binders »
    - Dissolved in solvent
- Suitable solvent mixes
  - Base = cyclohexanol

→ **creamy paste**



TME/DMHD mix



TME/NPG mix

Application: microfluidics

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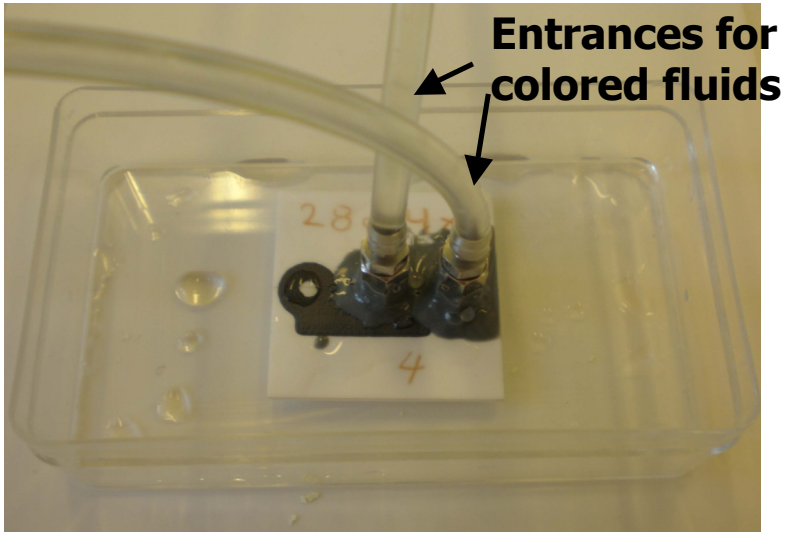
Mixing circuit



Application: microfluidics

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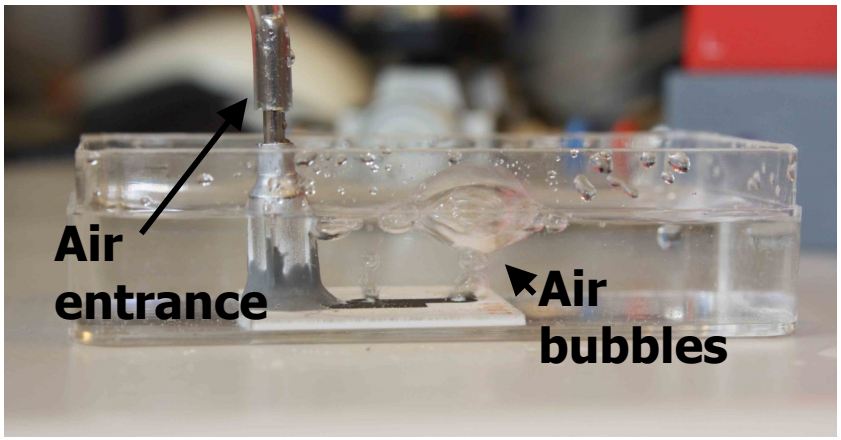

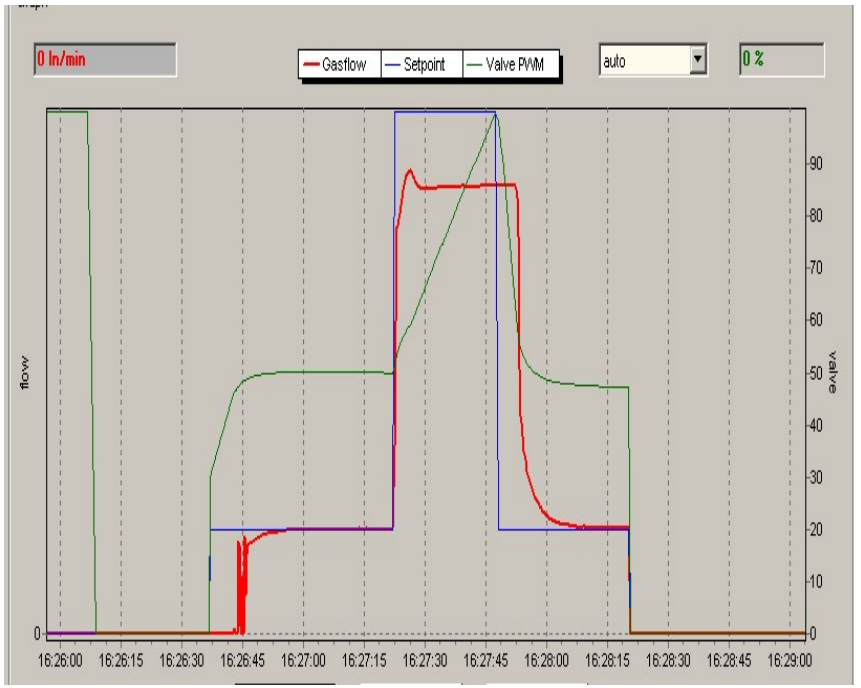

- Flowmeter plugged to the microfluidic circuit
- Air circulates through the device

Flow in the circuit

- Flow setpoint
- Actual flow
- Valve opening

Conclusions & outlook

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- Optimisation of formulation of polyol-based sacrificial layers
- Successful manufacturing of small devices

- Incorporation of amine groups for stability reason
  - complex NPG/2-amino,2-methyl-1,3-propanediol (AMPD)

  → stabilise "plastic" high-temperature cubic phase
  - Substitution of cyclohexanol by 2-amino-2-methyl-1-propanol (AMP)

  → "reactive" solvent, compatible with plastic phase