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Microfabrication group in 2004

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Research themes in microfabrication

- Silicon, glass and polymer processing
  - Etching (wet, plasma, electrochemical)
  - Bonding (anodic, adhesive)
  - Thin films (Pt, DLC, ECD, LPD, SOG,…)

- Fluidic, thermal and chemical applications

Microfluidic benefits

Small devices are faster

==>reduced analysis time

==>thermal speed superior

New possibilities arise at small scales

==>surface tension and electrical forces can be beneficially used

==>high sensitivity at low flow rate

Microfabrication precision

==>new nozzle designs

Microfabrication economics

==>disposable chips, ease of operation, less contamination

==>reusable chips, cheap compared with macroscopic counterparts

Reduced sample amounts required

==>new possibilities in bioanalysis

Different functions can be integrated

==> fewer analytical steps

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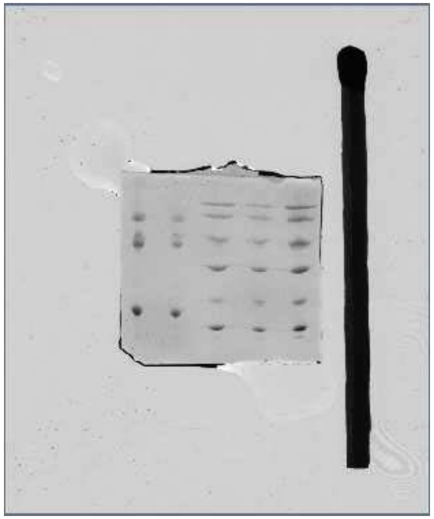
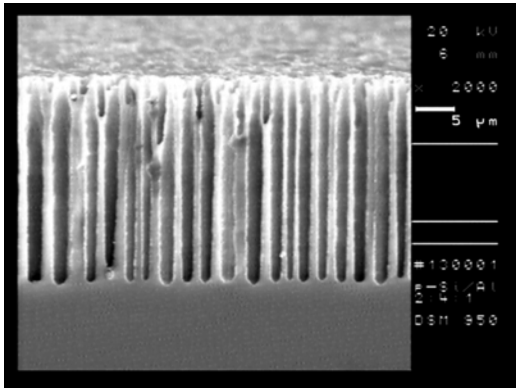
Miniturized protein chip

- milli- and microfabrication
- two separation steps on one chip
- separation in 30 minutes vs. 24 hours in macrosystem



Porous silicon membranes

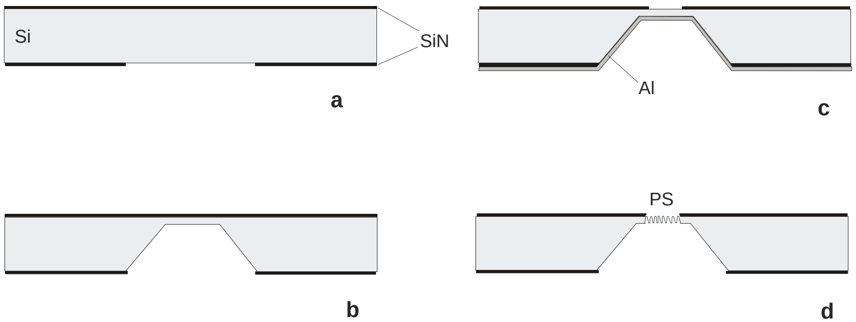
Filtration of microbeads in biomedical samples.



Integrated, on-chip micromembranes

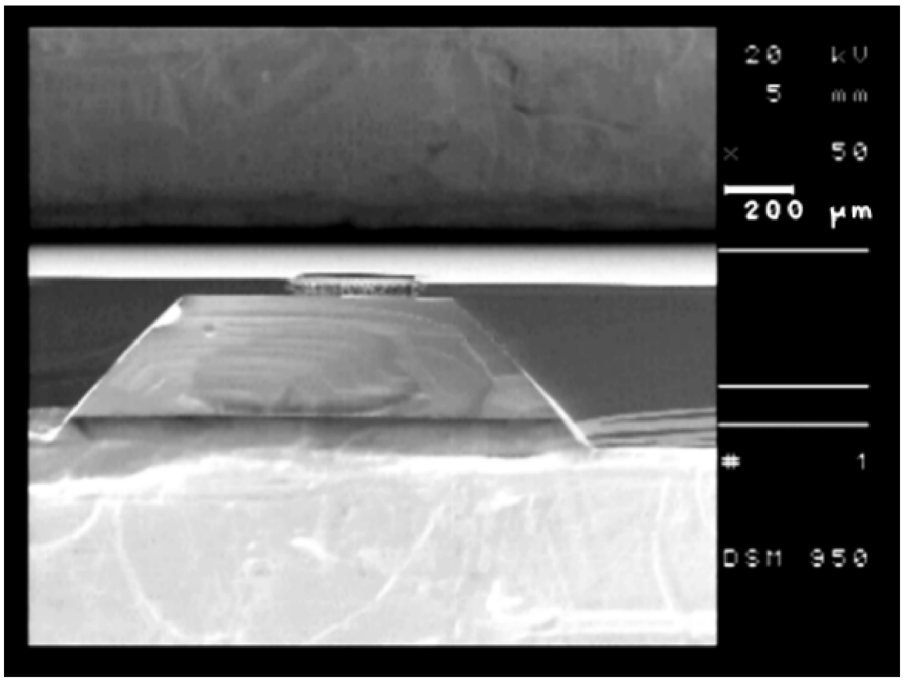
Electrochemical etching – adjustable pore size

- Lithography
- Back-side etching in TMAH
- Porous layer formation in HF: DMSO



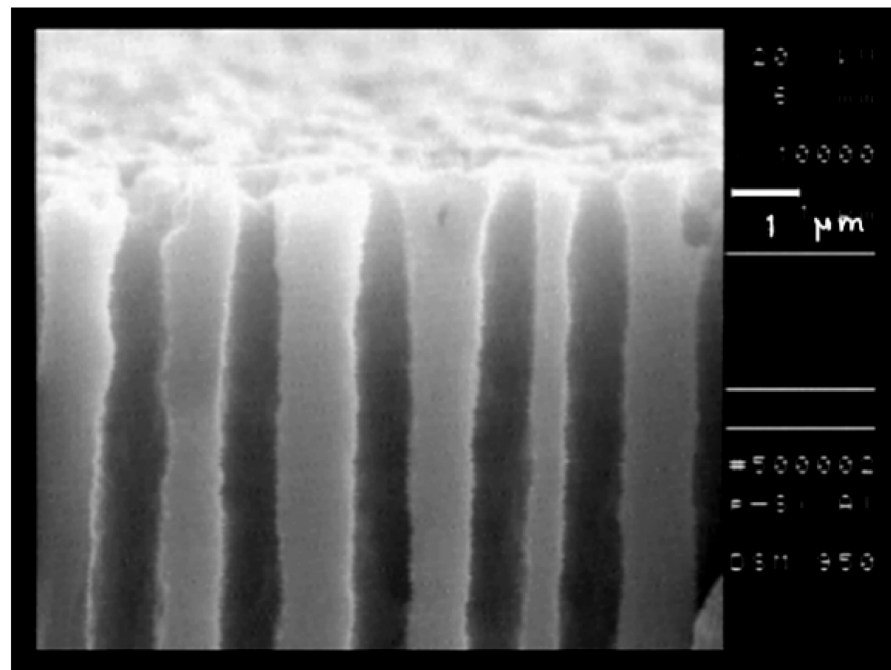
K.Grigoras, S. Franssila, T. Sikanen, T. Kotiaho, R. Kostiainen, **Phys.stat.sol.(c),** 002, 2004

Porous silicon membranes



40 µm thick porous membrane

macropore cross-section < 1 µm



K.Grigoras, S. Franssila, T. Sikanen, T. Kotiaho, R. Kostiainen, **Phys.stat.sol.(c),** 002, 2004

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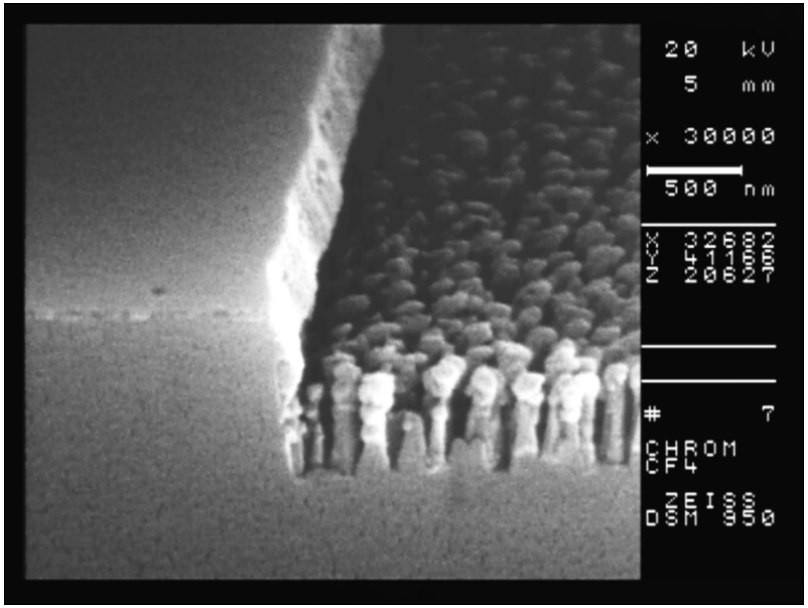
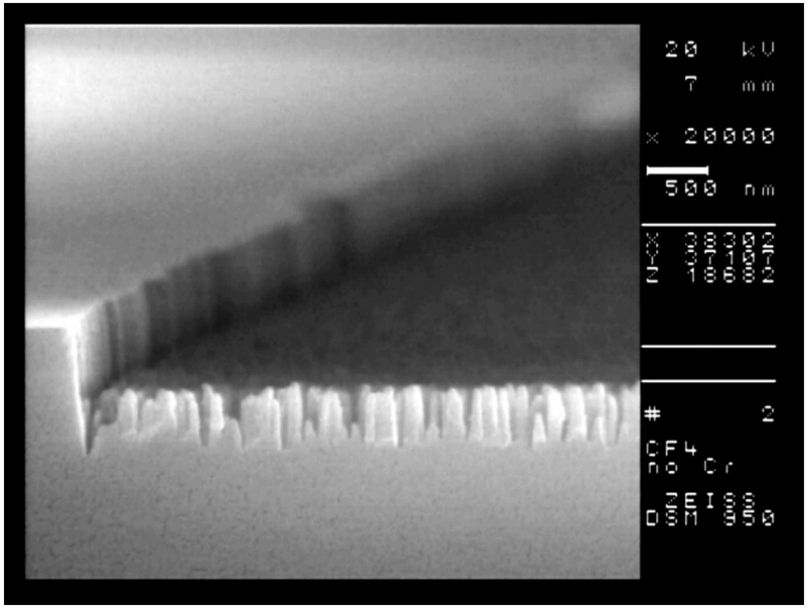
Formation of nanoporous glass





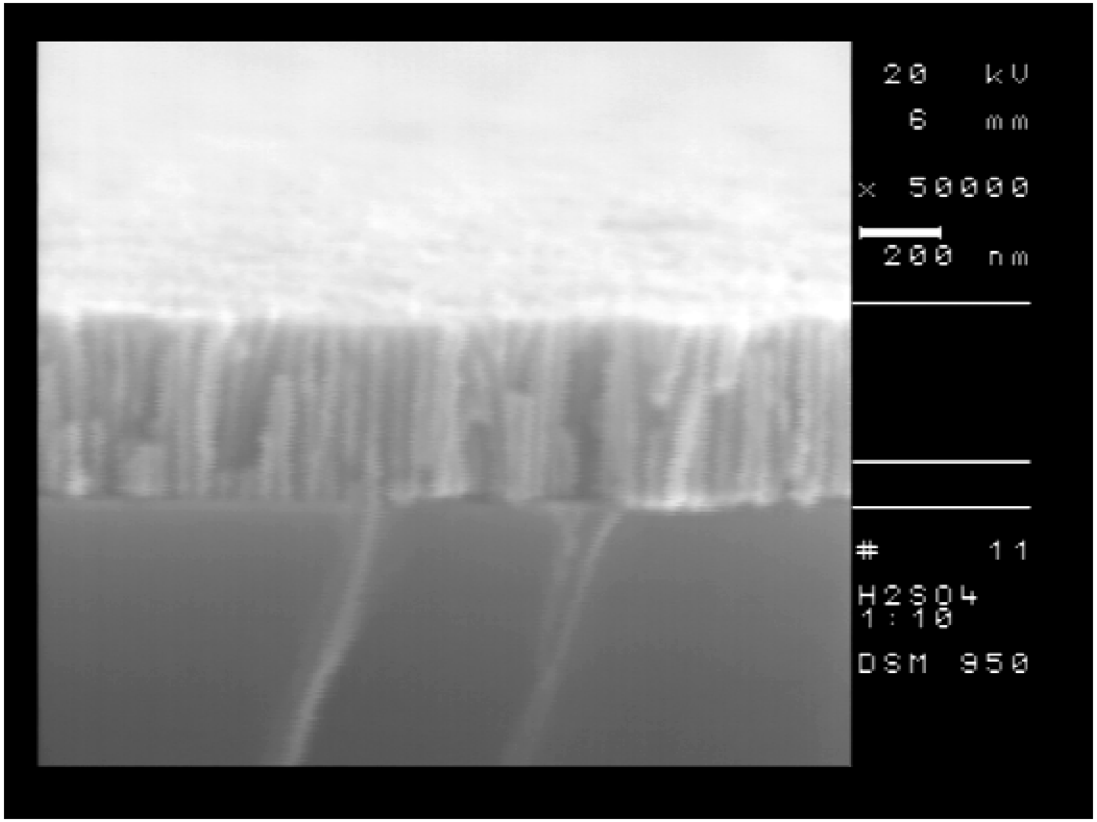
Plasma etching of pyrex glass in CF_4/Ar gases

pillars of 500 nm high and 60—120 nm in cross-section

K.Grigoras and S. Franssila, **Physica Scripta**, 2004

Formation of nanoporous alumina by electrochemical etching

- uniform pore distribution
- pore size: 50 nm
- application as a fluidic filter or as etching mask



K.Grigoras, MEK TKK, 2004

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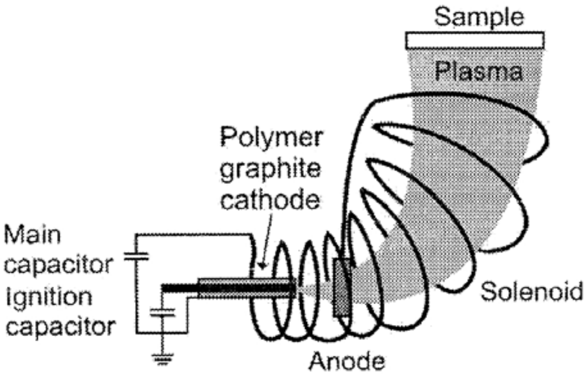
Diamond-like carbon, DLC

- DLC deposited at University of Helsinki
- Filtered Pulsed Arc Deposition FPAD
- room temperature deposition
- 85% sp^3 hybridized, 80 GPa hardness
- thick layers (up to 100 μm)



M. Kiuru, E. Alakoski, Materials Letters, 58, (2004), 2213-2216

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DLC-PDMS-h material properties

- Diamond surface properties:
  - scratch resistance
  - hydrophobic nature
  - 0.15° sliding angle
- Non-porous
- Hardness 20 GPa (vs. 80 GPa for DLC)
- Thermal stability up to 400°C

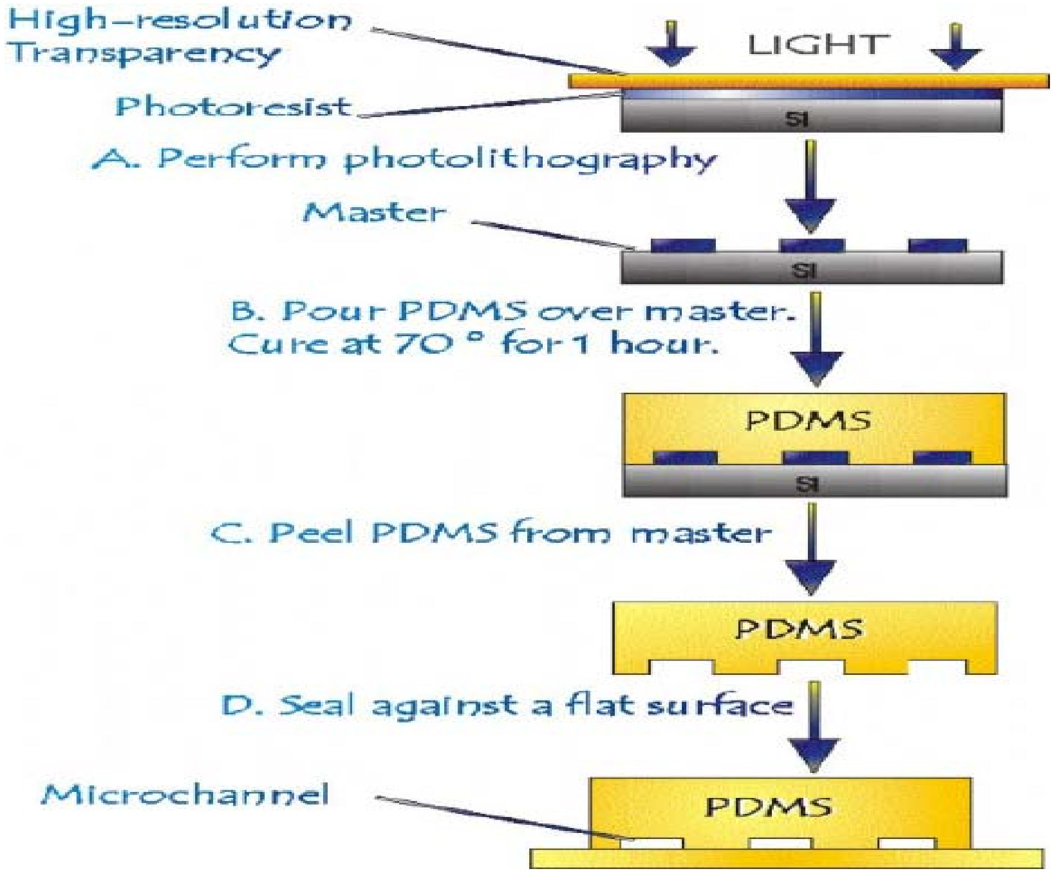
DLC-PDMS-h processing

-hydrophobicity adjustment by plasmas

a) As deposited b) O_2 plasma treated c) CF_4/Ar plasma treated

Juvonen T., Soininen A. J., Franssila S., MICROTAS 2004, Malmö, September 2004, proceedings of MicroTAS 2004 **Vol. 2**, pp. 103-105

DLC in mold masters



Huikko, K., Östman, P., Grigoras, K., Tuomikoski, S., Tiainen, V.-M., Soininen, A., Puolanne K., Manz, A., Franssila S., Kostiainen R., Kotiaho, T., *Lab on chip*, **3,** (2003), 2, 67-72.

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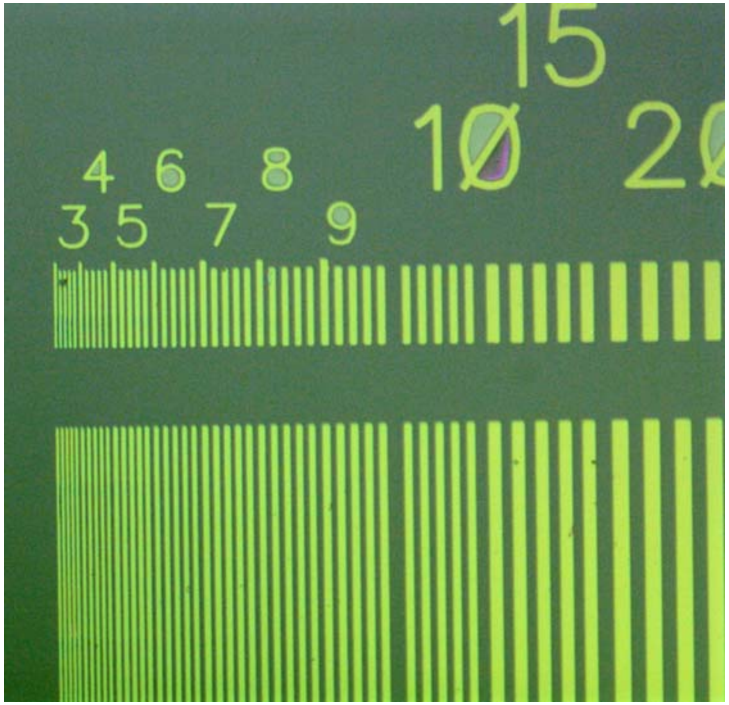
DLC-PDMS-hybrid patterning by lift-off



3 μm minimum linewidth

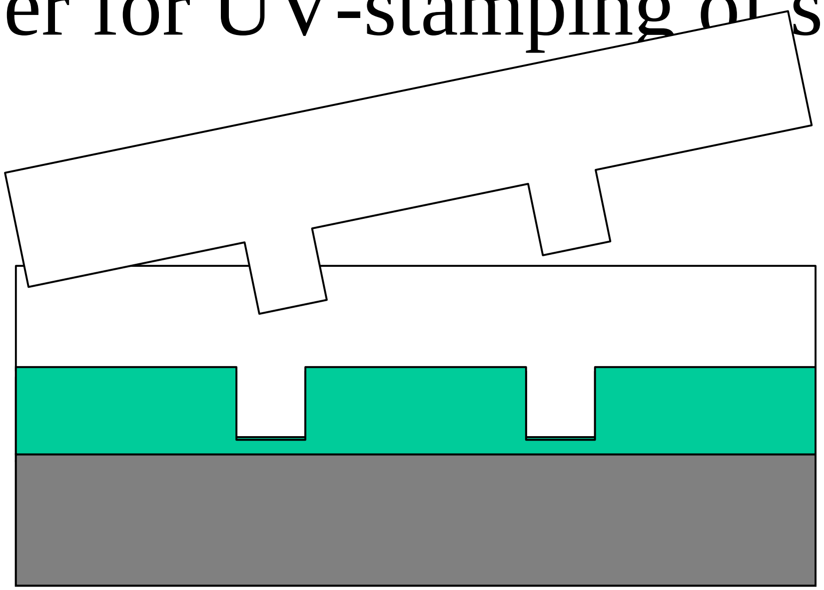
Juvonen T., Soininen A. J., Franssila S., MICROTAS 2004, Malmö, September 2004, proceedings of MicroTAS 2004 **Vol. 2**, pp. 103-105

Photoactive hybrid glasses

- act as negative resists (not unlike SU-8)
- siloxane-based (oxide character)
- spin-coated
- 400 nm to 400 µm thickness
- thermally stable up to 450^{o}C
- resistant to most chemicals used in microfabrication
- hydrophobic surfaces

Embossing polymers

- optical transparency and antisticking nature of DLC-PDMS-h are utilized in antisticking layer for UV-stamping of siloxanes



stamp release

stamping, UV-exposure

spin siloxane on the substrate

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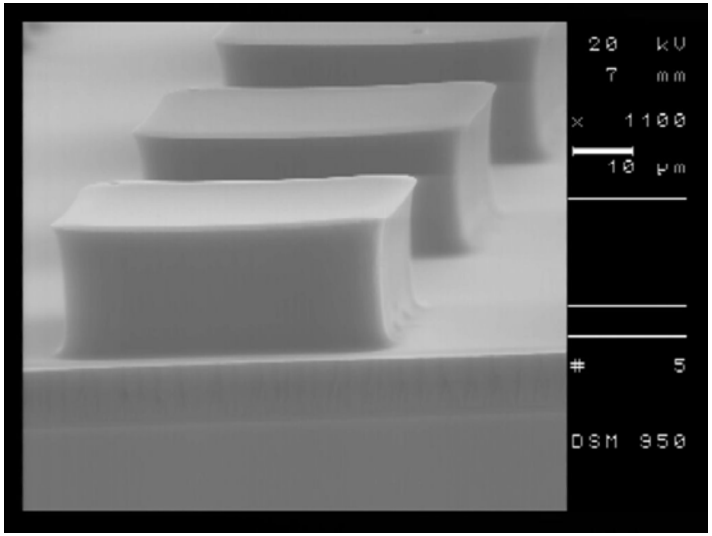
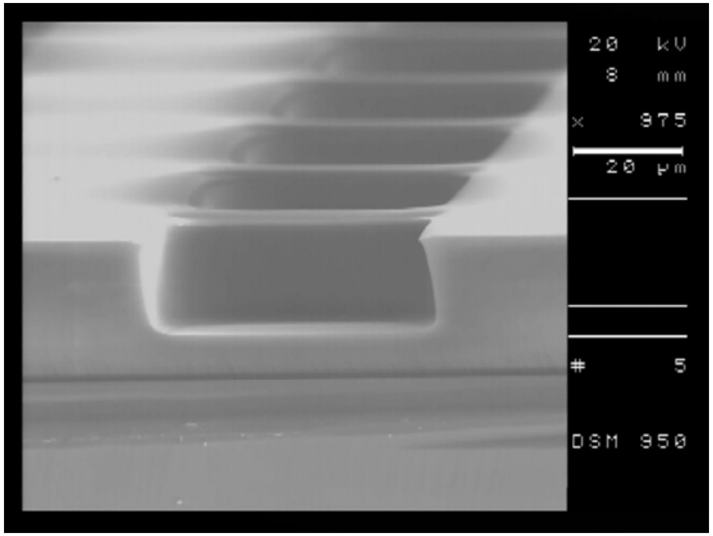
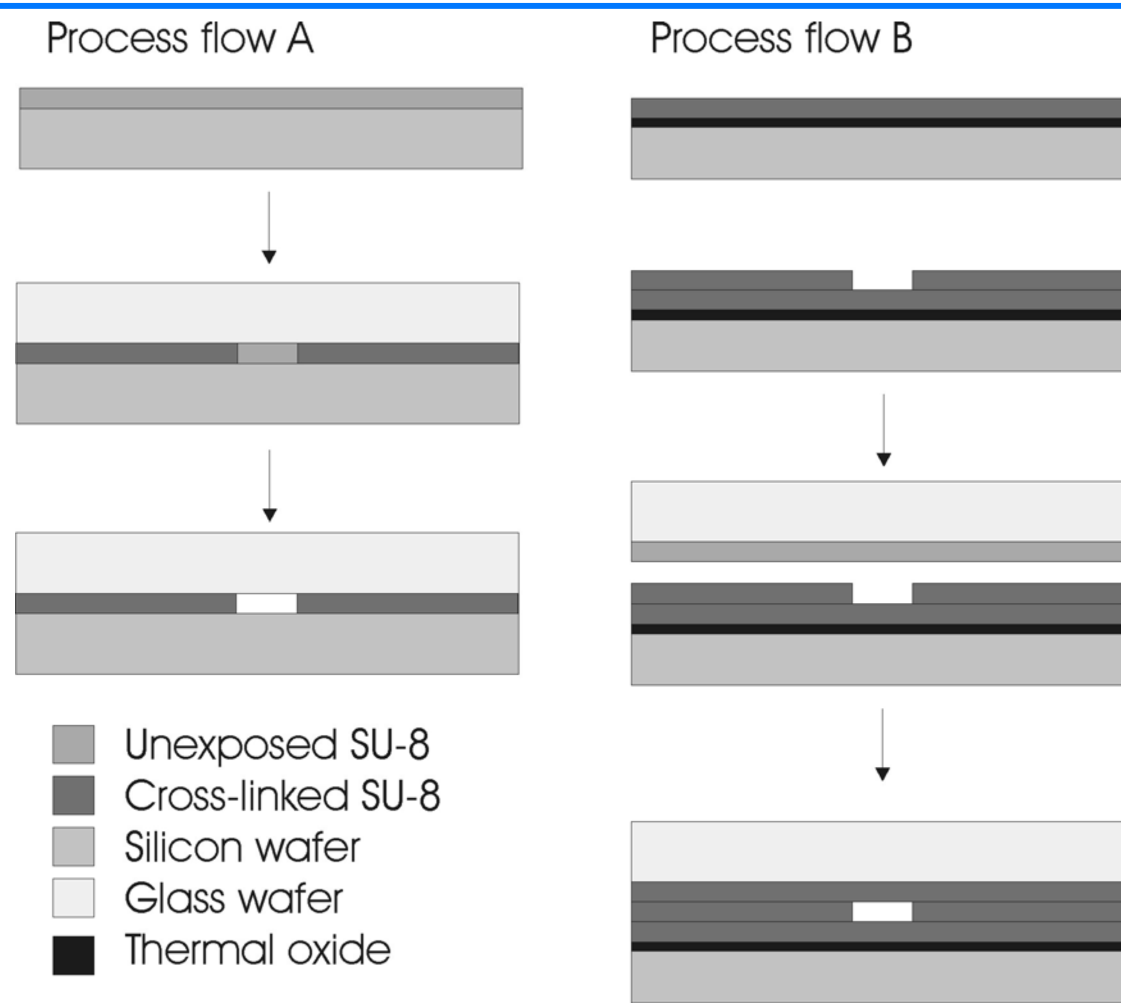
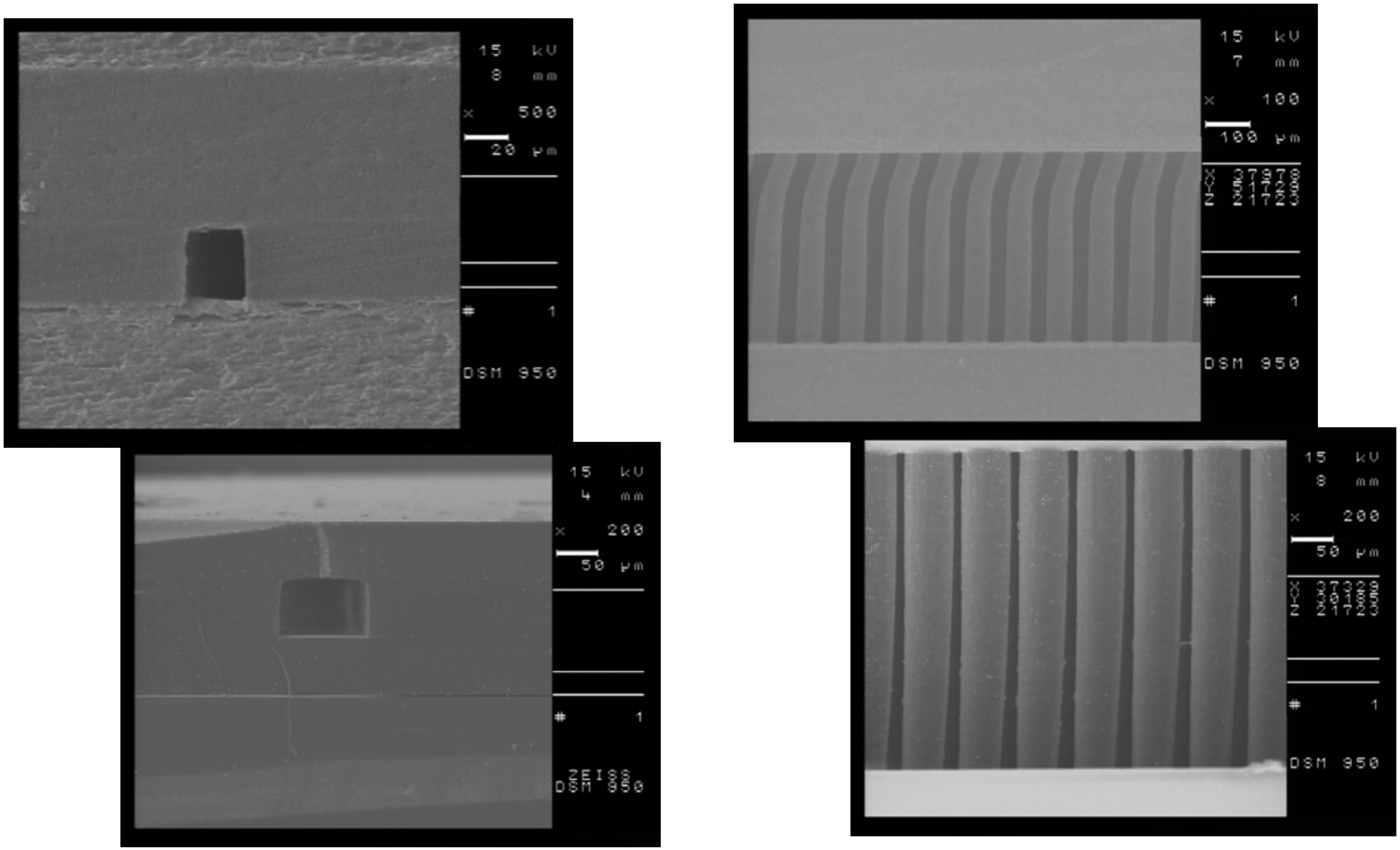
Embossing results





SU-8 adhesive bonding





Tuomikoski, S., Franssila, S., *Physica Scripta*, accepted for publication.

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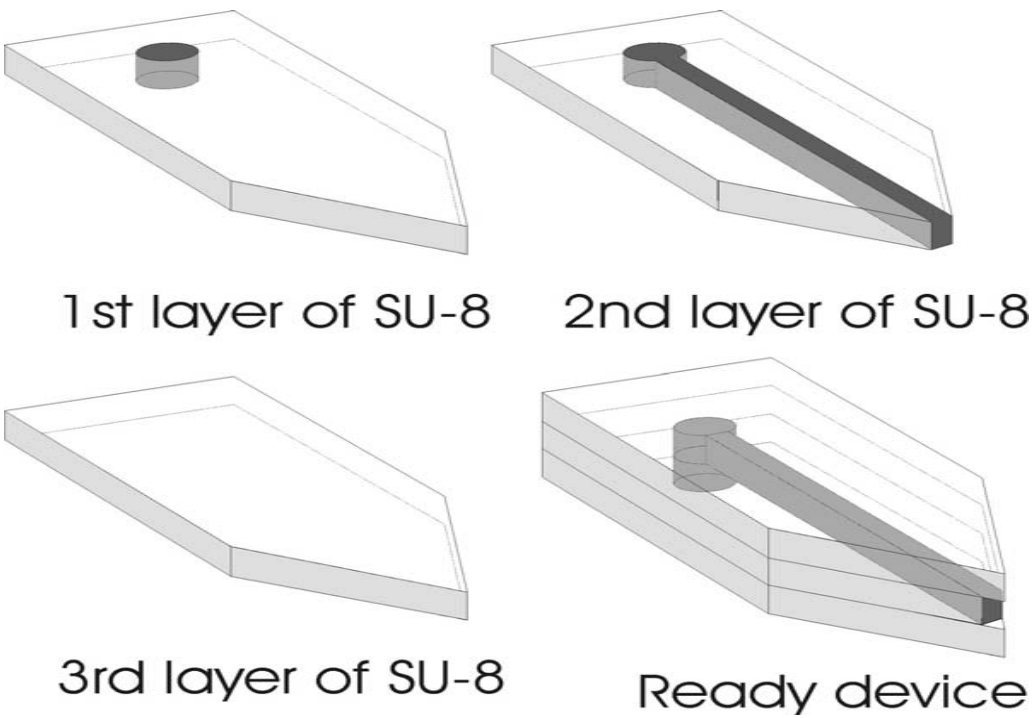
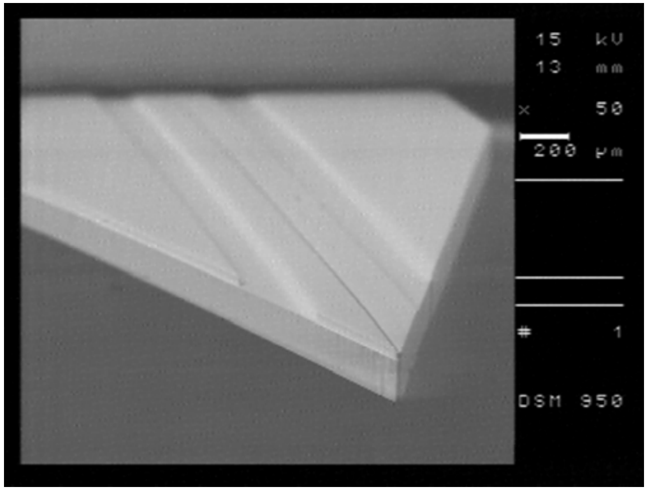
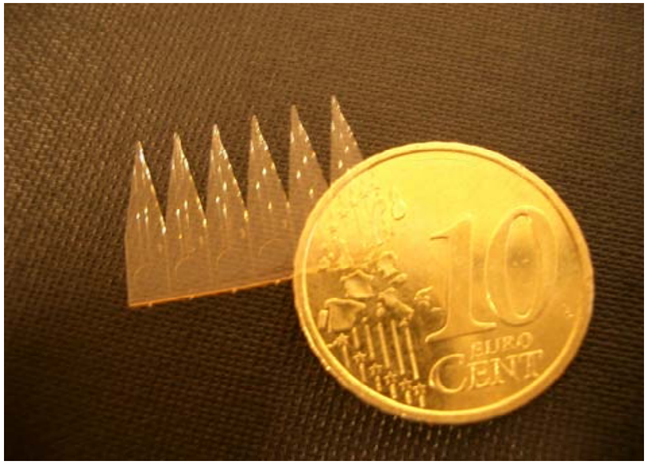
ESI in SU-8







Tuomikoski, S., Sikanen, S., Kostiainen, R., Kotiaho, T., Franssila, S., MICROTAS 2004, Malmö, September 2004, proceedings of MicroTAS 2004 **Vol. 2**, pp. 339-341.

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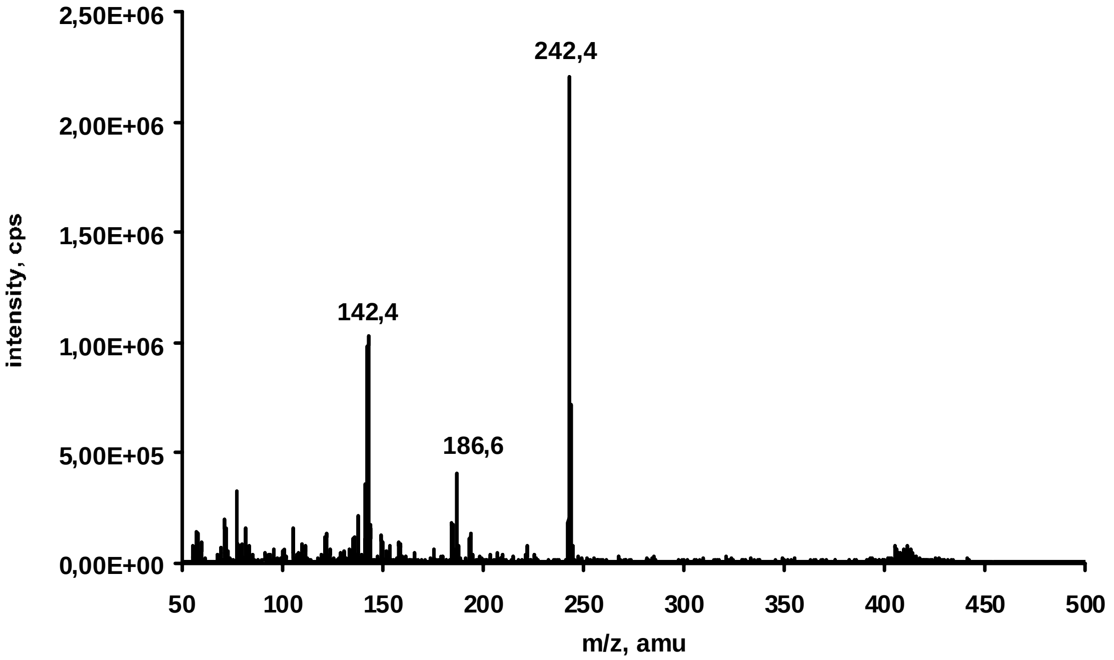
Tetra-n-butylammonium $[M]^+$=242 at 2 μM concentration. Methanol:water 4:1. Microtip 10μm*20μm.



Tuomikoski, S., Sikanen, S., Kostiainen, R., Kotiaho, T., Franssila, S., MICROTAS 2004, Malmö, September 2004, proceedings of MicroTAS 2004 **Vol. 2**, pp. 339-341.

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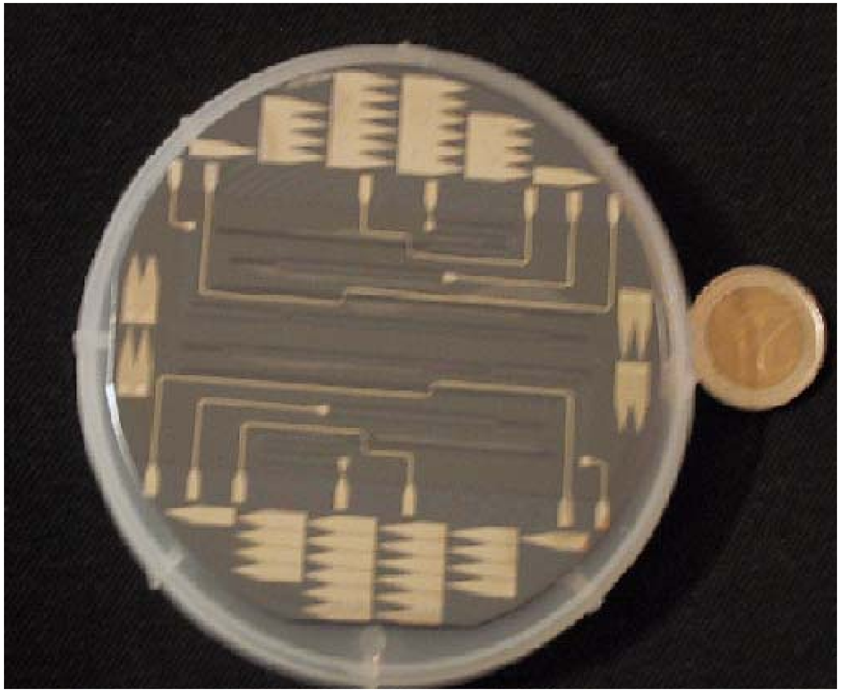
ITP microfluidic chips with integrated platinum electrodes



Ristola, R., Tuomikoski, S., Franssila, S., Submitted.

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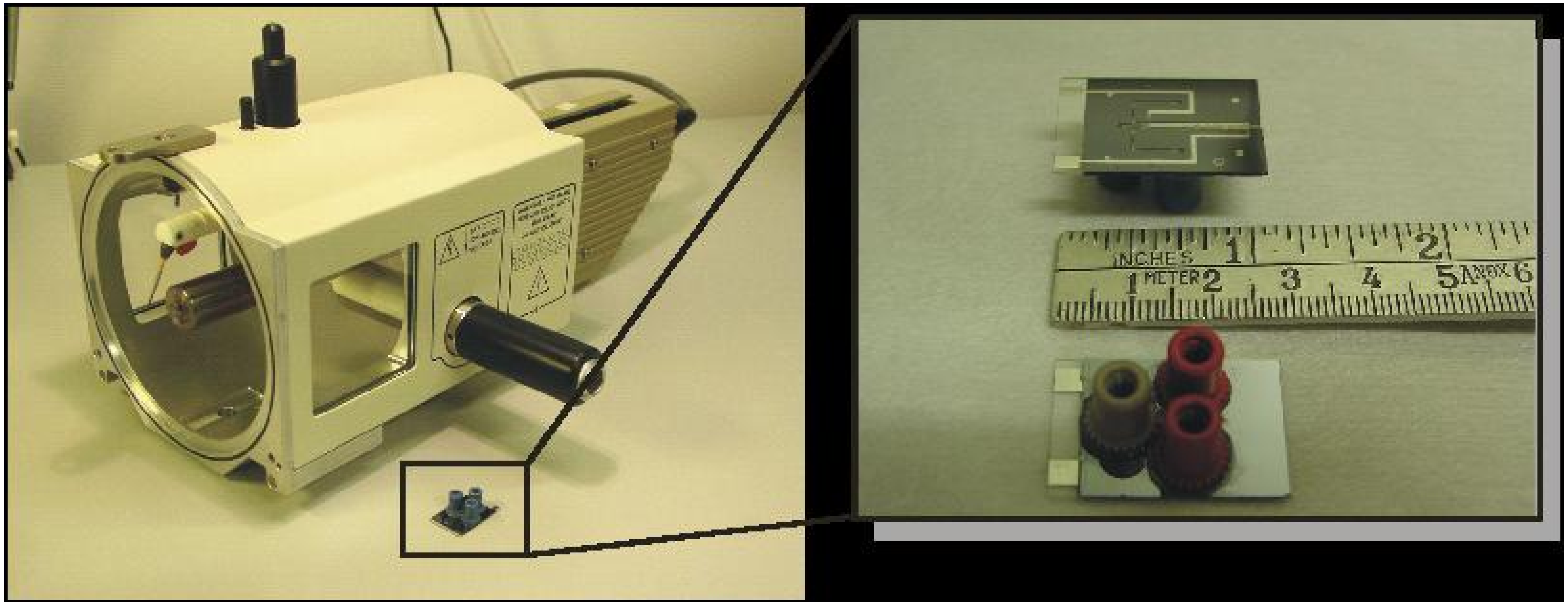
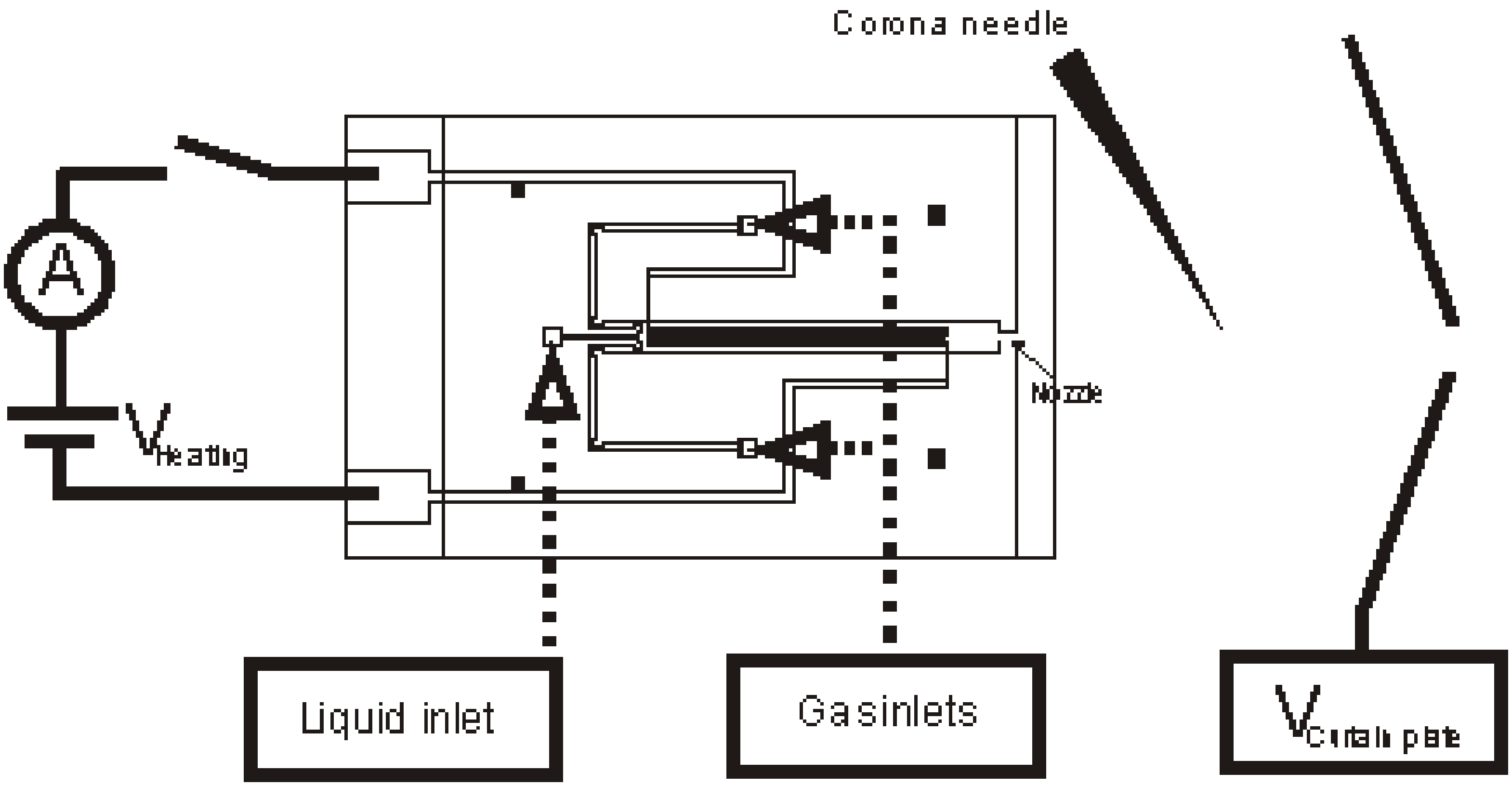
µAPCI source vs. macroAPCI source (PE Sciex API-300)



Atmospheric Pressure Chemical Ionization



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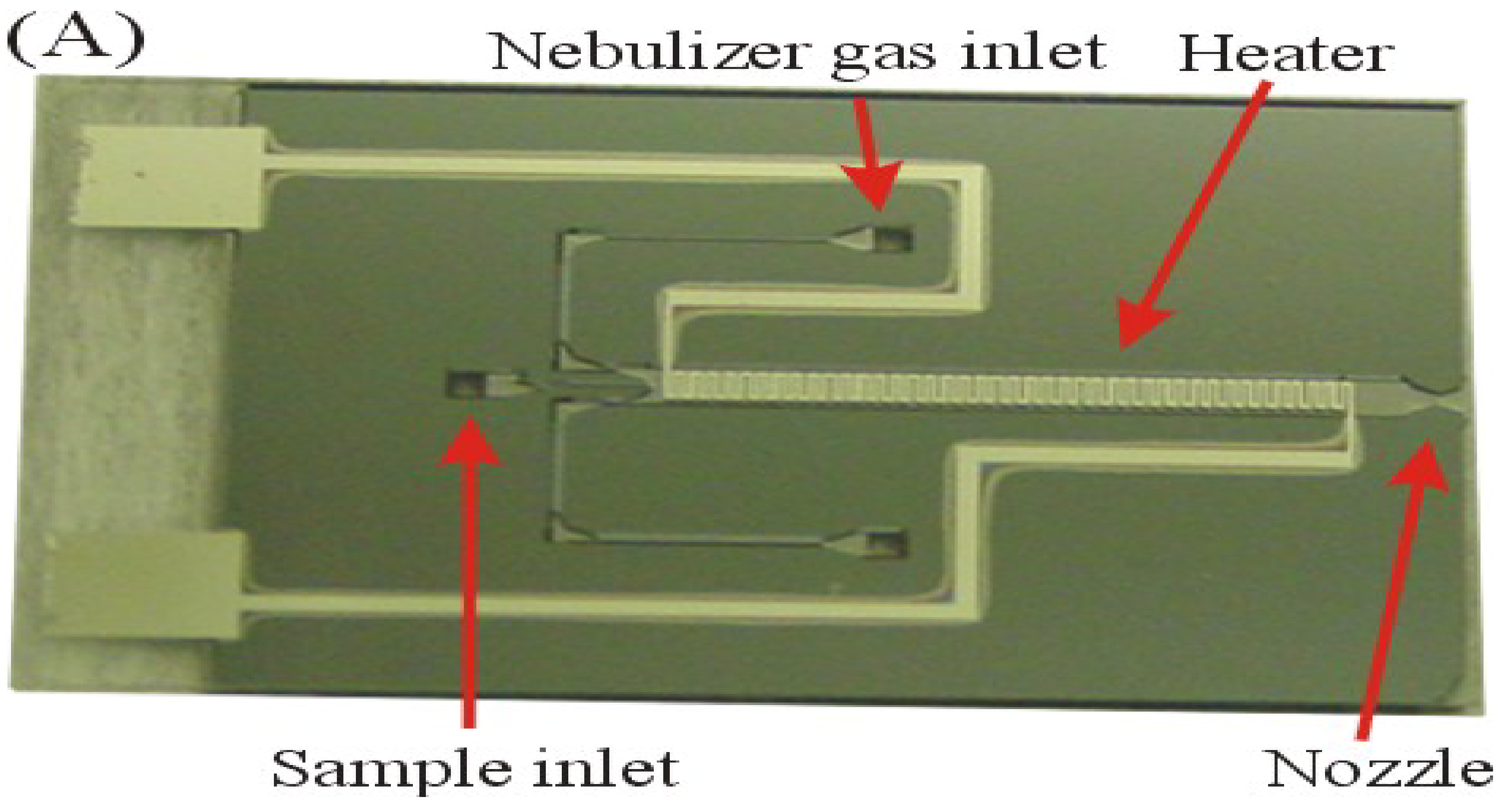
Ionization (APCI) chip



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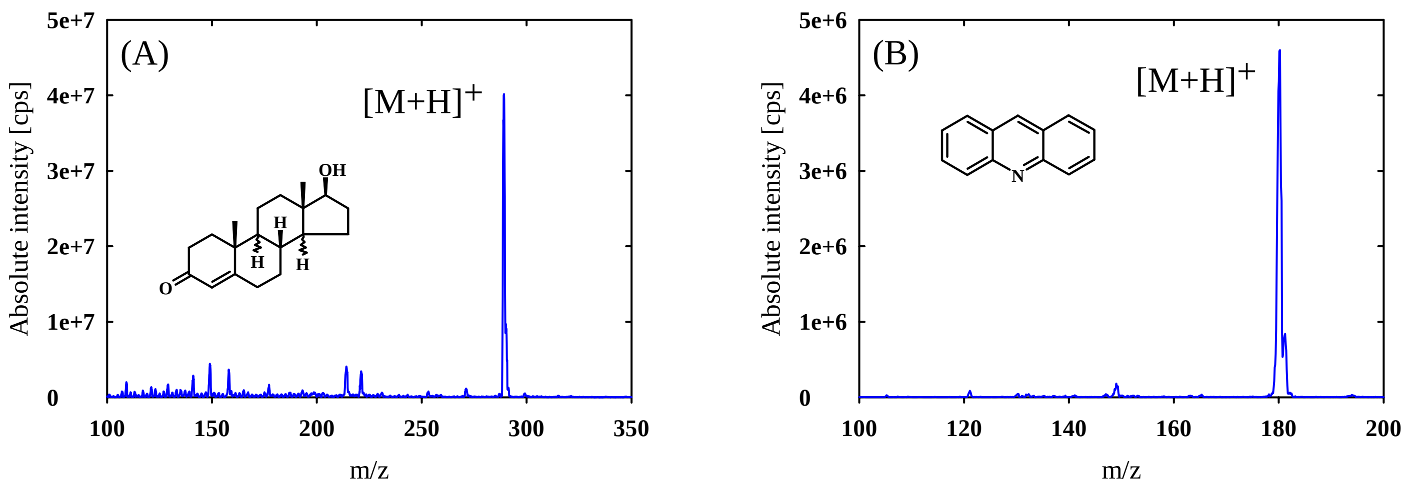
Mass spectra: excellent

a) testosterone; b) acridine



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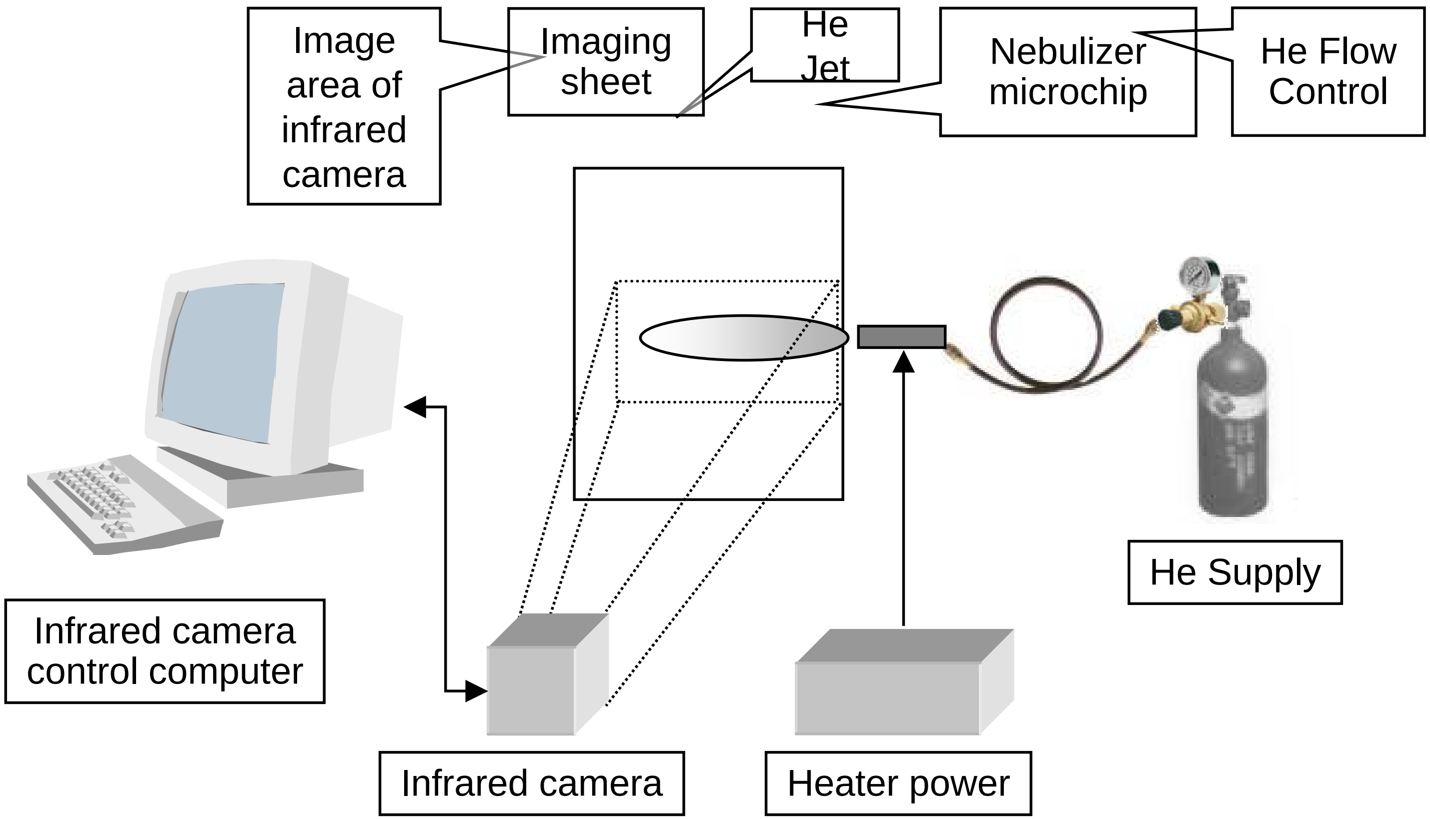
Detection limits

	flow rate [μl/min]	detection limit [mol/l]	mass flow [g/s]
μAPCI	6.2	$5 * 10^{-9}$	$0.1 * 10^{-12}$
macroAPCI	6.2	$75 * 10^{-9}$	$1.4 * 10^{-12}$
macroAPCI	1000	$5 * 10^{-9}$	$14.9 * 10^{-12}$

Jet shape measurement set-up



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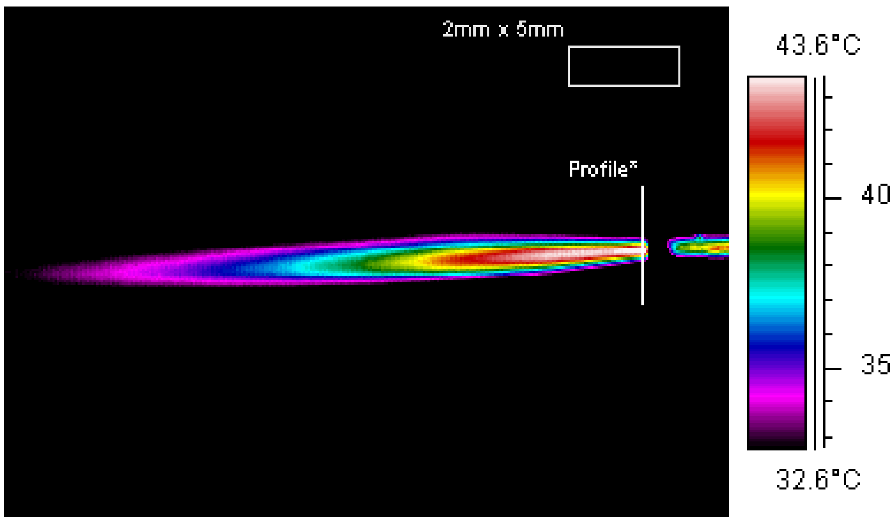
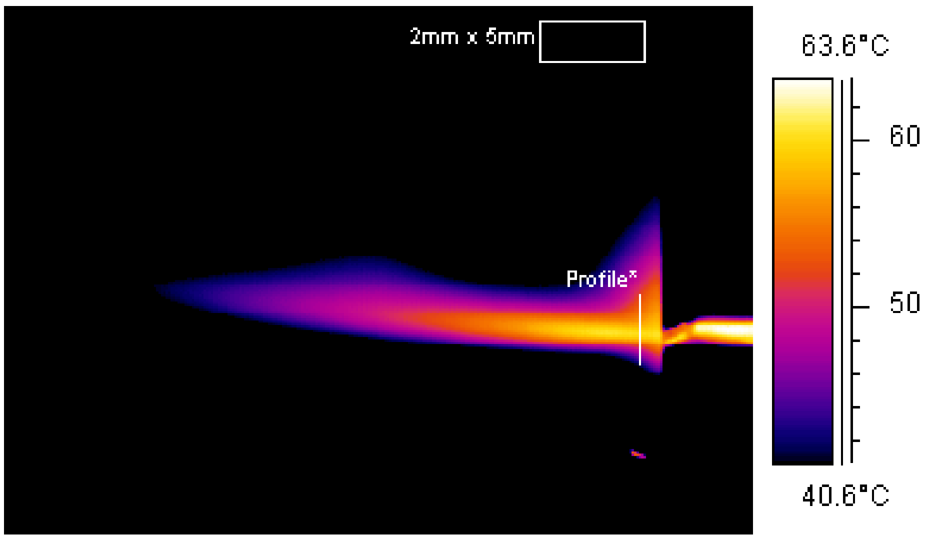
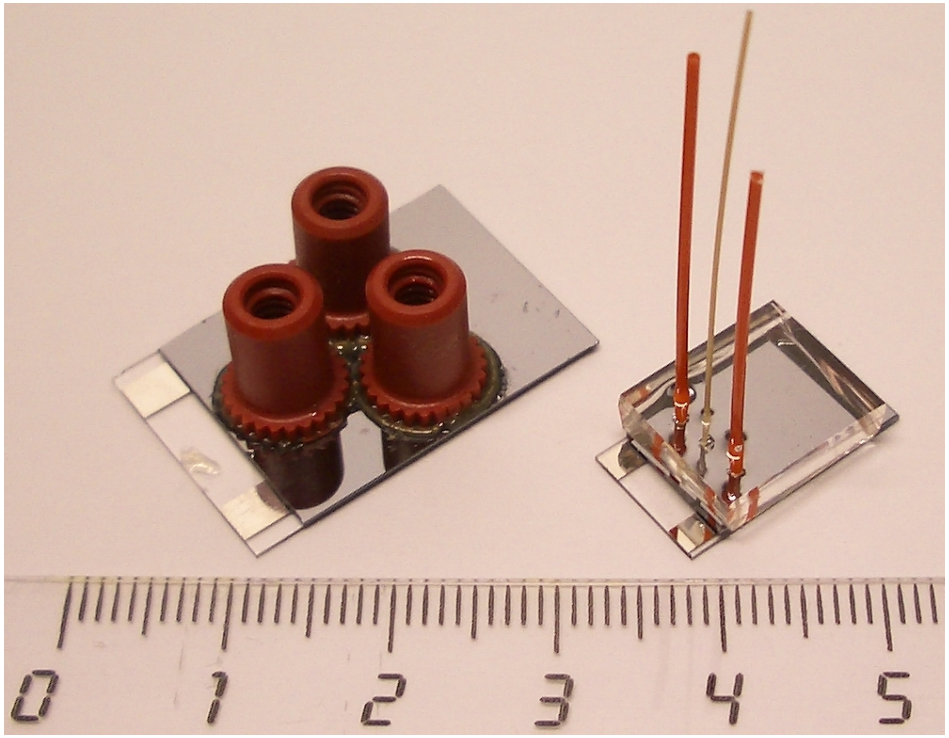
NOKIA

DRIE nozzle vs. wet etched nozzle

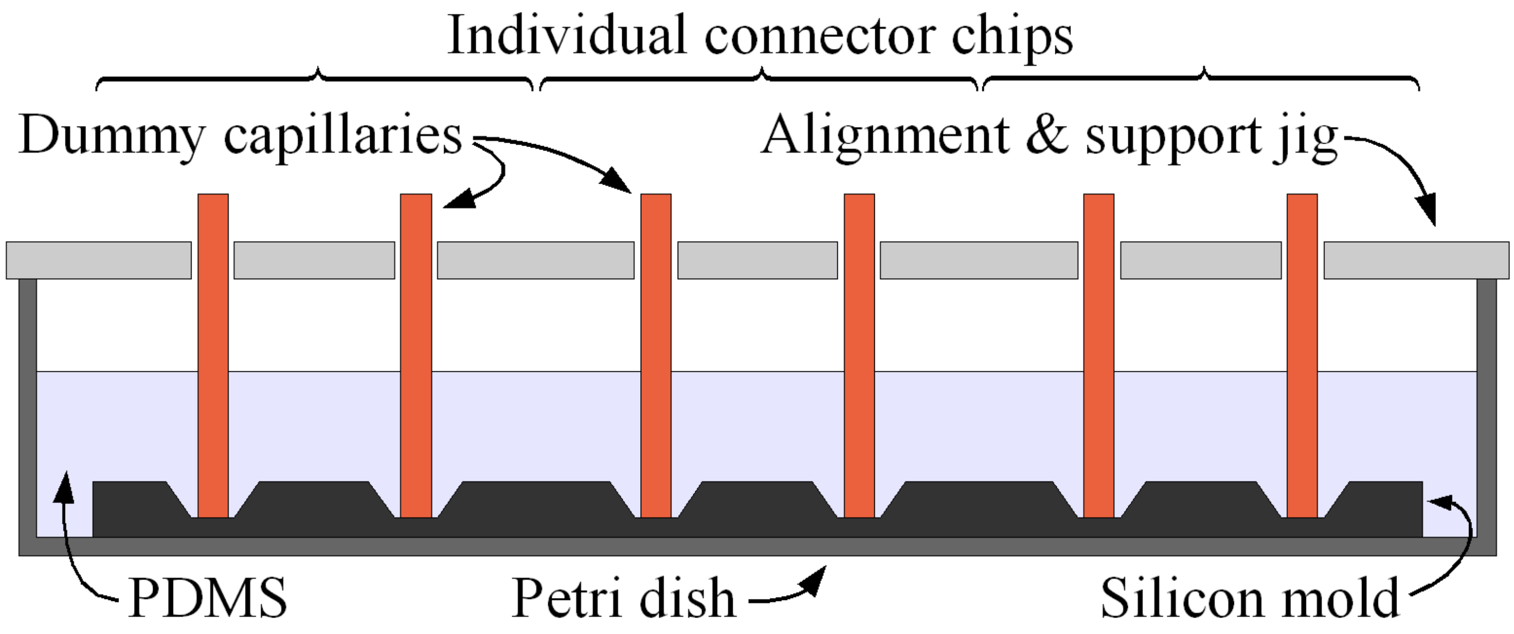




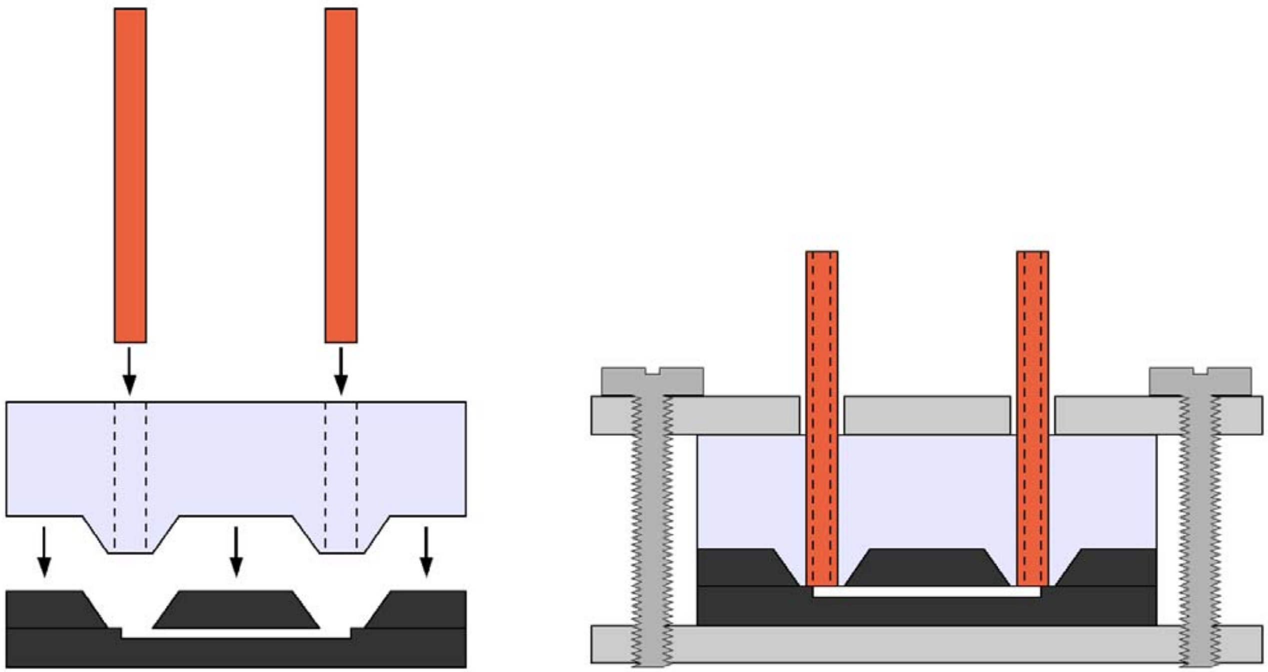
Fluidic connectors



PDMS connector chip fabrication



PDMS connector chip usage



(a) (b)

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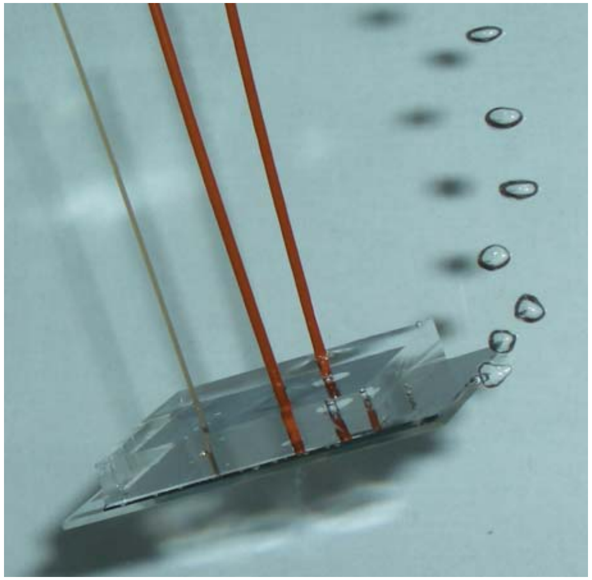
PDMS connector chip

- Detachable connector and tubing
- Pressure tolerance up to 190 kPa
- Simple fabrication
- Inexpensive
- Self-sealing
- No yield loss
- Reusable
- Multiple inlets
- Small surface area per inlet
- Small dead-volume



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