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Multiple semi-continuous chemical detection by bacterial bioreporters in a microfluidics chemostat

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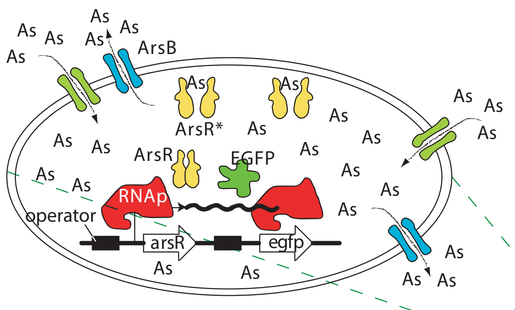
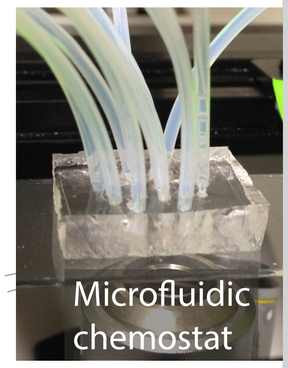
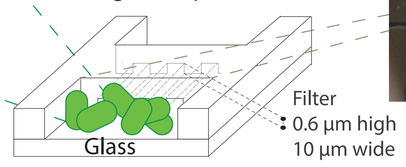
Autonomous cell-based sensing microsystem

Whole-cell bacterial bioreporters are genetically-modified for the detection of different groups of chemicals (e.g. arsenite)
Such bioreporters synthesize an easily measurable reporter protein (e.g. GFP)



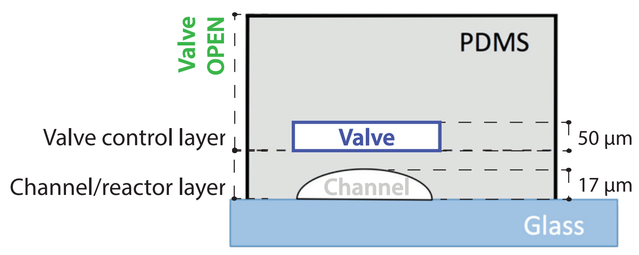
Bacterial bioreporters
accumulate against the filter
=> signal amplification



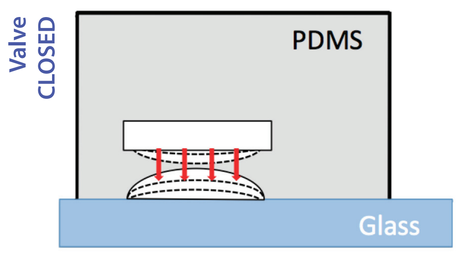


Sensing element = Arsenic bioreporter
(*E. coli* DH5α, pPRarsR-ABS-egfp, KmR)
Reporter signal = Gfp fluorescence

Side view - valve actuation principle



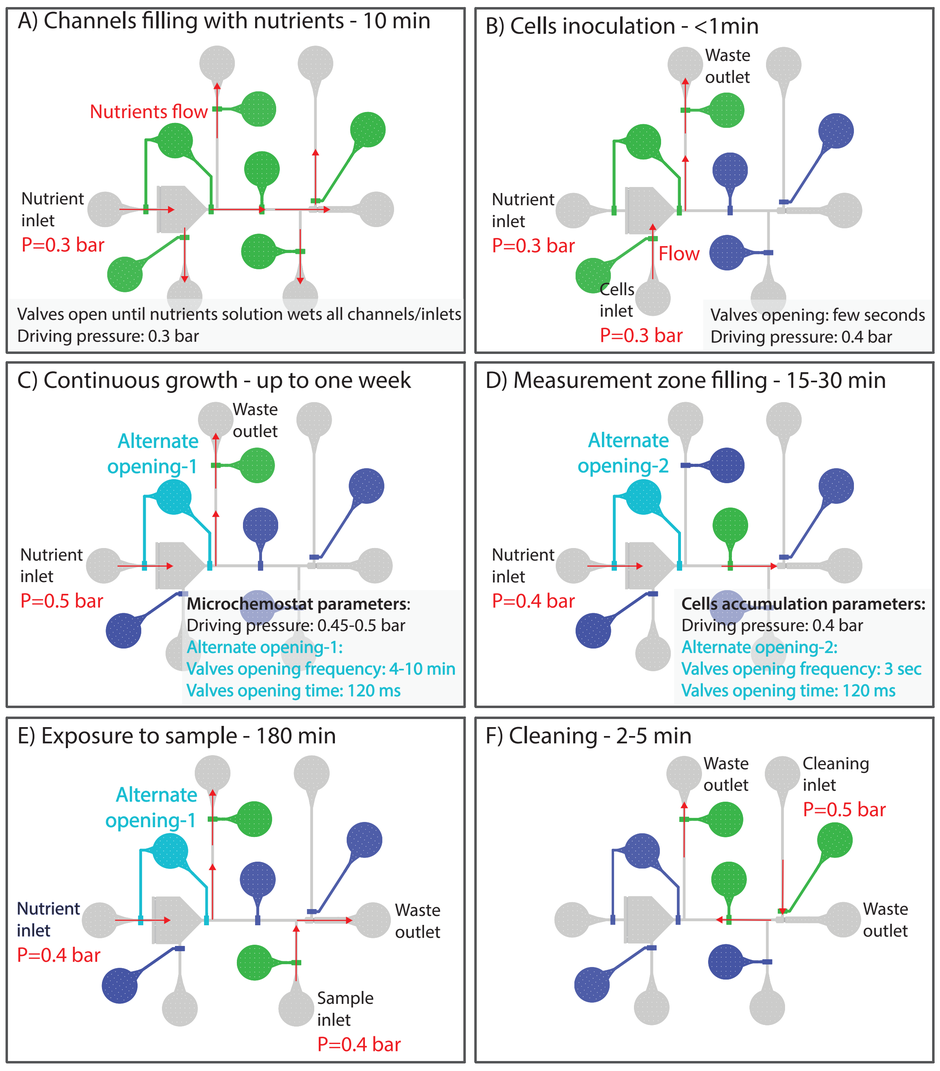
Two layer PDMS chip cross section showing the valve location with the upper control channel and the lower flow channel



As a pressure is applied in the upper channel, the thin membrane deflects and close the lower channel

- Solenoid valves allow switching air pressure and driving the opening or closing of the PDMS valves; valves can be closed by applying air-pressure of 1.5 bar
- The different flows in the bottom layer are also driven by air-pressure

Operating the microfluidic system

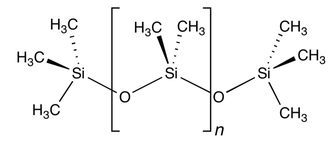


C) Maintaining cells actively growing imply discontinuous addition of fresh nutrients and removal of extra cells/medium

E) Continuous growth while cells exposed to the sample during 180 min

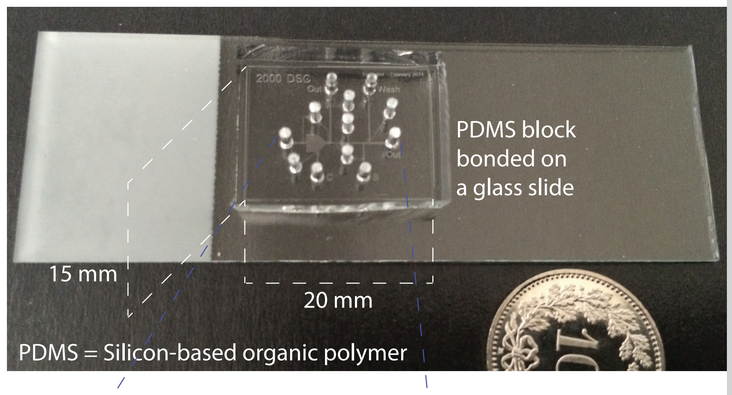
F) Measurement zone and channels cleaning before and after each cells exosure to the sample

Two-layered PDMS block



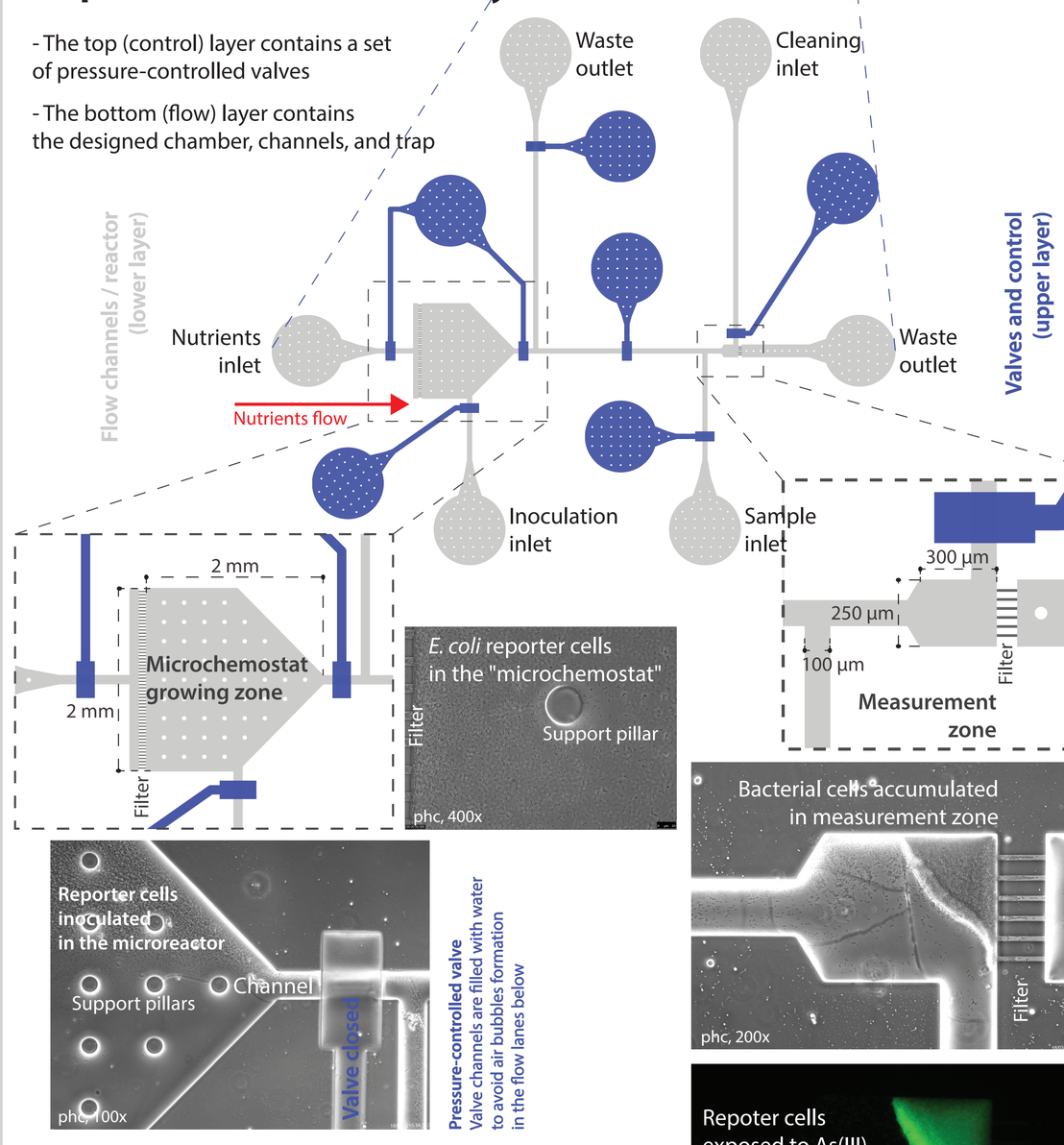
Polydimethylsiloxane (PDMS)

- Useful rheological (or flow) properties
- Easy to produce
- Permeable to oxygen
- Optically clear (transparent)
- Inert, non-toxic

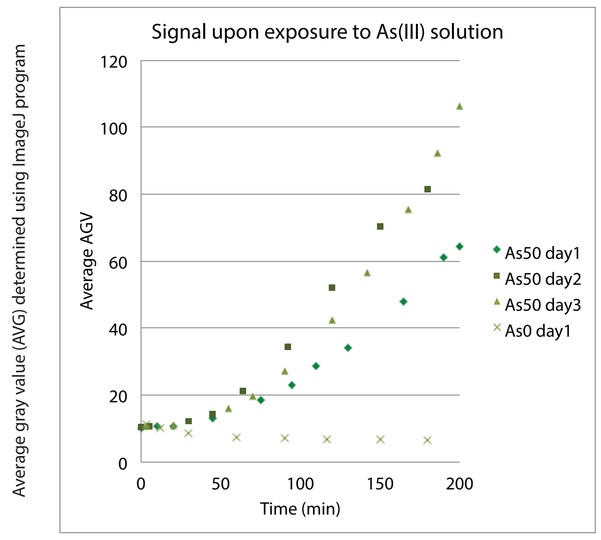


Top view - schematic layout (Mask/PDMS mold)

- The top (control) layer contains a set of pressure-controlled valves
- The bottom (flow) layer contains the designed chamber, channels, and trap



Signal measurement



- In absence of arsenite no signal increase
- The out put signal of cells exposed to As(III) at 50 µg/L is comparable over days

Conclusions

- Bioreporter cells can be maintained actively growing for one week
- Multiple exposures to contaminated samples is possible
- Signal can be measured by an opto-electronic device (Hes-so Valais)

Acknowledgment: control and flow wafers fabrication as well as PDMS chip fabrication (soft lithography) were performed at CMi, EPFL

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Hes·so VALAIS WALLIS

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