Wafer Level Fabrication of an Integrated Microdispenser with Electrical Impedance Detection for Single-cell Printing

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Summary

We present a wafer level fabrication for the integrated microdispenser featuring a **parallel facing electrodes embedded in the microchannel**. The fabrication has been realized using combination of Silicon/TMMF/Pyrex. The bonding process has been achieved at low temperature (75°C). Experimental characterization has shown that, **the sensor has fully functional with capability to detect individual polystyrene bead flowing through the electrodes pair**. Good SNR has been obtained with the amplitude signal for single polystyrene bead of 2.5 mV.

Introduction

In previous work [1], we presented a **microfluidic based dispenser for printing of single particles or cells**. The single particle detection has been implemented using a computer vision system, which is robust, but unable to obtain accurate information about the particles/cells' velocity. Therefore, as an improvement to the sensor systems, the electrical impedance detection technique is employed [2]. **Two sets of electrode pairs (parallel facing) are embedded in the microchannel that serve to detect individual particles** flowing through the electrodes and to measure their transit times before dispensing through the nozzle.

Electrical Impedance Detection Principle

Two types of electrodes configurations are normally implemented for the flow through impedance measurements of single cells:-

- A co-planar electrodes
- (fig. 1a) – The electric field distribution in the detection area is inhomogeneous. Thus, the detection signals is dependent with the particle position.
- A parallel facing electrodes (fig. 1b) – The electric field distribution is virtually homogeneous between the electrodes space. The detection sensitivity is less dependent to the particle position.
- Transit time, $\Delta t = t_B - t_A$

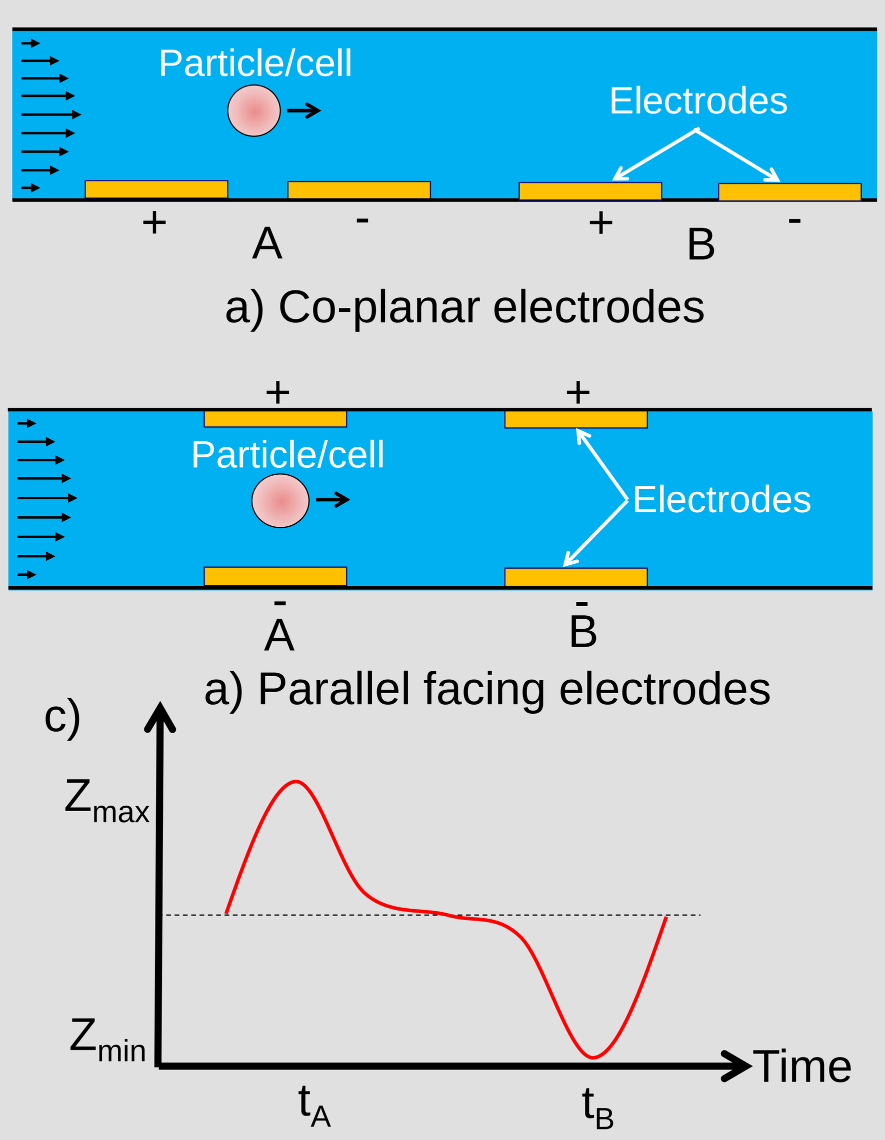


Figure 1 : Impedance detection principle. a) A co-planar electrodes arrangement. b) A parallel facing electrodes arrangement. c) Typical detection signal when single particle flow past the electrodes.

Fabrications (Parallel Facing Electrodes)

Silicon wafer:

- Thermal oxide: growth of 500 nm SiO_2 as passivation layer.
- Patterning of 300 nm Platinum electrodes

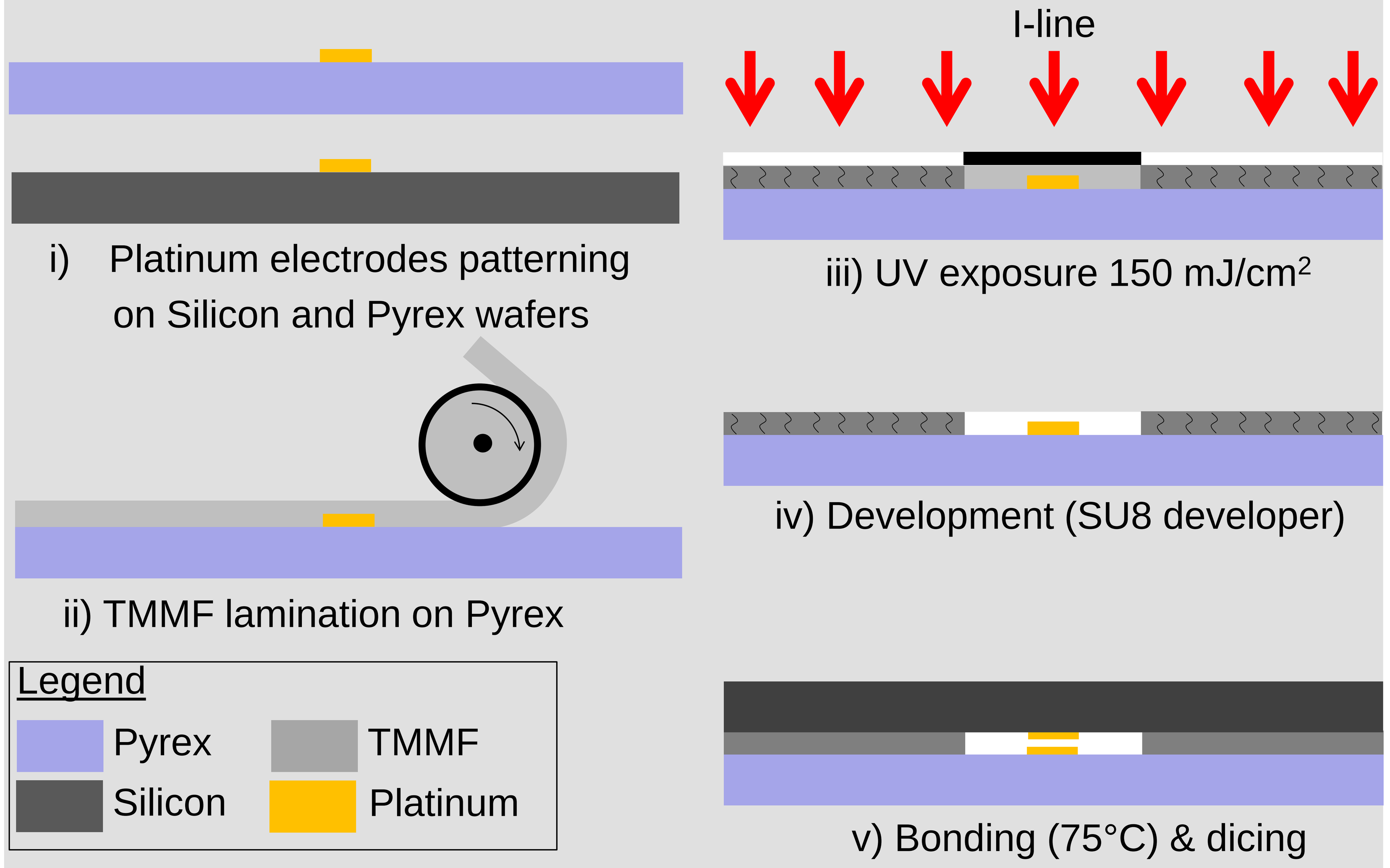
Pyrex wafer:

- Patterning of 300 nm Platinum electrodes
- Opening of hydraulic access holes via deep wet etching.
- **Lamination of TMMF and development of microchannels**

Device packaging:

- Bonding at 75 °C & dicing.

Fabrications (Summary of the Process Steps)



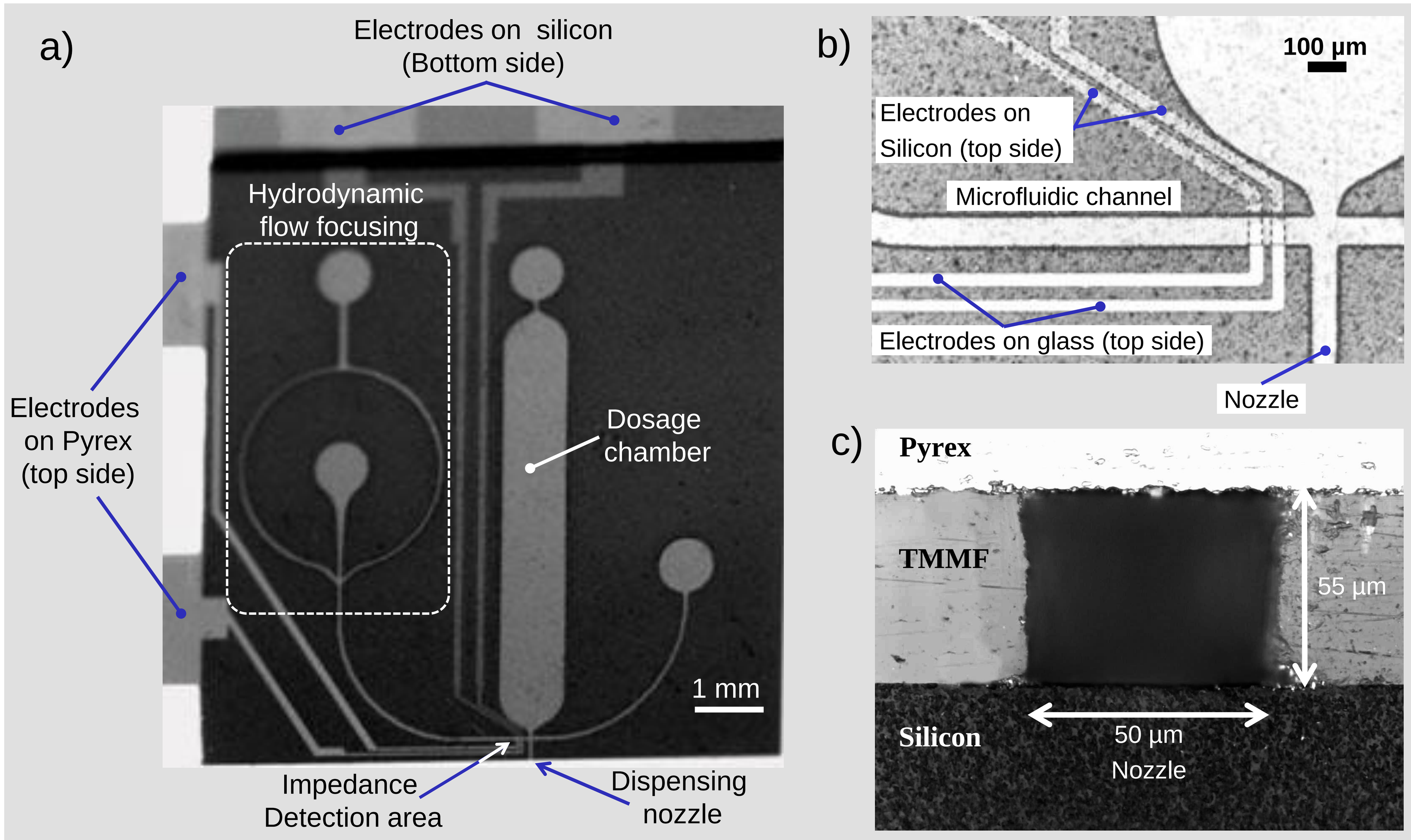


Figure 2 : a) Fabricated chip & features. (b) Detailed view at the measurement cell (electrodes). (c) Detailed view showing the nozzle orifice.

Impedance Detection of Microbeads

Electrical interfacing

- Current amplifier (Gain = 10)
- Impedance analyzer
- Voltage: 1 V, f = 500 Hz.

Microbead detection

- Polystyrene beads (10 µm) suspended in PBS.
- Mean amplitude signals: 2.5 mV

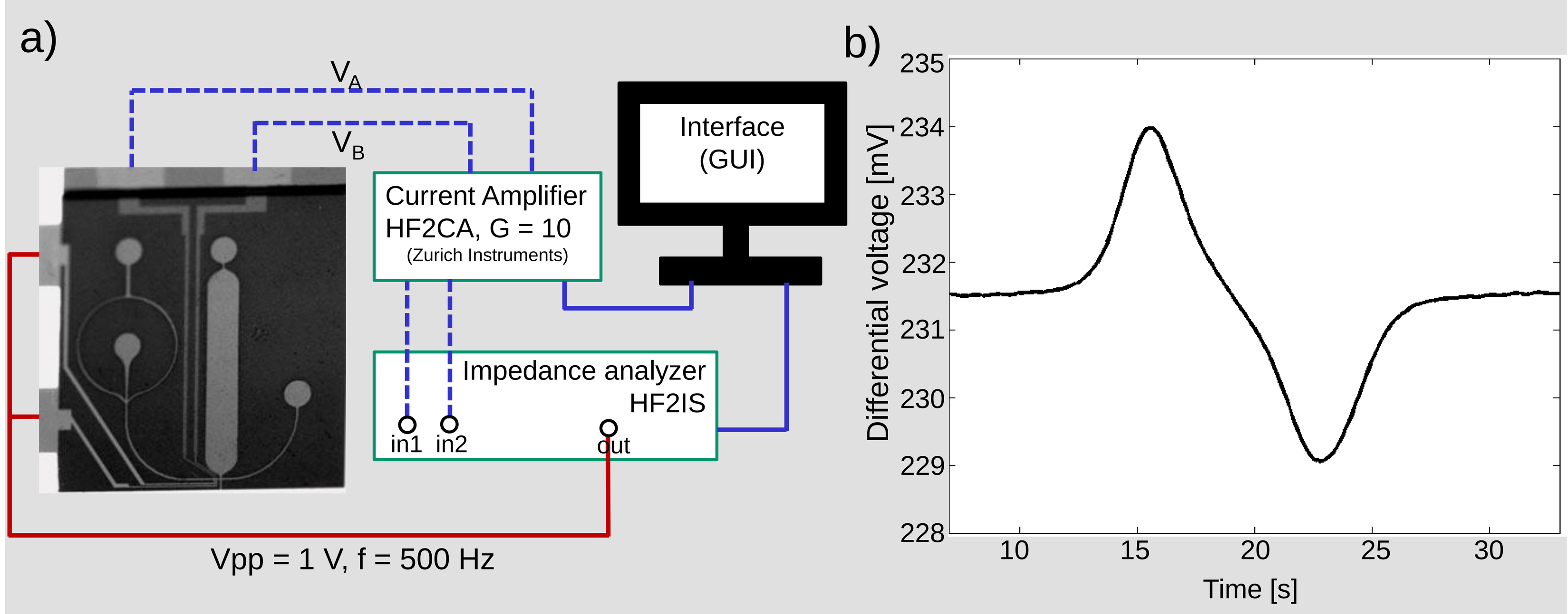


Figure 3 : a) Schematic of the electrical connections. b) Impedance detection signal showing single bead flowing through the electrode pairs.

Conclusions

We have successfully demonstrated a wafer level fabrication of a microfluidic dispenser featuring an integrated impedance sensor. The measured signals for single polystyrene beads demonstrate the functionality of the sensor system.

[1] A. Yusof, et.al., *Proc. MEMS 2011*.
[2] R. Tornay, et al., *Proc. TRANSDUCERS 2007*

Acknowledgement
This work has been supported by the European Commission (FP7 GA257073).

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