Multiplexed impedimetric detection of virus capturing gold nanoparticle

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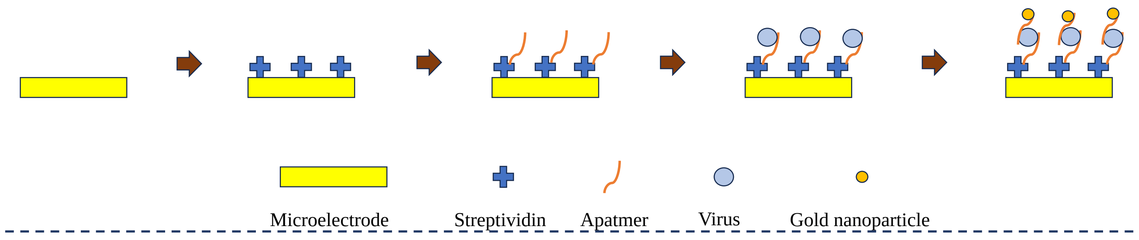
Introduction

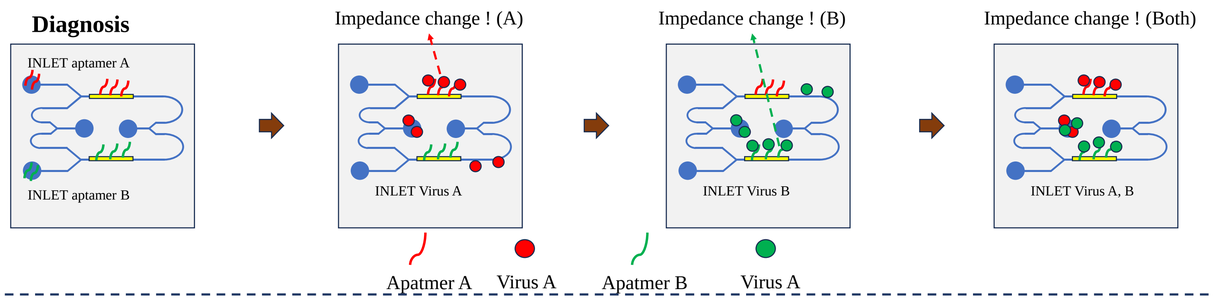
The current pandemic highlights the need for fast and reliable diagnostic methods capable of detecting viruses at low levels before symptoms appear. While standard PCR is the most reliable method, it is slow and requires specialized reagents and trained personnel. Impedimetric detection offers a rapid and accessible alternative to PCR, addressing the need for simpler and faster diagnostic methods during pandemics. **By measuring changes in electrical impedance, impedimetric assays could enable early detection of viral infections with minimal equipment and training requirements,** potentially complementing PCR in diagnostic capabilities. However, impedance measurement of existence of virus is vulnerable to noisy conditions coercing introduction of amplification method for high-specificity and high-sensitivity to be functionalized as reproducible device. **We tried to overcome such restrictions by immobilizing streptavidin on the microelectrode surface and introducing biotin labeled aptamer, which will provide an amplified difference in detecting presence of target virus.**

Scheme

Detection



Diagnosis



Experimental Methods

Device fabrication method

1. Channel part(PDMS) fabrication

Width : 200μm
Depth : 100μm
Dimension : 2cm X 2cm

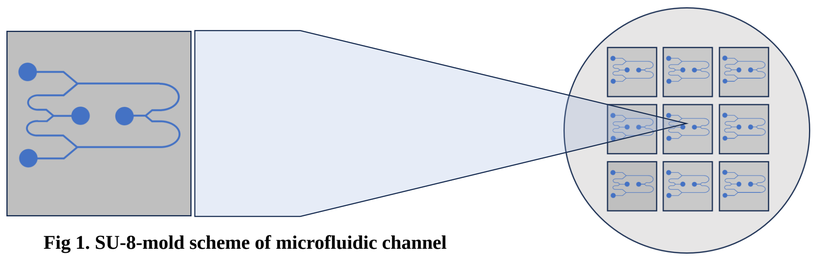
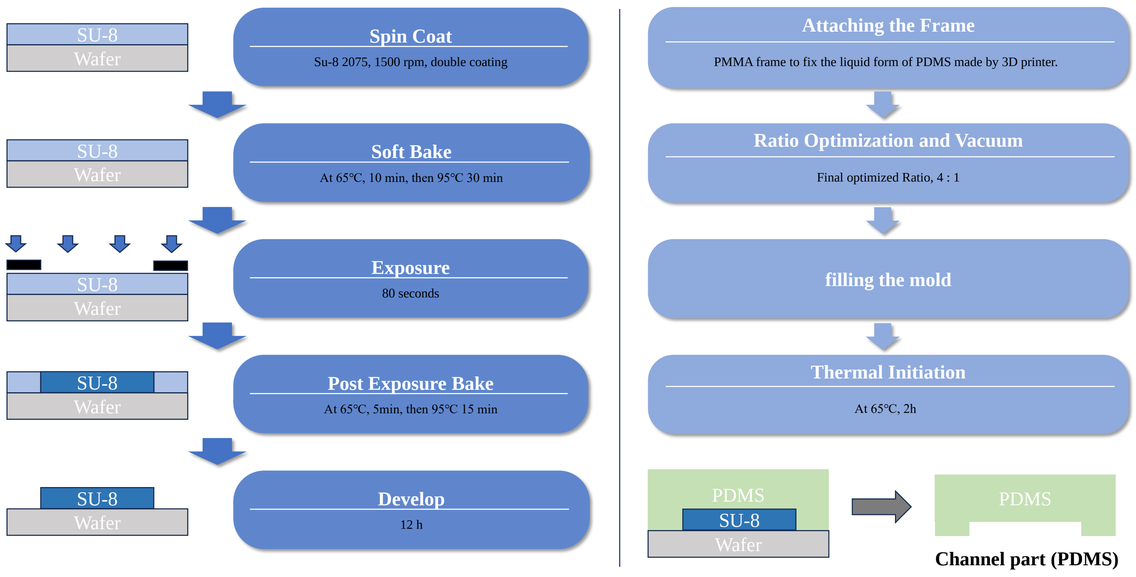


Fig 1. SU-8-mold scheme of microfluidic channel

SU-8 mold → **PDMS fabrication (synthesis)**



2. Electrode part fabrication

X10

Sensing IDE array

Width : 10μm
Gap : 10μm
50 fingers per IDE array

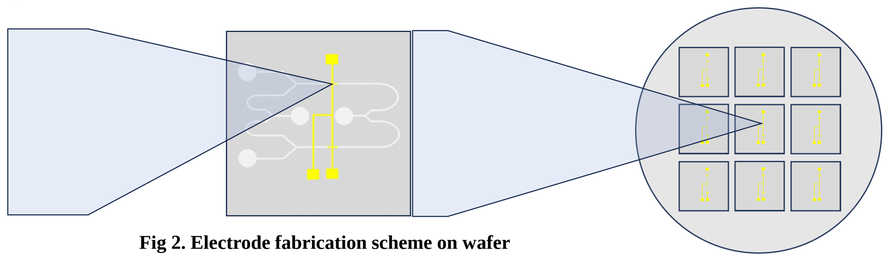
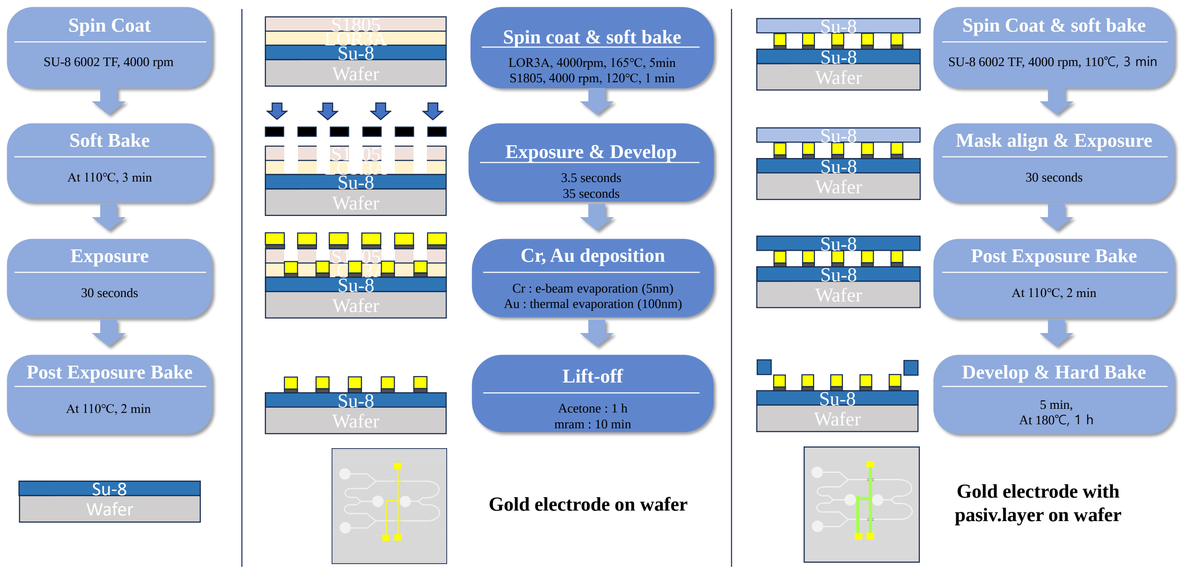


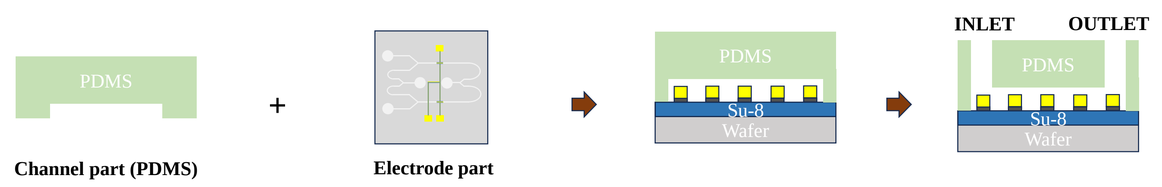
Fig 2. Electrode fabrication scheme on wafer

SU-8 Pasiv. layer1 | **Gold Electrode Deposition** | **SU-8 Pasiv. layer2**



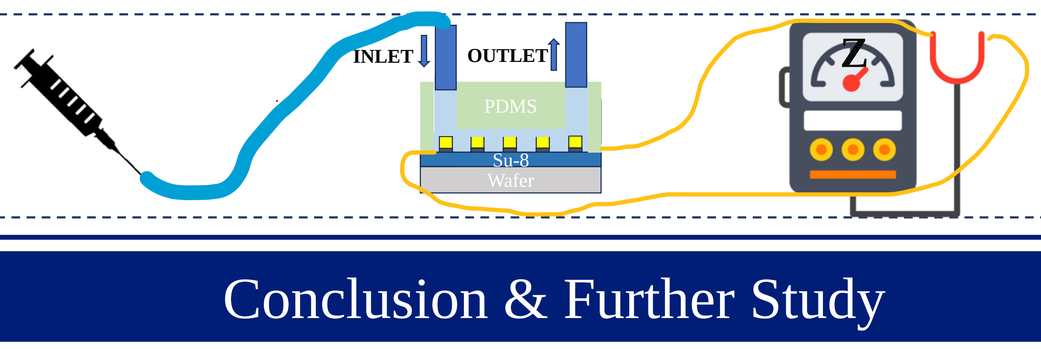
3. Channel part + electrode part fabrication

1. Plasma treat and APTES{(3-Aminopropyl)triethoxysilane} treat to chemically combine two part(PDMS – channel part + Wafer – electrode part) and combine it.
2. Thermal initiation 95°C 2hours.
3. Use a puncher to make holes in the INLET and OUTLET sections to insert the hose.



Microfluidic chip experiment

1. Connect the hose and check if liquid flows from the INLET to the OUTLET.
2. Wash with acetone.
3. Flow DI water, PBS(phosphate-buffered saline), and DI water containing gold nanoparticle, and measure impedance.



Results

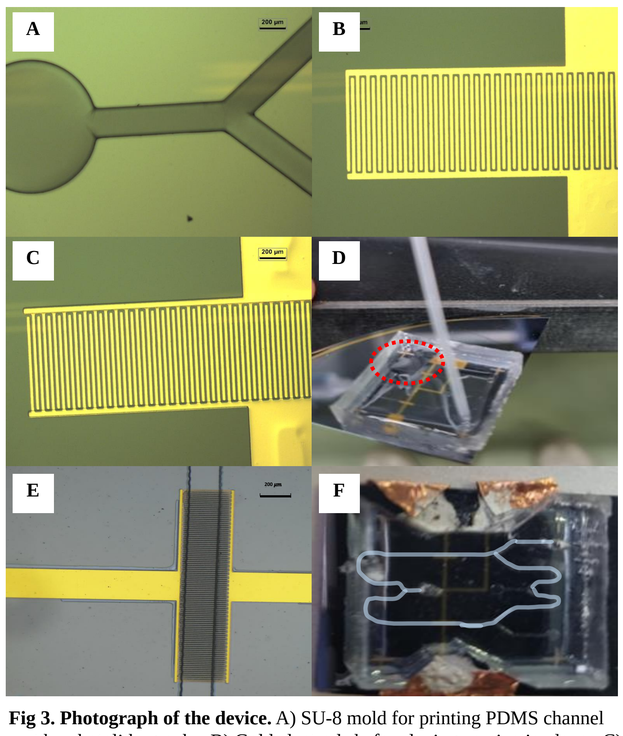
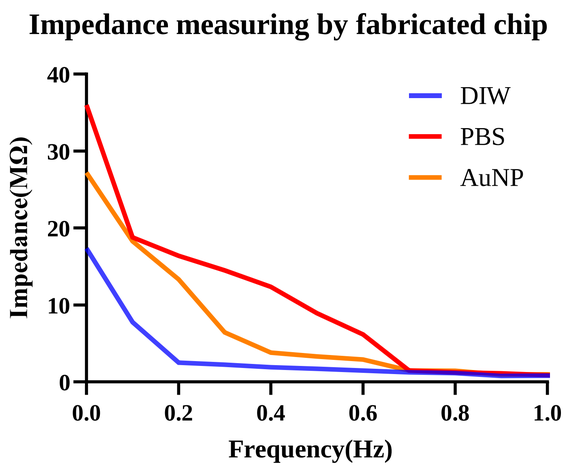


Fig 3. Photograph of the device. A) SU-8 mold for printing PDMS channel part by photolithography. B) Gold electrode before laying passivation layer. C) Gold electrode after laying passivation layer by mask aligned photolithography. D) Flow observation through chip. E) IDE array part of the chip where DI water flows. The channel is filled with DIW. F) Full image of completed chip conformation. The channel drawn in light blue is filled with water.



- A significant impedance difference appeared below $10^{0.7}$ Hz. It was confirmed that the impedance decreased in the order of PBS, AuNP in DIW, and DIW.
- PBS is a solute with many ions, and DIW can be considered of as a solute with trace amounts of ions. Seeing that the case of AuNP in DIW exists between these two graphs, it can be assumed that AuNP may play a role as an ion to some extent.
- Our goal**, 'Detecting AuNP-labeled viruses',** appears to be possible as it shows significant differences.

Conclusion & Further Study

I fabricated a device with idea about 'Multiplexed impedimetric detection of virus capturing gold nanoparticle'. I was able to confirm that different impedances were measured depending on the type of flowing fluid with my fabricated microfluid chip and one case, with gold nanoparticle inside. The device was able to discriminate the existence of gold nanoparticle residing above gold electrode. The initial goal was to introduce pathogen on those electrodes and observe the whether the chip has ability to differentiate foreign materials that has been introduced to the system. However, with limited time, I could only check existence of gold nanoparticle.

If I had more time, I would like pursue further study as below;
First, I would like to introduce bio-samples as illustrated on diagnosis scheme. We aimed to design pathogen detection by coordinating wo difference aptamer coexisting inside device at same time.
Second, then I would like to check specificity of each electrode. I would like check the impedance measured from each electrode separately, and even combined for multiplexed detection. The result will be crosschecked with gaining from outlet for exclusion detection mechanism.
Lastly, I would like to implement actual pathogen sample rather than mock viruses. It would a progression in experimental step.

Reference

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