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Supporting Information

Remotely tunable microfluidic platform driven by nanomaterial-mediated on-demand photothermal pumping

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Additional Experimental Details

Synthesis of Fe_3O_4 NPs-secondary antibody conjugates

The Fe_3O_4 NPs-secondary antibody conjugates were synthesized as per previously published protocols with slight modification.[1,2] Basically, *N*-hydroxysulfosuccinimide (Sulfo-NHS, 25 mg/mL) and 1-ethyl-3-[3-dimethylaminopropyl]carbodiimide hydrochloride (EDC·HCl, 30 mg/mL) were added to the Fe_3O_4 NPs dispersion (0.25 mg/mL), followed by reaction at room temperature for 40 min. Then 40 μg of polyclonal PSA secondary antibody was added into the nanoparticle dispersion, and reacted for 2 h on an orbital shaker. The nanoparticle dispersion was centrifuged at 12,000 rpm for 10 min and washed with phosphate buffer saline (PBS, pH 7.4, 0.01 M) three times. The as-produced Fe_3O_4 NPs-secondary antibody conjugates were dispersed in 1 mL PBS buffer and stored at 4 °C before use.

Immunosensing procedures

In a typical sandwich enzyme-linked immunosorbent assay (ELISA), 120 μL of monoclonal PSA primary antibody (30 μg/mL) was added in a PCR tube, followed by overnight incubation at 4 °C. After washing the tube with PBS buffer for three times, 200 μL of 5% BSA was added and incubated for 30 min at 37 °C in order to block remaining active sites. Then 120 μL of PSA solutions with different concentrations from 0 to 64 $ng \cdot mL^{-1}$ were added to each tube and incubated for 1 h at 37 °C, followed by washing steps. 120 μL of freshly synthesized Fe_3O_4 NPs-secondary antibody conjugates were added and incubated at 37 °C for 1 h, after which the tube was washed thoroughly with PBS buffer.

Nanoparticles transformation

According to the previous work published from our group,[1,2] a weak photothermal agent, Fe_3O_4 NPs (captured in the sandwich immunoassay system), was herein transformed into a strong photothermal agent, Prussian blue (PB) NPs. Briefly, 120 μL of HCl solution (0.1 M) was added into the above tube, followed by ultrasonication for 1 h at room temperature. Potassium ferrocyanide aqueous solutions (30 μL, 90 mM) were then added into each tube, followed by vigorous mixing for 1 h. Finally, the PB NPs were produced via the ferric ferricyanide reaction under acidic conditions.

Visual quantitative immunosensing using the PT-Chip

The above PB NPs captured in the immunoassay were pipetted to the photothermal bar-chart chip (PT-Chip) for visual quantitative detection of PSA. In detail, 30 μL of the above solution was loaded into each reservoir on the PT-Chip, along with 2 μL of food dye solution (a deep blue color for better observation of bar chart movement). All reservoirs on a single chip were then irradiated simultaneously under an 808 nm NIR diode laser at a power density of 2.2 $W \cdot cm^{-2}$. With the increasing heat generated under the laser irradiation (up to 5 min), vapor pressure accumulated inside the PT-Chip,

which pumped the solutions to microchannels and displayed bar chart movement. Therefore, the visual quantitative detection of PSA was achieved by simply recording the bar-chart pumping distances of the immunosensing solutions, which were conveniently read by using an on-chip ruler from the PT-Chip.

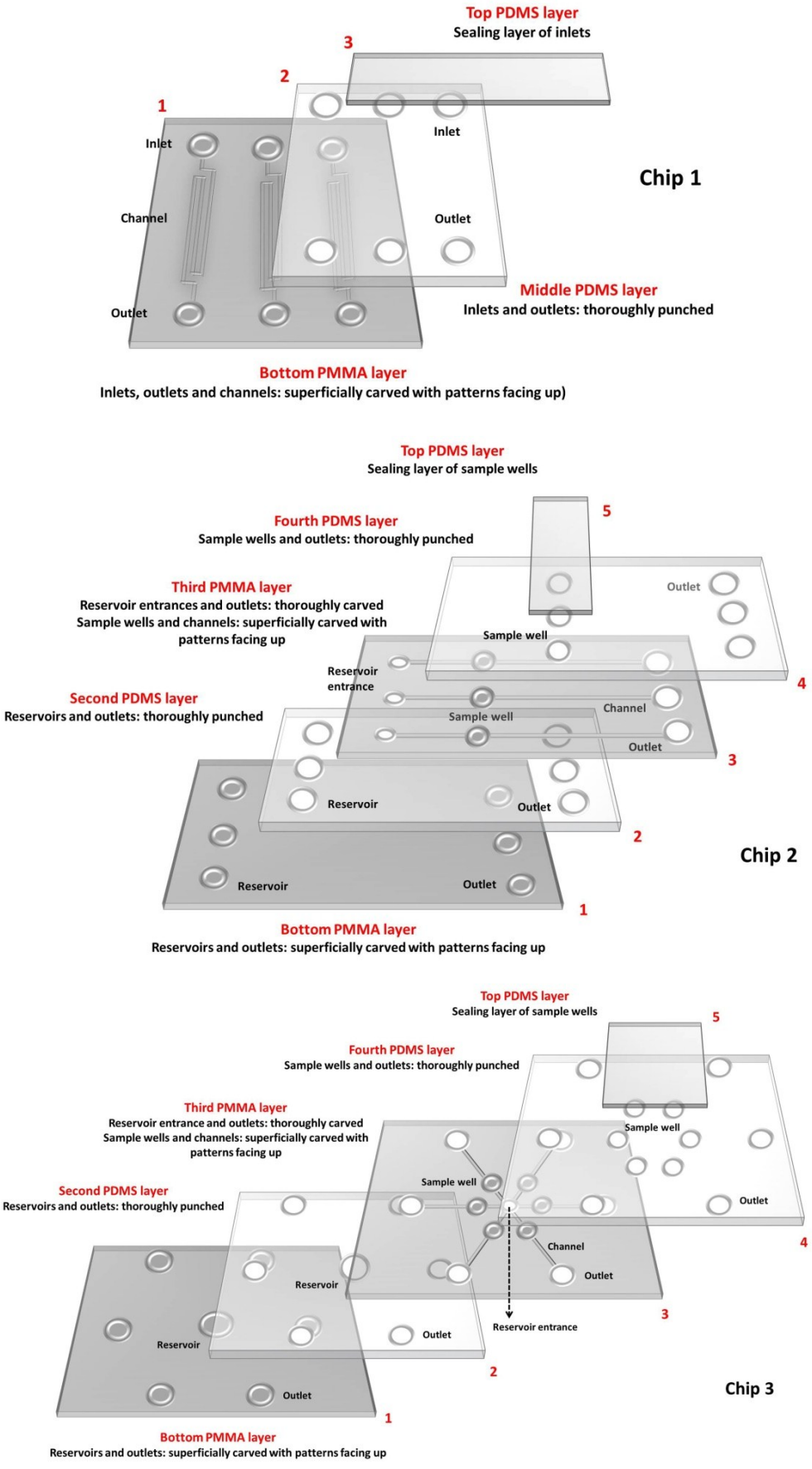

Figure S1. Schematic illustration of structures of **Chip 1**, **Chip 2**, and **Chip 3**.

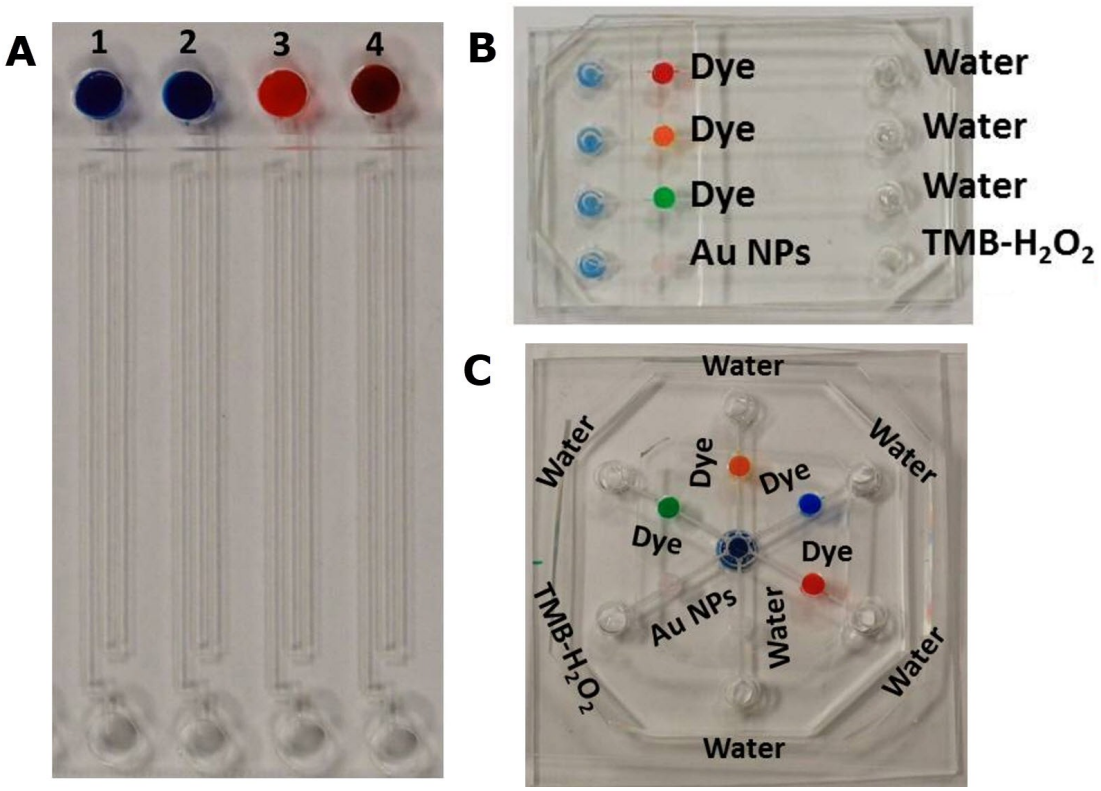

Figure S2. Photographs of (A) **Chip 1**, (B) **Chip 2**, and (C) **Chip 3**.

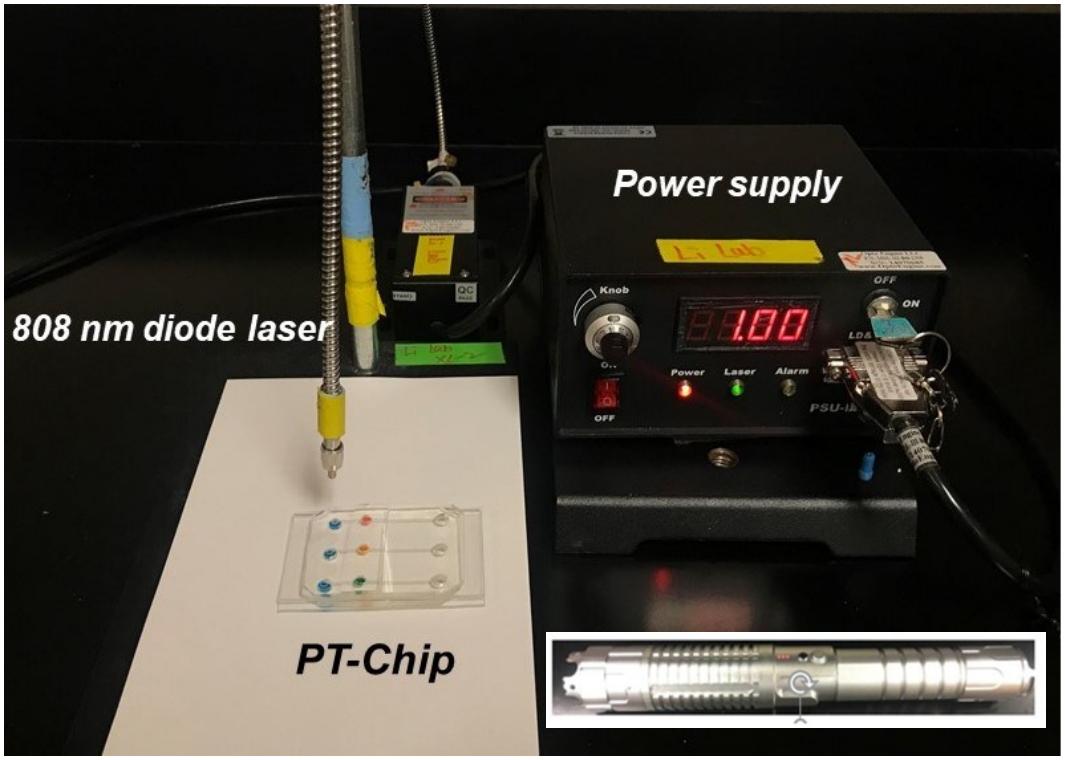
808 nm diode laser
Power supply
Knob
OFF
ON
1.00
Power
Laser
Alarm
OFF
PT-Chip

Figure S3. Photograph of the platform setup including the laser and the PT-Chip. The inset is a NIR laser pointer.

References

1. G. Fu, S. T. Sanjay, W. Zhou, R. A. Brekken, R. A. Kirken and X. Li, *Anal. Chem.*, 2018, **90**, 5930-5937.
2. G. L. Fu, S. T. Sanjay, M. W. Dou and X. J. Li, *Nanoscale*, 2016, **8**, 5422-5427.