Supplementary information for

Distributed fibre optofluidic laser for chip-scale arrayed biochemical sensing

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Simulation of Michaelis–Menten equation

According to Michaelis–Menten equation[1], the enzyme catalyse rate dC/dt can be expressed as

$$\frac{dC}{dt} = \frac{V_{\max} S}{K_m + S}. \tag{1}$$

Here, C is the concentration of product, $V_{\max} = k_c \cdot E$ is the maximum reaction rate. k_c is the turnover number, i.e., the maximum number of substrate molecules converted to product per enzyme molecule per second, E is the enzyme concentration. The concentration of substrate $S = S_0 - C$ varies with time in the catalysis reaction due to the substrate consumption. K_m is the Michaelis-Menten constant. C can be numerically solved using Runge-Kutta methods.

Tabel S1 Parameters in the simulation in Fig. 2

Parameters	Value	Remark
k_c	1.8×10^{5} min^{-1}	Turnover number
S_0	8×10^{-5} mol/L	Initial substrate concentration
K_m	2.75×10^{-4} mol/L	Michaelis-Menten constant
L	1 mm	Thickness of solution
α	4×10^{4}	Molar attenuation coefficient of product

Protocol for HRP detection

Step 1: HRP stock solution with a concentration of 227 μM was prepared by dissolving lyophilized HRP powder in 0.1 M potassium phosphate buffer (pH 6.0).

Step 2: HRP working solution with concentrations of 1.12 nM, 0.56 nM, 0.28 nM, 0.14 nM, 0.07 nM was freshly prepared by diluting the HRP stock solution with 0.1 M potassium phosphate buffer (pH 6.0).

Step 3: Working substrate solution was prepared by mixing 100 μl color reagent A and 100 μl of color reagent B.

Step 4: 20 μl HRP working solution and 80 μl working substrate were mixed for colorimetric detection.

Step 5: The final mixture of HRP and substrate was flowed through the square capillary and the images of lasing HOF was recorded over reaction time.

For regeneration of the sensing channels, the following wash steps were performed.

Step 6: After each test, the square capillary was filled with 0.4% hydrofluoric acid (HF) for 2 minutes to remove the residual HRP and substrate molecules.

Step 7: The capillary was then filled with wash buffer (WA126, R&D Systems) and incubated for 5 min. This wash process was repeated twice for better regeneration of the capillary. Then the capillary was ready for the next test.

Illustration of the 1D-FOL with long distributed lasing distance

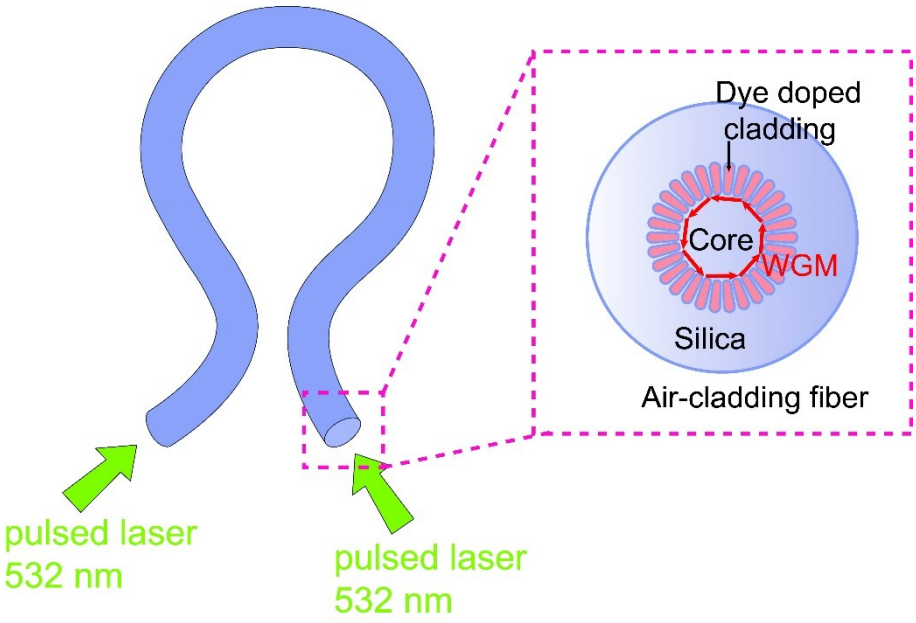

Figure S1. Schematic diagram of the air-cladding fiber based long distributed 1D-FOL. Inset, the cross section of air-cladding fiber. By utilizing the air-cladding optical fiber (ACF), the 1D-FOL with long distributed lasing distance may be achieved. The ACF consist of a solid core and micro holes (air cladding) separated by microscale support bridges. The liquid gain medium with an index lower than silica can be drawn into the holes using the capillary force. Due to the cylindrical structure of the fiber core and its higher refractive index, the core-liquid boundary supports the WGMs, thus providing optical feedback for lasing. The pulsed laser is coupled into fiber core from two end faces and counter propagates in the fiber core with low loss. Due to the low transmission loss of pump laser in optical fiber, increase in the length of 1D laser by one order of magnitude can be expected.

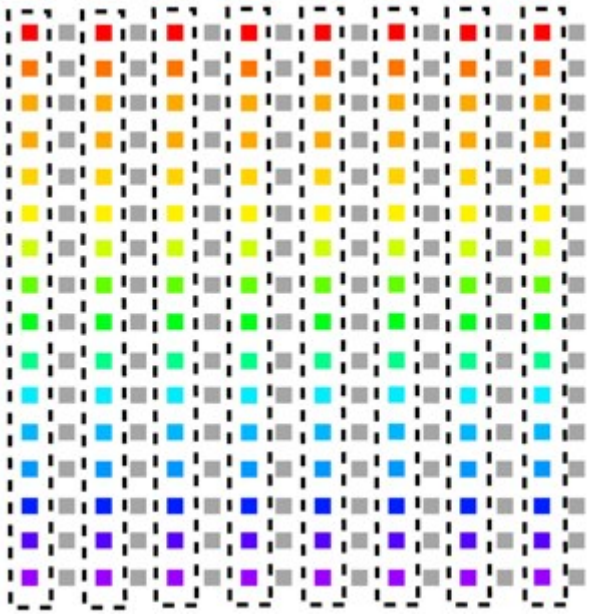

Figure S2. Illustration of the concept of 2D microfluidic chip for spectral analysis of various liquid samples. The transmission of DFOFLs at different wavelength through the same solution in one channel, e.g., Ch. 1, could give rough information of absorption spectrum for the sample in it. The spectral resolution is determined by the wavelength difference between adjacent channels and their linewidths. Absorption linewidths of liquid samples are often tens of nanometers that have loose requirement on the spectral resolution. The wide tunability of DFOFLs enhances the capability of the chip for versatile analysis of various samples.

Reference

1 Wagner JG. Properties of the Michaelis-Menten equation and its integrated form which are useful in pharmacokinetics. J Pharmacokinet Biopharm 1973; **1**: 103-121.