Electronic Supplementary Material (ESI) for Lab on a Chip.

Supporting Information

Title: Ultra-sensitive chemical and biological analysis via specialty fibers with built-in microstructured optofluidic channels

Authors: Nan Zhang, Kaiwei Li, Ying Cui, Zhifang Wu, Perry Ping Shum, Jean-Louis Auguste, Xuan Quyen Dinh, Georges Humbert*, and Lei Wei*

* Email: WEI.LEI@ntu.edu.sg

* Email: georges.humbert@xlim.fr

Theory

1. Interference pattern of a fiber Sagnac interferometer.

In fiber Sagnac interferometer, the interference pattern reflects the relative phase difference between two counter-propagating optical paths converging at the 3 dB coupler. In our setup, the relative phase difference is predominantly introduced by modal birefringence of fundamental mode propagates in the 535 mm-long SC-PCF. The transmission ratio (T) of optical power can be expressed as the following equation ignoring insertion loss of the fiber loop:[1]

$$T = (1 - cos(2\pi LB/\lambda))/2$$

where L is the length of the SC-PCF, λ is wavelength, and $B = n_x - n_y$ represents the birefringence of the SC-PCF. n_x and n_y are the effective refractive indices (ERIs) of two orthogonally polarized fundamental core modes. As *T* is a period function against wavelength, the relationship between the birefringence coefficient of the fundamental mode in SC-PCF and the period of resonance wavelength ($\Delta\lambda$) in the transmission spectra can be expressed as $B = \lambda_{res}^2/(\Delta\lambda \cdot L)$, where λ_{res} is the central wavelength of a resonance period.

2. Detection limit (DL) calculation.

The DL of this optofluidic RI sensor, which indicates its sensing resolution, can be estimated by taking into consideration of the full-width at half-max (FWHM, $\Delta\lambda_{FWHM}$) value of the resonant dip, signal to noise ratio (SNR), as well as the sensing sensitivity (S) with the relationship,[2]

$$DL = (3\Delta\lambda_{FWHM}/4.5SNR^{0.25})/S$$

Additional figures:

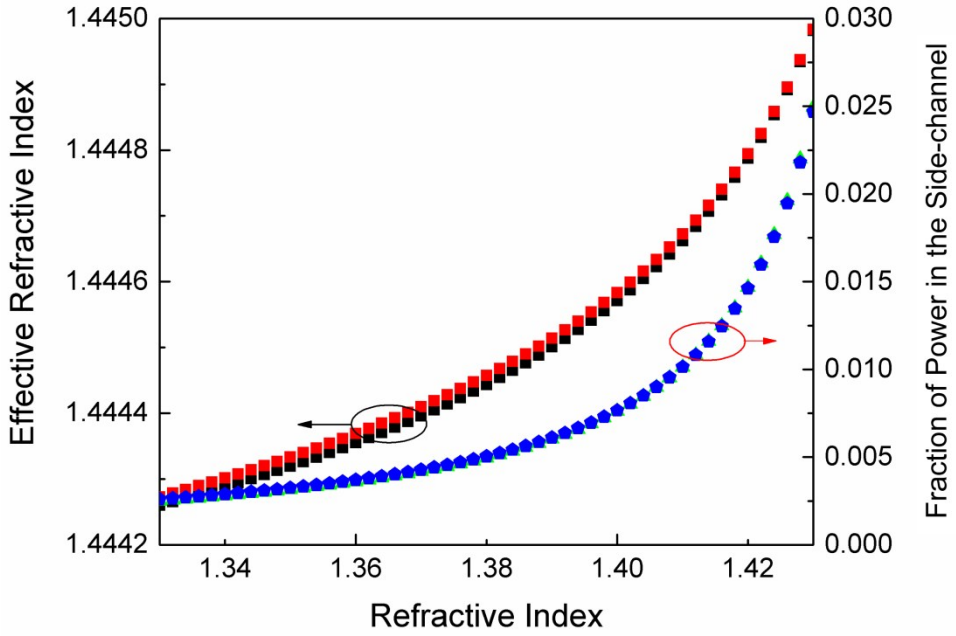

Figure S1. Effective refractive indices of the core modes and fraction of evanescent power in the side-channel for two different polarizations against the refractive index of the side-channel.

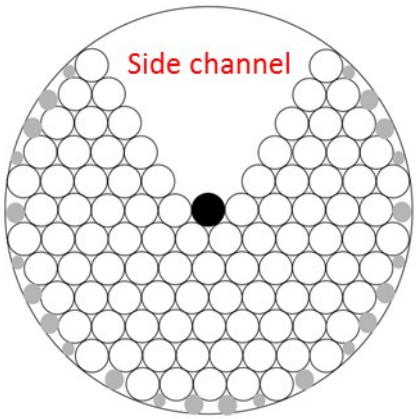

Figure S2.Fiber map (dimension not to scale). Black and gray solid circles represent the solid silica rods for fiber core and supporting rods, respectively. Hollow rings represent silica capillaries for constructing the holy triangular lattice cladding structure.

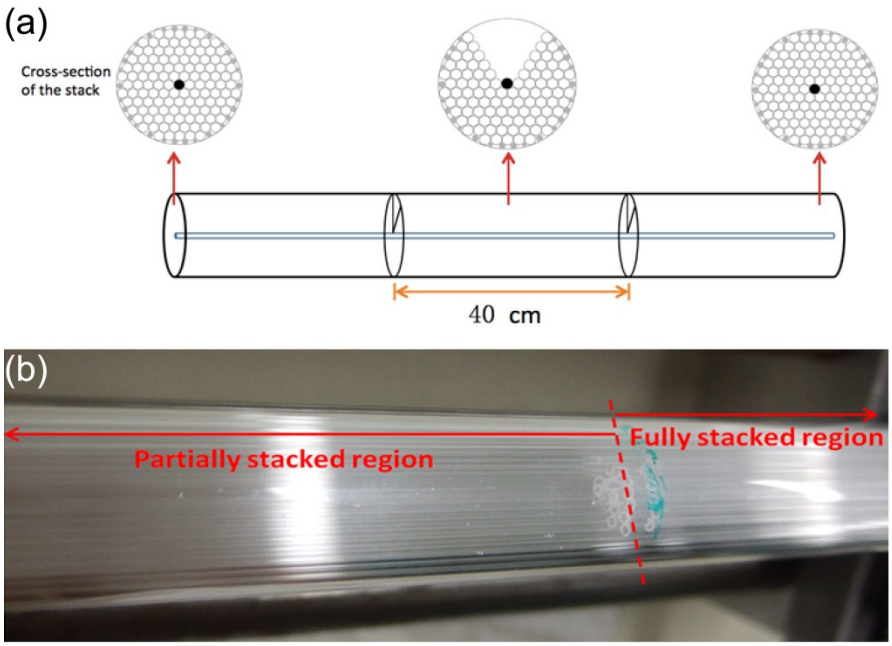

Figure S3. (a) Illustration of the preform of the SC-PCF. (b) Image of one of the transitory sections of the preform from partially stacked region to fully stacked region.

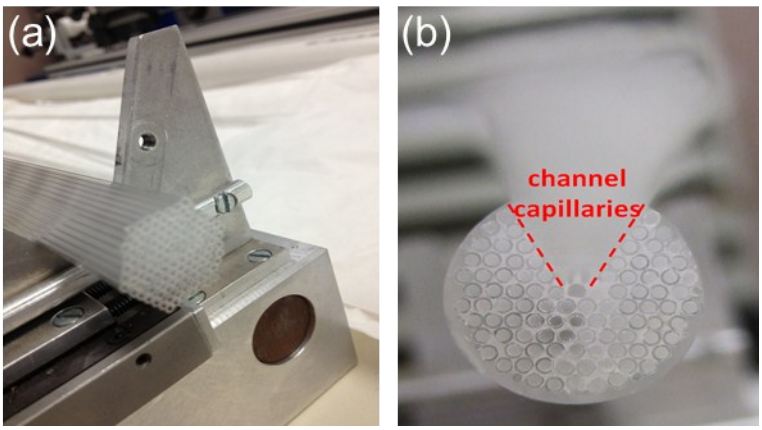

Figure S4. Photos of the cross sections of (a) fully stacked region and (b) SC-PCF structure.

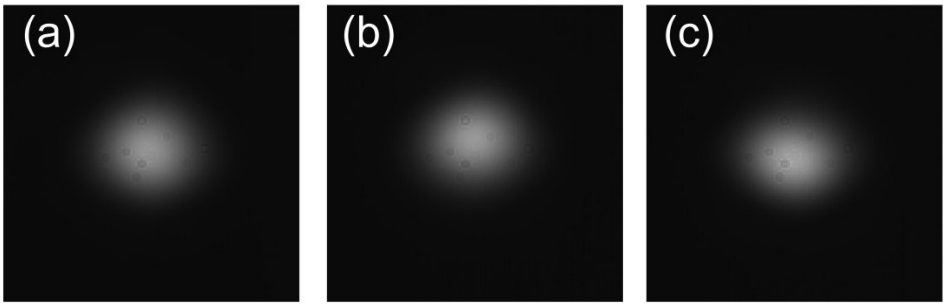

Figure S5. Transmitted mode profiles at the fiber output of SC-PCF (a) without wrapping, (b) with 5-coil wrapping, and (c) 10-coil wrapping around a 0.5-inch-diameter rod.

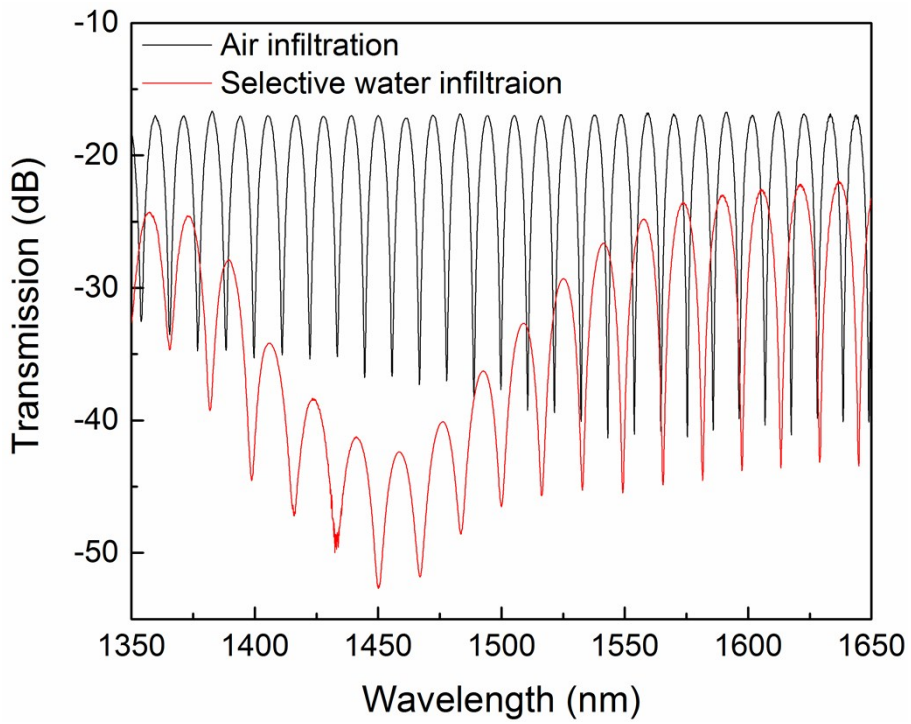

Figure S6. Transmission spectra collected in the conditions of pure air infiltration (black curve) and selective water infiltration in the side-channel only (red curve). The light source (Infinon Research, IRBL-11111-F) we use in the experiment is a broadband light source.

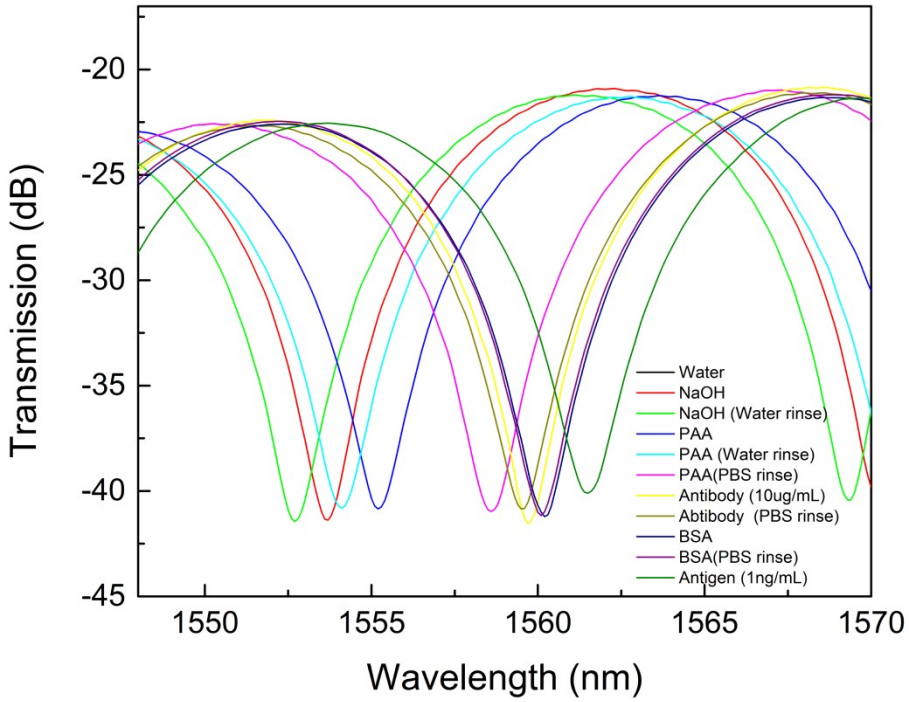

Figure S7. Spectra recorded *in situ* during the chemical binding procedure.

Materials:

Methylene blue (MB) solutions are prepared by dissolving MB powders (SIGMA-ALDRICH) in DI water to different concentrations.

Refractive Index (RI) solutions are prepared by dissolving sodium chloride powders (Affymetrix, J21618) in DI water to different concentrations to achieve different RI values.

Sodium hydroxide (NaOH) solution is prepared by dissolving NaOH powder (Alfa Aesar, A16037) in DI water.

Poly (allylamine) (PAA) solution is purchased from SIGMA-ALDRICH (479144) with a molecule weight of ~65,000, and used after dilution with PBS.

Cardiac troponin T (cTnT) antibody (ab10214) and antigen (ab9937) solutions are purchased from abcam, and used after dilution with PBS.

Bovine serum albumin (BSA) solutions are prepared by dissolving BSA powder purchased from Aladdin in PBS solutions.

Phosphate buffered saline (PBS, pH 7.4) is purchased from Vivantis (PB0344 – 1L).

References

1 X. Dong, H. Y. Tam and P. Shum, *Appl. Phys. Lett.*, 2007, **90**, 2005–2008.
2 I. M. White and X. Fan, *Opt. Express*, 2008, **16**, 1020–1028.