Electronic Supplementary Information (ESI)

Integration of Nanostructured Dielectrophoretic Device and Surface-Enhanced Raman Probe for Highly Sensitive Rapid Bacteria Detection

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Supplementary Information Figure S1

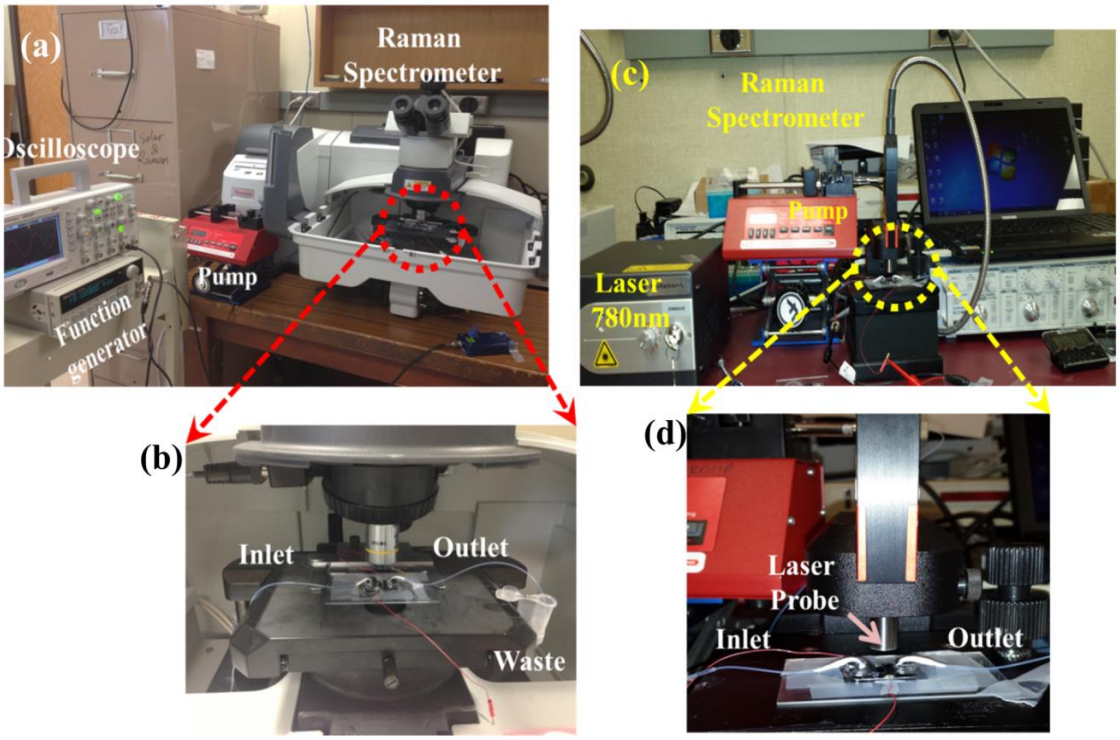

Figure S1. Experimental setup of Raman measurement on the DEP chip. (a) The confocal Raman microscope (DXR Raman spectrophotometer, Thermo Scientific) and (b) the microfluidic device under 10X objective of the Raman microscope. (c) The portable Raman Instrument (Pro Raman L, Enwave Optronics Inc.) and (d) is the alignment to the microfluidic device under 100 µm probe.

Supplementary Information Figure S2

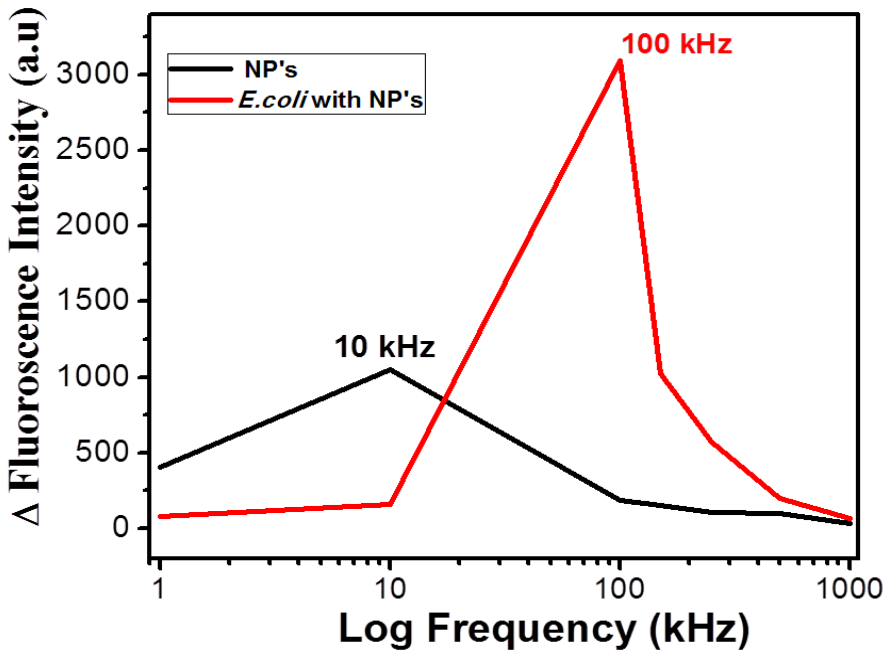

Figure S2. The difference in DEP capture efficiency of IO-Au NOV labeled *E. coli* DHα5 cells and free IO-Au NOV solution, as monitored by the fluorescence intensity change after 50 s of DEP capture. The concentration of IO-Au NOV labeled *E. coli* DHα5 cells is 5.3 x 10^5 cfu/mL and the concentration of free IO-Au NOV solution is equivalent to the amount of NOVs in the 9 x 10^5 cfu/mL of labeled *E. coli* sample. The DEP experiments were carried out at the varying frequency from 1 kHz to 1000 kHz while other parameters are fixed: voltage (10 V_{pp}) and flow velocity (0.33 mm/s). The capture of free IO-Au NOV at 100 kHz is negligible.

Supplementary Information Figure S3

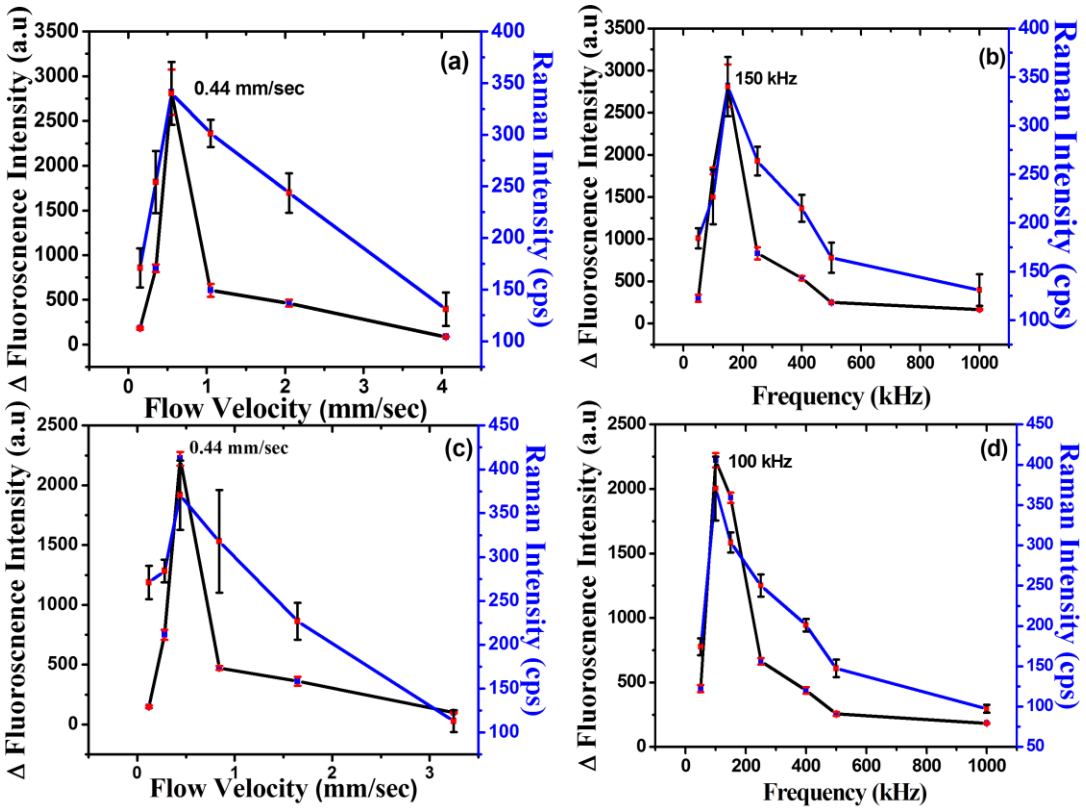

Figure S3. Assessing DEP capture of IO-Au NOV labeled *E. coli* DHα5 cells in complex matrices by fluorescence and the confocal Raman measurements. The DEP capture of 5 x 10^5 cfu/ml of *E. coli* DHα5 cells spiked in the chicken broth (a) at varying AC frequency and (b) at varying flow velocity. The optimum conditions are 150 kHz in frequency and 0.44 mm/sec in flow velocity. The DEP capture of 5 x 10^5 cfu/ml of *E. coli* DHα5 cells spiked in soil solution (c) at varying AC frequency and (d) at varying flow velocity. The optimum conditions are 100 kHz in frequency and 0.44 mm/sec in flow velocity.

Supplementary Information Figure S4

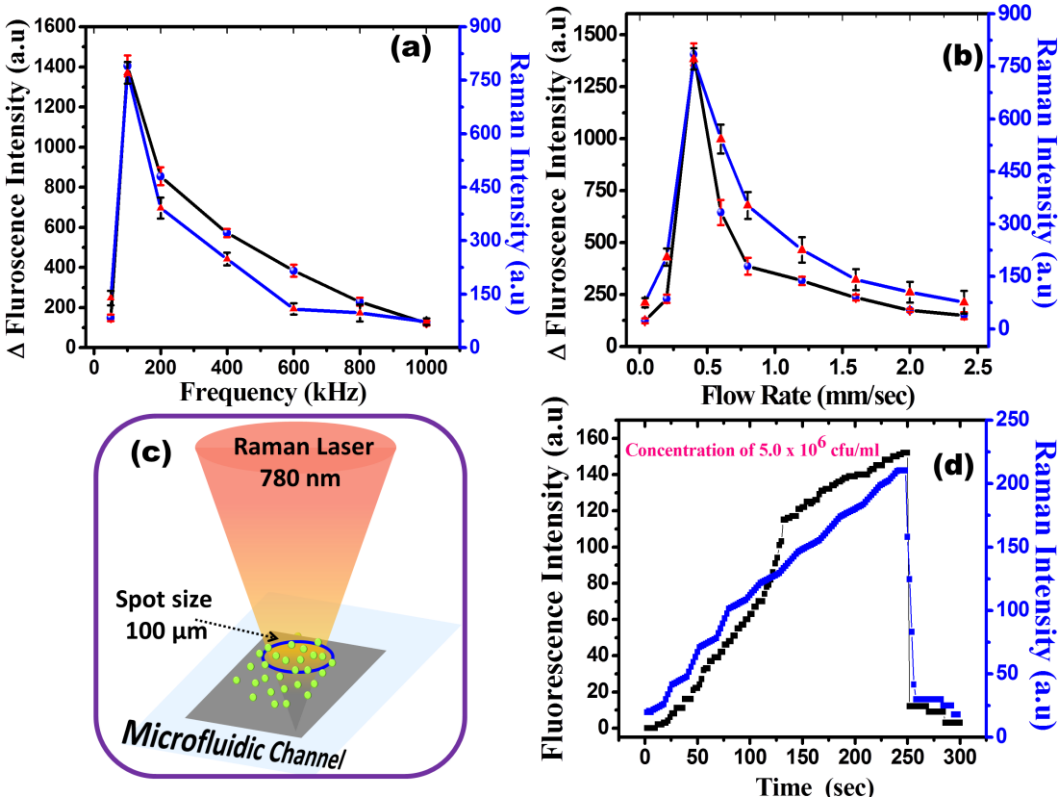

Figure S4. Assessing DEP capture of 5.3 x 10^5 cfu/mL of IO-Au NOV labeled *E. coli* DHα5 cells with fluorescence and the portable Raman system (a) at varying AC frequency and (b) at varying flow velocity. The optimum frequency of 100 kHz and optimum flow velocity of 0.40 mm/sec were observed. (c) Schematic diagram of 100 µm diameter laser probe focused on the active DEP area of the microfluidic device. (d) The kinetic DEP capture curves measured at an AC frequency of 100 kHz and a voltage of 10 V_{pp} while 5 x 10^6 cfu/mL IO-Au NOV labeled *E. coli* DHα5 cells flowing through the DEP device at 0.40 mm/sec flow velocity

Supplementary Information Figure S5

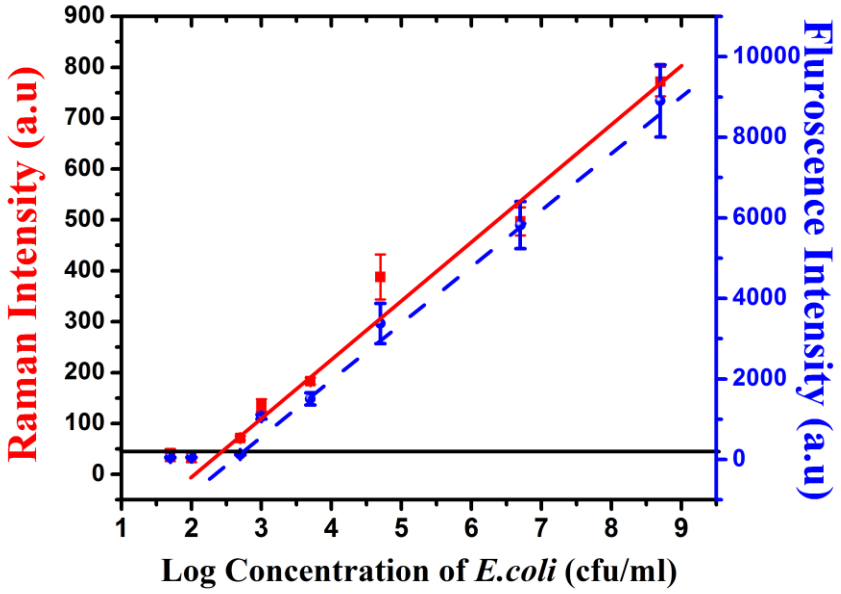

Figure S5: The increase in the Raman (left) and fluorescence (right) intensity after 50 s of DEP capture of *E. coli* cells from the bacteria solution as the concentration varying from 5 cfu/mL to 1.0 x 10^9 cfu/mL. The Raman measurements were carried out by focusing the 100-µm-diameter laser beam within the 200 µm x 200 µm active DEP area with a ProRaman L portable Raman system (Enwave Optronics). The fluorescence intensity was integrated over the whole 200 µm x 200 µm active DEP area with the CCD videos recorded using Carl Zeiss microscope (50X objective at excitation wavelength of 540-552 nm and emission wavelength of 567-647 nm).

Supplementary videos:

Three fluorescence videos to view the DEP capture of bacteria as they move in solution along the microfluidic channel are provided. Experiment is carried out in the following sequence: 12 s voltage off (V_{off}), 50 s voltage on (V_{on}), and again 32 s voltage off (V_{off}).

The videos include:

(a) Capture of bacteria at 0.21 mm/sec flow velocity, 100 kHz, 10 V_{pp} voltage;

(b) Capture of bacteria at 0.33 mm/sec flow velocity, 100 kHz, 10 V_{pp} voltage;

(c) Capture of bacteria at 2.43 mm/sec flow velocity, 100 kHz, 10 V_{pp} voltag