## **Electronic Supplementary Information**

## High-Resolution Integrated Piezoresistive Sensors for Microfluidic Monitoring

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Supplemental Figure S1: Cross-sectional dimensions of the sensor. The functional metal layer is sandwiched in between two layers of PDMS



**Supplemental Figure S2**: Hysteresis of the sensor under loading and unloading for 20 times. It is clear that the sensor follows different trajectories when loaded and unloaded.



Supplemental Figure S3: Left figure is the channel of microfluidic chip under no flow and no pressure, and the sensor is not deformed; right figure is the deformed sensor under flow, which has higher pressure, and the sensor is deformed



Supplemental Figure S4: Simulated results of the pressure drop across the length of a microfluidic channel



**Supplemental Figure S5**: Detection limit and resolution test. Flow rate increases from 0 to 30  $\mu$ l/min with 2  $\mu$ l/min increment. Blue, green, and red shaded areas are three flow rate sections, which are 2, 4, and 6  $\mu$ l/min. Sensor signal (blue line) starts to increase when flow rate is greater than 6  $\mu$ l/min



**Supplemental Figure S6:** The fabrication process of the microfluidic chip. a) a one-sided adhesive film (red, ~50μm thickness) is put on top of a piece of acrylic. b) laser etches the channel design and remove unnecessary parts. c) press down a piece of acrylic frame and glue the edges. d) fill the mold with PDMS. e) after cured, take out the PDMS chunk. f) remove the adhesive film from the PDMS, puncture holes at the inlet and outlet position. g) plasma treat the PDMS chunk and the sensor, then press together. h) bonded sensor and microfluidic channel



**Supplemental Figure S7:** Sensing the pump pattern generated by an oscillator pump. As pressure changes propagate through the ring oscillator, pump valves are opened and closed in a peristaltic pumping pattern. A sensor embedded pump valve detects changes in valve state that correspond to the instantaneous flow rate from the pump. A backward flow pulse occurs when valve 3 opens followed by two forward flow pulses that occur when valves 2 and 3 close.



Supplemental Figure S8: Monitoring oscillator frequency. The frequency of the ring oscillator was adjusted by adding varying resistances to the air inlets of one inverter gate. Fourier transforms of the sensor measurement and video-based measurement were compared for four different resistance values and show excellent agreement.