Impedance Cytometry Based on Multi-fingered Interdigitated Electrodes

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Highly sensitive biomarker detection is often performed using fluorescence based labeled optical measurements, which are often bulky and costly. On the other hand, electrical bio-detection is lower in cost and allows for label-free assays which can be integrated into portable devices. However, this often comes at a loss of sensitivity. Detection of nanoscale biological molecules requires the use of pores that are also nanometer in scale.

We present a novel method of achieving high SNR electrical impedance measurements using multi-fingered interdigitated electrodes in conjunction with a matched filter resulting in processing gain. With a sufficient number of electrodes, one can envision SNRs comparable to nanopores yet with the simplicity in fabrication and compatibility with mass production of micron scale devices.

As shown Fig. 1A, the electrodes are interdigitated, where the alternating electrodes are connected to the 300k Hz AC power and lock-in amplifier respectively. The PDMS micropore channel is oxygen plasma bonded to the electrodes chip. The lock-in amplifier can measure the current between electrodes which is determined by the impedance between them. When the molecules or the beads passing through the space, it results in a current decrease, so that the multi-fingers electrodes would result in a train of negative peaks, as Fig. 1B shown. The impedance between two electrodes is comprehensively affected by the dimension of the pore, diameter of particles, the resistivity of solution, and also the flow rate (Fig. 2).

Assuming the spacing between the microfabricated electrode is 15 um and resistivity of solution is 1.129 Ω/m, a flow rate of 0.1 uL/min, the plot of SNR vs number of electrode fingers and beads diameter is Fig. 2. The photo of 16 fingers electrodes pair and the entrance of nanopore are shown in Fig. 3A and Fig. 3B. The typical experiments results are shown in Fig. 4A for a scenario where we expect three peaks. The presence of three peaks results in a 3X processing gain in SNR after applying the match filter.
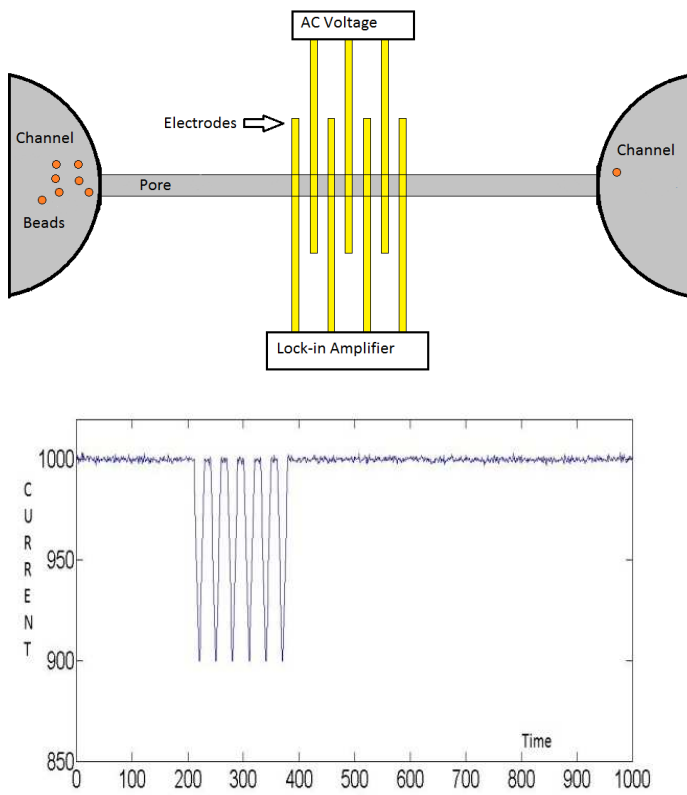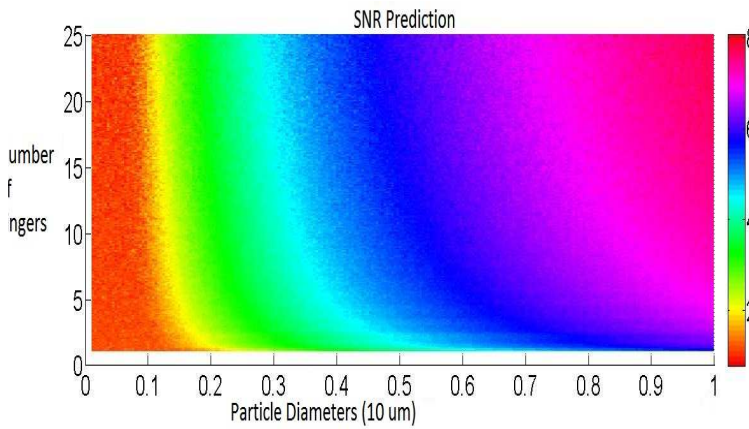
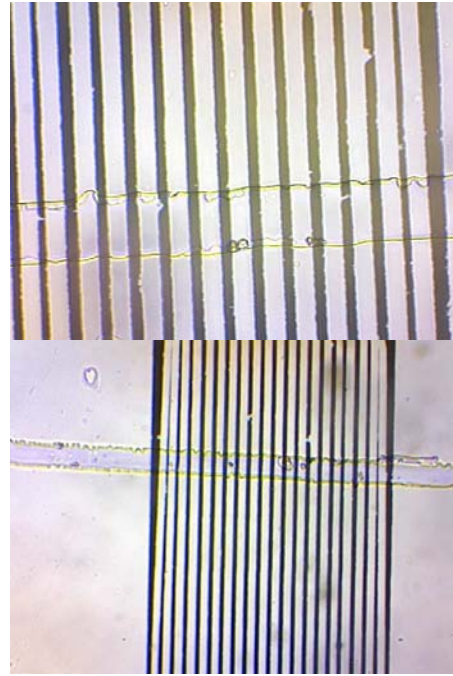Fig. 1. Device schematic.

Fig. 2. Theoretical Simulations.

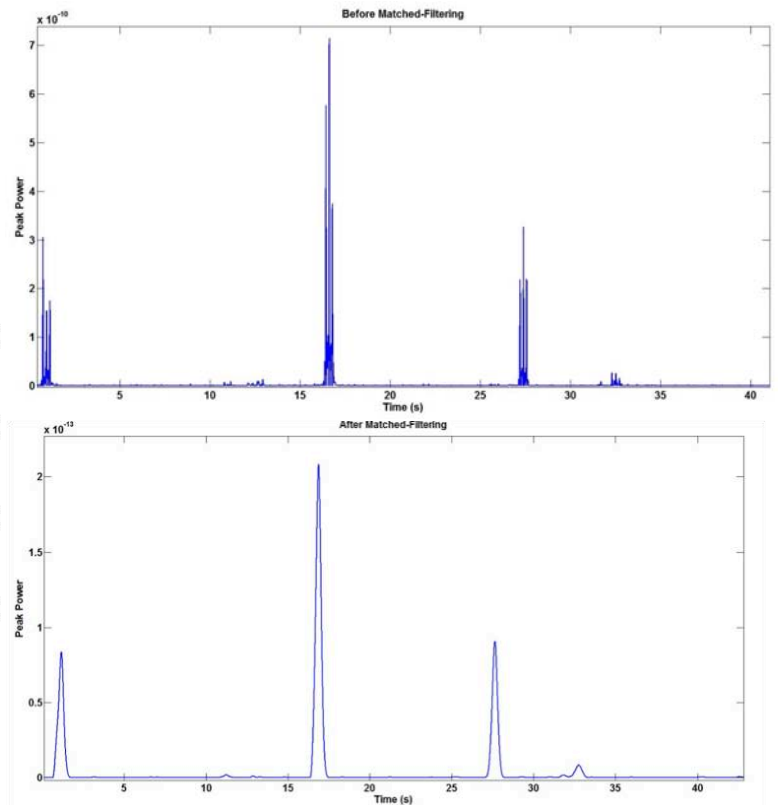Fig. 3A & 3B Photo of Device 16 fingers and 21 fingers

Fig. 4 Data before matched filter and after the matched filter