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Multi-channel Microfluidic Particle Counter via Optical Absorption Sensing

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Extended Abstract

With the utilization of advanced nanofabrication techniques, the microfluidic particle counter demonstrates significant potential due to its high efficiency, precise manipulation, and portability [1]. Current microfluidic particle counters are primarily classified into two base types: optical and electrical. Optical detector typically based on fluorescence [1, 2], which is not a label-free method, and light scattering methods often require the production of sheath flow and is limited to single-channel detection[3, 4], which restricts their application in high-throughput analyses. This work addresses these problems by presenting a microfluidic particle counter based on optical absorption, enabling simultaneous easy manipulation and detection [5]. Our system offers several advantages, including label-free detection, high-throughput capability, fast analysis, real-time display, ease of operation, and low cost.

To achieve precise particle detection, a Christmas tree-like structure was implemented to separate single particle from cluster, which was then detected in independent multiple parallel channels. The micro-chip was fabricated from polydimethylsiloxane and glass using nanofabrication and soft-lithography methods. Photo detectors integrated in a multi-channel circuit convert the light intensity into electric signals. The output signals transition from a high-level voltage to a low-level voltage as particles traverse the detection region, and these falling edges were recorded by a microcontroller for the purpose of counting.

So far, the system exhibits a high degree of reliability, as evidenced by a linear correlation coefficient over 0.99 obtained during testing with gradient-concentrated beads. Furthermore, we obtained the counting data and calculated the number of NIH 3T3 cells per mL in three density levels, in accordance with the range of common density 10^4 - 10^6 cells/mL of NIH 3T3 cell cultural and analysis [6, 7]. Compared with the results obtained from a traditional flow cytometer BD (FACSymphony™) A1 Cell Analyzer, the system achieves a substantial agreement percentage ranging from 87.5% to 99.9%, while significantly shortening the acquisition time, which was just one-sixth of the flow cytometer while testing with similar amount of the sample.

We are now working on the classification of different cell types by identifying the length of the low-level voltage signal and machine leaning. Hopefully, this will enable the detection of the ultra-low number of circulating tumor cells for diagnostic purposes. Additionally, we are testing the chips using glass as the base material, which has higher stiffness and may improve the performance. Overall, this high-throughput platform with diverse potential applications shows promise as a tool for real-time, point-of-care testing.

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