ELECTRODYNAMIC WALL LOSS REDUCTION FOR AIRBORNE PARTICLE PROCESSING

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ABSTRACT

This paper presents an wall loss reduction technique using electrodynamic disturbances. First, the proposed technique is applied to a general microchannel as a feasibility test, and then it is applied to a virtual impactor, which is an inertial airborne particle classifier used for environmental monitoring. In the microchannel application, when the electric potential was 3 kV at 1 kHz, wall loss was decreased by 16% for particles with a 0.89 μm diameter. In the virtual impactor, wall loss curve of 1 kV at 1 kHz showed a maximum wall loss reduction of 10% compared with initial wall loss curve.

KEYWORDS: electrodynamic disturbance, wall loss, airborne particle processing

INTRODUCTION

An integrated microfluidic device for miniaturized analytical systems for environmental applications had been reported [1]. In airborne particle processing, a virtual impactor has been the key element for the size-dependant sampling of particles because of its high performance and real-time classification capability. The virtual impactor is classifying airborne particles according to their sizes using inertia momentum of particles, and the cut-off diameter is determined by the size of the channel. However, the wall loss due to the adhesions of airborne particles is the major cause of deteriorating their performance and reliability of systems. Also, the wall loss can be even more significant problem in structures of the virtual impactor because it makes unexpected changes on the structures and operational conditions [2]. However, there are not enough researches regarding the reduction of the wall loss in air-based microfluidic devices [3]. In this paper, we propose an electrodynamic wall loss reduction technique to detach particles from the walls of a microchannel. First, the wall loss reduction technique was applied to a general microchannel as a feasibility test, and then, it was applied to a virtual impactor for environmental monitoring.

DESIGN AND FABRICATION

Figure 1 shows a schematic view of the proposed devices of a (a) general microchannel and a (b) virtual impactor to examine the wall loss and its reduction. Particles that were adhered to walls were detached from the walls of the microchannel using electrodynamic disturbance by applying AC electric potential to interdigitated electrodes (IDEs). These proposed chips were integrated with IDE pair at the bottom of the microchannel for the reduction of the wall loss. Figure 1 (c) shows a simplified fabrication sequence and (d) is an optical image of the fabricated devices. Figure 2 shows experiment setup for evaluating wall loss in the (a) general microchannel and the (b) virtual impactor. Airborne particles were supplied to the general

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microchannel and the virtual impactor for measuring the wall loss. Afterwards, electric potentials at 1 kHz were applied to the IDEs and the wall loss was measured again.

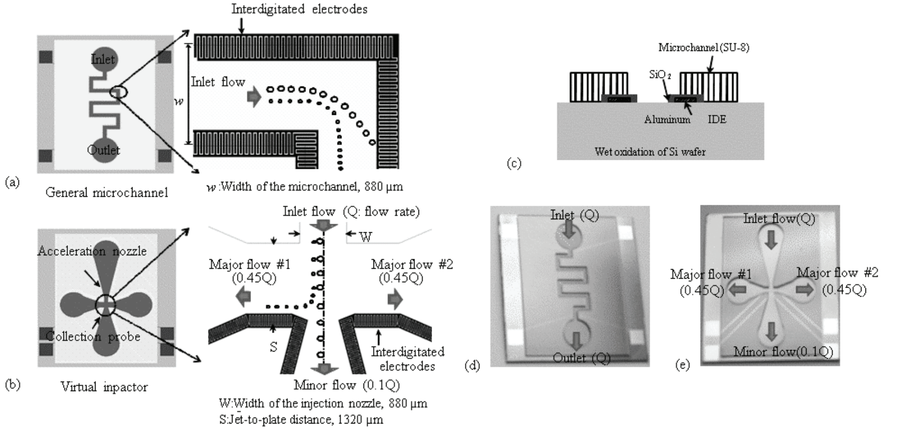

Figure1. Schematic view of (a) the general microchannel and (b) the virtual impactor and integrated interdigitated electrodes at the bottom of the channel, (c) a cross-sectional view of proposed devices, (d) a fabricated microchannel and (e) a fabricated virtual impactor

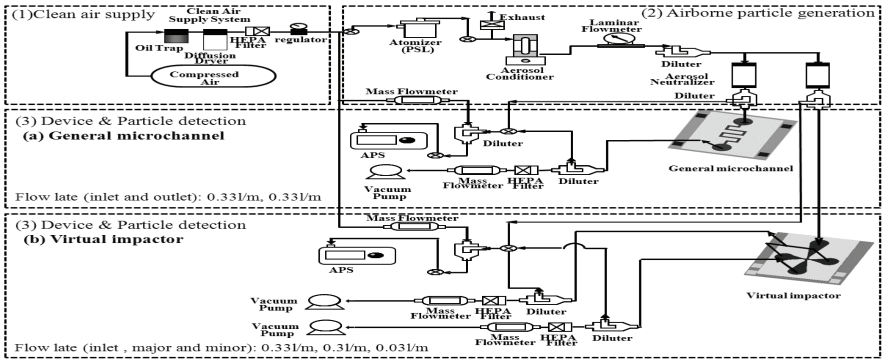

Figure2. Experimental setup of the (a) general microchannel and the (b)virtual impactor

RESULTS AND DISCUSSION

1) Wall loss reduction in a general microchannel structure

Figure 3 (a) shows the inlet concentration of the particles and Figure 3 (b) shows the concentration of the collected particles. For Particle diameter of 0.83 μm, inlet concentration was 632 particles/cm^3. But concentration of the collected particles at the outlet was 49 particles/cm^3. Only 8% of the supplied particles were arrived at the outlet and 92% were adhered to the wall of the microchannel. By applying AC electric potentials from 1 to 3 kV at 1 kHz, the collected particle concentration was increased and collected particles were 146 particles/cm^3 at 3 kV. Figure 3 (c) shows the wall loss as a function of aerodynamic diameters. The wall loss was decreased with increasing the magnitude of electric potentials and enlarging the diameters of particles. when the electric potential was 3 kV at 1 kHz, wall loss was decreased by 16% at 0.89 μm in diameter.

2) Wall loss reduction in a virtual impactor

To examine the wall loss of the virtual impactor with the cut-off diameter of 1 *μm*, particles ranging in the diameter from 0.6 to 1.4 *μm* were classified. The measured cut-off diameter was 1.03 *μm* as shown in Figure 4 (a). At the cut-off diameter, the wall loss was 35%. Then by applying alternating electric potentials to 1 *kV* at 1 kHz, the wall loss was 25%, which means that the wall loss was reduced by 10% as shown in Figure 4 (b).

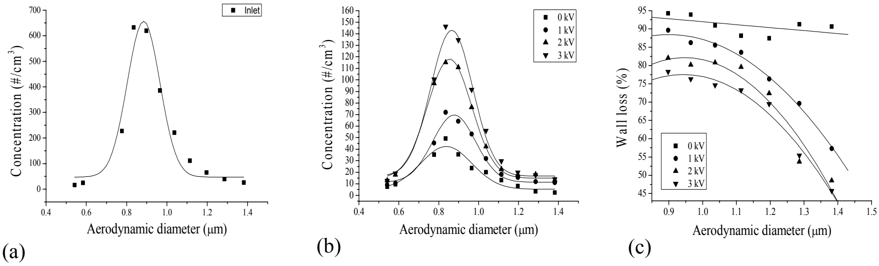

Figure 3. General microchannel: Particle concentration at (a) inlet, (b) outlet and (c) measured wall loss as a function of aerodynamic diameters

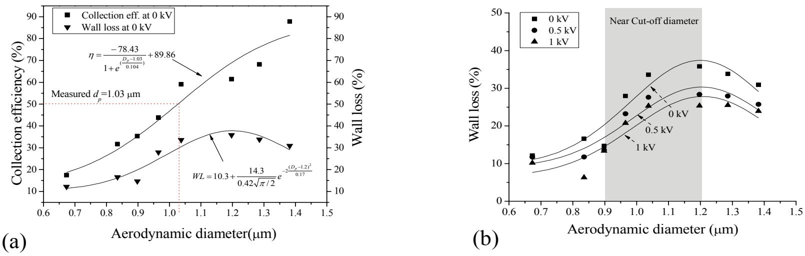

Figure 4. Virtual impactor: (a) Collection efficiency and wall loss and (b) measured wall loss as a function of aerodynamic diameters

CONCLUSIONS

We demonstrate an electrodynamic wall loss reduction technique to the general microchannel and the virtual impactor. According to the measured results, it was confirmed that the proposed technique could reduce the wall loss and enhance the performance of air-based microfluidic devices.

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