A TUNABLE FLUIDIC MICROLENS WITH FLUORESCENCE ENHANCEMENT

L. K. Chin\textsuperscript{1}, Y. C. Seow\textsuperscript{1}, C. S. Lim\textsuperscript{2} and A. Q. Liu\textsuperscript{1†}

\textsuperscript{1}School of Electrical & Electronic Engineering
\textsuperscript{2}School of Mechanical & Aerospace Engineering
Nanyang Technological University, Singapore 639798
(†Corresponding author. Tel: +65-6790 4336; Email: eaqliu@ntu.edu.sg)

ABSTRACT

This paper reports an enhancement in fluorescence detection via the formation of fluidic microlens in micro-optical fluidic system (MOFS). The fluidic microlens is formed by three laminar flows in the expansion chamber. By changing the flow rate of each flow, the shape and focal length of the fluidic lens will be changed. Therefore, the fluidic microlens provides a wide range of tunability to enhance the detection of fluorescence signal in MOFS chip. With such tunability, the designed MOFS can be used to suit different detection methods and applications especially in low-concentration bio-molecules.

KEYWORDS: Fluidic microlens, fluorescence, micro-optical fluidic system, Rhodamine 6G

INTRODUCTION

Microlenses are designed to improve the fluorescence detection method [1-3]. However, these lenses have no or limited tunability in the shape and focal length. This paper presents the method to form fluidic microlens, by three laminar flows, with wide range of tunability to enhance the detection of fluorescence signal in micro-optical fluidic system (MOFS) chip.

DESIGN AND FABRICATION

Figure 1 illustrates the schematics of fluidic microlens for fluorescence detection enhancement. The fluidic microlens is formed using CaCl\textsubscript{2} solution ($n_{\text{core}} = 1.46$) focused by DI water ($n_{\text{clad}} = 1.33$). One of the cladding streams is added with fluorescent dye for detection. The argon ion laser (488 nm) is used as the excitation light and injected on the chip from the top. The formation of the fluidic lenses, either planar convex lens or biconvex lens, will focus the fluorescence emission to the detection fiber for de-

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure1.png}
\caption{Schematics of fluidic microlens formation in MOFS for fluorescence detection enhancement.}
\end{figure}
tection enhancement. Fig. 2 shows the fabricated MOFS chip using PDMS soft lithography. In the chip, there are three inlets, with the central one for the core stream and the two side branches for the cladding streams. The fluidic lens is formed inside the wider region. The shape and radius of curvature ($R$) of lens can be changed by tuning the flow rates.

RESULTS AND DISCUSSIONS

Figure 3 shows the change of the shape and $R$ of the fluidic lens when the flow rate in the core is changed. To form a biconvex lens, both cladding streams have the same flow rate while the one of the core is maintained to be higher. When the flow rate of the core is increased, the $R$ of both interfaces are decreased which greatly improves the focusing power of the lens. The same principle is applied to planar convex lens.

Figure 4 shows the excitation of Rhodamine 6G when it is added to one of the cladding. Two cases are compared in the experiment. Firstly, the detected intensity is compared between the one without lens and half filled with Rhodamine 6G (Fig. 4a) and the one with planar convex lens formed (Fig. 4b). From the result in Fig. 4c, the detected intensity is improved with the planar convex lens formed, i.e. an intensity enhancement (intensity ratio of 4a and 4b) of 2. Then, the detected intensity is compared for biconvex lens between the one in Fig. 5a and the one in Fig. 5b. As shown in Fig. 5c, the detected intensity is improved with an intensity enhancement of 3.

CONCLUSIONS

In conclusion, a tunable fluidic lens is formed in MOFS using three laminar flows of different solutions. The fluidic lens has wide tunability in shape and focal length by changing the flow rate of each stream. With such tunability, the designed MOFS can be used to suit different detection methods and applications especially in low-concentration bio-molecules.
Figure 4: Rhodamine 6G excitation. (a) Half-filled; (b) planar convex lens; (c) comparisons of emission intensities without and with planar convex lens.

Figure 5: Rhodamine 6G excitation. (a) Biconvex lens ($R = 320$); (b) Biconvex lens ($R = 215$); (c) comparisons of emission intensities of the biconvex lenses.

REFERENCES

