Extended Abstracts of the 2018 International Conference on Solid State Devices and Materials, Tokyo, 2018, pp1085-1086

2D pH images in microfluidic by thin-Si LAPS

Xin Rong You[1], Tsung-Cheng Chen[1], Yu-Ping Chen[2], Dorota G. Pijanowska[3,*] and Chia-Ming Yang[1,2,4,5*]

[1] Department of Electronic Engineering, Chang Gung University, Taiwan
[2] Institute of Electro-Optical Engineering, Chang Gung University, Taiwan
[3] Nalecz Institute of Biocybernetics and Biomedical Engineering, Polish Academy of Sciences, Warsaw, Poland
[4] Biosensor Group, Biomedical Engineering Research Center, Chang Gung University, Taoyuan, Taiwan
[5] Department of General Surgery, Chang Gung Memorial Hospital at Linkou, Taiwan
Phone: +886-3-2118800-5960 E-mail: cmyang@mail.cgu.edu.tw

Abstract

A chemical reaction of solution mixture in microfluidic channel is investigated by means of our proposed Mirror-LAPS system. A frame of 200x200 pixles can be generated within 54 sec with a scanning rate is 1.33 ms/pixel. A clear boundary and area of 2 different buffer solutions can be clearly observed. Further study on the reaction or flow status in microfluidics could be performed based on this well-proven platform.

1. Introduction

Microfluidic system had been widely studied for chemical and biomedical application due to the less sample waste and high efficiency of sample preparation in past few decades. [1] To monitor the real response, most of them used the dye or label technique, which leads to drawback of high cost. Light-addressable potentiometric sensor (LAPS) had be proposed with the ability of 2D image of chemical concentration by the collection of photocurrent. [2] Few literatures are successful to integrated LAPS with microfluidic system to demonstrate 2D chemical images. [3-5] However the limitation of previous proposed system could be high complexity of 64 fiber-mounted LEDs [3], small signal by OLED light source [4] and slow spend of scanning laser beam [5]. We presented the fast scanning speeding LAPS system by using a single red laser and analog micromirror in 2014. [6] In this study, a further improved system by using FPGA to fully integrate with a miniature light source and readout system is proposed to investigate the chemical images within a microfluidic system.

2. Experiments

Thin-Si LAPS devices with remained Si thickness of 150 μm for sensing area were processed with Si_3N_4 sensing membrane and KOH back-side etch from double-polished P-type Si wafer with thickness of 350 μm. [7] Microfluidic channel was fabricated by using a tape with thickness of 50 μm and removed area with a pattern of letter "Y" for a channel width of 2000 μm. A capping layer with ITO/glass was used as the pseudo reference electrode in this study. Due to the non-stable surface potential in various solutions, current measurement results could be only to investigate to ability of 2D image. To have the precise concentration in measurement, a standard reference electrode is necessary. Detail process is shown in Fig. 1(a). Different pH standard buffer solutions (Merck Inc., USA) were selected to inject into the microfluidic channel by different condition. The schematic plot and picture of sample is shown in Fig. 1(b) and (c), respectively. The FPGA-based Mirror-LAPS measurement system with is shown in Fig. 2.

3. Results and Discussion

2 inlets and 1 outlet are fabricated on the hole through PDMS and top ITO/glass for the selective solution injection as shown in Fig. 3(a). To verify the basic sensing characteristic, photocurrent versus bias voltage curves are measured for different pH buffer solution. (not shown here) A fixed bias voltage of -1V was selected to check the difference of image generated by different pH buffer solution. As shown in Fig. 3(b) and (c), a clear sharp of letter "Y" can be clearly observed for the area with pH 12 (light blue or green color) and pH 2 (orange color) compare to the area of PDMS encapsulation (blue color). This 2D chemical image could be referred as the statistic image due to fixed pH solution in the microfluidic channel. To further evaluation on the dynamic response of mixture of different pH buffer solutions, pH 2 and pH 12 buffer solutions were injected through inlet#1 and inlet#2 with the same flow rate. Our current scanning rate is approximated 1.33 ms per pixel. Therefore this image of 200x200 pixels can be generated after 53.2 sec. With this fixed flow rate setting, the dynamic stability between 2 solutions could be clearly seen by the area of different color as shown in Fig. 4. In the mixture area, a clear straight line as the boundary between pH 2 and 12 could be clearly defined. With adjustable setting of Mirror-LAPS system, a desired area can be selected and zoom in, which could be a powerful tool to monitor the chemical or biomedical reaction in the microfluidic system.

4. Conclusion

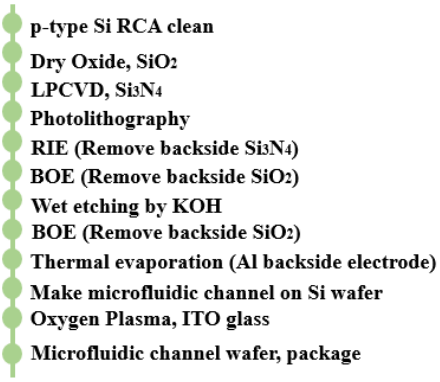
A clear chemical image is obtained in the microfluidic channel by the integration of LAPS chip and top ITO pseudo electrode. Mirror-LAPS system owns a superior scanning speed to real-time monitor the chemical reaction by 2D image generated by photocurrent.

References

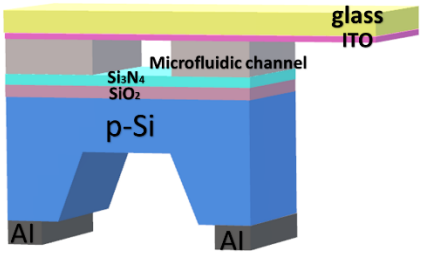
[1] G. M. Whitesides, Nature 442 (2006) 368-373.
[2] D.G. Hafeman, et al., Science 240 (1988) 1182–1185.

[3] K.-i. Miyamo et al., Sens. Actuators B 194 (2014) 521- 527.
[4] K.-i. Miyamoto et al., Electrochim. Acta 113 (2013) 768-772.
[5] K.-i. Miyamoto et al., Sens. Actuators B 189 (2013) 240-245.
[6] A. Das, et al., Sens. Actuators B 198 (2014) 225-232.
[7] C.-M. Yang, et al., IEEE Sensors Journal 18 (6) (2018) 2253-2259.

(a)



(b)



(c)

Fig. 1 (a) process flow, (b) schematic plot, and (c) picture of this fabricated microfluidic device.

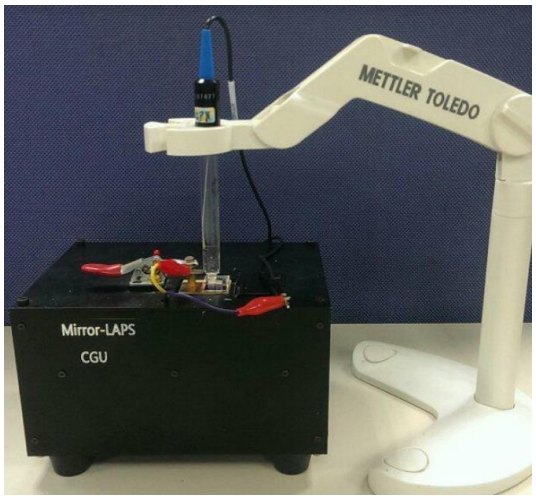
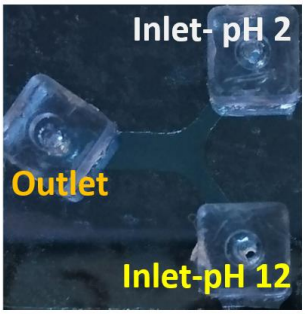
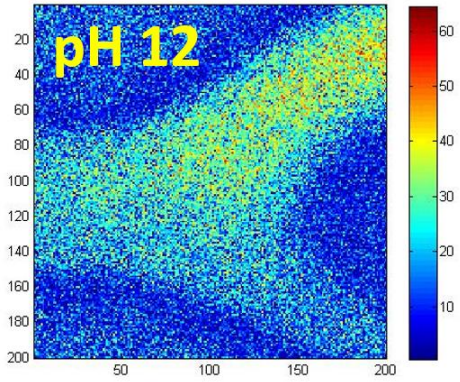


Fig. 2 The picture of FPGA based Mirror-LAPS system.

(a)



(b)



(c)

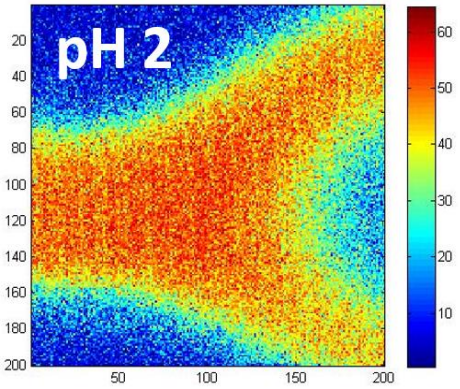


Fig. 3 (a) the top view of real microfluidic integrated on LAPS and the static 2D chemical image for all (b) pH 12 and (c) pH 2 buffer solution in the microfluidic channel.

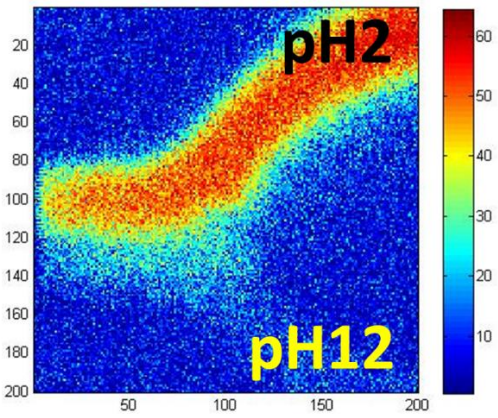


Fig. 4 2D chemical image for top inlet with pH 2 and bottom inlet with pH 12 buffer solution in the same flow rate.