Real-time 2D pH images by fast scanning light-addressable potentiometric sensor system controlled by LabVIEW program

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***Abstract*—Up to now, real-time two dimensional (2D) chemical images are not available in a simple platform, results from big data with low generating rate by complicated process including movement of light source and ultra-low current measurement. A synchronization of all inputs including coordination of scanning step, ac signal of laser spot, and dc bias of LAPS is achieved by a field-programmable gate array (FPGA)-based system and self-developed LabVIEW program. Photocurrent, pH response, 2D pH images of different resolution of Si_3N_4/SiO_2 LAPS can be easily obtained by this system. It could be integrated with microfluidics for a real-time Lab-on-chip with biomedical sensor array.**

Keywords—FPGA, LabVIEW, LAPS, 2D image

I. Introduction

Light-addressable potentiometric sensor (LAPS) is firstly proposed with the possibility of two dimensional chemical image by Hafeman et. al. in 1988 [1]. A LAPS is derived from ion sensitive field-effect transistor (ISFET) and introduce a ac signal from illumination to have the ability to address the sensing area [2]. 2D chemical images of LAPS are available by laser movement by x-y stage [3] and light emitted diode (LED) array [4] with easy setup and slow speed in past decades. Recently fast scanning systems including organic light emitter diode (OLED) [5], multi-channel optical fiber [6], and analog micro mirror [7] are presented. However there are still some drawbacks need to be improved for real-time 2D chemical images including low photocurrent by OLED, complicated modulation system of multi-channel fiber, and non-synchronization of analog micro-mirror system. In this study, a method to integrated all input and output signals by field programmable gate array (FPGA) and LabVIEW program is presented to have real-time 2D chemical image of LAPS.

II. Experimental

As shown in Fig. 1(a), novel system is designed based on a commercial FPGA board and self-design control board. With the advantage of fast scanning by analog micro mirror [7], scanning control, photocurrent measurement and recording are all established by a self-designed FPGA-based system with an excellent synchronization by cooperation with Mirrorcle Technology Inc. as shown in Fig. 1(b). To have standard LAPS samples, p-type (100) silicon wafers with thickness of 500 and 350 um were both used to grow thermal dry oxide (SiO_2) with thickness of 30 nm and a Si_3N_4 layer of 30 nm deposited by low pressure chemical vapor deposition (LPCVD). Then Si_3N_4 and SiO_2 layer in the backside were removed by reactive ion etch (RIE) and buffer oxide etchant (BOE), respectively. For the red laser illumination and scanning from LAPS backside, the backside contact of Al layer was opened with an area of 1.2 cm* 1.4 cm by using shadow metal mask with similar pattern of opening area. An additional encapsulation of PDMS tank was attached to top surface of LAPS chip.

An ac signal with frequency modulation is applied to red laser as the illumination source. Then laser spot is illuminated to the surface of analof micro mirror and then injected to backside of silicon substrate. The laser spot is focus on the backside of silicon substrate. During the mirror scanning, the coordination of movement is recorded and then photocurrent is collected by filtering and amplifying original signal corresponding to this coordination. Once photocurrent is obtained, then mirror will move to next step and following the photocurrent measurement. Photocurrent signal of LAPS can be amplified, filtered and converted to an output voltage signal. A buffer is designed to collect all data and automatically rescale into 6 bits (0-63) and color mapping by embedded Matlab program. After few ms, photocurrent of all measured points are shown in 2D image with pixel and color definition.

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