Characteristics and Fabrication of 2-Dimensional Image Sensor Using a Light Addressable Potentiometric Method

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1. Introduction

LAPS(Light Addressable Potentiometric Sensor) is a device which can detect pH with surface potential variation based on the location of illuminated light. It has very application value as a multiple channel sensor for multiple analysis.

Therefore the researches for the analysis of micro-organism and protein have been much reported recently in the application fields such as environments, bio-chemical and radiological measurement of military area, and the inspections of foods and water by detecting pH variation occurred by the immunity reaction [1]. But monitoring of linear pH change in the fixed location is unsuitable for the detection of the diffusion speed and distribution of the microorganism. In the recent years, researches for detection of the diffusion speed and 2-dimentional distribution occurred by the material ambassador of the microorganism and cell have been focused. However, such sensors suffer from the problem of the resolution and analysis time[2].

In this paper, we proposed the fundamental research for the measurement a real time diffusion and distribution of the microorganism. The image detection system was designed using LAPS. We investigated the basis characteristics of image biosensors with high resolution and sensitivity. The applicability and usefulness as a biosensor were examined.

2. The operation principle of Image LAPS

Alternative light of regular frequency is illuminated into the LAPS device and DC voltage was applied into the electrolyte. The DC bias voltage forms the inversion layer in the LAPS device and then the charges in the inversion and insulator layer are modulated by the electron-hole pair to make the AC photocurrent[1,3]. If DC bias voltage forms the accumulation state, there is no photocurrent because of absence of electric field on the surface of silicon. Therefore, the curve of AC photocurrent versus DC bias voltage shows large changes between accumulation state of no photocurrent and inversion state of maximum photocurrent[3]. Photocurrent curve to the potential change on the interface between sensing membrane and electrolyte tends to shift along the bias voltage axis, and it can be realized by calculating inflection point of the curve like Fig. 1.

The biggest characteristic of LAPS is that it causes the reaction at the location , where the light of source was illuminated. To apply image LAPS, we can use the X-Y stage for the micro-control of location of light. If photocurrent including this illuminated location information express of 3-dimensional image by using the amplifier of the system and A/D converter was generated, we can see the image of analyzed material and when we apply on biosensor, it can sense the diffusion speed or distribution of cell.

3. Experiment and results

Fig. 2 shows schematic diagram of LAPS system with fabricated sensor. P-Si ((100),ρ= 6 ~ 12 $\Omega \cdot cm$, 5 inch,) was used for the substrate of LAPS device. The gate oxide of about 300 Å was grown by dry

oxidation and silicon nitride of about 1000Å was deposited by LPCVD. The pattern of the LAPS device for the detection of image defined and formed the star shape by using photo-lithograph method. The optical part consists of optical fiber coupled with pig-tail LD (650 nm, 830 nm), instead of using complexed with the lens and laser, mirror. For correct locational information, we used the X-Y stage where the optical fiber is fixed and which could control the location of LAPS device. An alternating frequency light of LD was produced by a current source and function generator connected bias-tee(RF-device), and these generated the frequency of the 2kHz. The generated signal ordered the image through amplifier and A/D converter, with the PC program (MATLAB).

Fig.3 (a) and (b) show the star shape patterns about the 650 nm, 830 nm's light-source and the image consist of the 30×30 pixel of 3-D. We can see in Fig. 3(a) and Fig. 3(b) that the image of the star shape using light-source 830 nm is clearer than the 650 nm. For this reason, because of the large absorption coefficient, most of the carriers are generated at the backside of the Si substrate in 650 nm. On the other hand, the light penetrates into the Si substrate before the absorption, when 830 nm is used [4].

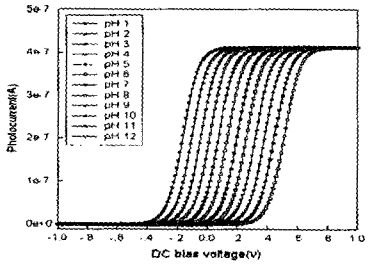

Fig.1 The pH vs. Photocurrent curve

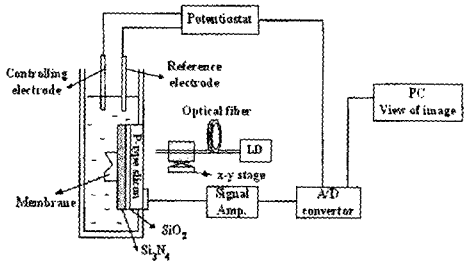

Fig.2 Schematic diagram of image LAPS system

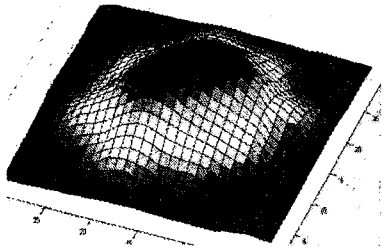

Fig.3 (a). 3-D Star shape image of 30×30 pixel (Using the 630nm's light-source)

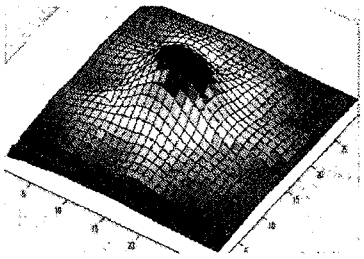

Fig.3 (b). 3-D Star shape image of 30×30 pixel (Using the 630nm's light-source)

4. Conculusions

In this studies, we have used the LAPS image sensor as a fundamental research that can detect the cell distribution or diffusion speed. Using tha LAPS device and pig-tail LD, we detected the LAPS image with wavelength of the light-source 650 nm and 830 nm. In the image detection of LAPS, the light-source of the 830 nm was able to get more improved images than that of 650 nm. But we found the problem of signal noise and the measurement time. In the future work, we should supplement such defect. We will try to develop the image biosensor that can detect the diffusion speed and distribution of the cell that have the high resolusion and sensitivity.

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