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Noise Filtering by Bioelectronic Device Consisting of Bacteriorhodopsin and Spiropyran

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Noise Filtering by Bioelectronic Device Consisting of Bacteriorhodopsin and Spiropyran

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A bioelectronic device consisting of bacteriorhodopsin (bR) and spiropyran (SP) was constructed for noise filtering in the information processing of optical image. The effect of concentration on the photochromism of spiropyran films by spin coating technique was investigated. The effect of number of layers on the photocurrent of bR LB films was analyzed. The enhancement efficiency of signal to noise ratio by the device using two spiropyran films was increased to about 40% with 40 min of irradiation time while that of the device with one spiropyran film was 25% with 40 min.

Keywords: bacteriorhodopsin; spiropyran; bioelectronic device; signal-to-noise ratio; noise filtering

INTRODUCTION

Silicon-based electronic devices for visual information processing are currently being engineered to possess a parallel-processing function of biosystems. Silicon-based technology, however, necessitates the integrated device consisting of software-type high speed computational circuits. But the biological visual system possesses a special function for real-time parallel processing of visual information with minimal hardware [1]. The optical devices and memories that consist of bacteriorhodopsin (bR) films for information processing have been developed according to its high response characteristics and excellent stability in optical and photoelectrical property. Simulating the biological photoreceptor, an artificial photoreceptor consisting of bR was constructed, which showed the photoswitching function and the

differential response to light intensity [2,3]. In this study, the bioelectronic device consisting of bacteriorhodopsin and spiropyran films was constructed to eliminate the noise in the image information processing.

Spiropyran has been widely studied due to its photochromic properties that can be applied to optical memory. The effect of film structure on the photochromic properties has been studied and the multi-frequency optical memory using the spiropyran state and J-aggregate state having different absorption spectra has been proposed [4]. A photoreceptor consisting of 6-nitro spiropyran and TCNQ films has been developed by the authors [5].

In this study, the effect of concentration on the photochromism of spiropyran films was investigated and the effect of the number of bR LB layers on the photocurrent was analyzed. The noise filtering efficiency of the proposed device was investigated with respect to the number of spiropyran films.

EXPERIMENTALS

Spiropyran (SP) with long alkyl chain (C_{16}) (3',3'-Dimethyl-1'-hexadecyl-6-nitro spiro-(2H-1-benzoypyran-2,2'-indoline) was deposited onto the one side of glass slide by the spin coating method, and then bR LB films (5 layers) were deposited onto the other side of glass on which ITO was pre-deposited. Prior to the deposition of the upper electrode (Al), 6 monolayers of viologen were deposited onto the surface of bR films to prevent the denaturation of bR molecules during the deposition process of Al electrodes. Other optical measurement systems were previously reported [5,6].

RESULTS AND DISCUSSIONS

The effect of concentration on the photochromism of spiropyran film was investigated to enhance the noise filtering capacity, which means the increase of the signal to noise ratio. As shown in Figure 1(a), the absorbance values of spiropyran state and photomerocyanine state were increased with respect to

the concentration. But the absorbance change between spiropyran and photomerocyanine indicating the degree of photochromism was increased upto 0.2M of spiropyran. At 0.5M of spiropyran, the photochromism of spiropyran film was weakly appeared due to the lack of the space between molecules needed for photoreaction, which might be resulted from the aggregation of spiropyran molecules. Figure 1(b) shows the effect of the layer number of LB films on the photocurrent of bacteriorhodopsin. The photocurrent of bacteriorhodopsin was not significantly affected by the number of layers. Except that of the monolayer, this result was fairly well consistent with the previously reported one [7]. Based on the results, the concentration of spiropyran and the layer number of bR LB films were determined as 0.2 M and 5 layers, respectively.

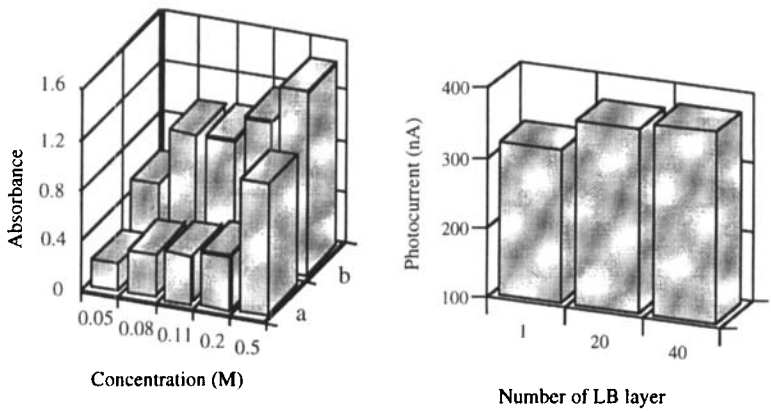
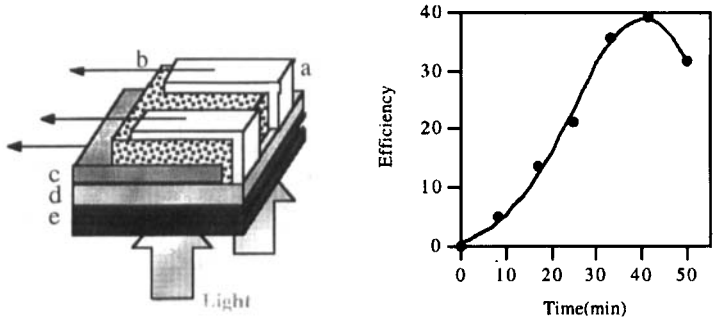


FIGURE 1. (a) The effect of concentration on the photochromism of the spiropyran films by spin coating technique; a, spiropyran; b, photomerocyanine. (b) The effect of number of LB layers on the photocurrent of bacteriorhodopsin.

Generally, the optical information is composed of target image (signal) and background image (noise) due to diffraction, reflection and so on. The signal to noise ratio could be increased by the proposed device with time. By the principle of the signal to noise ratio enhancement, the increment of intensity

ratio of transmitted lights in comparison with that of input lights was obtained through the photomerocyanine films as time went when input lights with the different light intensities were irradiated on the films [6]. For the further increase of the enhancement efficiency of signal to noise ratio (25% with 40 min) [6], two spiropyran films were used to construct the photoreceptor.

Figure 2 shows that the extraction efficiency of the proposed device using two spiropyran films was about 40% with 40 min. It might be resulted from the further increment of the degree of photochromism of spiropyran films. From this result, it can be suggested that the use of two spiropyran films makes it possible to increase the extraction efficiency of the proposed device.



(a) (b)

FIGURE 2. (a) A schematic illustration of the proposed device using two spiropyran films; a, Al electrode; b, bR film + viologen film; c, ITO electrode; d, Glass; e, two spiropyran films. (b) Enhancement efficiency of the device.

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