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Jeong-Woo Choi [a c], Yun-Suk Nam [a], Dongho Kim [b], Won Hong Lee [a] & Masamichi Fujihira [c]

[a] Department of Chemical Engineering, Sogang University, Seoul, 121-742, Korea

[b] Department of Chemistry, Yonsei University, Seoul, 120-749, Korea

[c] Department of Biomolecular Engineering, Tokyo Institute of Technology, Nagatsuta, Yokohama, Japan

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Fractal-Time Response Function of GFP/Viologen/TCNQ Structured Molecular Photodiode

JEONG-WOO CHOI[a,c], YUN-SUK NAM[a], DONGHO KIM[b], WON HONG LEE[a] and MASAMICHI FUJIHIRA[c]

[a]*Department of Chemical Engineering, Sogang University, Seoul 121-742, Korea,*
[b]*Department of Chemistry, Yonsei University, Seoul 120-749, Korea and*
[c]*Department of Biomolecular Engineering, Tokyo Institute of Technology, Nagatsuta, Yokohama, Japan*

Fractal-time response of the molecular photodiode consisting of hetero-molecular film was investigated. GFP, viologen, and TCNQ were used in the molecular photo diode as an electron sensitizer, first electron acceptor and second electron acceptor, respectively. Based on decay time profile of transient photocurrent by 400nm laser pulse irradiation, the decay time constant value *a* of molecular photodiode was obtained. With the decay time constant value, the simulation of the fractal-time response to the pulse train inputs corresponding to different ASCII codes was performed.

Keywords: Molecular photodiode; Green fluorescent protein (GFP); Transient photocurrent; Fractal-time response

INTRODUCTION

Various artificial photodiodes have been fabricated by mimicking the electron transport function of biological photosynthesis. In this study, simulation of fractal-time response of photocunductivity of a molecular photodiode consisting of molecular layers sandwiched between metal electrodes has been investigated. For construction of the molecular photodiode, a metal/insulator/metal(MIM) structured electronic device was fabricated with GFP/Viologen/TCNQ hetero-LB films used as an

electron sensitizer, first electron acceptor and second electron acceptor, respectively, between the aluminum electrode[1].

To investigate the fractal-time response of the proposed device, the transient photocurrent of the device was measured and simulation of fractal-time response was done.

EXPERIMENTAL DETAILS

Green fluorescent protein (GFP), N-allyl-N'-[3-propylamido-N",N"-di(n-octadecyl)]-4, 4'-bipyridium dibromide (viologen), and N-docosil quinolinium tetracyano dimethan (TCNQ) were used as the electron sensitizer (S), the first electron acceptor (A_1), and the second electron acceptor (A_2), respectively.

The device fabrication method was reported in our previous study[1]. Fig.1 shows a structure of the molecular photodiode.

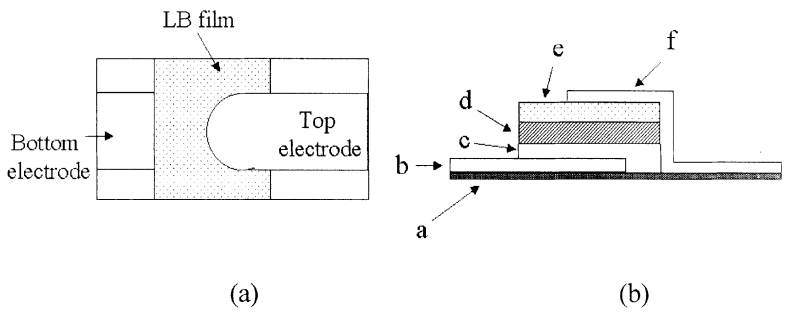


FIGURE 1. Schematic structure of the molecular photodiode; (a) top view, (b) side view, a, glass substrate, b, Al bottom electrode, c, TCNQ, d, viologen, e, GFP, f, Al top electrode

The light pulse from the laser system consisting of a femtosecond Ti:Sapphire laser was used to excite the GFP molecules. The transient photocurrent measurement method was reported in our previous study[1]. All electrical measurements were carried out in ambient condition at room temperature.

RESULTS AND DISCUSSION

In applied constant voltage, photosignal of fractal-time response device by laser-pulse irradiation was decayed with time. Intensity and pattern of photocurrent were changed by variable patterned input signals. It is 'Fractal-time response', and this phenomenon is express with plasticity.

Let us consider an input consisting of n pulses, each t_w wide, entering at a constant time interval T. We assume that the location of the k'_{th} pulse on the time-axis is given by as follows, $-(T_k + t_w) < t < T_k = -(n-k)T$, and that the height is either E or 0 [2]. The pulse train are now defined as a vector, $P(n) = (P_1, P_2, ,, P_{n-1}, P_n)$ with $P_k = 1$ or $P_k = 0$, e.g., (1,0,1,…,1). If $t_w << T$, the current response of molecular photodiode can be approximated as [2],

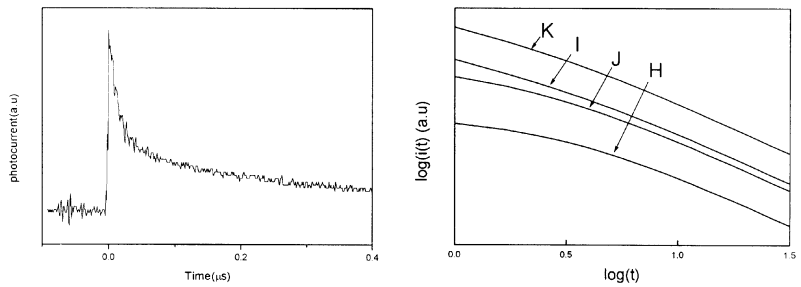
$$i(t) = i_0 \sum_{k=1}^{n} P_k \{t + (n-k)T\}^{-a-1} \quad . \qquad \text{Eq. (1)}$$

We can simulate the current response of multiple laser-pulse input corresponding to ASCII codes "H","I","J",and "K" with different time-delay by Eq.(1). Table 1 shows the vector elements of ASCII codes "H","I","J",and "K". Fig.2(a) shows the transient photocurrent decay profile of molecular photodiode by single pulse input.

From the transient photocurrent, exponent a from single pulse fitting was -0.6367. Fig.2(b) shows the simulation results of current responses to various pulse vectors $P(7)$ ASCII codes inputs using Eq.(1) with a= -0.6367.

ASCII Code	Vector Elements						
	P_1	P_2	P_3	P_4	P_5	P_6	P_7
"H"	1	0	0	1	0	0	0
"I"	1	0	0	1	0	0	1
"J"	1	0	0	1	0	1	0
"K"	1	0	0	1	0	1	1

TABLE 1. Vector elements of ASCII codes "H","I","J","K"



(a) (b)

FIGURE 2. (a) Decay profile of molecular photodiode by single pulse input, (b) Simulated results of current responses to various pulse vectors $P(7)$ inputs with a= -0.6367.

In this research, it can be concluded that the fractal-time response effect of molecular photodiode was successfully simulated based on the transient photo current measurement. It is suggested that the fractal-time response effect of molecular photodiode can be used to the potentials of real-time computations for measuring, controlling and simulating those systems associated with the fractal effect. Furthermore, fractal-time response of molecular photodiode can be used to the separation of overlaped electrical signals caused by light inputs.

Acknowledgements

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