【Grant-in-Aid for Scientific Research (S)】

Science and Engineering (Engineering)

Title of Project : Development of Digital Bio-Molecular Device and Biomedical Applications

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Research Project Number : 15H05769 Researcher Number : 60179893
Research Area : Biofunction, Bioprocess
Keyword : Biosensor, Nanobiodevice, BioMEMS

【Purpose and Background of the Research】

We focus on excellent molecular recognition and molecular signal amplification feature in the biological system and promote molecular level analysis to be coded as digital information. Digital bio-molecular devices require microfluidic chips specifically fabricated and oriented for single molecule arrangement, and molecular recognition linked with amplified signal from a single molecule. Sensitive and label-free sensors are developed for “digital bio-molecular devices” based on nano-electrochemical and localized plasmon resonance sensor systems. Our proposed devices enable digital analysis of bio-molecules and analytical tools will promote the application and development of the medical diagnostic field.

【Research Methods】

For the "digital bio-molecular devices" challenge, "microfluidic device" and “sensing device” are considered key elements for molecular recognition and amplifying molecular reactions. They are based on ultrasensitive molecule measurement by integrating these devices and we aim to clarify the fundamentals of the design for device that enables digital analysis of the molecules, (Fig. 1). A microfluidic device produces chambers of very small volume and it is possible to prepare dispersion of a single molecule in a single chamber, to achieve this single molecule sensing, it is essential to concert signal recognition with signal amplification. For examples of signal amplification, we consider redox enzymes with high turnover number (million molecules / sec turnover number per one molecule) and DNA amplification process to achieve one million times molecular amplification. If these molecular amplification reaction systems can be induced in the chamber, it can be amplified to a very large molecular signal even from a single molecule. Presence of single molecule in such a chamber with the presence of molecular recognition amplified signal will be expressed as digital number corresponding to the number of chamber arrays detected. This is the "digital bio-molecular devices".

Further, based on the Poisson distribution of molecules entering the chamber, it is possible to accurately measureultra-wide dynamic range. We utilize electrochemical and localized plasmon resonance device tracking record to promote basic research and biomedical applications for the digital bio-molecular devices.

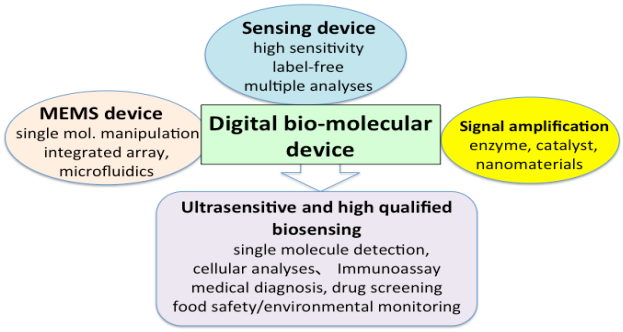

Fig.1 Concept of “Digital bio-molecular device”

【Expected Research Achievements and Scientific Significance】

This study opens new analytical methods and biosensing with ultra sensitive and ultra wide dynamic range. The feature of the presented study, namely, to capture the distribution of analyte molecules in super integrated very small area as digital data "digital bio-molecular device", is expected to breakthrough research results in the sensing field.

【Publications Relevant to the Project】

- Eiichi Tamiya et.al.(edt.) “Nanobiosensors and Nanobioanalyses”, Springer (2015)
- Eiichi Tamiya, Digital Biodevice, Bunseki Kagaku, 64, 397-411 (2015)

【Term of Project】 FY2015-2019

【Budget Allocation】 129,700 Thousand Yen

【Homepage Address and Other Contact Information】

http://dolphin.ap.eng.osaka-u.ac.jp/nanobio/