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

Broad Section C

Title of Project : Ultimately-Time-Resolved Imaging Devices Using Ultrafast Hybrid Cascade Photo-Charge Modulators and Their Applications

Shoji Kawahito
(Shizuoka University, Research Institute of Electronics, Professor)

Research Project Number : 18H05240 Researcher Number : 40204763
Keyword : Time-resolved imaging, photo-charge modulator, Biomedical imaging, Time-of-flight imaging

【Purpose and Background of the Research】

In this study, we investigate ultimately time-resolved imaging devices for detecting very weak light, non-visible light or very weak light under a strong ambient light and their applications. A new high-speed photo-charge modulator so-called the HyCAM (Hybrid cascade photo-charge modulator) is proposed for the visible and near-infrared ultra-highly time-resolved imaging particularly with multiple-window time-resolved pixels. The purpose of this study is to demonstrate the significance of the HyCAM in biological, medical, scientific and industrial applications by actually using the implemented time-resolved image sensors.

【Research Methods】

The HyCAM is a high-speed highly-sensitive low-noise charge modulation device that uses both vertical electric field created by tapped p+ electrodes in a pinned photodiode and lateral electric field created by a set of gates arranged along the channel of photo-carrier transportation and is suitable for large-aperture multiple-window time-resolved pixels. To investigate the optimal structures and dimensions and a new function of the HyCAM pixels, a test element group of the HyCAM pixels with different designs and parameters and 2D pixel arrays or time-resolved image sensors (TRISs) will be implemented and characterized. The implemented TRISs are used for a FLIM (fluorescence lifetime imaging microscopy) -based biomedical imaging for tumor detection, spatial- and time-resolved NIRS (near infrared spectroscopy) for monitoring brain activity, a SRS (stimulated Raman spectroscopy)-based unstained bio-imaging, and extremely depth-resolved TOF (time of flight) range image sensors in order to investigate what new values and findings are obtained by the TRIS chips.

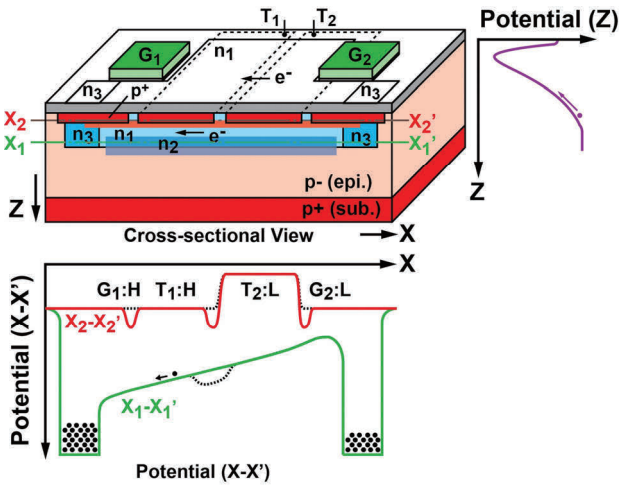

Figure 1 Hybrid cascade photo-charge modulator.

【Expected Research Achievements and Scientific Significance】

The HyCAM and TRISs using the HyCAM pixels will bring a significant paradigm shift in time-resolved imaging system concept from a spatial- and time-scanning based system to spatially-parallel (pixel-array) and multiple-window time-resolved pixel based system. This semiconductor-based system will be one of key technologies in next-generation biological, medical, scientific and industrial imaging tools.

【Publications Relevant to the Project】

・M.-W. Seo, Y. Shirakawa, Y. Kawata, K. Kagawa, K. Yasutomi, S. Kawahito, "A time-resolved four-tap lock-in pixel CMOS image sensor for real-time fluorescence lifetime imaging microscopy", IEEE J. Solid-State Circuits, pp.1-12, vol.53, 2018.
・D. X. Lioe, K. Mars, S. Kawahito, M. Hashimoto, "A stimulated Raman scattering CMOS pixel using a high-speed charge modulator and lock-in amplifier," Sensors, vol. 16, pp.532-547 , 2016.

【Term of Project】 FY2018-2022

【Budget Allocation】 147,600 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.idl.rie.shizuoka.ac.jp/
kawahito@idl.rie.shizuoka.ac.jp