Form 1

2019 Report Form for Collaboration with Research Center for Biomedical Engineering

Year/month/date	
Number	

Date /Month/Year
date: 16th March 2020

To Chairman, Board of Directors, Research Center for Biomedical Engineering

Applicant

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Ken Okano

Report Form for Collaboration Research

Research Theme	(和) 可視光からX線領域に及ぶ広帯域・高感度光検出器の試作 (英) Development of high-sensitivity photodetector for X-ray and wide range of light
Research Area	1. Biomaterials 2. Bioengineering 3. Functional molecules ④. Chemistry/Electrical Engineering/Mechanical Engineering/Materials Science
Research Period	From: 2019/05/14 To: 2020/03/31

Applicant Organization			
Name	Department	Title	Role
OKANO Ken	International Christian University	Professor	Principal Investigator
JOHN Joshua	International Christian University, Graduate School of Natural Science	PhD Student	a-Se fabrication, characterization
YAMADA Takatoshi	National Institute of Advanced Industrial Science and Technology (NAIST), Nanomaterials Research Institute	Senior Researcher	Carbon nano-emitter fabrication
MASUZAWA Tomoaki	Shizuoka University, Research Institute of Electronics	Associate Professor	Collation and publication of experimental results
Collaboration Partners in the Research Center	MASUZAWA Tomoaki		

Research Results (Including Purpose, Results, Figures, etc.)

X-ray is a key imaging modality but there is risk of cancer from such ionizing radiation. A possible solution is to reduce the dosage while maintaining the image quality. This requires image detectors with higher sensitivity than currently available. A possible highly sensitive detector is based on amorphous Selenium multilayer structures with the High-gain Avalanche Rushing Photoconductor (HARP) camera as a demonstrated application for visible photons. In our work, we adopt the multilayer structure and attach it to a photon absorbing material to form a Separate Absorption and Multiplication (SAM) structure detector.

We evaporated alternating layers of Se and As_2Se_3 onto n-type Si substrates using rotational evaporation. A study of the multilayer structure using Time of Flight Secondary Ion Mass Spectroscopy (TOF-SIMS) confirmed the multilayer structure and revealed that the thickness of each layer was about 8 nm. This qualified the structure as a superlattice, and it is expected to show quantum features such as formation of energy sub-bands, negative dynamic resistance (NDR) and resonant tunneling. The energy structure of the multilayer superlattice was investigated using Deep Level Transient Spectroscopy (DLTS). The results confirmed the existence of two sub-bands at 0.533 eV from the conduction band and 0.269 eV from the valence band. The transport features of the structure were investigated using current-voltage (I-V) measurements. The results, shown in Figure 1, show oscillation in the characteristics, indication regions of NDR.

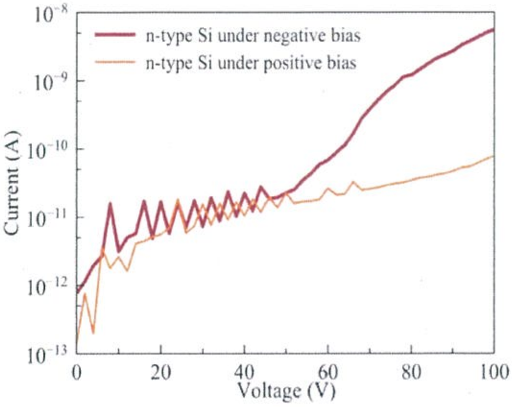

Figure 1. The I-V characteristics of superlattice Se, with oscillations indicating regions of negative dynamic resistance.

List of Publications Related to the Collaboration Research

1. John, J. D., Okano, S., Sharma, A., Selyshchev, O., Rahaman, M., Miyachi, N., Enomoto, K., Ochiai, J., Saito, I., Masuzawa, T., Yamada, T., Chua, D. H. C., Zahn, D. R. T., Okano, K., Transport Properties of Se/As_2Se_3 Nanolayer Superlattice Fabricated Using Rotational Evaporation. **Advanced Functional Materials**, 2019. 29, 1904758. https://doi.org/10.1002/adfm.201904758

List of Presentations (Conference, Meeting, etc)

2. John, J. D., Okano, S., Sharma, A., Selyshchev, O., Rahaman, M., Miyachi, N., Enomoto, K., Ochiai, J., Saito, I., Masuzawa, T., Yamada, T., Chua, D. H. C., Zahn, D. R. T., Okano, K., Sub-band formation in amorphous Selenium superlattice and its controlled physical properties, Institute of Electronics and Information Communication Engineering (IEICE) Electronic Devices Conference, 2019

Registration of research-theme continuation for next year Prior consent from the collaboration partner in the Research Center is necessary.	[✓ Yes] No

Research plan for the next year (from April 1, 2020 to March 31, 2021), if the collaboration research is continued.

We will investigate the effect of the superlattice film on conventional X-ray absorber materials Si or Ge. The superlattice structure will be deposited on to the Si or Ge substrate using rotational evaporation. The structure will then be characterized using current-voltage (I-V) measurements at room temperature under dark conditions and with the substrate illuminated using visible, ultra-violet and X-ray photons. The experiment will be controlled by measuring in the same way, unprocessed Si or Ge.

The superlattice is expected to improve the dark current noise performance due to its high resistivity which acts as a blocking layer. The superlattice structure is also expected to improve the signal current due to the photomultiplication effect in the structure. Overall it is expected that the Si or Ge with superlattice structure will show a significantly higher signal-to-noise ratio at room temperature compared to just the Si or Ge.