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Title: Photosensitive Inverters and Light-to-Frequency Conversion Circuits Based on Transistion Metal Dichalcogenides Field Effect Transistors

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Abstract

Recently transisiton metal dichalcogenides (TMDCs) such as MoS_2, WSe_2, $MoTe_2$, WS_2, and others haved been emerged and actively researched as one of next generation semiconductors for extending Moore's law. Among a variety of novel properties for TMDCs, one of interesting properties is to modulate energy bandgap (E_g) in variation of number of layers. In this study, for the improvement of noise immunity for IoT sensor systems, photo sensitive inverters and their light-to-frequency conversion circuts (LFCs) are proposed and experimentally demonstrated by using the platform comprised of an enhancement MoS_2 driver with light-shield layers(LSLs) (or GaN FET drivers) and MoS_2 depletion load. Moreover, for energy efficient circuits, complementary photo-sensitive inverters based on p-type $MoTe_2$ and n-type MoS_2 FETs are demonstrated. For the better understanding on performance of LFCs, we systematically studied basic design rules on LFCs via experimentally measured voltage transfer characteristics of photo-sensitive inverters and their spice simulation with their extracted model parameters based on RPI model (i.e., SILVACO, Smart-spice; level 36). The simulation results illustrate that key parameters of ring osciallators(ROs) such as oscillation frequency(f_{osc}) and peak-to peak voltage (V_{p-p}) can be systematically controlled by inverter parameters such as noise margin, voltage gains associated with electrical parameters (i.e., V_{th}, SS, current on/off ratio, field effect mobility, etc). In the present study, experimental implementation of photosensitive inverters based on MoS_2, $MoTe_2$, and GaN FETs, etc. and their systematic validation on performance via spice simulation yield insightful design rules required for reliable operation of LFCs, potentially contributing to emerging IoT security systems.

Figures if any (BW/Color):

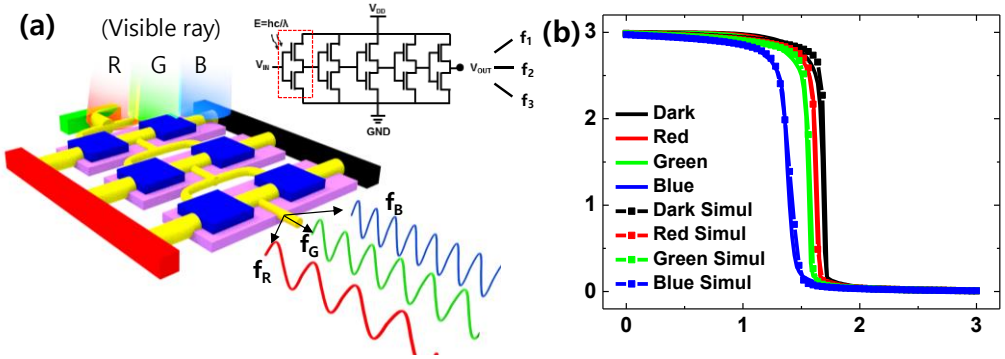


Fig.1 (1) Schematics for photo-sensitive ring osciallators based on complementary TMDC inverters (b) Voltage transfer characteristics depending on wavelength of light under illumination.

Recent Publications If any (S.H.Jin is a corresponding author in the following publication.)

[1] S.G. Seo, **S.H. Jin**, "Bias Temperature Stress Instability of Multilayered MoS_2 Field-Effect Transistors With CYTOP Passivation", IEEE Transactions on Electron Devices, 66, 2208-2213 (2019)

[2] J.K. Roh, J.H. Ryu, G.W. Baek, H.Y. Jung, S.G. Seo, K.S. An, B.G. Jeong, D.C. Lee, B.H. Hong, W.K. Bae, J.H. Lee, C.H. Lee, **S.H. Jin**, "Threshold Voltage Control of Multilayered MoS_2 Field-Effect Transistors via Octadecyltrichlorosilane and their Applications to Active Matrixed Quantum Dot Displays Driven by Enhancement-Mode Logic Gates", Small 15 (7), 1803852 (2019)

[3] M. Krishnaiah, R.K. Mishra, S.G. Seo, **S.H. Jin**, J.T. Park, "Annealing temperature and stabilizer effects on morphological evolution of Cu_2CoSnS_4 films on thermally oxidized Si wafers via direct spin-coating", Journal of Alloys and Compounds, 781, 1091-1100 (2019)

[4] S.G. Seo, J.H. Hong, J.H. Ryu, **S.H. Jin**, "Low-Frequency Noise Characteristics in Multilayer $MoTe_2$ FETs With Hydrophobic Amorphous Fluoropolymers" IEEE Electron Device Letters 40 (2), 251-254 (2019)

[5] S.G. Seo, S.W. Han, H.Y. Cha, S.G. Yang, **S.H. Jin**, "Light-Shield Layers Free Photosensitive Inverters Comprising GaN-Drivers and Multi-Layered MoS_2-Loads", IEEE Electron Device Letters 40 (1), 107-110 (2019)

Biography

Sung Hun Jin serves an associated professor in the department of electronic engineering at Incheon National University since 2014. His academic background includes Ph.D and MS. degrees in electrical engineering from Seoul National University (SNU), Seoul, Korea. Since 2006, he worked as a senior engineer in Samsung Electronics. After he served as BK assistant professor in Seoul National University in 2013, he joined in Incheon National University in 2014. His current research interests include hybrid multi-scale materials (SWNTs, TMDCs, Si, et) and devices for smart flexible system.

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