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Photosensitive inverters and light-to-frequency conversion circuits based on transistion metal dichalcogenides field effect transistors

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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 (Eg) 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 (fosc) and peak-to peak voltage (Vp-p) can be systematically controlled by inverter parameters such as noise margin, voltage gains associated with electrical parameters (i.e., Vth, 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.

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