How to simulate the photogating effect in InAs nanowire phototransistors?

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1. Majority carrier dominated InAs NWs near-infrared detector

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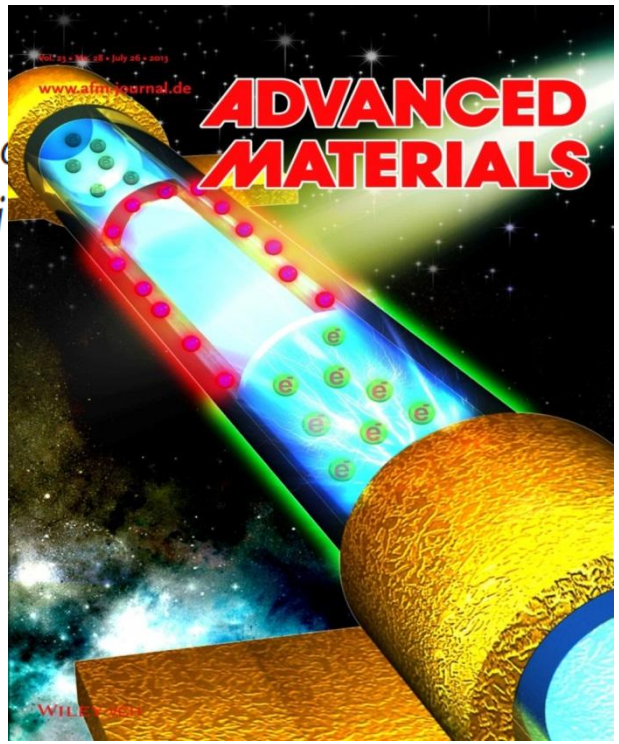
Anomalous and Highly Efficient InAs Nanowire Phototransistors Based on Majority Carrier Transport at Room Temperature

Nan Guo, Weida Hu, Lei Liao,* SenPo Yip, Johnny C. Ho*
Jin Zou, Tao Jiang, Shiwei Wu, Xiaoshuang Chen, and Wei



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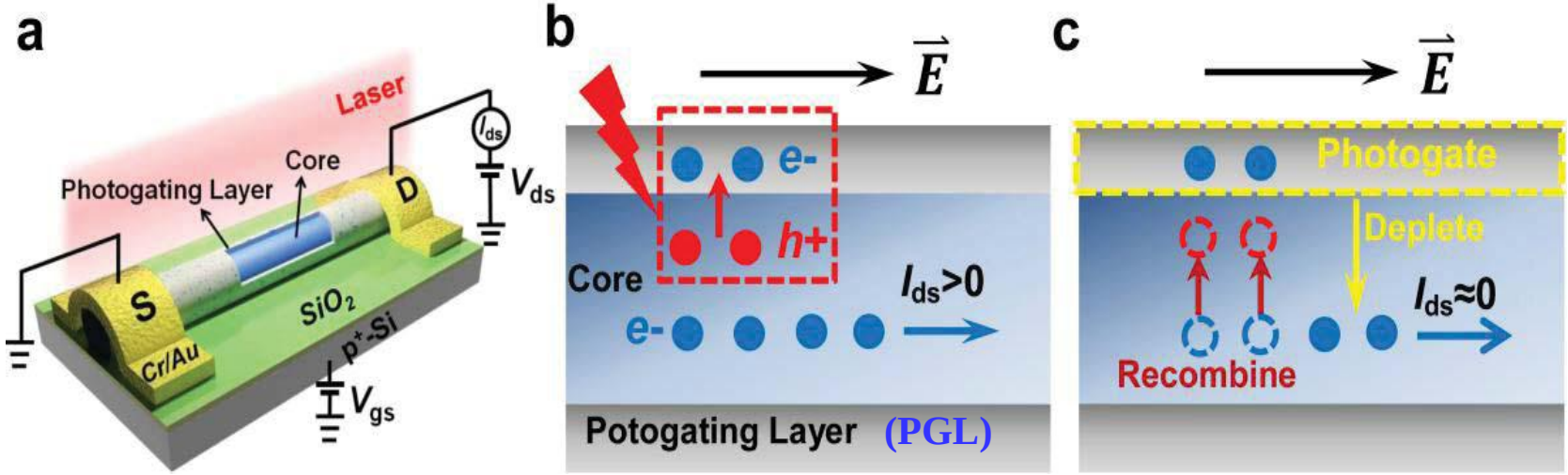
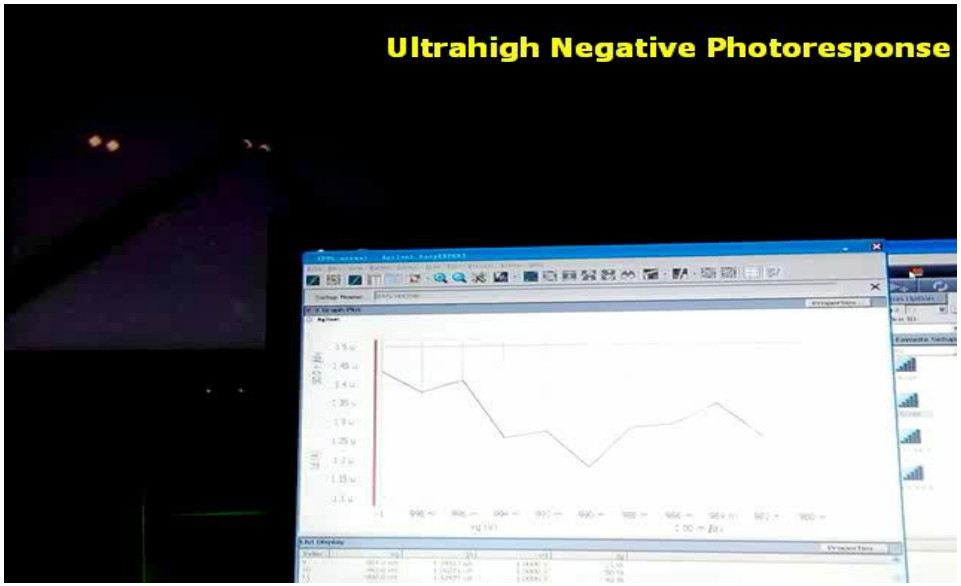
1. Majority carrier dominated InAs NWs near-infrared detector





The majority carrier is manipulated by photo gating effect, leading to an anomalous photodetection

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1. Majority carrier dominated InAs NWs near-infrared detector

Electrons trapped for a much longer time by PGL

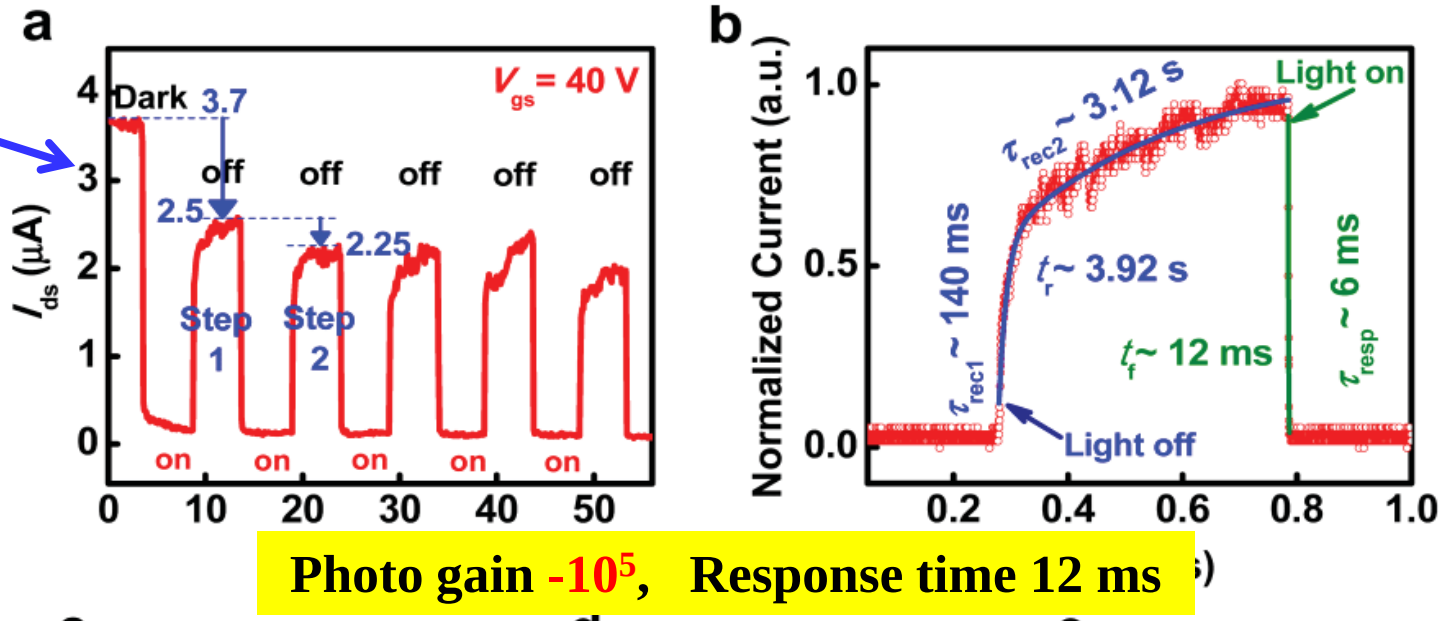
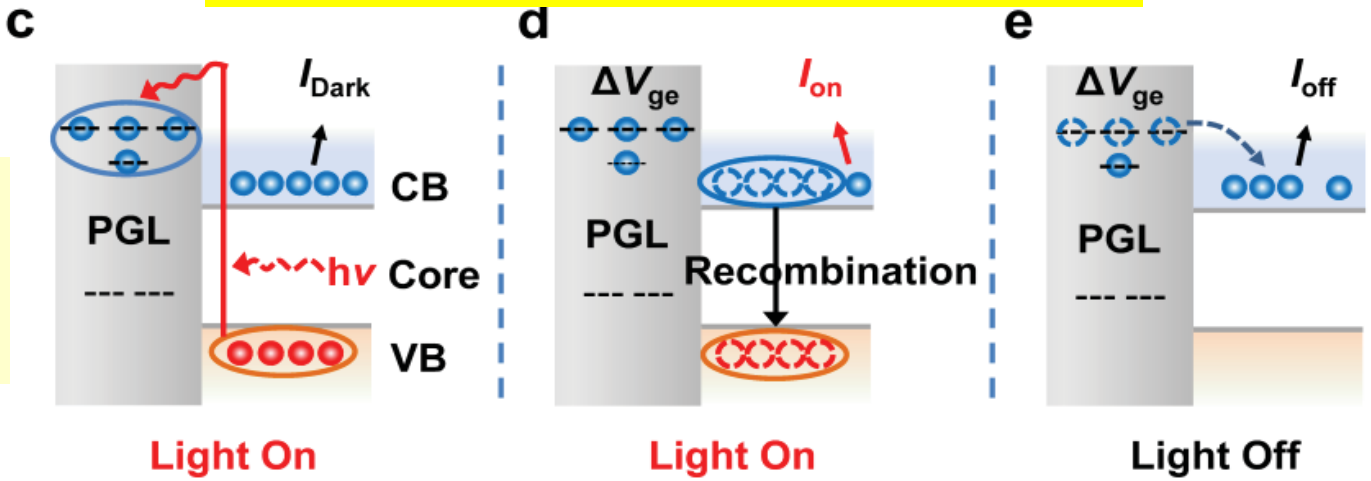


Photo gain -10^5, Response time 12 ms

Anomalous photodetector based on the majority carrier



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2. Single InAs NWs near-infrared detector

Single InAs Nanowire Room-Temperature Near-Infrared Photodetectors

ACSNANO www.acsnano.org

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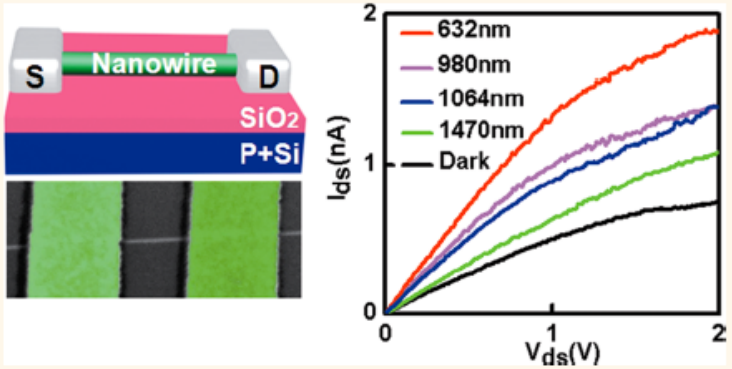
[†]National Laboratory for Infrared Physics, Shanghai Institute of Technical Physics, Chinese Academy of Sciences, 500 Yutian Road, Shanghai 200083, China, [‡]Department of Physics and Key Laboratory of Artificial Micro- and Nano-structures of Ministry of Education, Wuhan University, Wuhan 430072, China, [§]Department of Electronic and Computer Engineering, Hong Kong University of Science and Technology, Hong Kong SAR, China, [⊥]Department of Physics and Materials Science, City University of Hong Kong, Hong Kong SAR, China, and [#]Synergetic Innovation Center of Quantum Information and Quantum Physics, University of Science and Technology of China, Hefei, Anhui 230026, China

ABSTRACT Here we report InAs nanowire (NW) near-infrared photodetectors having a detection wavelength up to ~1.5 μm. The single InAs NW photodetectors displayed minimum hysteresis with a high I_{on}/I_{off} ratio of 10^5. At room temperature, the Schottky–Ohmic contacted photodetectors had an external photoresponsivity of $\sim 5.3 \times 10^3$ AW^{-1}, which is ~300% larger than that of Ohmic–Ohmic contacted detectors ($\sim 1.9 \times 10^3$ AW^{-1}). A large enhancement in photoresponsivity (~300%) had also been achieved in metal Au-cluster-decorated InAs NW photodetectors due to the formation of Schottky



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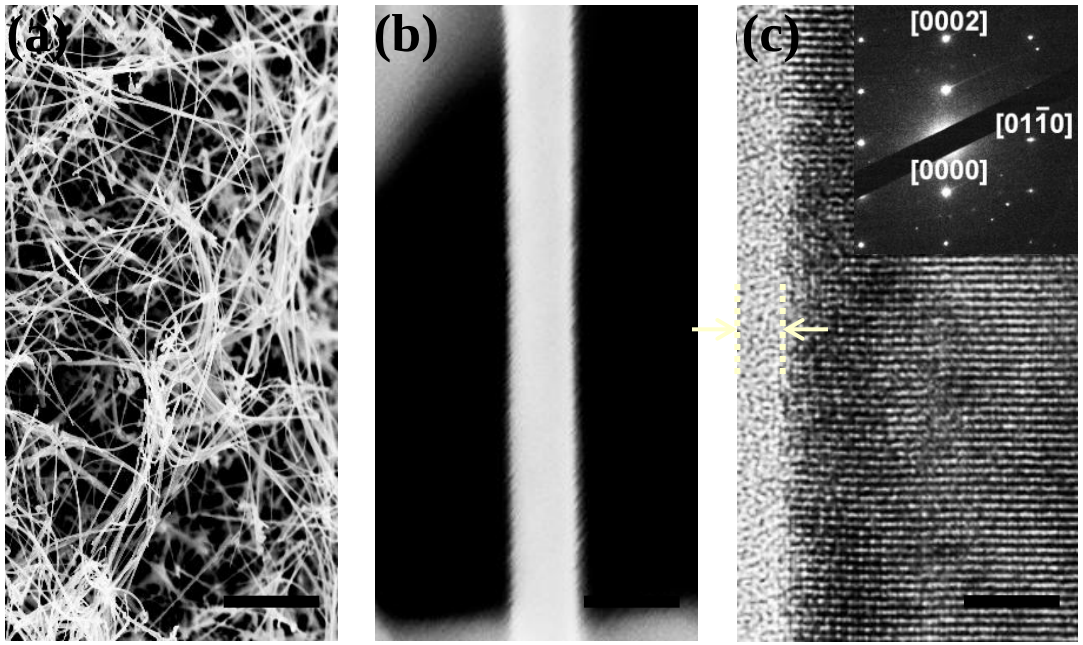
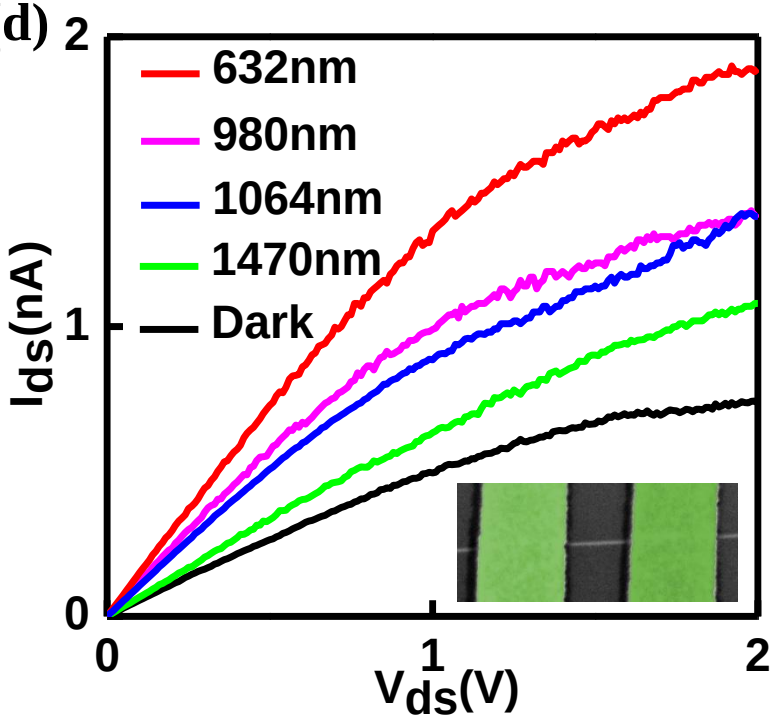
2. Single InAs NWs near-infrared detector

Single-crystline





SEM shows length 10um, diameter 50 nm

Photocurrent spectrum ranging from visible to near-infrared light. Detectors have distinct photoresponse.

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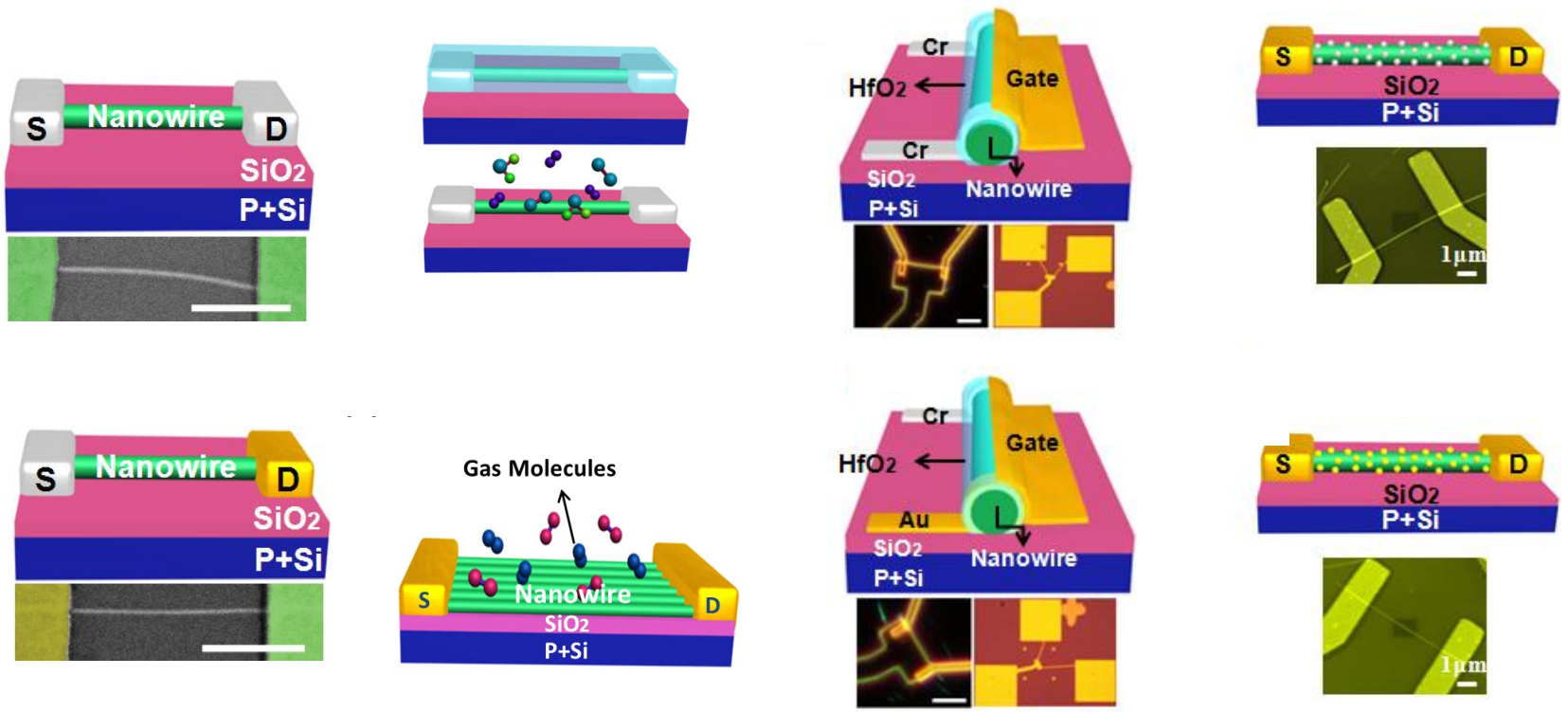

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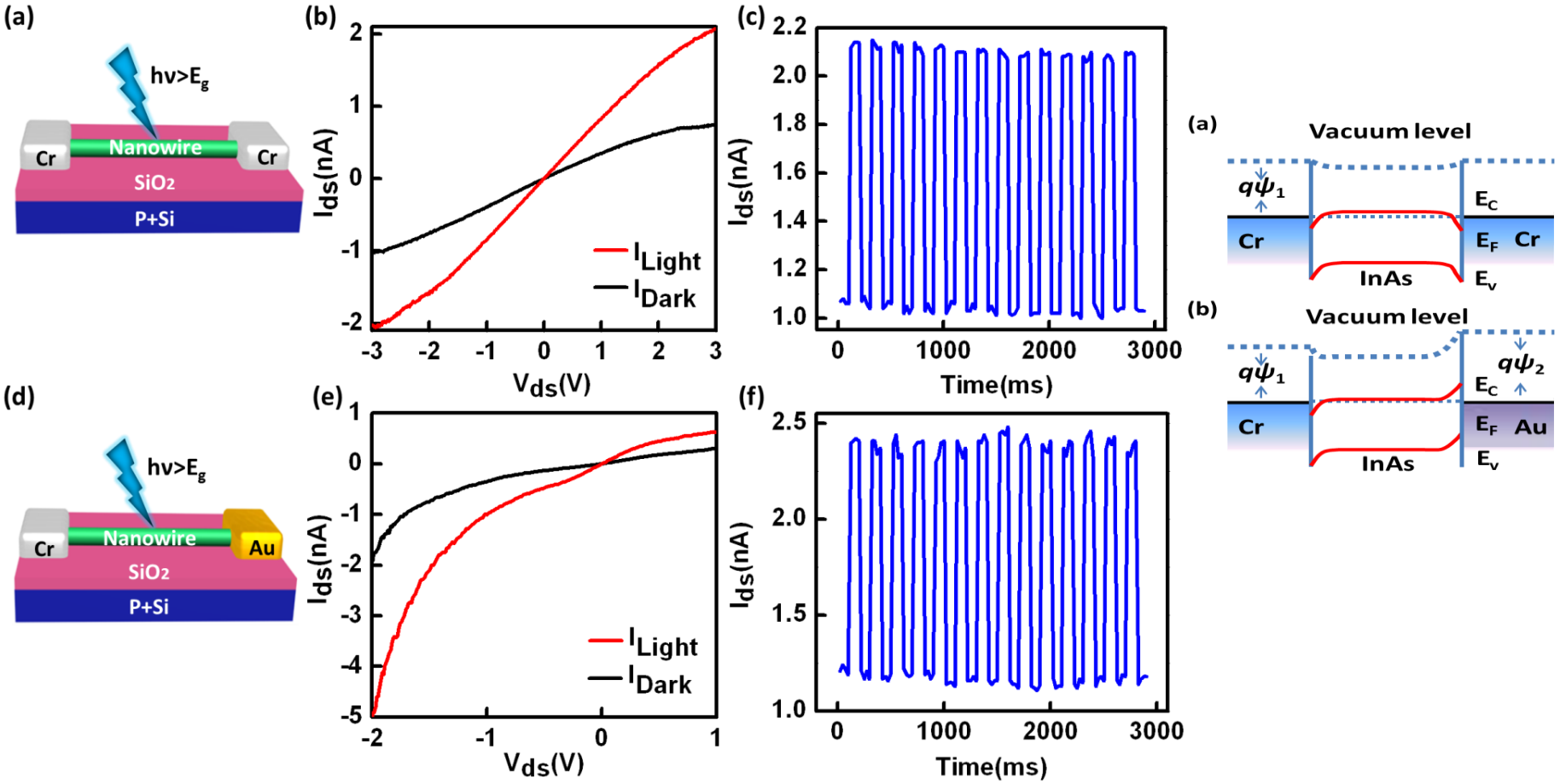

Time-resolution: Short photoresponse time (~ms)

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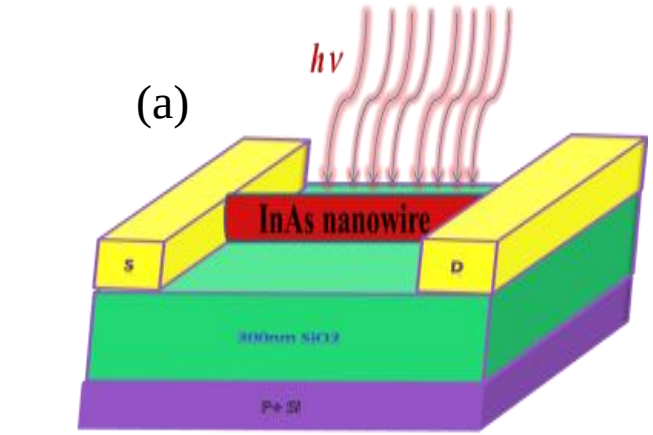
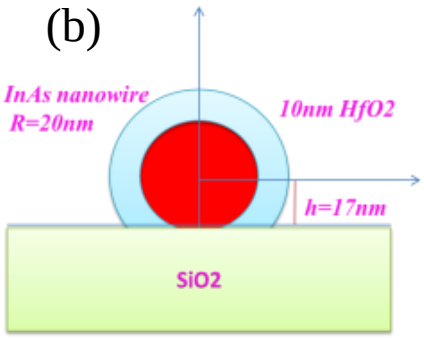
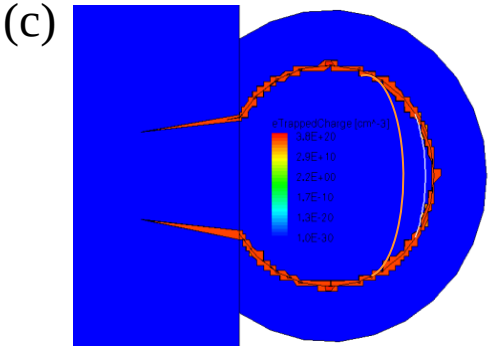
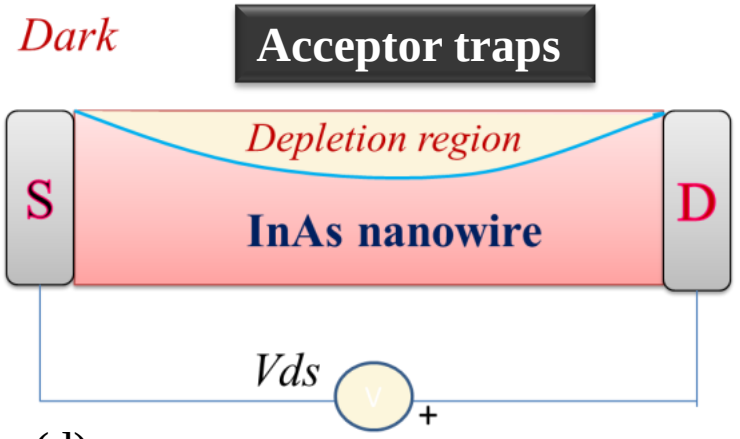
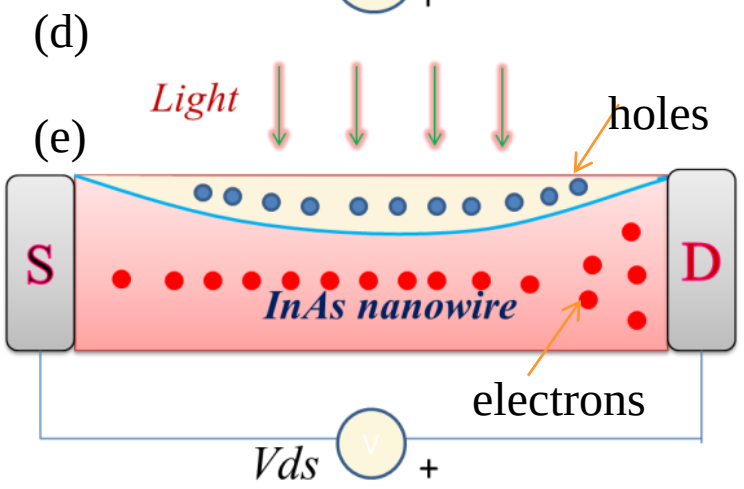


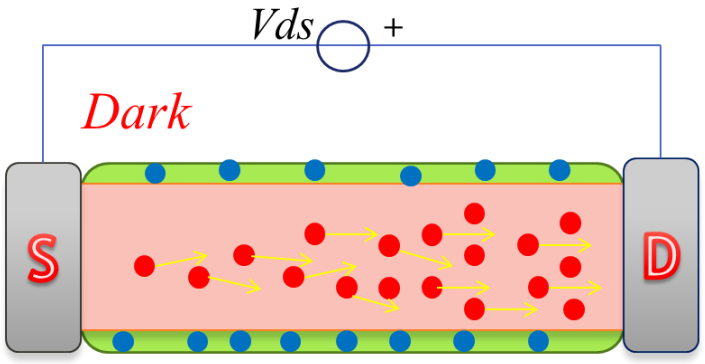


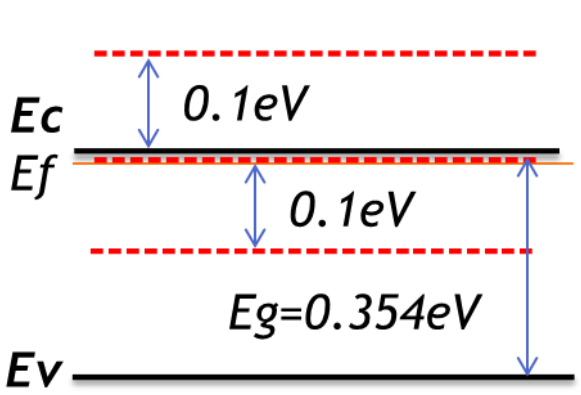






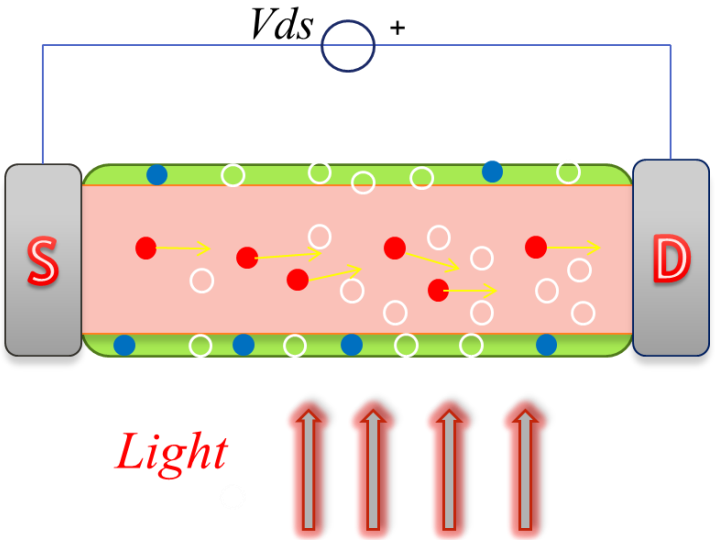
Surface acceptor traps which lead to a surface depletion will result in a positive photoresponse output. The mid band gap acceptor states at the InAs surface result in the trapping of majority carriers and surface depletion(Figure c) that causes band bending and a radial "gate" field (Figure d,e). Due to the gate field, photo generated holes are swept to the surface, where they recombine with trapped electrons, in effect modulating the gate field, while electrons are confined to the center of the nanowire.

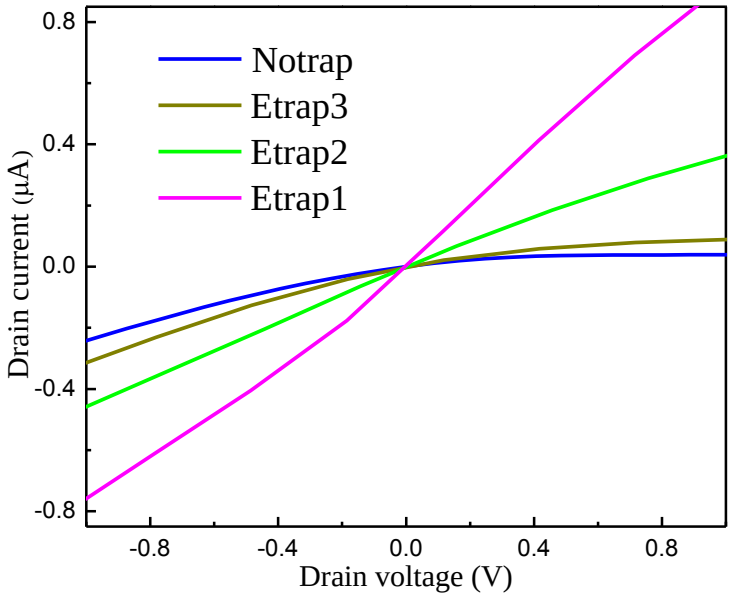




Donor traps

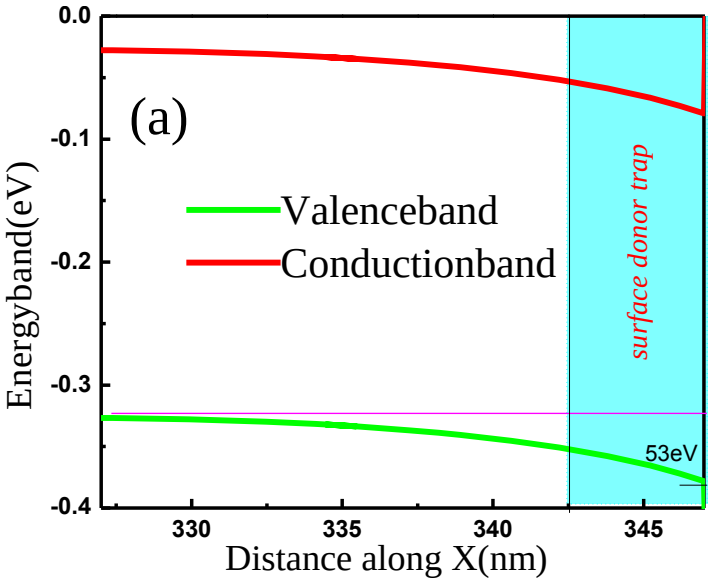
*Etrap1=Ec+0.1*eV;
Etrap2=Ec;
*Etrap3=Ec-0.1*eV.

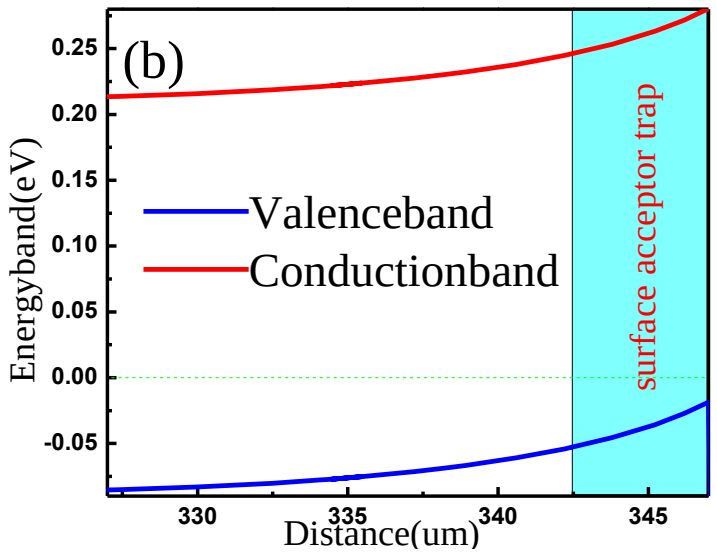




Surface donor traps will result in a negative photoresponse output

Duo to the high density of surface states located far from the conduction band contributed large number of ionization carriers, and the negative conductive gain can illustrated as that the photogenerated carriers are combined with these ionization carriers before being collected by electrodes.



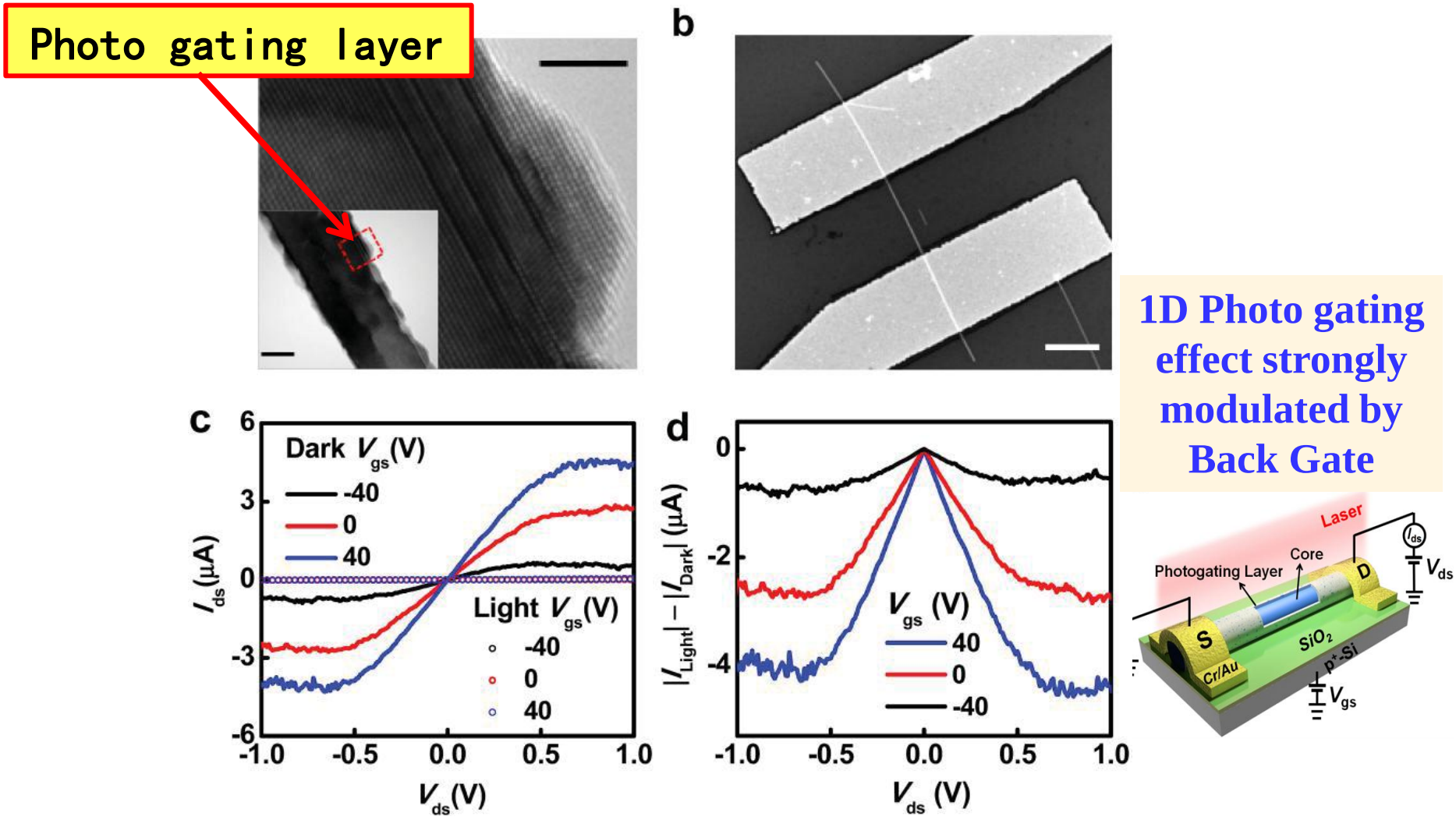


Questions

- Acceptor and donor traps?
- Transient response?

Thank you for your attention!

1. Majority carrier dominated InAs NWs near-infrared detector



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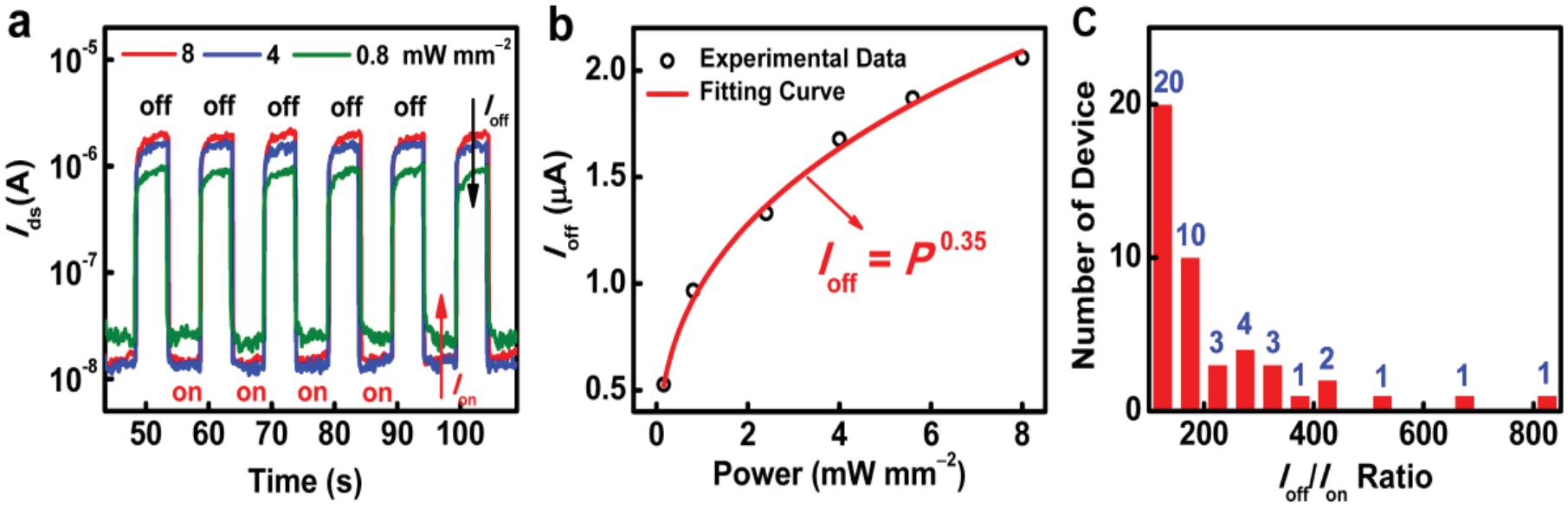

I_{off} satisfies the power law, proving that I_{off} origins from photoexcited carriers

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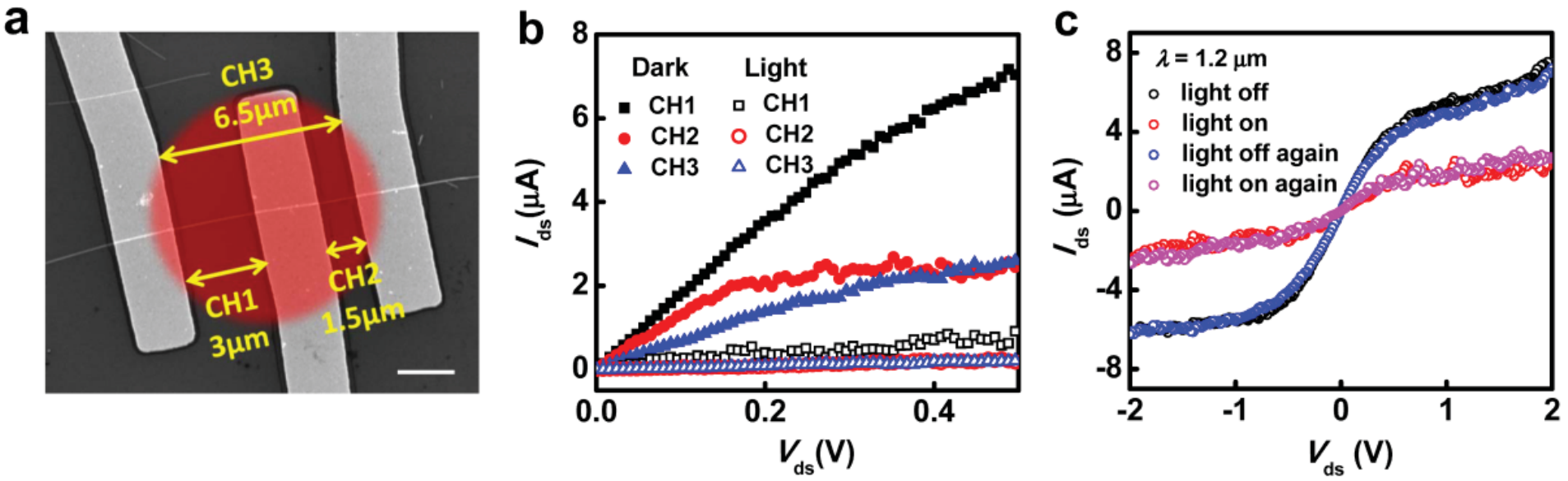

1D is superior to 2D

Infrared light:1.2μm
Photo gain -1.1

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