Visible Light Ultrasensitive Solution Prepared Layered Organic-Inorganic Hybrid Perovskite Field-Effect Transistor

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Abstract: One-step solution processed 2D layered $(C_6H_5C_2H_4NH_3)_2SnI_4$ perovskite film are applied as the channel layer of the visible light active field-effect transistor. Under 5 μW/cm^2 red light illumination, the photo to dark current ratio (P) and photoresponsivity (R) value is 800 and 14000 A/W at V_g = +13 V, V_{ds} = -40 V. These values reach up to 2000 (8000) and 16000 (19000) A/W at V_g = +14 (+16) V under green (blue) light of similar intensity. Both high P and R values are achieved, resulting in an extraordinary light detection performance.

Introduction

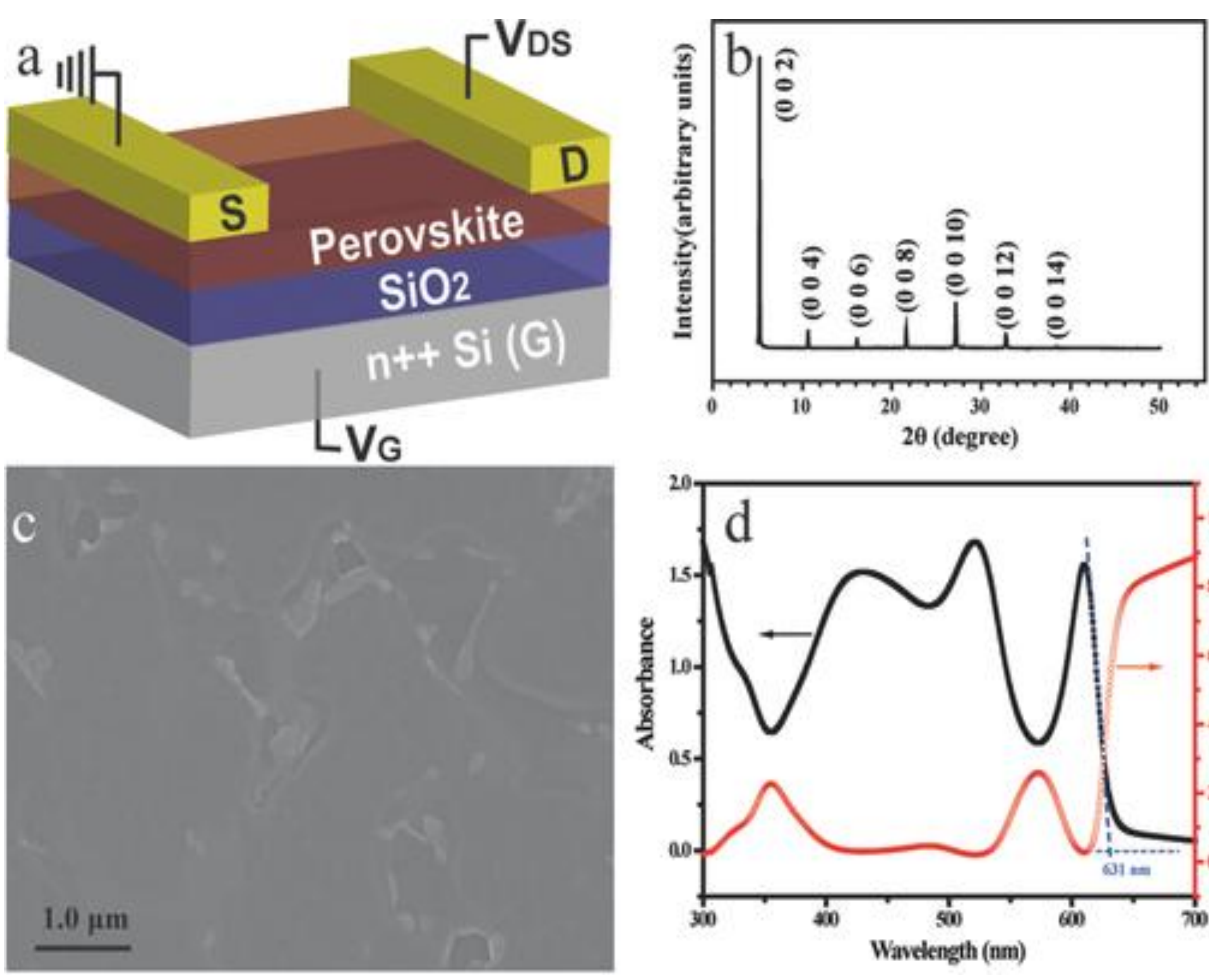

Figure 1. a) Schematic of $(C_6H_5C_2H_4NH_3)_2SnI_4$ perovskite phototransistors. b) X-ray diffraction pattern of spin-coated $(C_6H_5C_2H_4NH_3)_2SnI_4$ film. c) top-view SEM image, and d) absorbance and transmittance spectrum of spin-coated $(C_6H_5C_2H_4NH_3)_2SnI_4$ film. Scale bar, 1.0 μm.

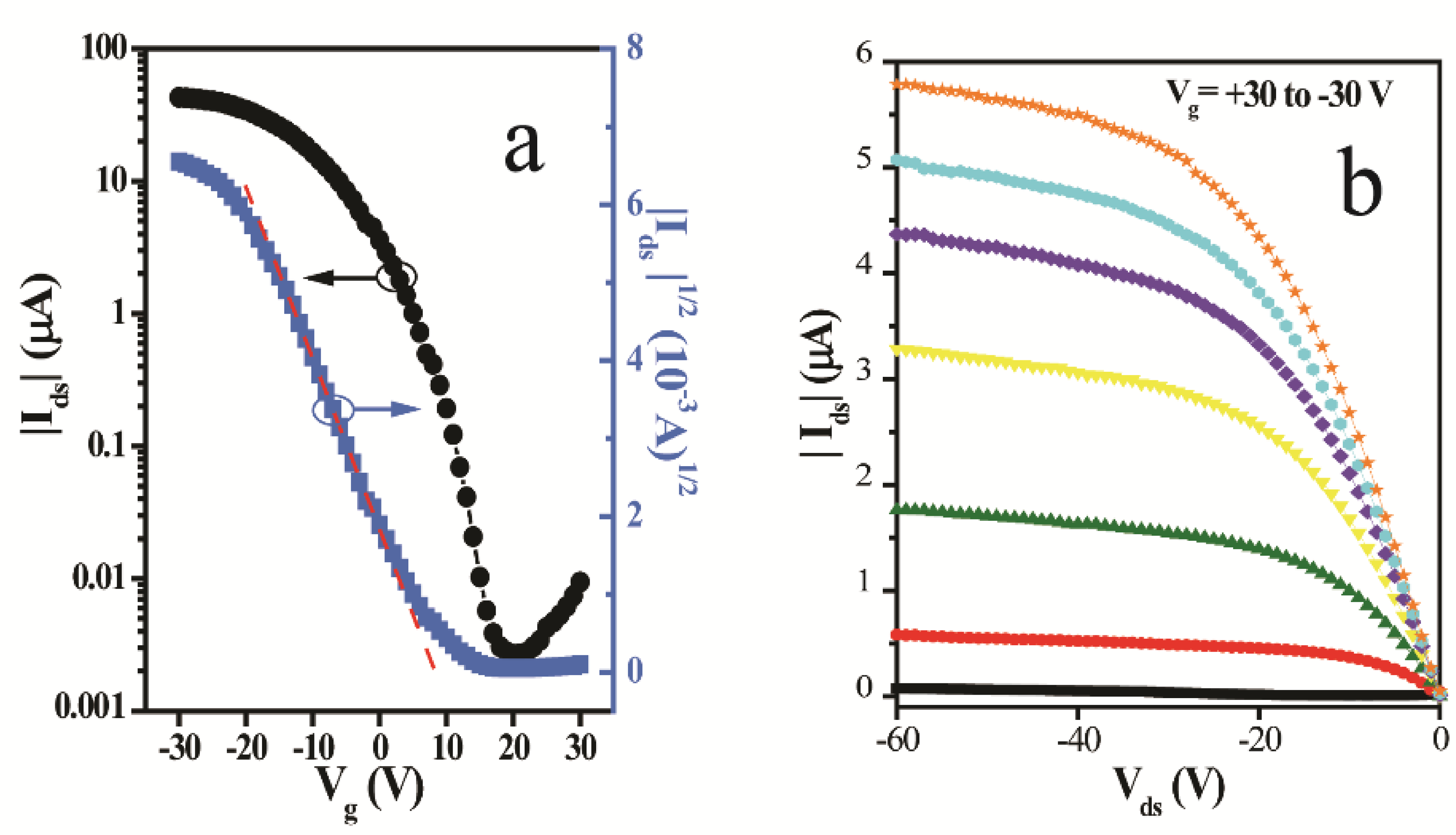

Figure 2. a) Transfer and b) output curves of the device in dark (V_{ds} = -40 V). Transfer and output curves showing excellent gate modulation character, hole mobility of 0.76 ~ 1.2 cm^2 V^{-1} s^{-1} were achieved.

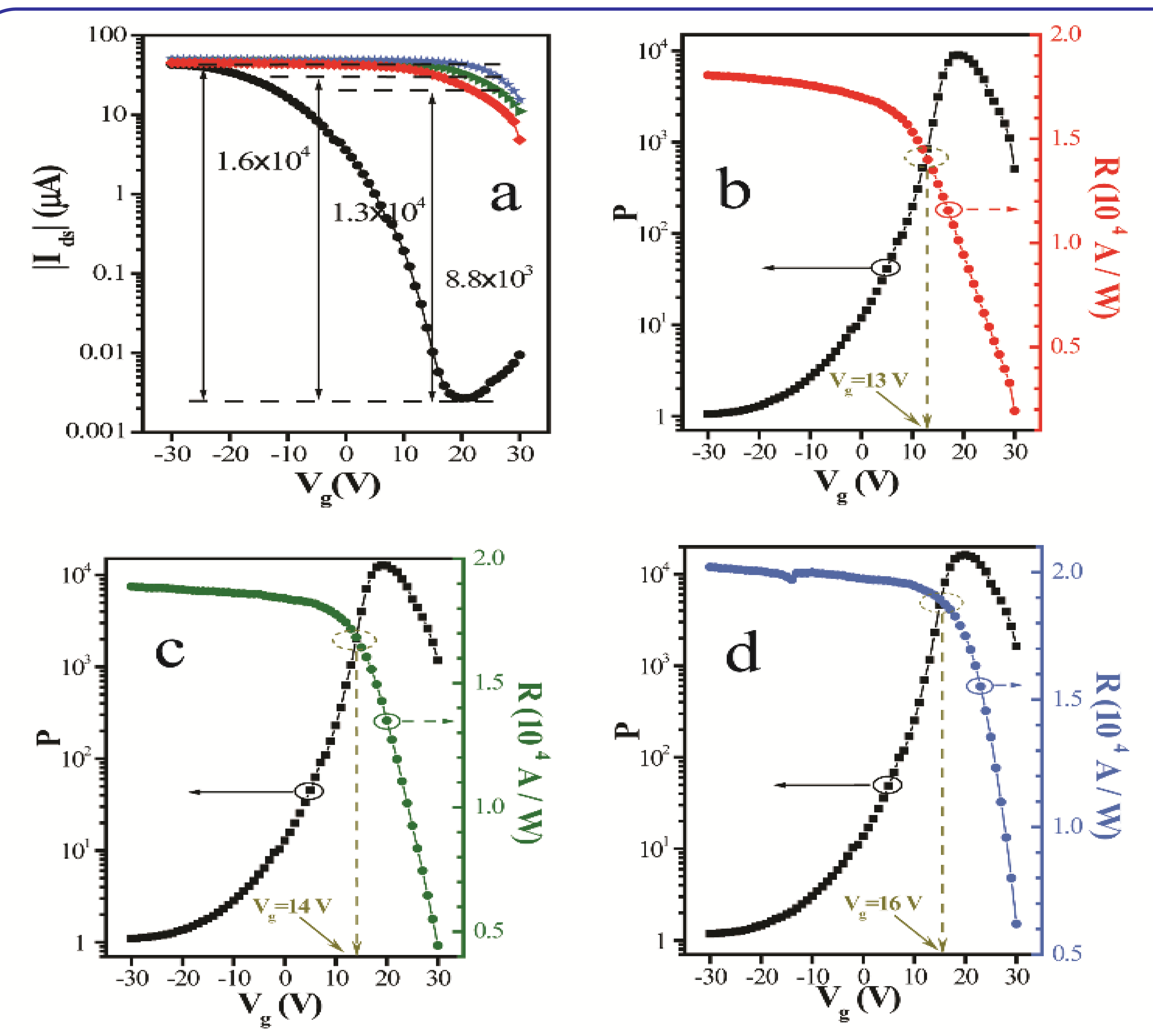

Figure 3. a) Transfer curves of the device (V_{ds} = -40 V) in dark (black) and under visible light (red, green, blue) of different wavelength; c, b, d) R and P versus Vg under b) 5 μW/cm^2 636 nm, at the crossing point (V_g= 13V), the P and R values was 800 and 14000 A/W, respectively. c) 3 μW/ cm^2 516 nm, the P and R values was about 2000 and 16000 A/W, d) 5 μW/cm^2 447 nm, the P and R values was about 8000 and 19000 A/W at the crossing point. The result is among the best perovskite phototransistors.

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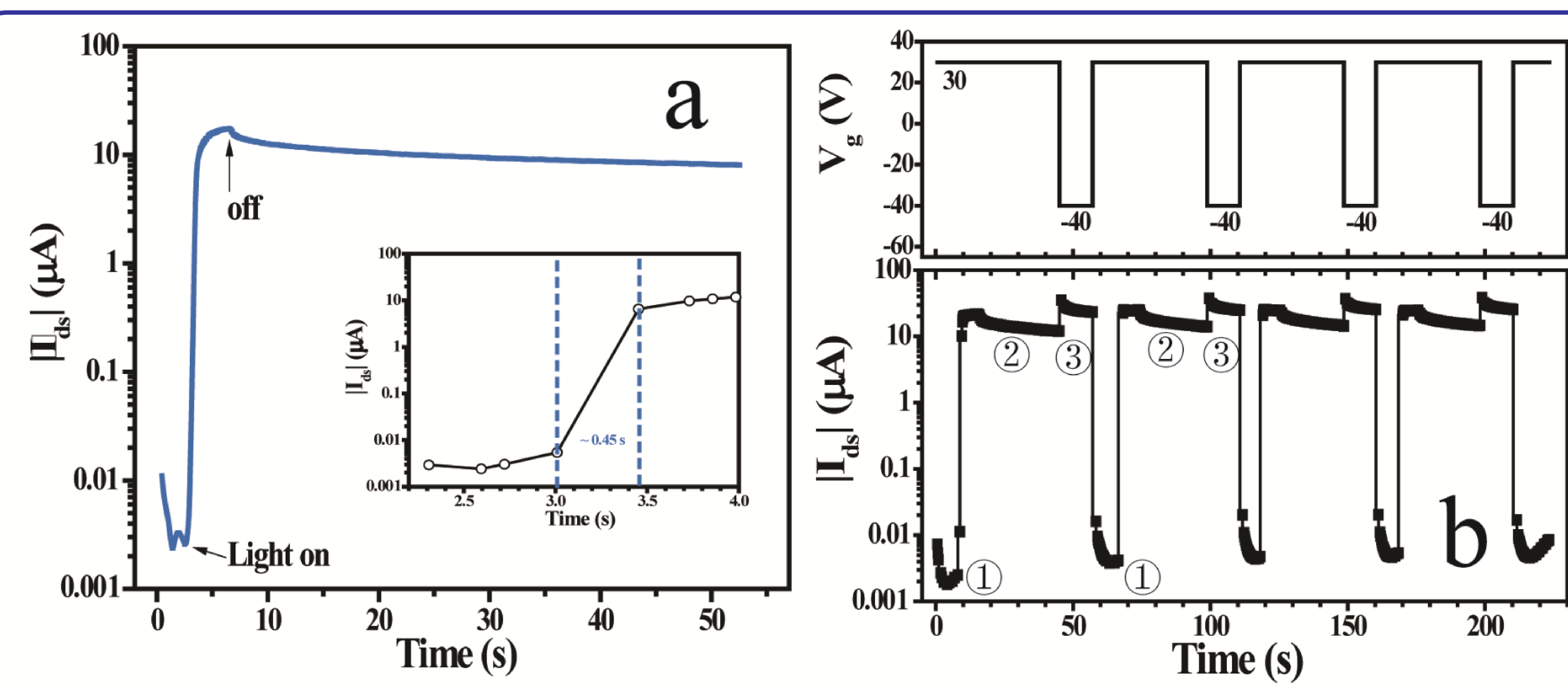

Figure 4. a) Open curve of perovskite transistor (inset: response time of < 0.45s). Light current stayed high because of trapped electrons and the resulting slow charge recombination. b) Charge recombination was accelerated by applying negative gate bias, so the current level was able to be manipulated by light and gate voltage.

Conclusions: In summary, 2D layered $(C_6H_5C_2H_4NH_3)_2SnI_4$ perovskite film prepared by one-step process can be applied to fabricate visible light sensitive phototransistor. The device exhibited ultrahigh photoresponse to visible light signals with different wavelength. This work offers the possibility of fabricating an ultrasensitive light sensor or light controlled memory device, and a new choice of organic-inorganic hybrid perovskite materials in photodetector applications besides $CH_3NH_3PbX_3$ structure.

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