

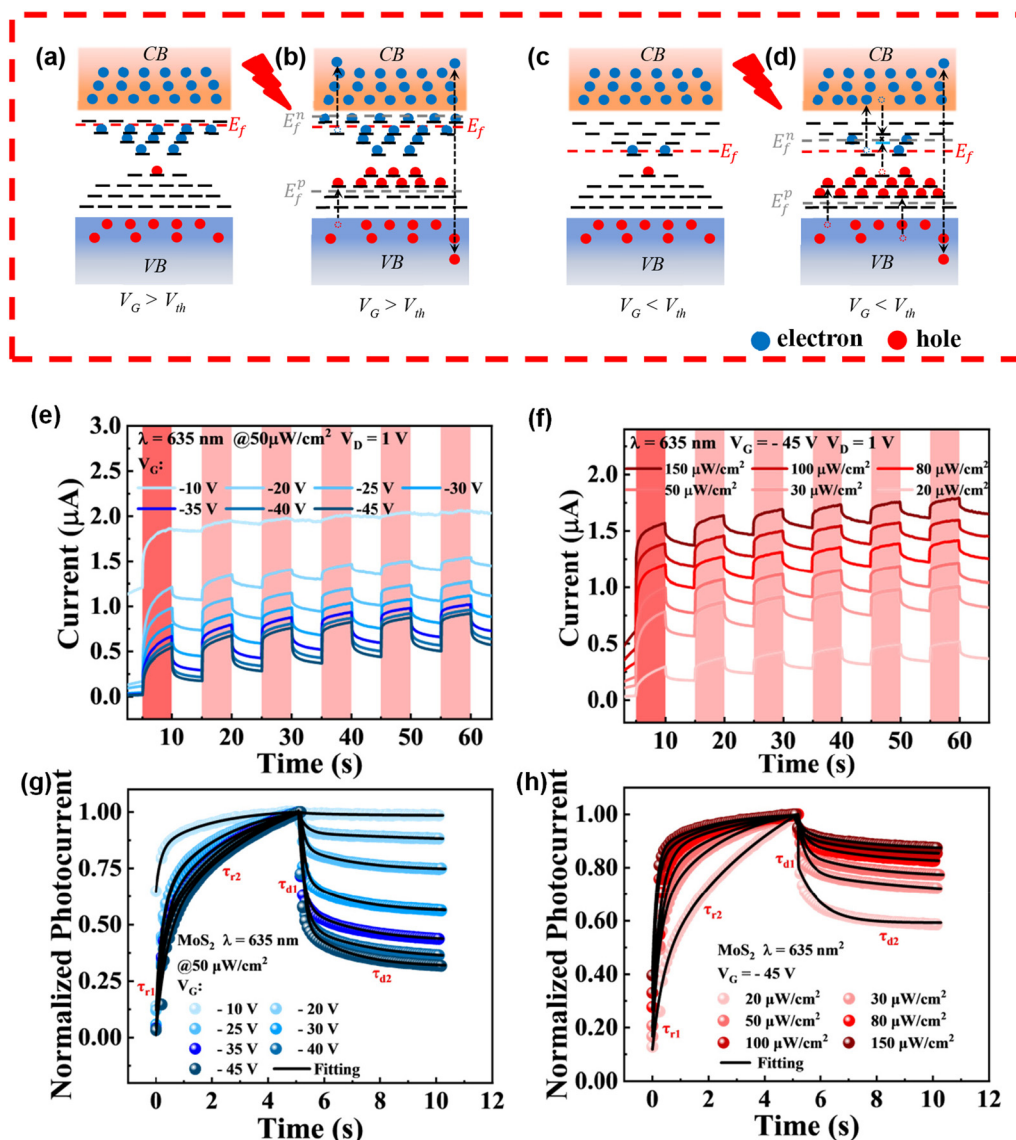


Fig. 3 Mechanism and photoresponsivity. Schematic to explain the behavior of trap states under $V_G > V_{th}$ and $V_G < V_{th}$, respectively. (a) and (b) In the dark and in light at $V_G > V_{th}$, respectively. (c) and (d) In the dark and in light at $V_G < V_{th}$, respectively. (e) Photoresponse of the MoS₂ phototransistor illuminated with 635 nm light with a power of $50 \mu\text{W cm}^{-2}$ for the optical ON/OFF switching cycles under various gate voltages. (f) Photoresponse of the MoS₂ phototransistor illuminated with different powers of 635 nm light for the optical ON/OFF switching cycles at -45 V gate voltage. The solid lines in (g) and (h) are the fitted curves for the first loop in (e) and (f), respectively.

equation,^{39–41} as illustrated in Fig. 3g and h. The corresponding equations are given as follows:⁴²

$$I_{ph} = A_1 \exp\left(-\frac{t}{\tau_1}\right) + A_2 \exp\left(-\frac{t}{\tau_2}\right)$$

In the rise edge, the times of the fast process and the slow process are designated as τ_{r1} and τ_{r2} , respectively. The values of the current changes in these two stages were recorded as I_{AB} and I_{BC} , respectively. In the decay edge, the times of the fast process and the slow process are designated as τ_{d1} and τ_{d2} , respectively. The values of the current changes in the two stages were recorded as I_{CD} and I_{DE} , respectively. The extracted

four-stage currents are shown in Fig. 4 and the times of the extracted four stages are shown in Fig. S6.†

As illustrated in Fig. 4a, a decrease in α is accompanied by an increase in I_{BC} , while an increase in α is associated with a decrease in I_{BC} . These two variables are strongly correlated. I_{AB} is slightly correlated with α ; it is not as strong as the correlation observed for the I_{BC} stage. As demonstrated above, α is a measure of the extent to which trap states contribute to the current. A reduction in α results in an increase in the contribution of trap states to the current, and *vice versa*. This implies that the currents in the AB and BC stage are influenced by trap states. To investigate the mechanism of the trap states in the two stages in detail, the photocurrent was extracted at the

