Highlights

Activity D - Light-matter interaction and non-equilibrium dynamics in advanced materials and devices - 2021

Coexistence of negative and positive photoconductivity in few-layer $PtSe_2$ field-effect transistors

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Platinum diselenide ($PtSe_2$) field-effect transistors with ultrathin channel regions exhibit p-type electrical conductivity that is sensitive to temperature and environmental pressure. Exposure to a supercontinuum white light source reveals that positive and negative photoconductivity coexists in the same device. The dominance of one type of photoconductivity over the other is controlled by environmental pressure. Indeed, positive photoconductivity observed in high vacuum converts to negative photoconductivity when the pressure is raised. Density functional theory calculations confirm that physisorbed oxygen molecules on the $PtSe_2$ surface act as acceptors. The desorption of oxygen molecules from the surface, caused by light irradiation, leads to decreased carrier concentration in the channel conductivity. The understanding of the charge transfer occurring between the physisorbed oxygen molecules and the $PtSe_2$ film provides an effective route for modulating the density of carriers and the optical properties of the material.

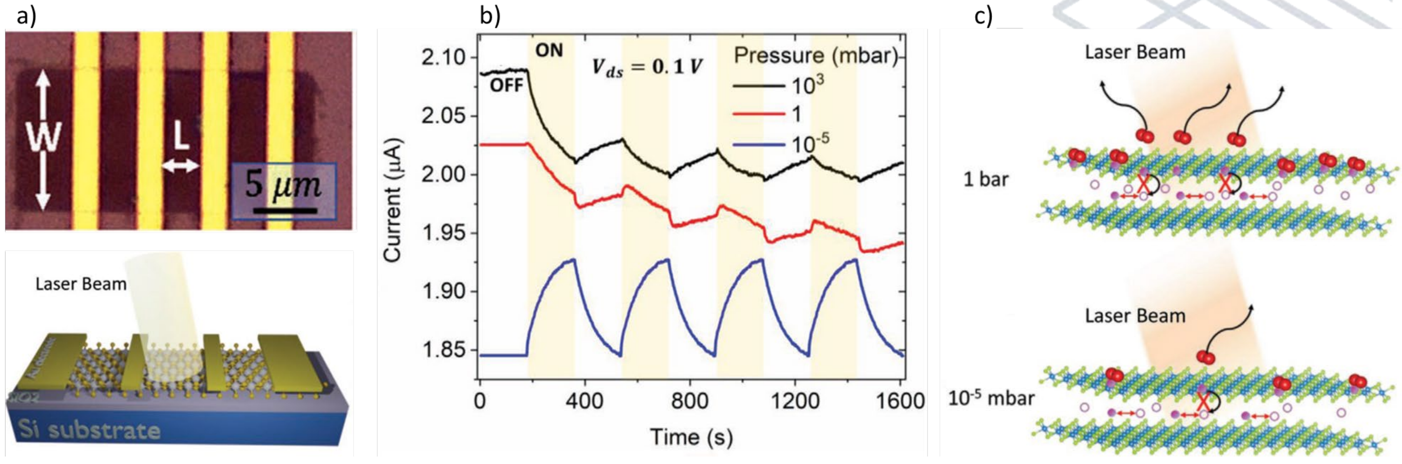

Fig. 1: a) Schematic of the device under light irradiation by a super-continuous white laser with wavelength ranging from 450 to 2400 nm. The laser spot of about 10 mm^2 was located between the two contacts to completely cover the channel. b) Current versus time characteristics at 10^3 mbar (black dots), 1 mbar (red dots), 10^{-5} mbar (blue dots) under switching light. The laser was switched on (yellow zone) and off (white zone) every 3 min. c) When the device is exposed to light (at 1 bar), oxygen is removed from the surface. Free electrons are trapped or recombine with holes reducing the density of available carriers and resulting in a negative photoconductivity. When the device is exposed to light at 10^{-5} mbar, the photogenerated electron–hole pairs and charge-carrier detrapping increase the conduction in the material, leading to a positive photoconductivity.