Journal Name

Supporting Information

Gate tunable photovoltaic effect in $MoSe_2$ homojunction enabled with different thickness

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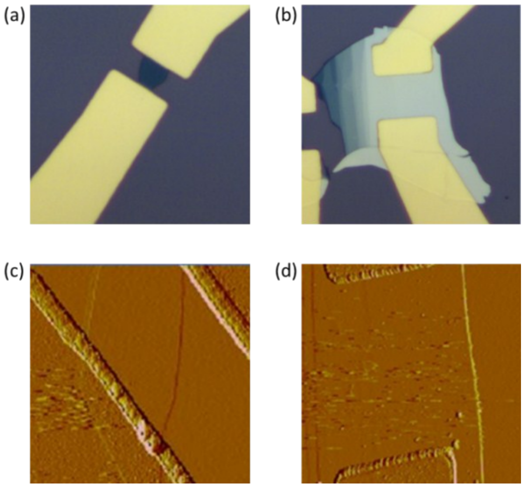

Fig. S1 (a, b) Optical microscope images of the $MoSe_2$ devices with thin and thick flakes, respectively, and with Ti (2 nm)/Au (50 nm) electrodes. (c, d) Atomic force microscopy (AFM) images of thin and thick $MoSe_2$ flakes, depicting ~4 nm and ~28 nm, respectively.

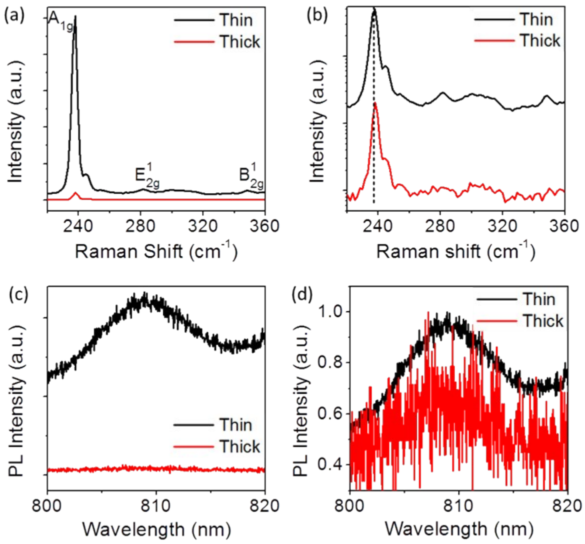

Fig. S2 (a, b) Linear and Log plot of raman spectra of the thin and thick $MoSe_2$ flakes, respectively. (c, d) PL and Normalized PL spectra of the thin and thick $MoSe_2$. The obvious E^1_{2g} and B^1_{2g} Raman modes were observed in thin flakes corresponding to few layer characteristics, while both modes disappeared in thick flakes corresponding to bulk feature. All these Raman phenomena are very consistent with previous reports.[31] we can observe the weak PL peak at 809 nm from thin flakes due to the radiation recombination of band gap of 1.53 eV. Also the Raman and PL intensity is much dropped in bulk compared to that in few layer flakes.

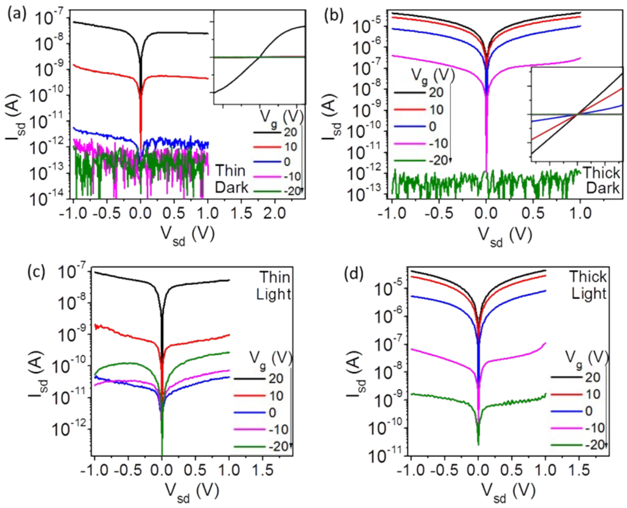

Fig. S3 (a, b) Output characteristic of the device based on thin and thick $MoSe_2$ flakes, respectively in the dark state. The insets are correponding I-V curves with linear scale of y-axis. In both devices with same thickness, the output curves under dark are nearly symmetrical and linear indicating the negligible contact barrier. (c, d) Output curves of the thin and thick $MoSe_2$ device under light illumination, respectively. No photovoltaic effect under light illumination in these control devices are observed, which confirms that the lateral homojunction indeed contributes to the photovoltaic property of our homojunction device.

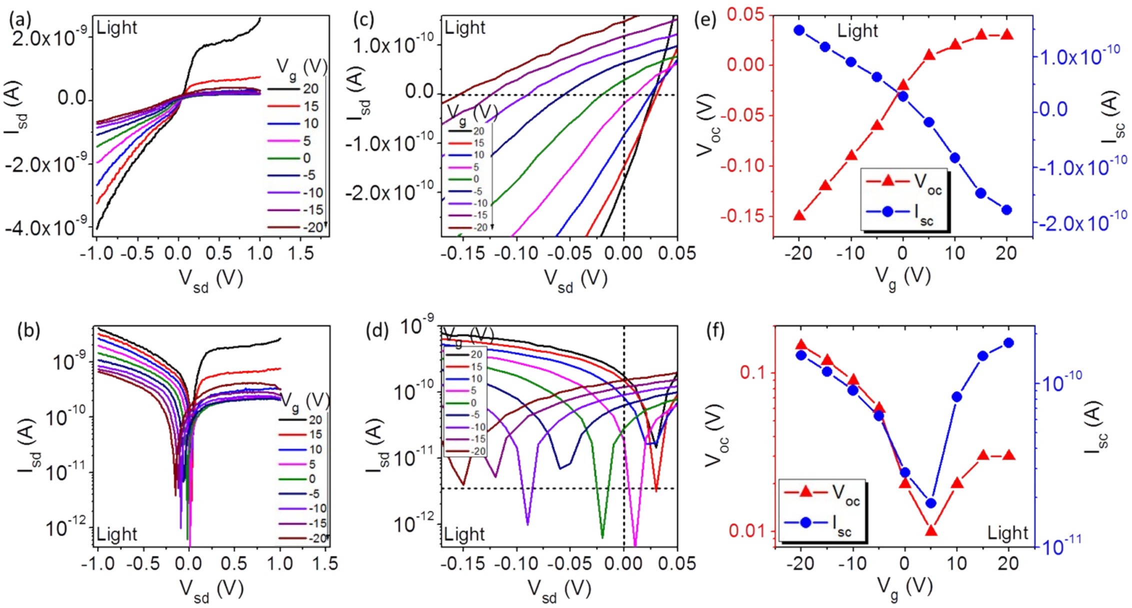

Fig. S4 (a, b) Output curves of another $MoSe_2$ homojunction device under light illumination in linear and log scale, respectively. Enlarged linear (c) and log (d) plot of output characteristic of the device. (e, f) Open-circuit voltage V_{oc} and short-circuit current I_{sc} as a function of back-gate voltage V_g in linear and log scale, respectively. In this device, we also observed the significant and gate tunable photovoltaic effect. These phenomena are similar to that of our fabricated $MoSe_2$ homojuction device in the text, indicating that our work is reliable and repeatable.

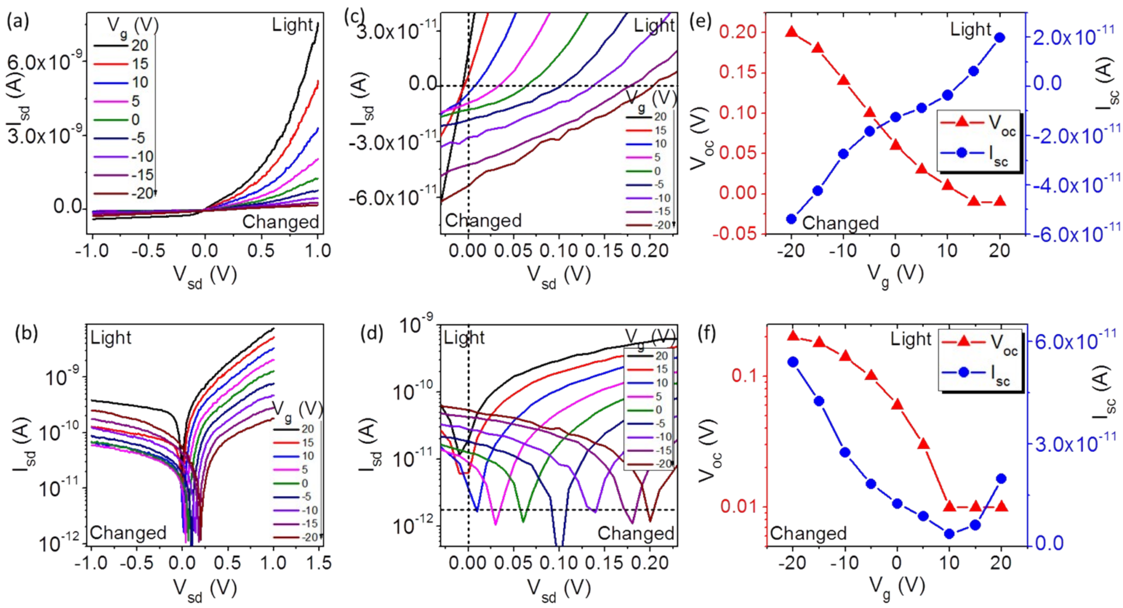

Fig. S5 The corresponding performances of the homojunction device when the source and drain was switched. Compared to the performance shown in Fig. S4, the gate-tunable V_{oc} and I_{sc} was inverted by switching the source and drain.

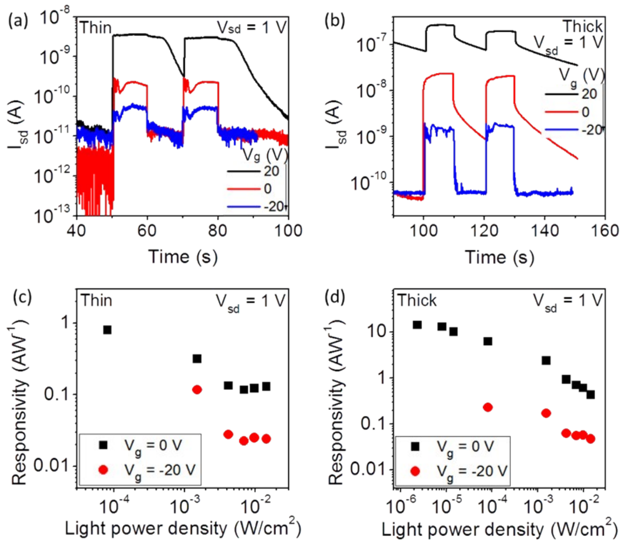

Fig. S6 (a, b) Time-resolved photoresponse of the thin and thick $MoSe_2$ device, respectively, for different back gate V_g measured at V_{sd} = 1V. (c, d) Dependence of the responsivity on illumination intensity for thin and thick device, respectively. The responsivity in these devices with same thickness is much lower than that in the $MoSe_2$ homojuction device at a bias voltage V_{sd} of 1 V. These results indicate that the homojunction device can not only possess gate tunable photovoltaic property but also improve the photo-response in term of the temporal response and responsivity.