# *Supporting Information*

## Multifunctional black phosphorus pressure sensors with bending angle and direction recognition characteristics

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## The file includes:

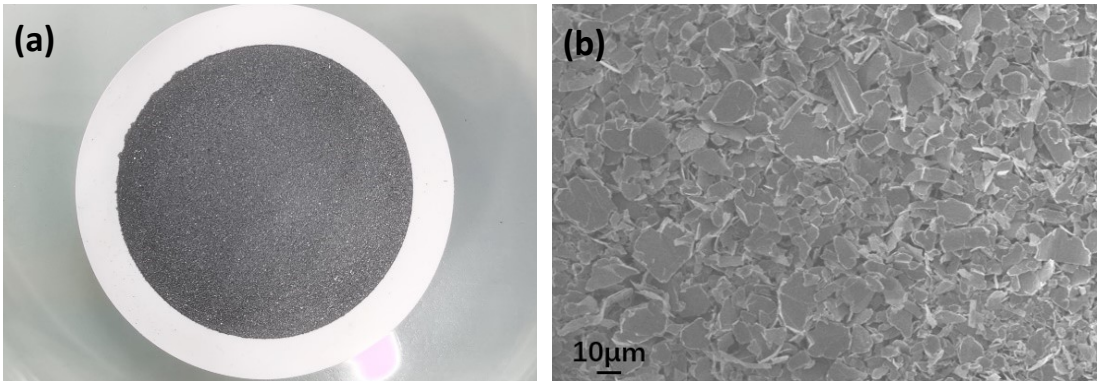


**Figure S1** (a) the photograph of the vacuum-filtered BP film, (b) surface SEM observation of black phosphorus film.

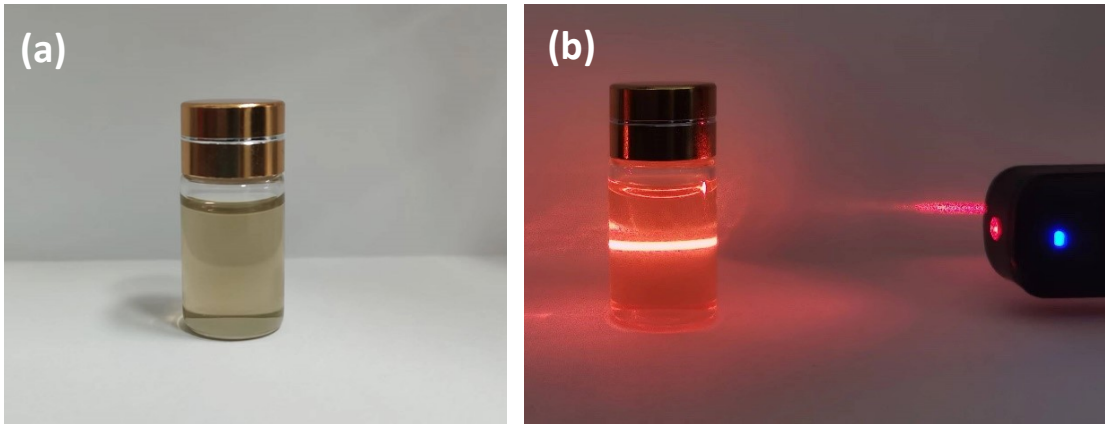


**Figure S2** BP dispersion in NMP (a) and Tyndall phenomenon (b).

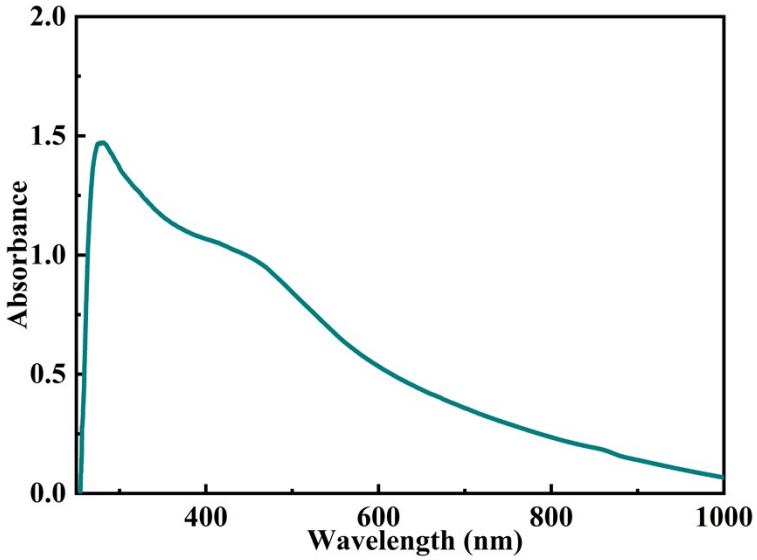


**Figure S3** UV-vis-NIR absorption spectrum of BP dispersion in NMP.

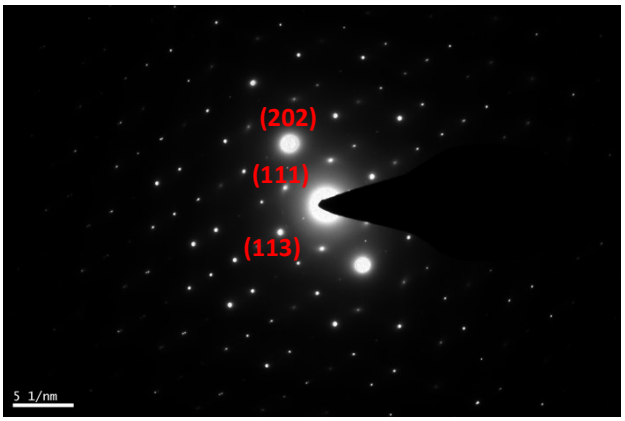


**Figure S4** SAED pattern of BP nanoflakes.

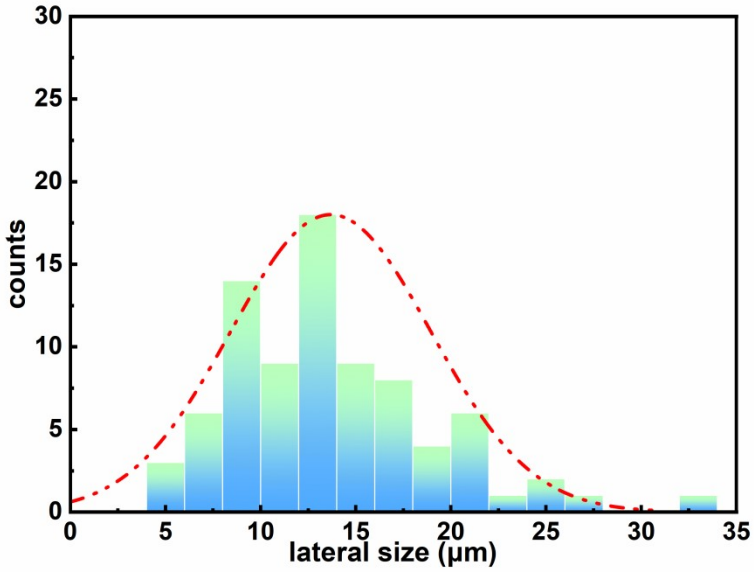


**Figure S5** Lateral size distribution of BP nanoflakes.

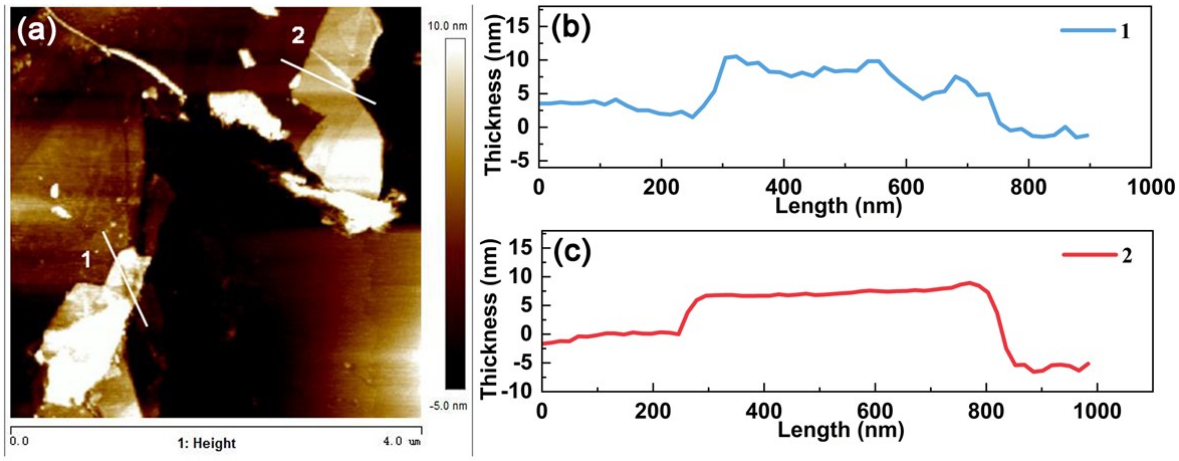


**Figure S6** AFM topography of BP (a), and corresponding height profiles along the white lines (b) and (c).

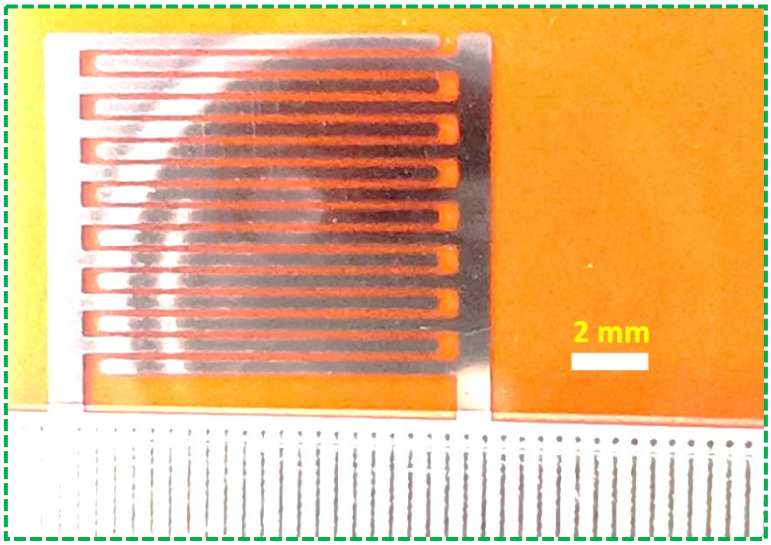


**Figure S7** The photograph of the interdigital electrode fabricated by thermal-evaporated copper film on flexible PI substrate.

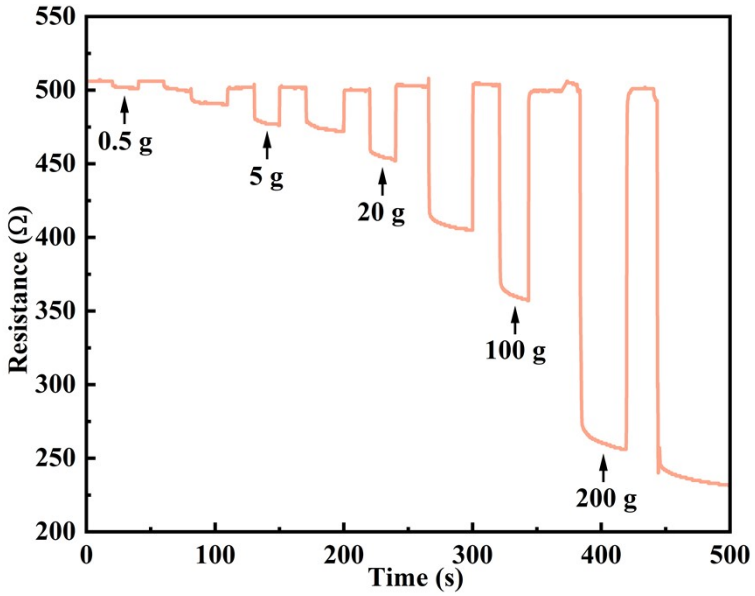


**Figure S8** The resistance changes of the device under different applied pressures.

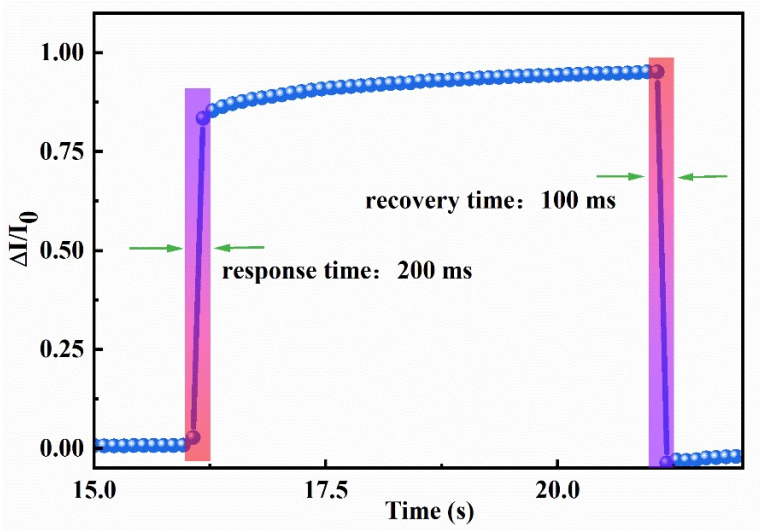


**Figure S9** Response and recovery curve of the sensor under the pressure of 40 kPa.

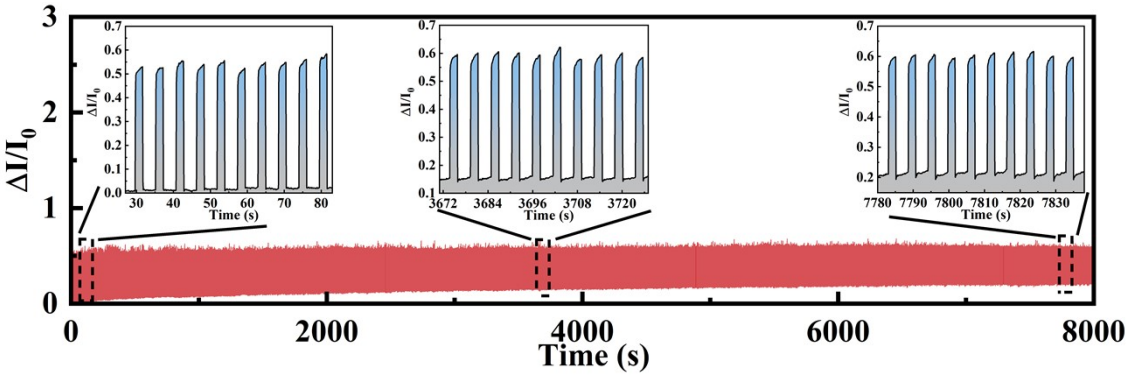


**Figure S10** The stability test of the sensor over 1400 loading-unloading cycles under pressure of 24 kPa.

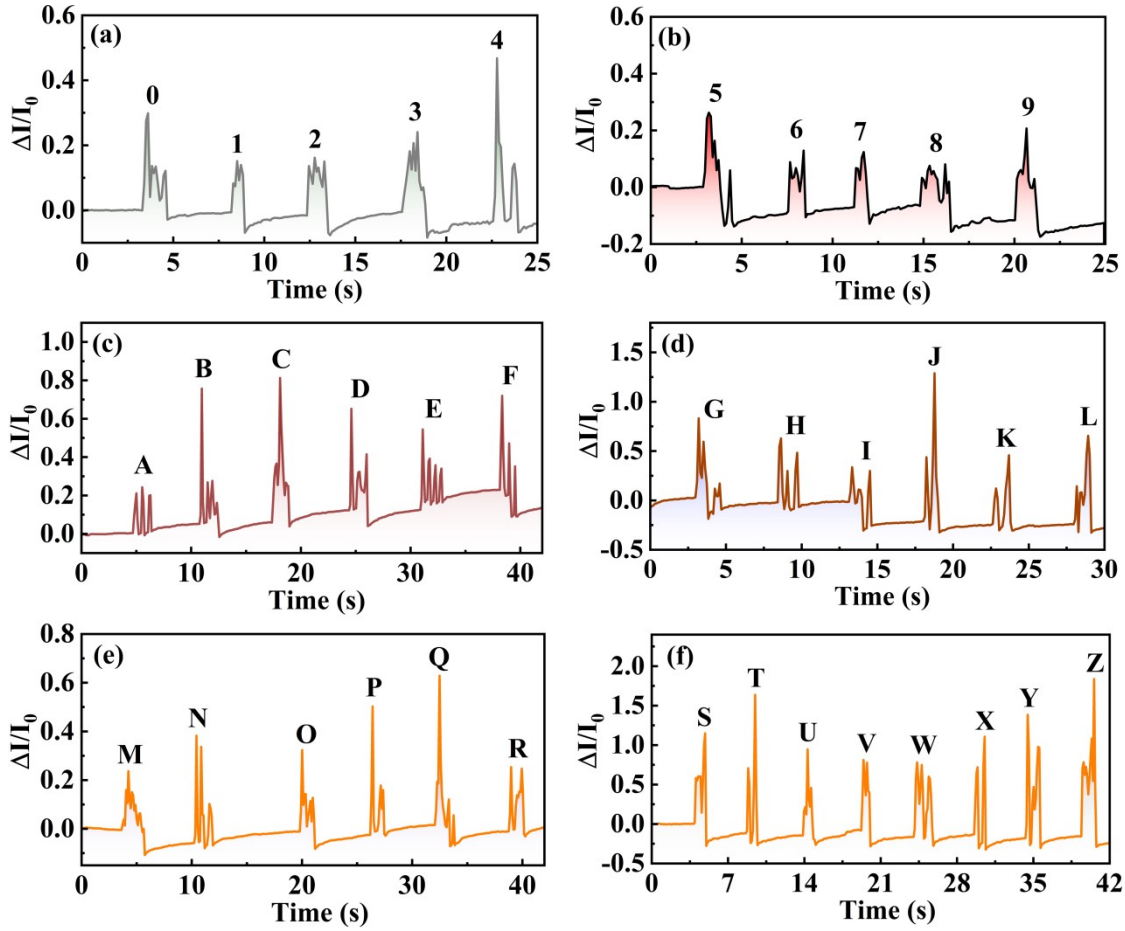


**Figure S11** The sensing curves of handwriting process with numbers 0-9 (a, b) and English letters A-Z (c, d, e and f). The handwriting process is performed by volunteer.

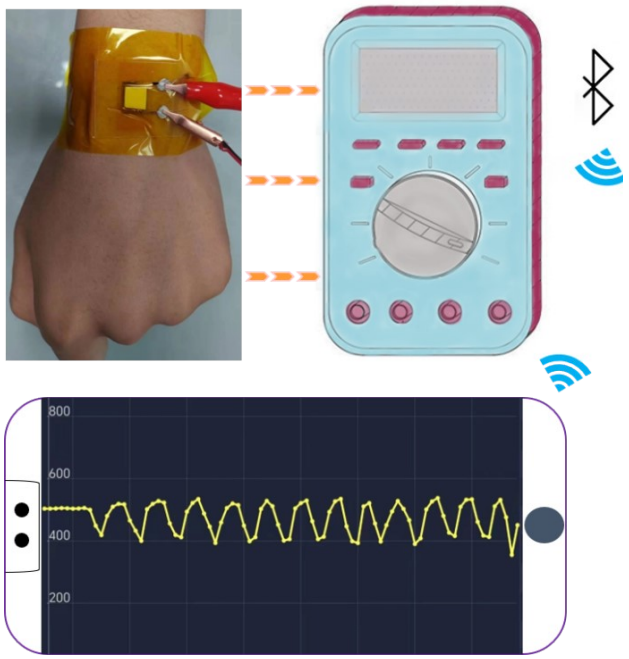


**Figure S12** Schematic diagram of remote monitoring, collecting current change by a multimeter and showing on a mobile phone in real time via a Bluetooth module.

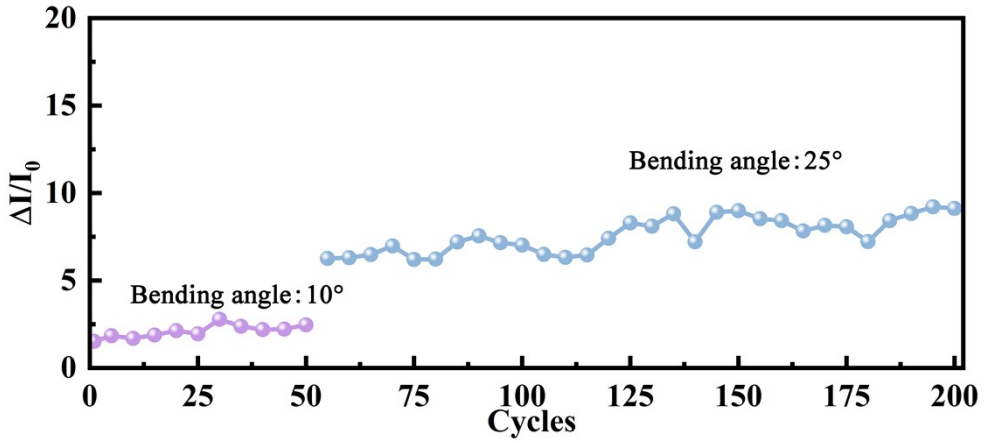


**Figure S13** The durability of the sensor under bending cycling test with angles of 10 and 25°.

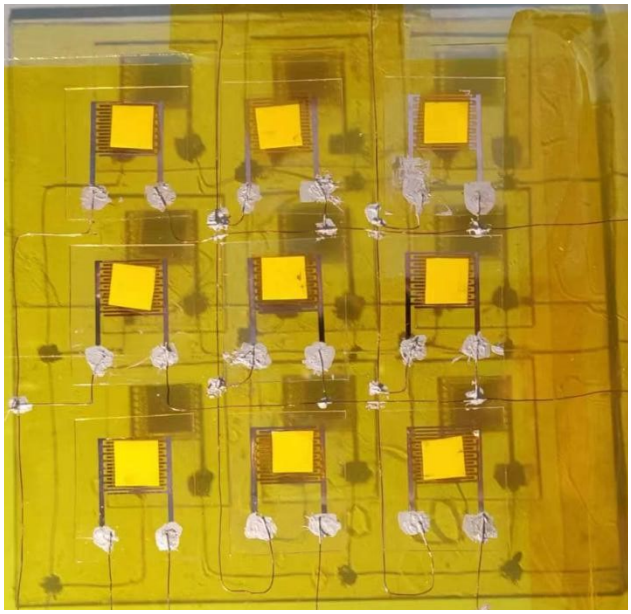

**Figure S14** Photograph of BP-based pressure sensor array that fixed on a piece of glass.

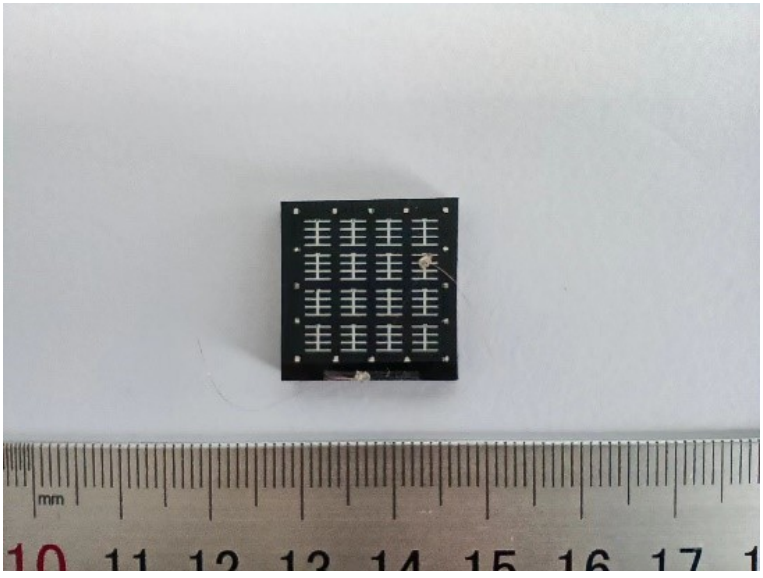


**Figure S15** Photograph of our home-made $Cu_2ZnSn(S,Se)_4$ thin film solar cell arrays.

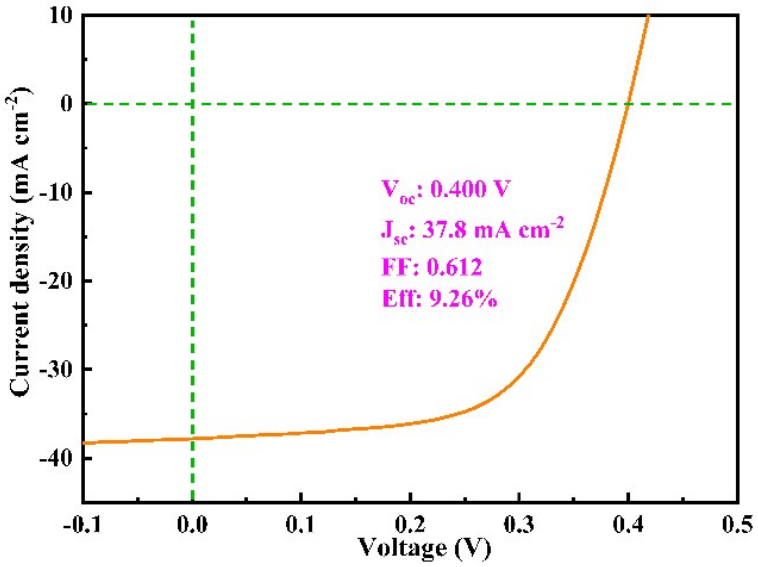


**Figure S16** Current density-voltage (J-V) characteristics of the solar cell based on $Cu_2ZnSn(S,Se)_4$ under calibrated AM 1.5G illumination generated by an AAA-class solar simulator (Oriel Sol3A 94023A, from Newport), current-voltage (I-V) curves were recorded on a Keithley 4200-SCS semiconductor measurement system.