The oxidation enhancement photocurrent response in $WSe_{1.95}Te_{0.05}$ nanosheets

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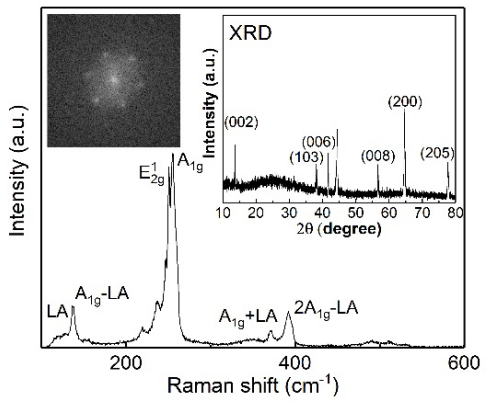
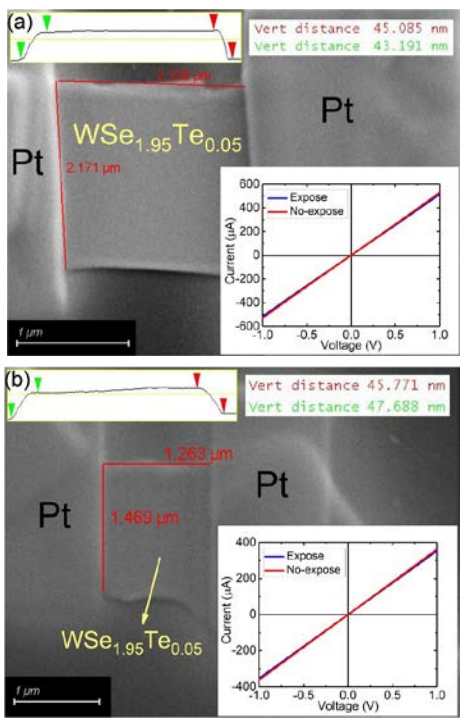
ABSTRACT

- In contrast to the high photoresponse, it is widely reported that these nanosheets were easily oxidized, and the surface oxidation or element adsorption severely suppresses the photocurrent performance because of the high surface-to-volume in the 2D TMDs. This effect limits its application potential. Hence, it is necessary to looking for an optical sensor system which can avoid the oxidation degradation.
- The photo responsivity increase from 173 A/W to 442 A/W at 0.5 V after air exposure in ambient conditions over half year. This value is the highest observed values in 2D TMDs without artificial treatments.
- The greatly photocurrent enhancement originated from the incident photo-to-current efficiency (IPCE) enhancement of WO_3 at the wavelength of 405 nm.

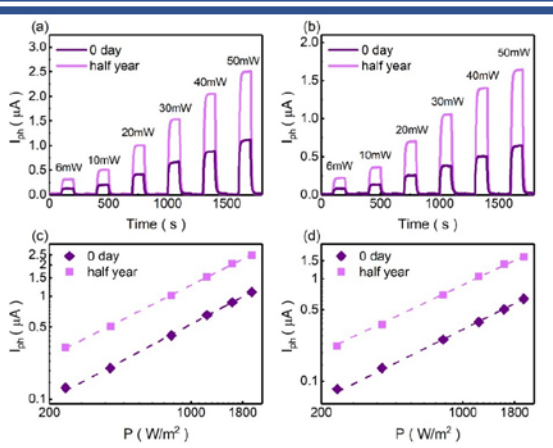
RESULTS



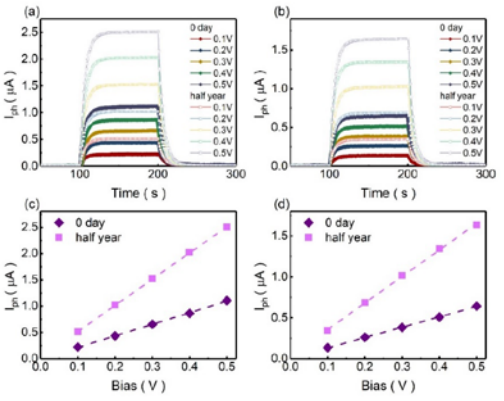
- Top-left inset: The electron diffraction pattern of the $WSe_{1.95}Te_{0.05}$. It is a hexagonal structure.
- The top-right inset: The XRD spectra of the $WSe_{1.95}Te_{0.05}$ single crystals. The position of the peaks is consistent with the database of the $WSe_{1.95}Te_{0.05}$ crystal. The full width at half-height of the peak (002) is 0.14° .
- The Raman spectra are consistent with the database. The oscillation modes are labeled at peaks. It exhibits three main peaks LA(M), E^1_{2g} and A_{1g} peaks at 120 cm^{-1} , 251 cm^{-1} , and 257 cm^{-1} , respectively.



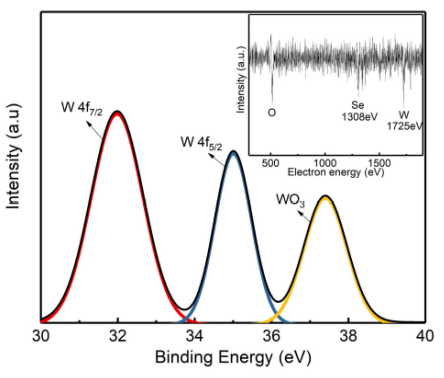
The SEM image of two $WSe_{1.95}Te_{0.05}$ nanosheets. Two Pt contacts are deposited on each $WSe_{1.95}Te_{0.05}$ nanosheet. The thickness is 45.0 and 46.7 nm for sample 1 and sample 2, respectively. The linear current-voltage dependence supports the contacts between Pt and $WSe_{1.95}Te_{0.05}$ nanosheet are ohmic contact.



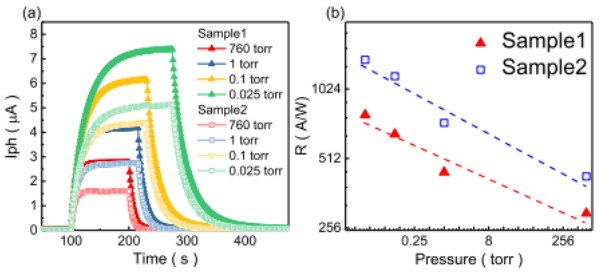
- The photocurrent is expressed as $I_P = AP^\beta$, and the fitting result supports that $\beta = 1.0$ (S1) and $\beta = 0.98$ (S2). This indicates that the photocurrent is proportional to the photo power intensity.
- The wavelength insensitive $\beta = 1$ indicates that the photocurrent is dominated by the band structure, and not by structure defect.



- (a) and (b) The photocurrent of different applied voltages for samples of as-prepared and half-year exposed.
- (c) and (d) The photocurrent is proportional to the applied voltage for two sample. The photocurrent are the same at the condition with and without air expose. The photoresponsibiliy increases after the air exposure.



- The XPS spectrum of W4f. The binding energy peak located at 31.9 eV, 35 eV and 37.4 eV corresponding to the W $4f^{7/2}$, $W4f^{5/2}$ of $WSe_{1.95}Te_{0.05}$ and WO3. The inset is the result of auger electron spectroscopy, the peak position of W shifts to lower value. This shows the absorption and oxidation on the surface.



- (a) The photocurrents at different pressures. It shows the higher photocurrents at lower pressures. (b) The responsivity as a function of pressure. The responsivity is inversely proportional to the pressure in log-scale.

- Table I, List of the reported photocurrent responsivity in two-dimensional transition metal dichalcogenides.

Material	Wavelength (nm)	Bias (V)	Responsivity (AW^{-1})	artificial treatments
				Our work
$WSe_{1.95}Te_{0.05}$ (S1, pristine)	405	0.5	118	none
$WSe_{1.95}Te_{0.05}$ (S1, half year exposed)	405	0.5	269	surface oxide
$WSe_{1.95}Te_{0.05}$ (S2, pristine)	405	0.5	173	none
$WSe_{1.95}Te_{0.05}$ (S2, half year exposed)	405	0.5	442	surface oxide
GaSe	254	5	2.8	none
GaS	254	2	4.2	on PET substrates
MoS_2	670	1	4.2×10^{-4}	back-gate voltage (50 V)
MoS_2	532	5	~ 6	none
MoS_2	532	10	0.57	none
MoS_2	633	1	0.12	back-gate voltage (-3 V)
MoS_2 nanoflake	532	0.1	30	none
MoS_2 nanoflakes	365	2	0.06	PN homojunction
MoS_2	655	5	4.1	none
APTES-doped MoS_2	655	5	56.5	APTES-dope
OTS-doped MoS_2	655	5	0.36	OTS-doped
WSe_2	655	5	20	none
APTES-doped WSe_2	655	5	0.59	APTES-doped
OTS-doped WSe_2	655	5	361	OTS-doped
WS_2 film	635	9	0.7	vacuum environment
WS_2 few layers	365	5	53.3	none
WS_2	532	10	0.99×10^{-6}	none
Nb-doped WSe_2 bulk	652	10	1.2	Nb-doped
Nb-doped WSe_2	652	5	3.5	Nb-doped
WSe_2	532	1	0.15	none
WSe_2 film	635	10	0.92	ITO electrode
$Mo_{0.5}W_{0.5}S_2$ polycrystal film	635	2.2	5.8	none
In_2Se_3 nanosheet	300	5	395	none
In_2Se_3 nanosheet	400	5	110	none
In_2Se_3 nanosheet	500	5	59	none
InSe layers	532	5	0.1	graphene/InSe heterostructure
InSe layers	450	10	12.3	back-gate voltage (-50 V)
$NbSe_2$ nanoflake	532	0.1	2.3	none
$NbSe_2$ nanoflake	808	0.1	3.8	none
SnS_2	530	3	1100	none

CONCLUSIONS

- The linear current-voltage characteristic indicates the ohmic contact between the $WSe_{1.95}Te_{0.05}$ nanosheet and Pt.
- The detected photocurrent is linear with the applied voltages and proportional to the light power intensity.
- The photo responsivity increase from 173 A/W to 442 A/W at 0.5 V after air exposure in ambient conditions over half year. This value is the highest observed values in 2D TMDs without artificial treatments and under similar conditions.
- The photon current enhancement originates from the incident photo-to-current efficiency enhancements of WO_3.