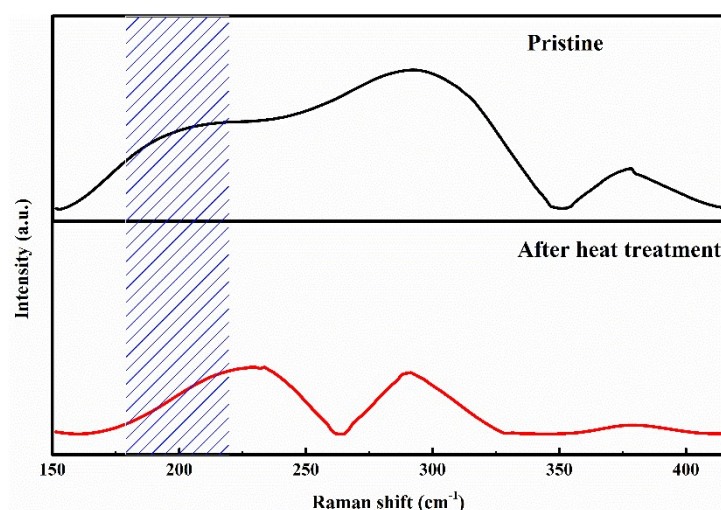


**Fig. S1** Cross-sectional HRTEM image of the heterojunction.



**Fig. S2** The typical Raman spectra of the samples (top:  $\text{WSe}_2$ , bottom:  $\text{WO}_{3-x}\text{-WSe}_2$ ) with a 532 nm excitation laser.

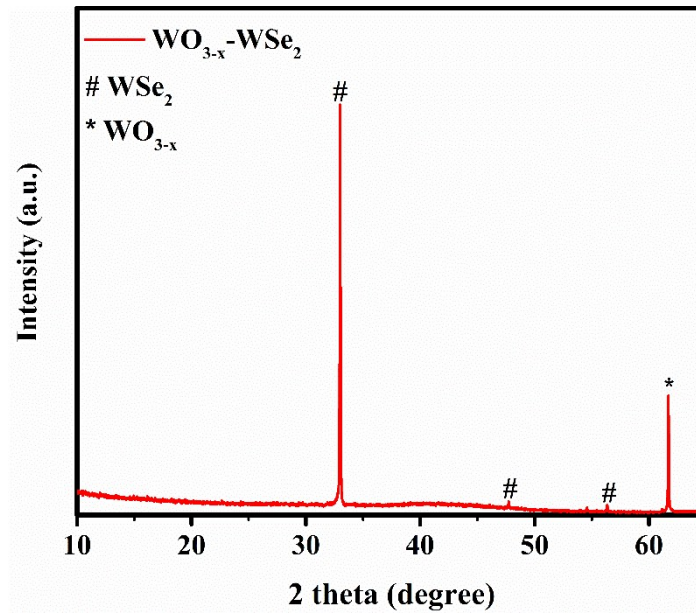


Fig. S3 XRD pattern of  $\text{WO}_{3-x}\text{-WSe}_2$ .

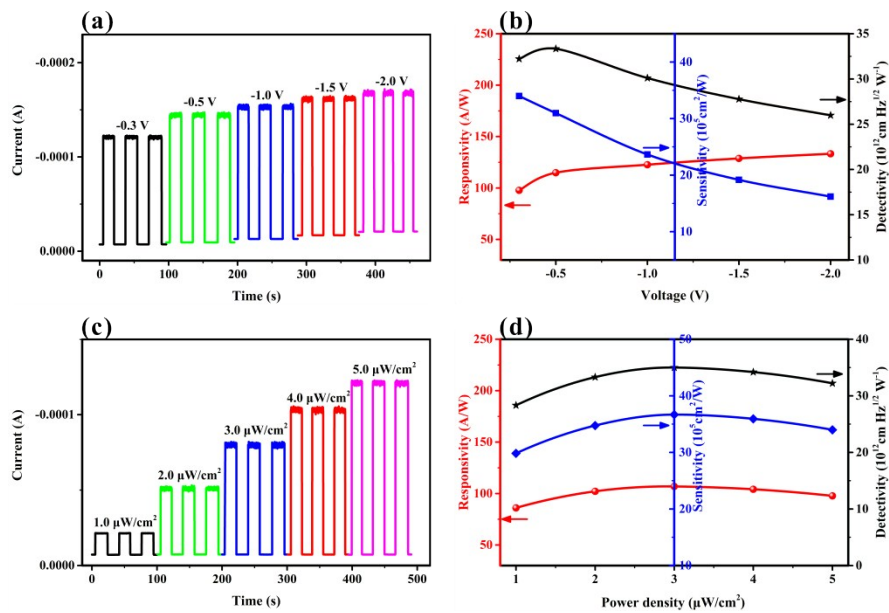


Fig. S4 (a) Photo switching curves under periodic 900 nm illumination with different external voltages. Power density:  $5 \mu\text{W}/\text{cm}^2$ . (b) Voltage-dependent figures of merit. Power density:  $5 \mu\text{W}/\text{cm}^2$ . (c) Photo switching curves under periodic 900 nm illumination with different power densities. External voltages:  $-0.3 \text{ V}$ . (d) Power-dependent figures of merit. External voltages:  $-0.3 \text{ V}$ . The above measurements are based on the  $\text{WSe}_2/\text{SiO}_2/n\text{-Si}$  heterojunction.

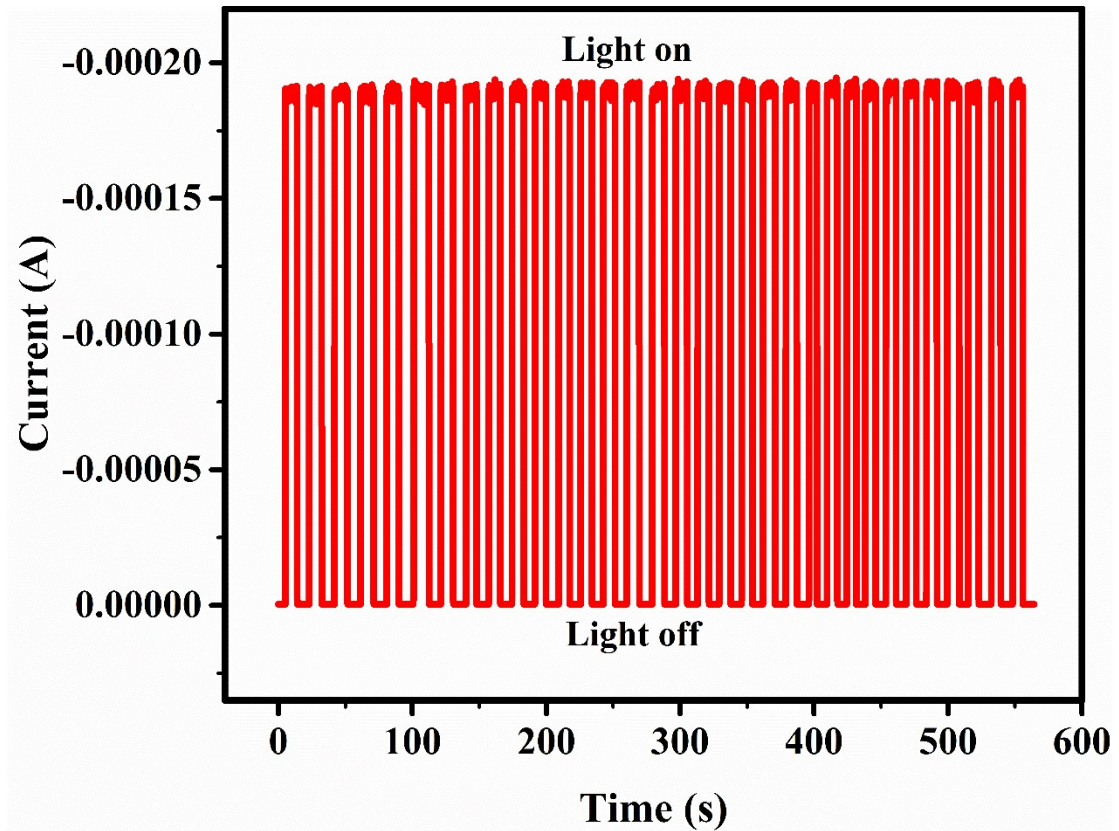


Fig. S5 Long-term curves (unbroken) under periodic 900 nm illumination (33 cycles).

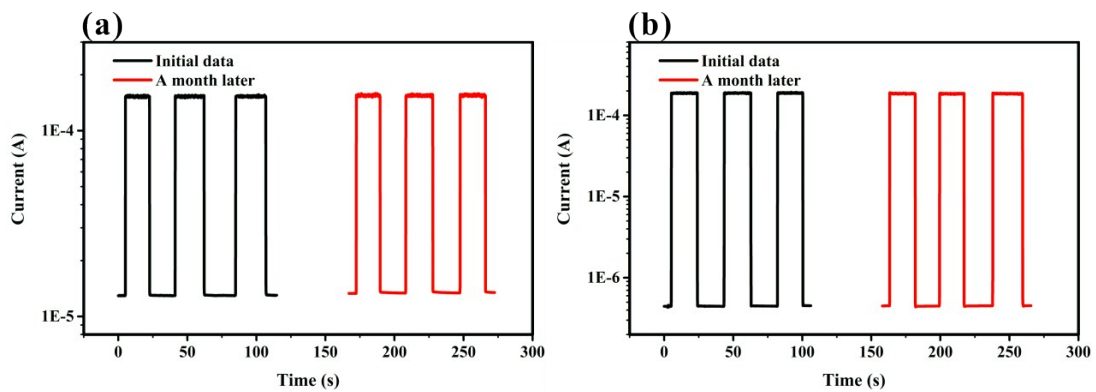
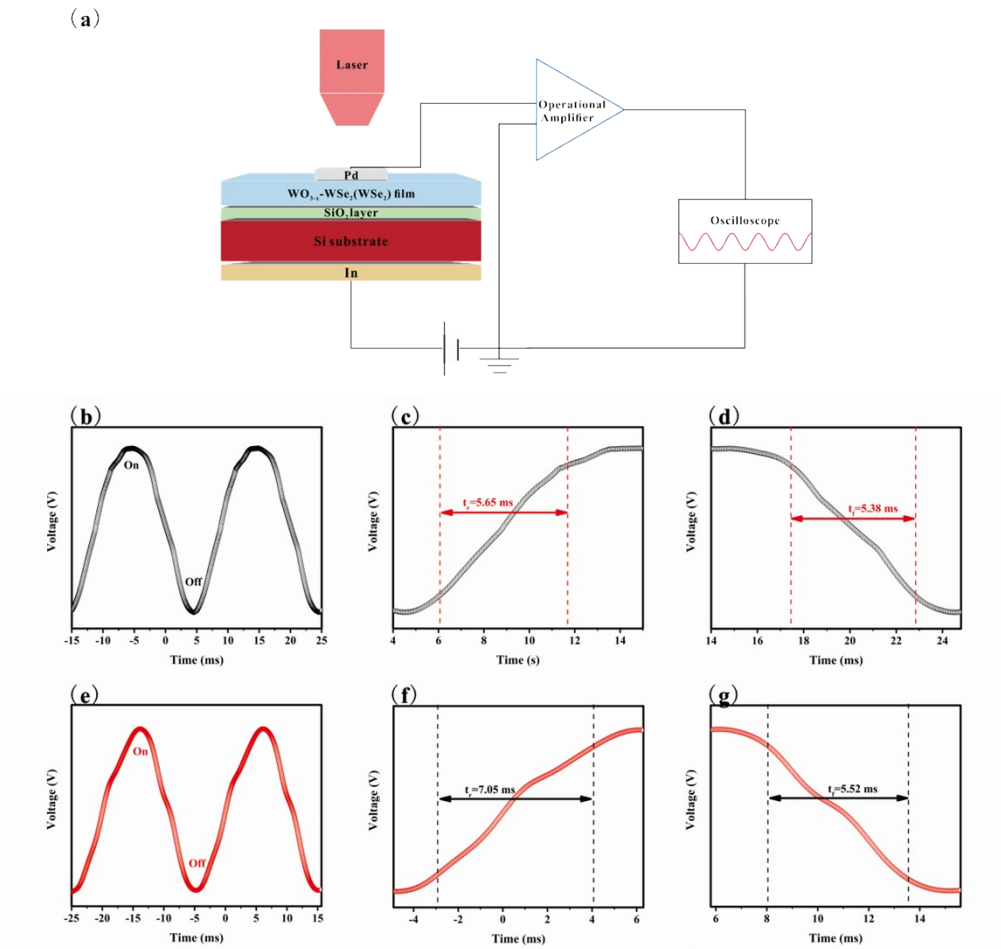
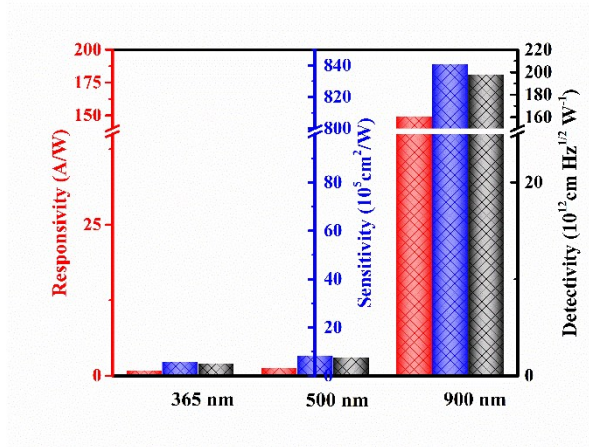


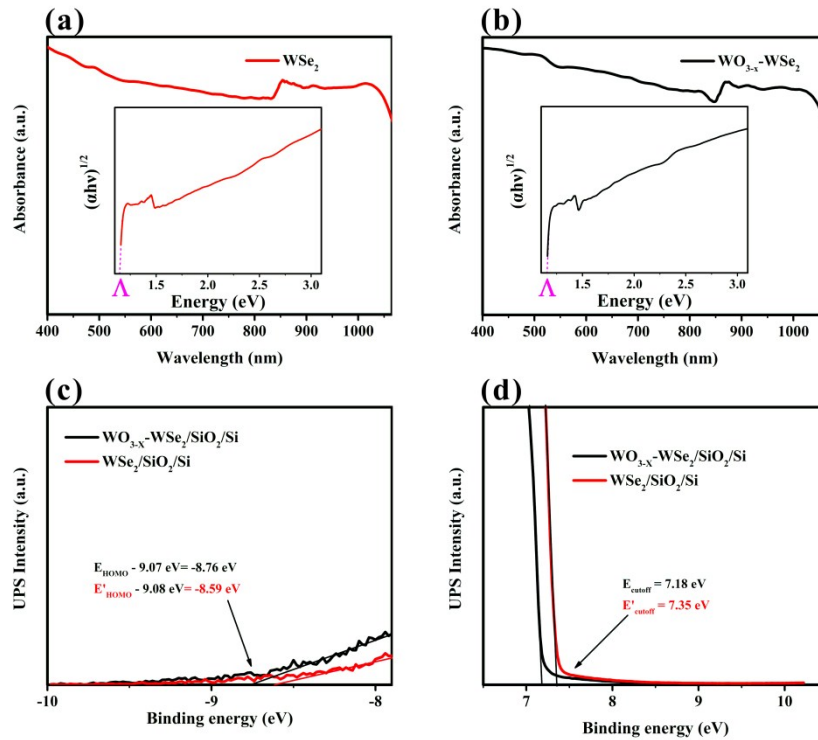
Fig. S6 Photo switching curves of (a)  $\text{WSe}_2/\text{SiO}_2/n\text{-Si}$  heterojunction and  $\text{WO}_{3-x}\text{-WSe}_2/\text{SiO}_2/n\text{-Si}$  heterojunction after exposing to ambient conditions for 1 month.



**Fig. S7** (a) Schematic illustration of the setup for measuring the response time of the devices. (b) Photoresponse of the  $\text{WSe}_2/\text{SiO}_2/n\text{-Si}$  heterojunction to the NIR light irradiation (900 nm laser). (c, d) show the rise and fall edge, respectively, of the  $\text{WSe}_2/\text{SiO}_2/n\text{-Si}$  heterojunction photoresponse curve. (e) Photoresponse of the  $\text{WO}_{3-x}\text{-WSe}_2/\text{SiO}_2/n\text{-Si}$  heterojunction to the NIR light irradiation (900 nm laser). (f, g) show the rise and fall edge, respectively, of the  $\text{WO}_{3-x}\text{-WSe}_2/\text{SiO}_2/n\text{-Si}$  heterojunction photoresponse curve.



**Fig. S8** The figures of merit of  $\text{WO}_{3-x}\text{-WSe}_2/\text{SiO}_2/n\text{-Si}$  heterojunction under illumination with different wavelengths. The power density and external voltages are  $5 \mu\text{W}/\text{cm}^2$  and  $-1.5 \text{ V}$  respectively.



**Fig. S9** (a) VIS-NIR spectrum of  $\text{WSe}_2$ . The inset shows a plot of  $(\alpha h\nu)^{1/2}$  versus  $h\nu$  for  $\text{WSe}_2$ . (b) VIS-NIR spectrum of  $\text{WO}_{3-x}\text{-WSe}_2$ . The inset shows a plot of  $(\alpha h\nu)^{1/2}$  versus  $h\nu$  for  $\text{WO}_{3-x}\text{-WSe}_2$ . UPS spectra of the samples, showing (c) the HOMO energies and (d) the cutoff energies respectively.