Electronic Supplementary Information

**Sulfur vacancy-induced reversible doping of transition metal disulfides via hydrazine treatment**

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Figure S1. Raman spectra of WS$_2$ devices treated with hydrazine for different amounts of time.
Figure S2. Total resistance ($R_T$) of WS$_2$ FETs. (a) $R_T$-$V_G$ curves of WS$_2$ FETs treated with hydrazine for various amounts of time, obtained from $I_{DS}$-$V_G$ curves in Fig. 2a. (b) Enlarged plots of the $R_T$-$V_G$ curves in Fig. S2a.
Figure S3. Doping stability of a hydrazine-doped WS\textsubscript{2} FET (a) without and (b) with a PMMA layer in ambient air. The on/off current ratio and field-effect mobility of the hydrazine-doped WS\textsubscript{2} FET covered with the PMMA layer remain almost unchanged in ambient air after even a month, demonstrating good air stability.
Figure S4. XPS spectra of W 4f and S 2p for (a) pristine, (b) hydrazine-doped, and (c) sulfur-annealed WS₂ flakes. Fitted curves of W 4f and S 2p spectra are represented as W⁴⁺ and S²⁻, respectively. Their S/W atomic ratios are estimated to be 1.90, 1.82, and 1.90 for pristine, hydrazine-doped, and sulfur-annealed samples, respectively.
Figure S5. AFM images of WS₂ flakes (a) before and (b) after hydrazine treatment.
Figure S6. S/W atomic ratios for pristine, argon-annealed, hydrazine-doped, and sulfur-annealed WS₂ flakes, taken by EDX measurements.
**Figure S7.** Raman spectra of a WS$_2$ flake upon five consecutive doping cycles, showing doping reversibility.
Figure S8. Transfer characteristics of a WS$_2$ FET upon five consecutive doping cycles, showing doping reversibility.
Figure S9. (a) AFM image and (b) thickness profile of a pristine MoS$_2$ FET.
**Figure S10.** Raman spectra showing doping reversibility of MoS$_2$. (a) Raman spectra of a MoS$_2$ flake upon five consecutive doping cycles, and (b) variations in the $E_{2g}^1$ and $A_{1g}$ peaks.
Figure S11. (a) Transfer characteristics and (b) variations in electrical properties including the on/off current ratio, field-effect mobility, and threshold voltage of a MoS$_2$ FET upon five consecutive doping cycles, showing doping reversibility.
Figure S12. Time-dependent photoresponse characteristics of pristine WS₂ devices under irradiation with visible light of various power densities at 625 nm, measured at (a) $V_{DS} = 1$ V and (b) 2 V.
Figure S13. Time-dependent photoresponse characteristics of WS$_2$ devices treated with hydrazine molecules for different amounts of time, measured under irradiation with visible light at 625 nm and 1 mW cm$^{-2}$, and at (a) $V_{DS} = 1$ V and (b) 2 V.