Supporting Information

Twist Angle Dependent High Degree of Anisotropic Emission and

Phonon Scattering in WS₂/NbOCl₂ Heterostructure

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Fig. S1. Comparison of PL and Raman peak intensity uniformity in PVD-grown WS₂ through surface scanning.



Fig. S2. Schematic diagram of NbOCl₂ exfoliation.



Fig. S3. Raman polarization characteristics of NbOCl₂ transferred by dry method. (a) Raman polarization spectrum of NbOCl₂ crystals measured at room temperature. (b)-(f) Raman polarization spectra of characteristic peaks P1-P5 of NbOCl₂.



Fig. S4. Schematic diagram illustrating the transfer method of WS₂/NbOCl₂ heterostructures.



Fig. S5. (a) Optical setup of the linear polarization sensitive Raman and PL experiments. (b) Optical setup of the valley polarization experiment, quarter-wave plate is used in the optical path to generate and detect circular polarization.



Fig. S6. PL (a) Optical image of 2L-WS₂/NbOCl₂ heterostructure together with PL intensity mapping. (b) and Raman (c) spectra of bilayer WS₂/NbOCl₂ heterostructures measured at room temperature.



Fig. S7. Polar plots of A_{1g} mode in 1L-Het Raman polarization.



Fig. S8. Polarization characteristics of photoluminescence and Raman modes in bilayer $WS_2/NbOCl_2$ heterostructures. (a) Photoluminescence polarization spectrum of bilayer

 $WS_2/NbOCl_2$ heterostructure measured at room temperature. (b) Polar plots of 2LA Raman mode. (c) Polar plots of A_{1g} Raman mode.



Fig. S9. (b) Contour plot of polarization-dependent PL intensity of 1L-WSe₂/NbOCl₂. (b) Polar plots of 1L-WSe₂/heterostructure at room temperature.



Fig. S10. Anisotropic photoluminescence response of 1L-Het with varying twist angles measured on the same $NbOCl_2$ sample.



Fig. S11. Anisotropic Raman vibration mode of 2LA with varying twist angles measured on the same NbOCl₂ sample.



Fig. S12. Other twisted angle dependent anisotropic PL emission test.



Fig. S13. Valley polarization of 2L-WS₂/NbOCl₂ heterostructures. PL spectra of bilayer WS₂ (a) and the heterojunction region (b) excited with right circularly polarized (σ^+) laser and detected with both right (σ^+) and left (σ^-) circularly polarized lasers.