Supporting Information

Symmetry-Reduction Enhanced One-Dimensional Polarization-Sensitive Photodetectors for Multi-Functional Applications

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Keywords: one dimensional (1D) van der Waals (vdW) material, broadband photoresponse, polarization sensitivity, convolutional processing, multiplexing optical communications

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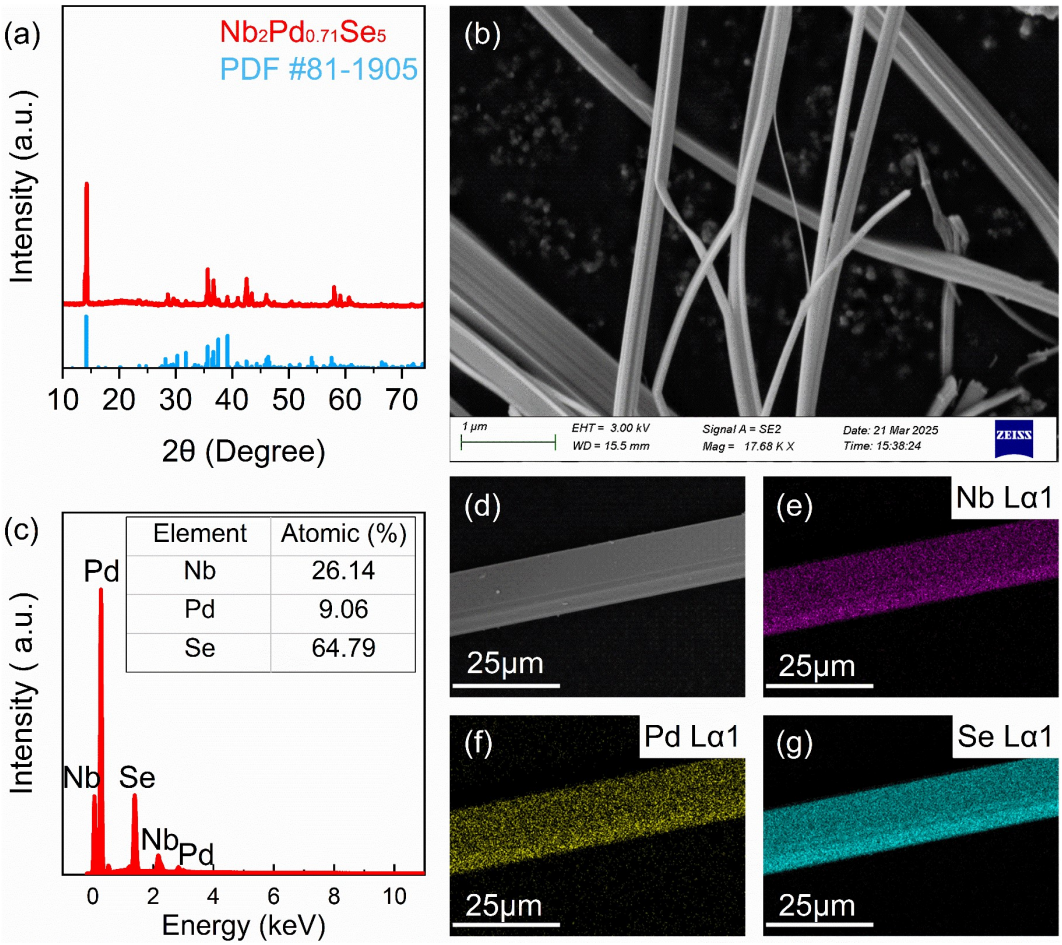

Figure S1 (a) XRD pattern of the as-synthesized $Nb_2Pd_{0.71}Se_5$ single crystal. (b) SEM of the $Nb_2Pd_{0.71}Se_5$ single crystal. (c) EDS spectrum of the $Nb_2Pd_{0.71}Se_5$ single crystal. (d) SEM image, (e) Nb element mapping, (f) Pd element mapping, and (g) Se element mapping of the $Nb_2Pd_{0.71}Se_5$ single crystal.

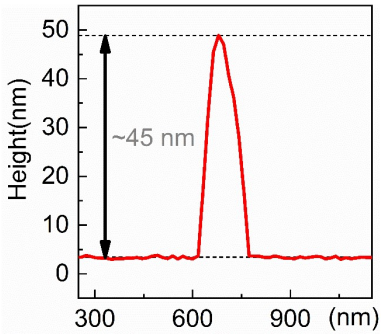

Figure S2 The atomic force microscope (AFM) height profile of the as-exfoliated $Nb_2Pd_{0.71}Se_5$, showing the diameter of ~ 45 nm.

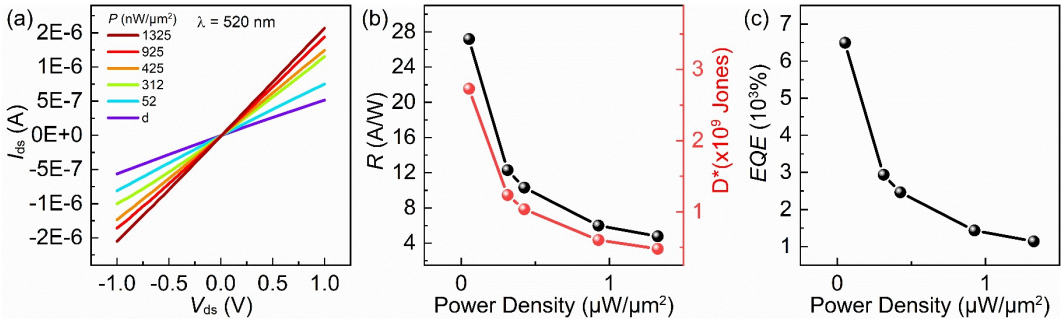

Figure S3 Photoresponse of the 1D vdW $Nb_2Pd_{0.71}Se_5$ photodetector under 520 nm laser irradiation with various power densities ranging from 52 to 1325 nW/μm² and 1 V bias voltage. (a) Linear output characteristics of the device under illumination with various power densities. (b) Responsivity (*R*) and Specific detectivity (*D**), (c) External quantum efficiency (*EQE*) of the device as functions of the laser power density.

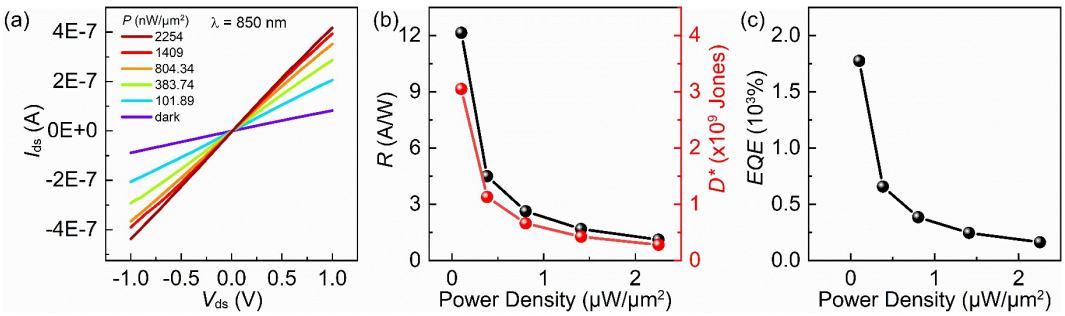

Figure S4 Photoresponse of the 1D vdW $Nb_2Pd_{0.71}Se_5$ photodetector under 850 nm laser irradiation with various power densities ranging from 101.89 to 2254 nW/μm² and 1 V bias voltage. (a) Linear output characteristics of the device under illumination with various power densities. (b) Responsivity (*R*) and Specific detectivity (*D**), (c) External quantum efficiency (*EQE*) of the device as functions of the laser power density.

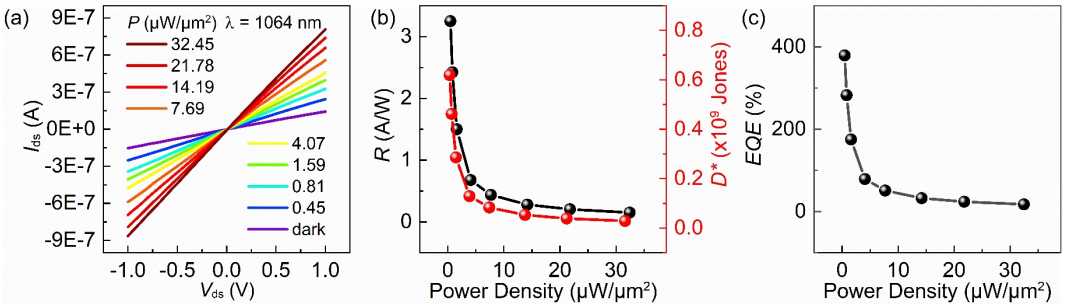

Figure S5 Photoresponse of the 1D vdW $Nb_2Pd_{0.71}Se_5$ photodetector under 1064 nm laser irradiation with various power densities ranging from 0.45 to 32.45 μW/μm² and 1 V bias voltage. (a) Linear output characteristics of the device under illumination with various power densities. (b) Responsivity (*R*) and Specific detectivity (*D**), (c) External quantum efficiency (*EQE*) of the device as functions of the laser power density.

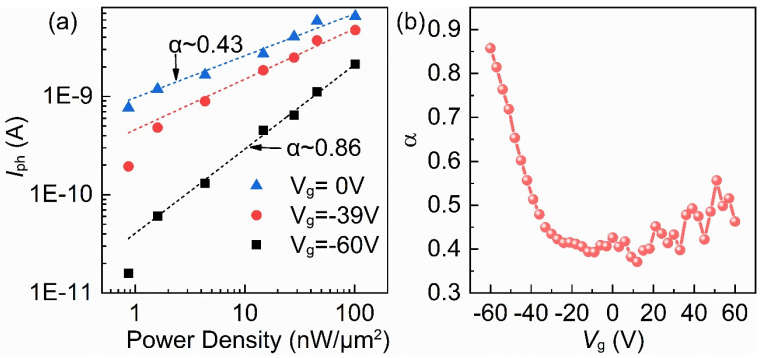

Figure S6 (a) Photocurrent as a function of power density at different gate voltages ranging from 0 V to -60 V. (b) Gate dependence of the power law coefficient (α) extracted from the fitting in (a).

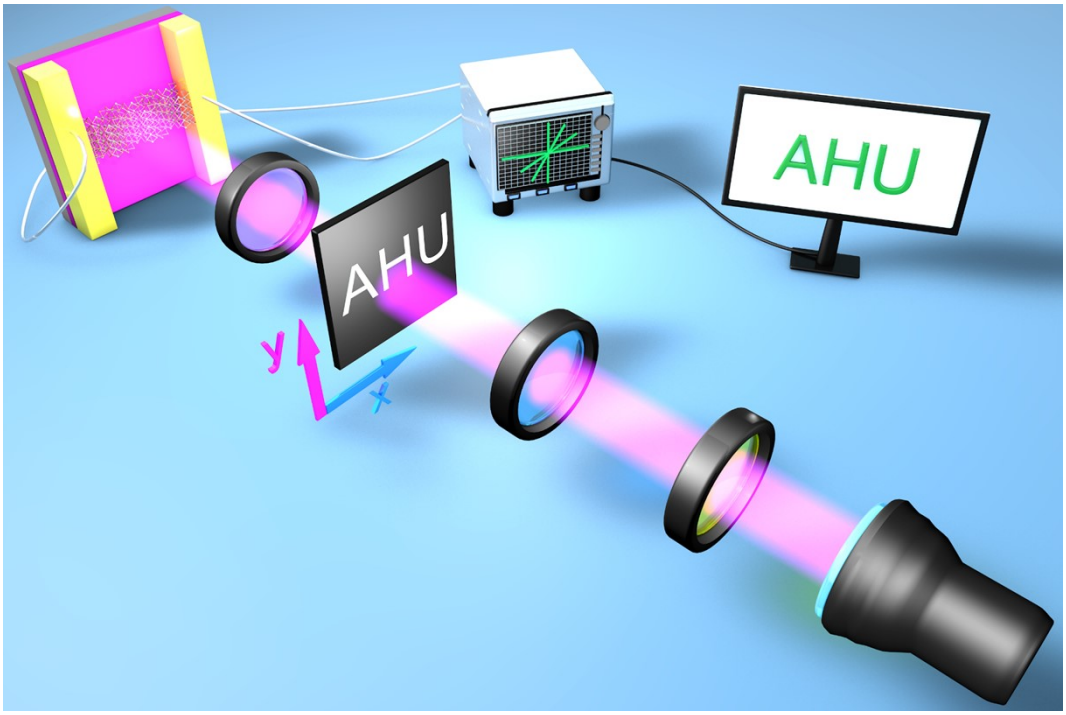

Figure S7 Experimental setup of the polarization imaging system.

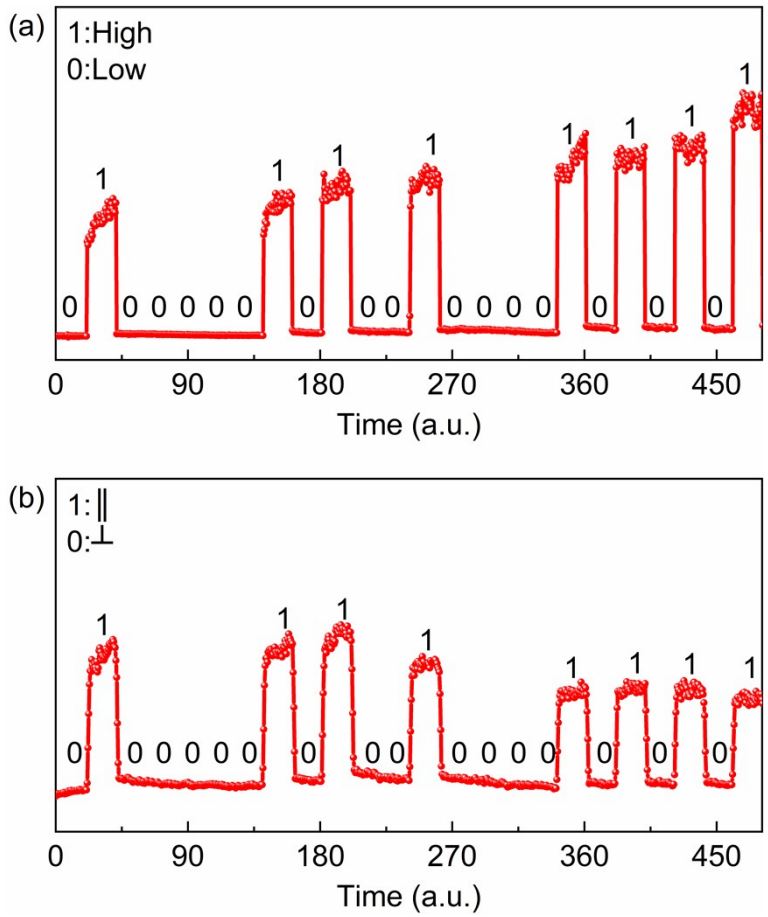

Figure S8 Information transmission of 0100000101001000 *via* merely (a) light intensity or (b) light polarization state, respectively. The "High" and "Low" represent the light intensity. The ↔ and ↕ represent the parallel and perpendicular polarization states, respectively.

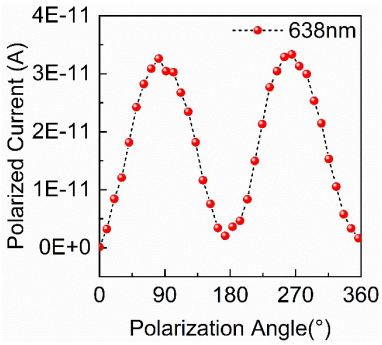

Figure S9 Polarization-sensitive photoresponse captured under 638 nm laser illumination, with the polarization angle systematically adjusted from 0° to 360°.

Table S1 Comparison of the photoresponse paramaters and anisotropic ratio of $Nb_2Pd_{0.71}Se_5$ photodetector with previous reports.

Structure	*R* (A/W)	Rise/decay time	Anisotropy ratio	Refs
$TaIrTe_4$	20 μA/W @ 10.6 μm	τ: 27 μs	1.88 @ 10.6μm	[1]
Ta_2NiSe_5	44 A/W @ 1064 nm	τ_r: 98 ms τ_d: 82 ms	3.24 @ 1064 nm	[2]
PdPS	1000 A/W @ 532 nm	τ_r: 1.4 ms τ_d: 1.2 ms	3.7 @ 808 nm	[3]
Sb_2S_3	0.34 A/W @ 450 nm	τ_r: 470 μs τ_d: 680 μs	2.54 @ 638 nm	[4]
In_2SnS_4	93.4 mA/W @ 532 nm	τ_r: 20 μs τ_d: 20 μs	1.7 @ 650 nm	[5]
Bi_2S_3	673.3 A/W @ 532 nm	τ_r: 1 ms τ_d: 4.5 ms	2.4 @ 405 nm	[6]
KNb_3O_8	30 A/W @ 254 nm	τ_r: 2.5 s τ_d: 1.8 s	1.62 @ 254 nm	[7]
$SbBiS_3$	7.8 A/W @ 532 nm	τ_r: 10 μs τ_d: 94 μs	1.12 @ 808 nm	[8]
$CrPS_4$	137 nA/W @ 405 nm	τ_r: 2 s τ_d: 2 s	1.33 @ 405 nm	[9]
$GaPS_4$	4.89 A/W @ 254 nm	τ_r: 110 ms τ_d: 50 ms	1.85 @ 254nm	[10]
$Nb_2Pd_{0.71}Se_5$	1590 A/W @ 638 nm	τ_r: 2.5 μs τ_d: 2.8 μs	14.4 @ 638 nm	**This work**

Note S1 The key parameters of photodetectors.

The photoresponse performance of the typical photodetectors are normally evaluated by responsivity (R), detectivity (D^*), and external quantum efficiency (EQE), which can be calculated through the following equations:[11]

$$I_{ph} = I_{light} - I_{dark}$$

$$R = I_{ph}/PS$$

$$D^* = RS^{1/2}/(2eI_{dark})^{1/2}$$

$$EQE = hcR/e\lambda$$

where I_{ph}, I_{light}, P, S, e, I_{dark}, h, c, and λ represent the photocurrent, current under illumination, incident light power density, functional area, electron charge, dark current, Planck constant, light velocity, and incident light wavelength, respectively.

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