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Supporting Information

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Highly Uniform, Self-Assembled AlGaN Nanowires for Self-Powered Solar-Blind Photodetector with Fast-Response Speed and High Responsivity

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S1. Photodeposition of Ru co-catalyst.

Ruthenium chloride ($RuCl_3$, Sigma Aldrich) was the precursor for the co-catalyst photodeposition process. Ru species were decorated on AlGaN nanowires (NWs) in a vacuum chamber with 2.5 mL of 10 mg/mL $RuCl_3$, 15 mL of methanol, and 55 mL of distilled water. AlGaN NWs were then irradiated for 15 minutes using a UV lamp (Tanon UV-100). The AlGaN NWs were subsequently rinsed with ethanol and distilled water to remove the residual precursor. The samples were then dried overnight in air.

Under the illumination of solar-blind UV light, the energy of photon exceeds the bandgap energy of the AlGaN nanowires, generating sufficient photoexcited carriers. The photoexcited electrons transfer to the surface sites of nanowires and preferentially reduce Ru^{3+}, anchoring them on the AlGaN nanowires, because the conduction band of AlGaN nanowires (Nearly -1.4 V vs NHE) is more negative than the reduction potential of Ru (0.6V vs NHE).

S2. Morphology characterization of AlGaN NWs on Si substrates.

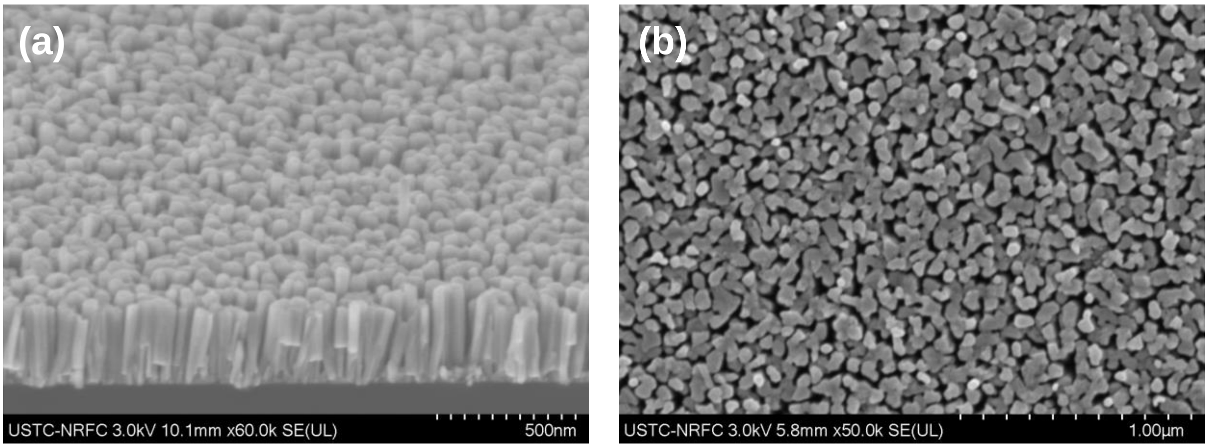

Figure S1 shows (a) top-view and (b) 30°-tilted SEM images of AlGaN NWs on Si substrates.

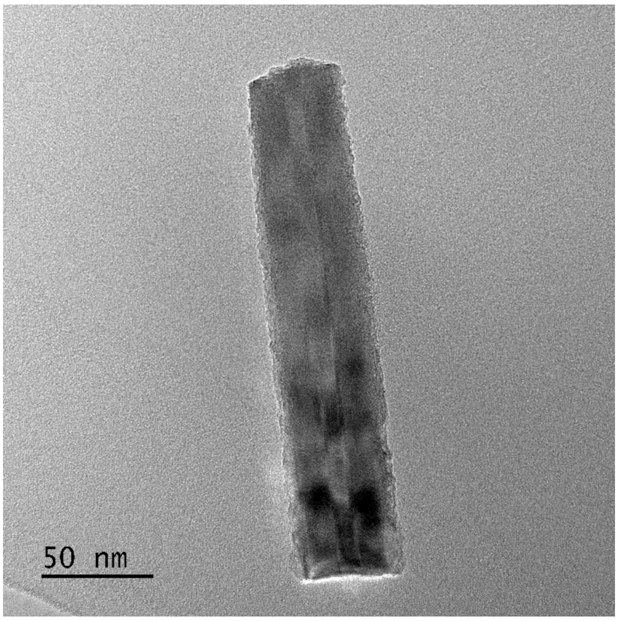

Figure S2 shows the TEM image of a single AlGaN nanowire.

S3. XPS characterization of AlGaN nanowire sample.

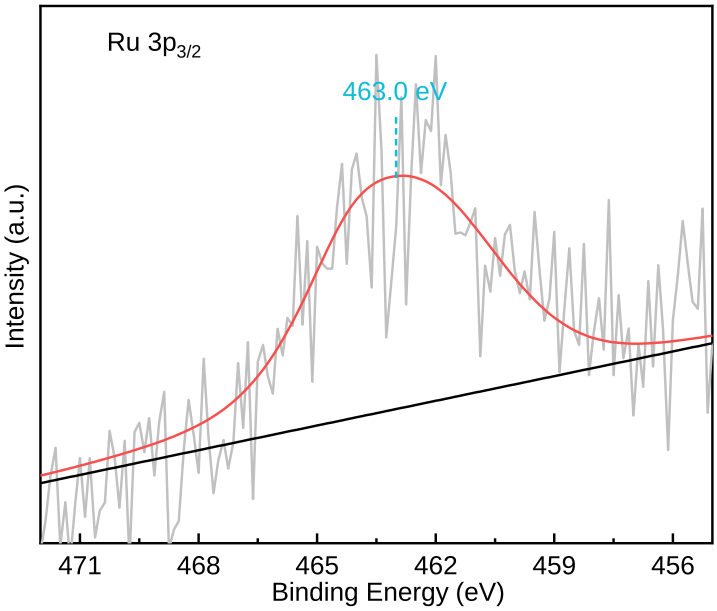

Figure S3 shows the XPS Ru 3p spectrum of AlGaN: Ru NWs. Different from the typical peak at 461.2 eV for Ru(0), the peak of 463.0 eV turns out the bonding of Ru species and AlGaN. Refer to previous investigation on Ru 3p spectra, the 463.0 eV peak is assigned to an oxidation state close to Ru(Ⅲ) or Ru(Ⅳ).[1]

S4. The comparison of previously-reported PEC UV PDs based on various nanostructures with this work.

Nanostructures	Irradiation (nm)	Electrolyte type	Self-powered	Photocurrent magnitude	Rise/decay time (ms)	Responsivity (mA W^{-1})	Ref.
ZnO nanoneedles	385	H_2O	Yes	uA	100/100	22	[2]
$ZnO@TiO_2$ nanostrawberries	365	I^-/I_3^-	Yes	uA	22/9	380	[3]
TiO_2 films	365	I^-/I_3^-	Yes	uA	80/30	~ 16.7	[4]
TiO_2 nanorods	365	0.5 M Na_2SO_4	Yes	uA	100/100	~ 0.5	[5]
TiO_2 nanorods	350	H_2O	Yes	uA	150/50	25	[6]
SnO_2 nanofibers	365	I^-/I_3^-	Yes	uA	30/10	600	[7]
SnO_2 microtube	365	I^-/I_3^-	Yes	uA	100/200	~ 64.5	[8]
α-Ga_2O_3 nanorods	254	0.5 M Na_2SO_4	Yes	uA	430/170	1.44	[9]
β-Ga_2O_3 nanorods	254	0.5 M Na_2SO_4	Yes	uA	290/160	3.81	[9]
α-Ga_2O_3/Cu_2O	254	0.5 M Na_2SO_4	Yes	uA	10300/10100	0.42	[10]
α-Ga_2O_3 nanorods	254	0.1 M NaOH	Yes	uA	76/56	0.21	[11]
ZnS nanowires	254	I^-/I_3^-	Yes	uA	250/210	33.7	[12]
AlGaN nanowires	254	0.01 M H_2SO_4	Yes	uA	83/19	48.8	This

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Table S1 contains photoresponse performances of ever-reported PEC UV PDs based on various nanostructures. The proposed AlGaN: Ru NW PEC PD shows ever-reported fastest photoresponse speed and highest responsivity compared with previous self-powered solar-blind PEC PDs. Even its performance can be compared with that of ~365 nm band UV PDs, but it is not difficult to find that compared with I^-/I_3^- type PEC PDs, its performance is obviously inferior in terms of response speed and responsivity. However, the safe, stable, environmental-friendly and self-powered characteristics of aqueous PEC PDs enable its further applications in compact energy harvesting nanosystems. Furthermore, the bandgap tunability of Ⅲ-nitrides opens possibility for the development of high-performance PEC-type PDs covering the detection spectral range from infrared to deep UV.

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