Access note: Some figures may not display correctly on Mac computers. If this occurs, try a Windows PC.

**—-------------------------------------------------------------------------------------**

**Fig. 1 (b)** XRD pattern of InGaN/GaN nanowires.

**Fig. 2 (a)** Temperature-dependent STH efficiency of Rh/Cr2O3/Co3O4-InGaN/GaN NWs. A 300 W Xe lamp equipped with AM1.5G filter was used to produce a concentrated light of 3800 mW cm-2 on a 0.8 cm × 0.8 cm Rh/Cr2O3/Co3O4-loaded InGaN/GaN nanowires wafer. **(b)** Stability test of Rh/Cr2O3/Co3O4-loaded InGaN/GaN NWs in the self-heated photocatalytic OWS system under the concentrated light of 3800 mW cm-2. Each cycle: 1 hour. **(c)** Temperature-dependent hydrogen-oxygen recombination reaction. **(d)** Free energy profile of hydrogen-oxygen recombination on the cocatalyst Co3O4, Rh and Cr2O3.

**Fig. 3** STH of Rh/Cr2O3/Co3O4-loaded InGaN/GaN nanowires in **(a)** tap water from Ann Arbor, Michigan, United States and **(b)** sea water simulated by 3.5wt% NaCl aqueous solution. The intensity of simulated solar light from 300 W Xe lamp equipped with AM1.5G filter was 3800 mW cm-2. Sample size: 0.64 cm2. Each cycle: 1 hour. **(d)** STH of 4 cm × 4 cm Rh/Cr2O3/Co3O4-loaded InGaN/GaN nanowires under concentrated natural solar light (~16,070 mW cm-2). Each cycle: 10 min.

**Extended Data Fig. 2 (a)** UV-visdiffuse reflectance spectroscopy of InGaN/GaN suggests that the visible-light response range of InGaN/GaN nanostructures are extended to 632 nm (1.96 eV). **(b)** Band diagram of InGaN/GaN segments.Wavelength-dependent theoretical maximum STH in **(c)** natural solar light57 and **(d)** simulated solar light produced by a Xe lamp equipped with a standard AM1.5G filter from Newport Corporation. The red dashed line corresponds to the photocatalyst with band gap of 1.96 eV (632 nm). The band-edge potentials were calculated according to reported formula:41

*E*CB = χ + *E*O – 0.5*E*g

where *E*CB, χ and *E*g are the conduction band-edge potential, absolute electronegativity and band gap of InxGa1-xN, respectively. *E*O is one constant (-4.5 eV) which stands for the Fermi level of normal hydrogen electrode at 25 °C with respect to the vacuum level. The valence band-edge potential (*E*VB) can be directly calculated by the following formula:

*E*VB = *E*CB – *E*g

**Extended Data Fig. 3 (c)** STH of InGaN/GaN NWs with different Rh/Cr2O3/Co3O4 precursor volumes at 70 oC. *x* (*x* = 2, 3, 4, 5, 6) μL of 0.2 mol L-1 Na3RhCl6, *x* μL of 0.2 mol L-1 K2CrO4, *x* μL of 0.2 mol L-1 Co(NO3)2·6H2O were used in the photodeposition of cocatalyst. **(d)** STH of Rh/Cr2O3/Co3O4-InGaN/GaN NWs under different light intensity at 70 oC. 1 sun: 100 mW cm-2.

**Extended Data Fig. 6 (b)** Photocatalytic OWS system without circulating water layer or heat insulating layer and corresponding time-course production of stoichiometric H2 and O2 in deionized water on Rh/Cr2O3/Co3O4-InGaN/GaN NWs. **(c)** Photocatalytic hydrogen production with methanol (20vol%) as electron donor at 70 oC. **(d)** Photocatalytic oxygen production with KIO3 (0.4 mol L-1) as electron acceptor at 70 oC. **(e)** Time-course production of stoichiometric H2 and O2 in deionized water on Rh/Cr2O3/Co3O4-InGaN/GaN NWs at 70 oC in 360 mins. **(f)** Time-course production of H2 and O2 in deionized water on Rh/Cr2O3/Co3O4-InGaN/GaN NWs with and without light source at 70 oC. Light source: 3800 mW cm-2 produced by a 300 W Xe lamp equipped with AM1.5G filter. Sample: 0.8 cm × 0.8 cm Rh/Cr2O3/Co3O4-loaded InGaN/GaN nanowires wafer.