Electronic Supplementary Information

$SrTiO_3$ Photoanode Prepared by Particle Transfer Method for Oxygen Evolution from Water with High Quantum Efficiency

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Table S1　Work function of metals used as the contact layer [6].

Metal	Work function / eV
Ta	4.25
Ti	4.33
Mo	4.6
Au	5.1
Ni	5.15

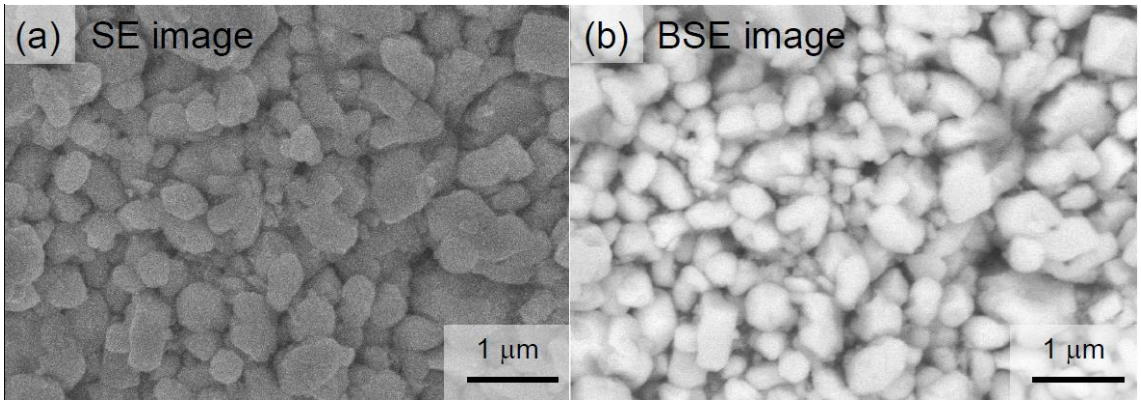

Figure S1　(a) Secondary electron (SE) image and (b) backscattering electron (BSE) image of STO/Ta(PT). The brightness in the BSE image is proportional to the density.

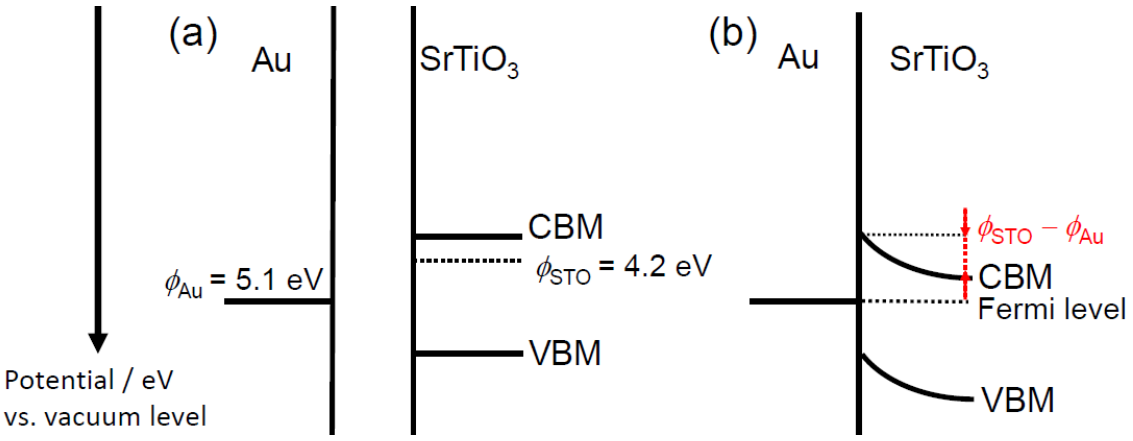

Figure S2 Band diagrams of (a) before and (b) after contact formation between Au and $SrTiO_3$. The Schottky barrier height is equal to the difference between the work functions of $SrTiO_3$ (ϕ_{STO}) and Au (ϕ_{Au}) [S1]. CBM and VBM are the conduction band minimum and valence band maximum, respectively.

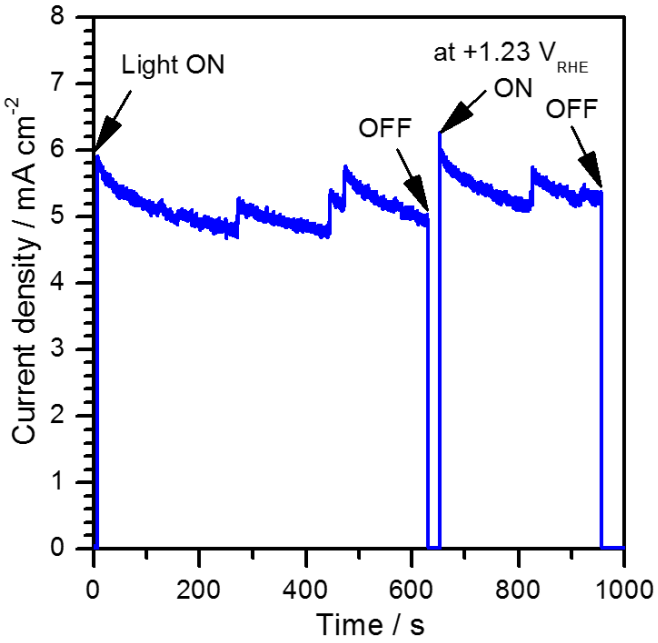

Figure S3 Current-time (*I-t*) curve for STO/Ta(PT) photoanode at 1.23 V_{RHE}. A 0.1 M Na_2SO_4 + NaOH aqueous solution with pH = 13 and a 300 W xenon lamp equipped with a cold mirror (λ > 300 nm) were used as the electrolyte and light source. The vibrations of photocurrent are because of adsorption and desorption of oxygen babbles.

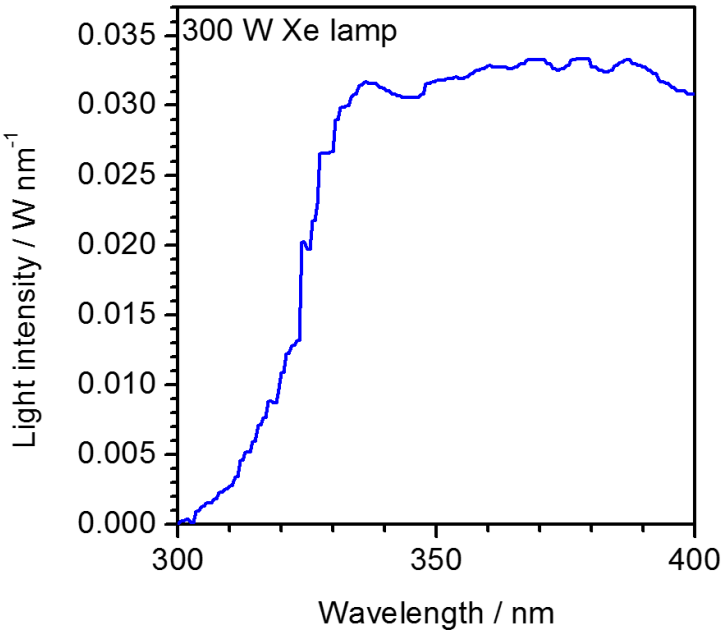

Figure S4 Spectrum of the 300 W xenon lamp (LX300, Perkin Elmer).

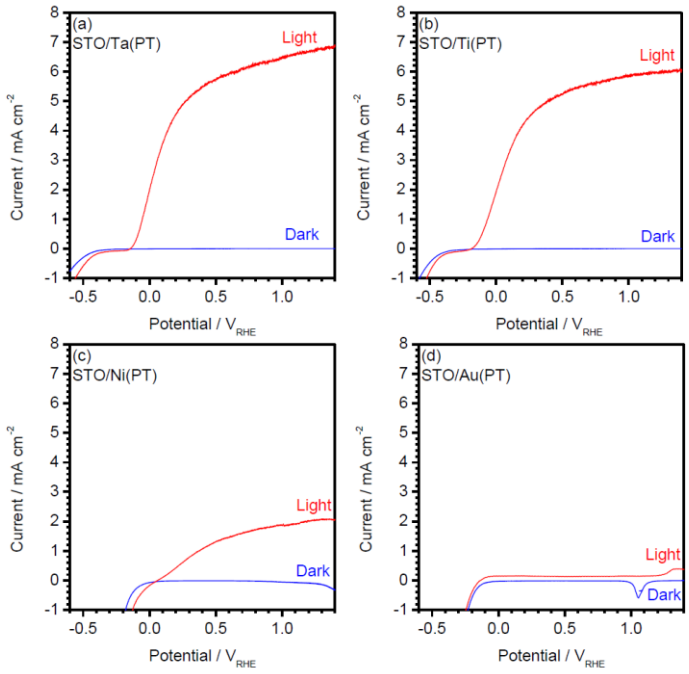

Figure S5 *I-E* curves for photoanodes prepared from Al:STO particles by PT method under the light and the dark. A 0.1 M Na_2SO_4 + NaOH aqueous solution with pH = 13 and a 300 W xenon lamp equipped with a cold mirror (λ > 300 nm) were used as the electrolyte and light source. The applied potential was swept at -10 mVs^{-1}.

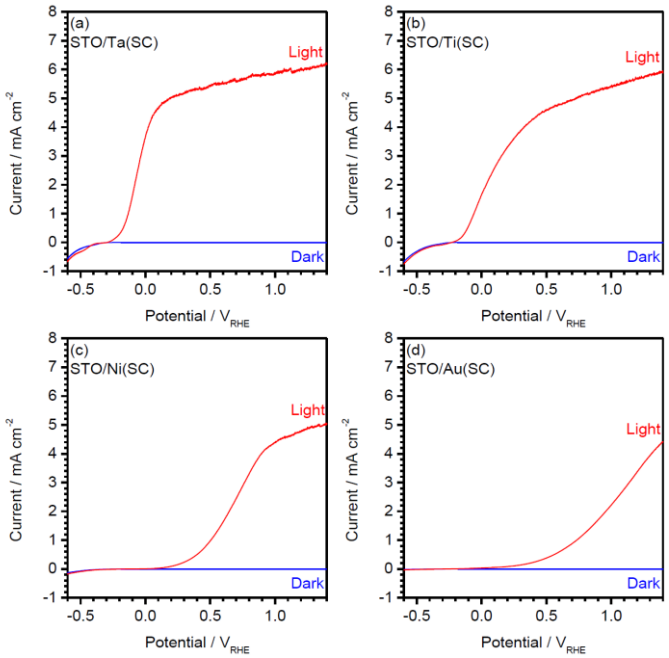

Figure S6 *I-E* curves for photoanodes prepared from a single-crystal wafer of Nb-doped STO under the light and the dark. A 0.1 M Na_2SO_4 + NaOH aqueous solution with pH = 13 and a 300 W xenon lamp equipped with a cold mirror ($\lambda > 300$ nm) were used as the electrolyte and light source. The applied potential was swept at -10 mVs^{-1}.

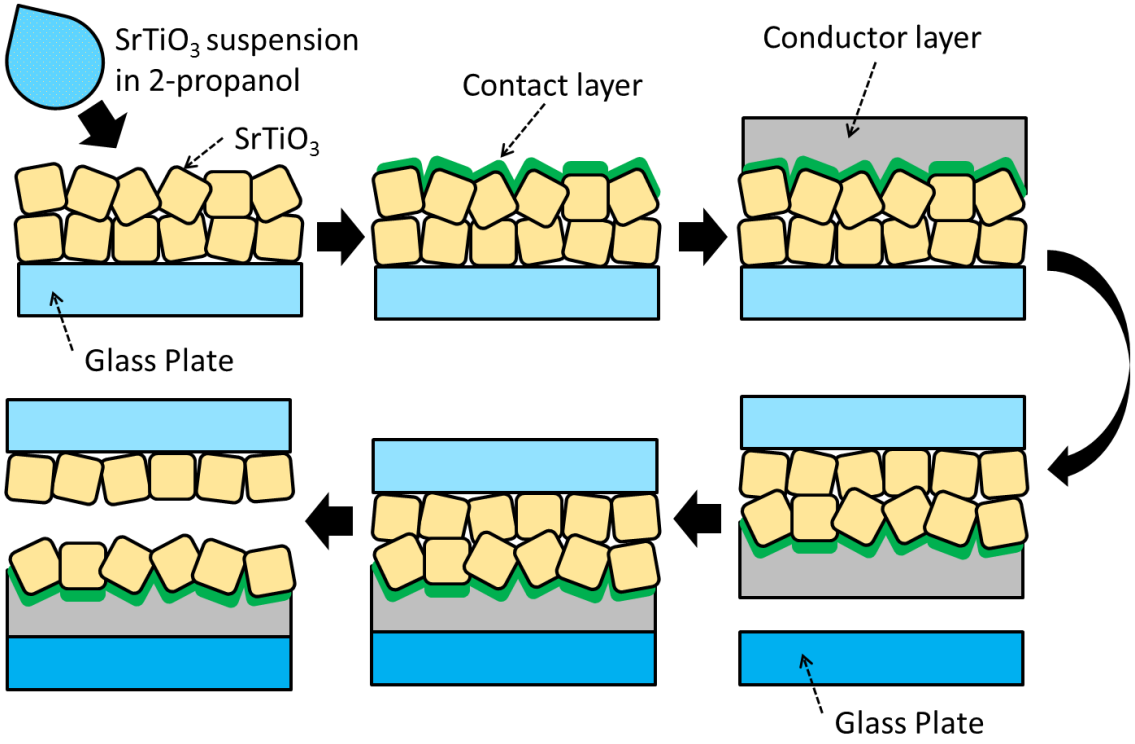

Figure S7 Schematic of the particle transfer method. A suspension of $SrTiO_3$ powder was prepared by dispersing $SrTiO_3$ powder in isopropanol by sonication and stirring. The photocatalytic particles were deposited on a glass plate using the prepared suspension through a drop casting followed by drying. The contact and conductor layers were deposited either by vacuum evaporation method or radio-frequency magnetron sputtering method. The material and deposition condition of contact layer are essential to form ohmic contact. To obtain sufficient conductivity and mechanical strength, a thicker conductor layer was formed using radio-frequency magnetron sputtering on top of the contact layer. The layers were bonded to another glass plate by adhesives and then peeled off from the original glass plate. The excess particles on the electrode which are not contact with contact layer directly were removed by ultra-sonication in water.

S1. Preparation of $SrTiO_3$ particles [S2]

Pristine $SrTiO_3$

$SrTiO_3$ (Wako Pure Chemicals Industries, Ltd, 99.9%) was used without any treatment.

Undoped $SrTiO_3$ synthesized via the flux method

$SrTiO_3$ (Wako Pure Chemicals Industries, Ltd, 99.9%), Al_2O_3 (Sigma-Aldrich Co, LLC., nanopowder), and $SrCl_2$ (Kanto Chemicals Co., Inc., 98.0%, anhydrous) were used as raw materials. $SrTiO_3$ and $SrCl_2$ were mixed in an agate mortar and then calcined in an yttria crucible at 1100 °C for 10 h. The resulting $SrTiO_3$ was separated from the solidified mass by repeated washing with deionized water until no white AgCl precipitate formed in the rinse solutions upon adding $AgNO_3$.

Al-doped $SrTiO_3$ synthesized via solid-state reaction

$SrTiO_3$ (Wako Pure Chemicals Industries, Ltd, 99.9%) and Al_2O_3 (Sigma-Aldrich Co, LLC., nanopowder) were thoroughly mixed in an agate mortar. The mixture was heated in an alumina crucible at 1100 °C for 10 h.

S2. Characterization results for prepared $SrTiO_3$ particles [S2]

	Composition (ICP-OES) 2[Al] / ([Sr]+[Ti])	Hydrogen evolution rate in photocatalytic overall water splitting / mmol h^{-1} [§]
Al:STO	1.0 at.%	575
Pristine $SrTiO_3$	N.D.	1.3
Al-doped $SrTiO_3$ synthesized via solid-state reactions	0.1 at.%	150
Undoped $SrTiO_3$ synthesized via the flux method	N.D	4.2

[§] A mixed oxide of rhodium and chromium was loaded as a cocatalyst by the impregnation method prior to the examination of photocatalytic overall water splitting.

References

[S1] H. B. Michaelson, *J. Appl. Phys.* 1988, **48**, 4729.

[S2] Y. Ham, T. Hisatomi, Y. Goto, Y. Moriya, Y. Sakata, A. Yamakata, J. Kubota, and K. Domen, *J. Mater. Chem. A*, DOI: 10.1039/c5ta04843e.