Electronic Supplementary Information

A porous ZnGaNO photoanode for efficient water oxidation modified by Co-based electrocatalyst

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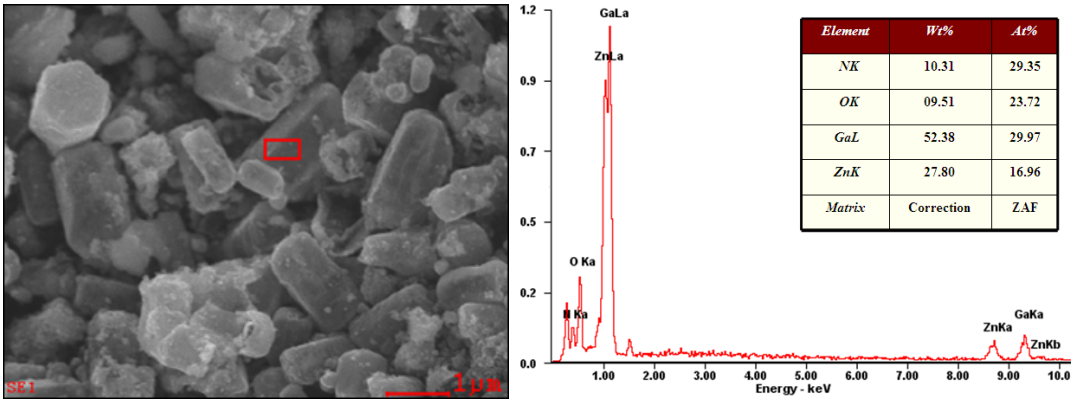
SI-1 Characterization of porous ZnGaNO microrods



Element	Wt%	At%
NK	10.31	29.35
OK	09.51	23.72
GaL	52.38	29.97
ZnK	27.80	16.96
Matrix	Correction	ZAF

Figure S1 EDS analysis for the porous ZnGaNO microrods prepared by heating the $KGaO_2$ coated ZnO microrods at 780 ^oC for 5h in flowing NH_3. EDS analysis indicated that the composition of the final product is $Zn_{0.17}Ga_{0.3}N_{0.3}O_{0.24}$.

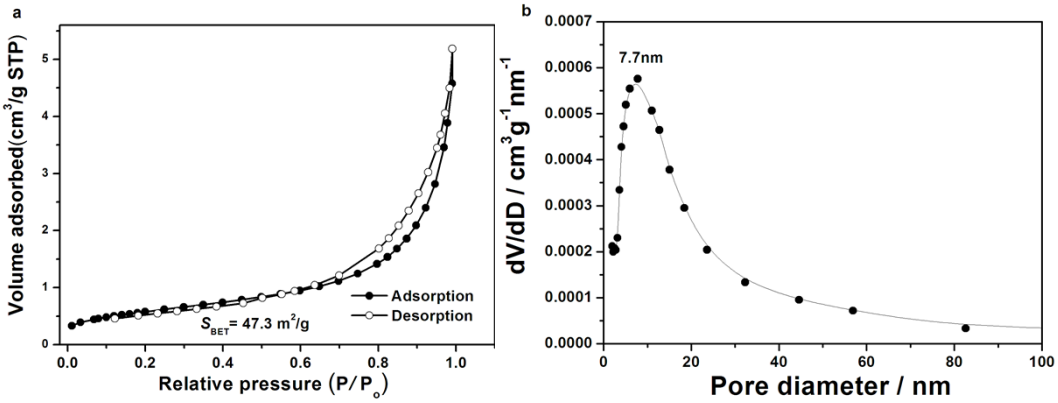
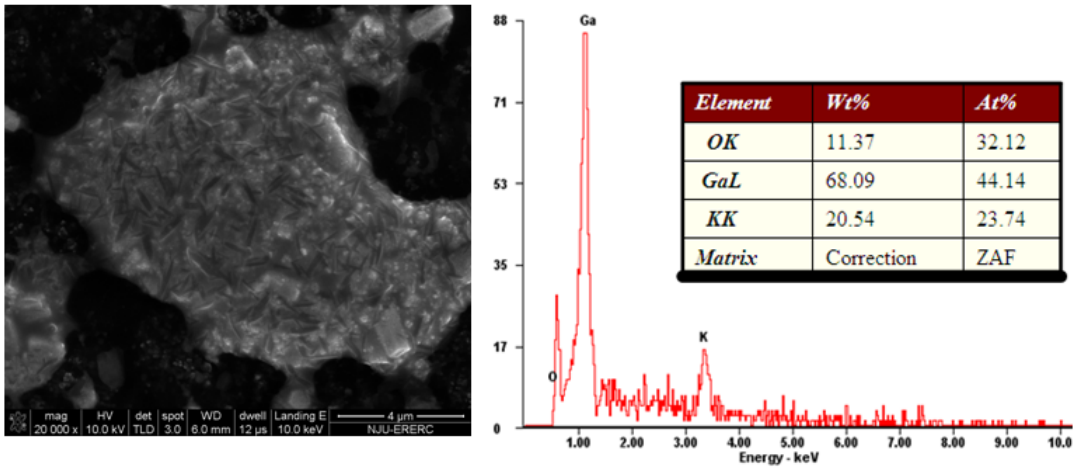


Figure S2 BET analysis for the porous ZnGaNO microrods. a) Nitrogen absorption-desorption isotherms. b) Pore-size distribution.



Element	Wt%	At%
OK	11.37	32.12
GaL	68.09	44.14
KK	20.54	23.74
Matrix	Correction	ZAF

Figure S3 SEM observation for sample obtained by heating the $KGaO_2$ coated ZnO

microrods at 780 °C for 1h in flowing NH_3. EDS analysis confirmed that the needle-shaped particles shown in SEM image are the $KGaO_2$.

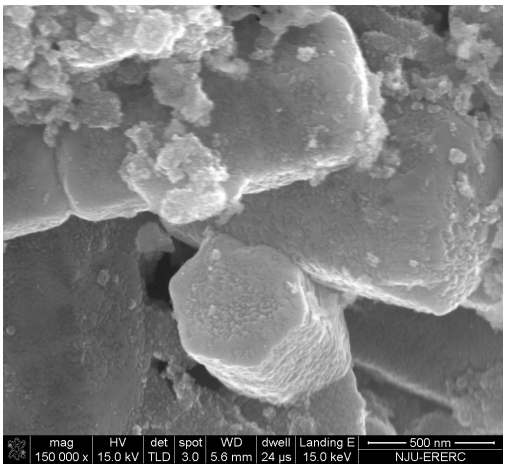


Figure S4 SEM observation for sample obtained by heating the $KGaO_2$ coated ZnO microrods at 780 °C for 1h in flowing NH_3 after washing by water. The SEM image shows an intermediate process for formation of ZnGaNO. After washing by water, the needle-shaped particles disappeared, further confirming that the needle-shaped particles shown in Figure S3 are water-soluble $KGaO_2$.

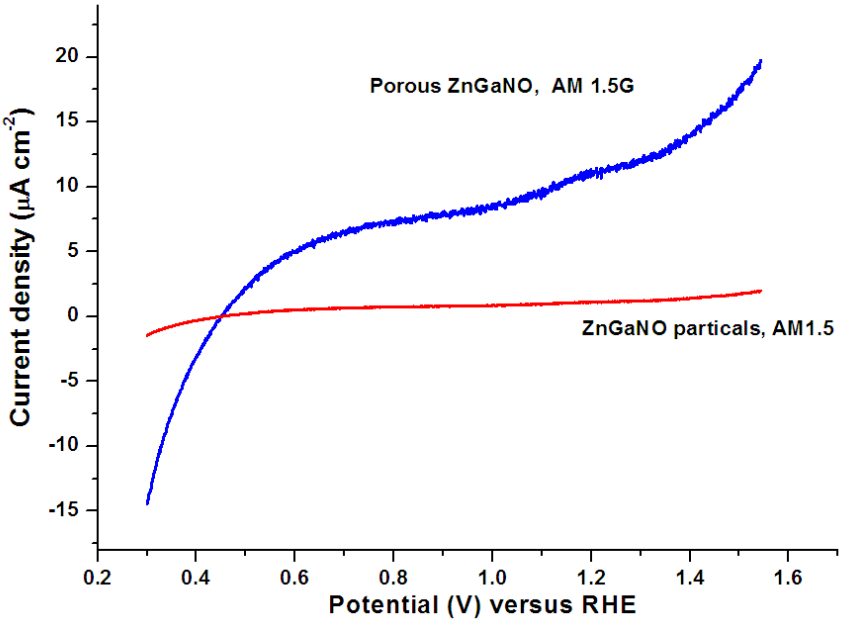


Figure S5 Photocurrent for ZnGaNO particles and porous ZnGaNO photoanodes

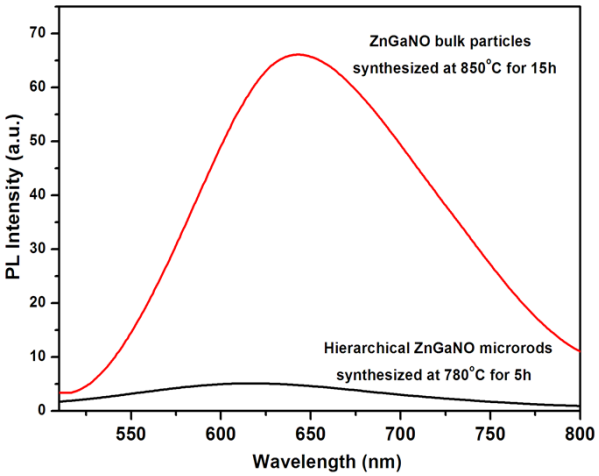


Figure S6 Room temperature PL spectra of ZnGaNO bulk particles and hierarchical ZnGaNO microrods with a fluorescent light excitation of 410 nm and filter wavelength of 420 nm.

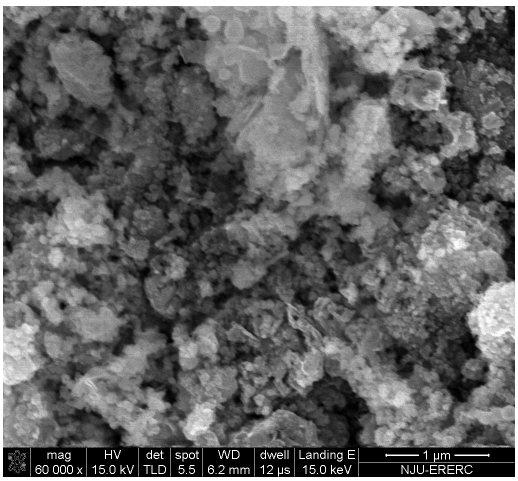


Figure S7 SEM image for the porous ZnGaNO microrods after mechanically milling. It can be seen that the porous structure of ZnGaNO microrods was destroyed into a dispersed nanocrystals.

SI-2 Synthesis and characterization of $CoGa_2O_4$

The $NaGaO_2$ solid powders, as a raw material, were first prepared by heating stoichiometric mixture of Na_2CO_3 and Ga_2O_3 at 850 ^oC for 12h. The preparation procedure of $CoGa_2O_4$ was as follows: in a typical procedure, 10mL of $NaGaO_2$ colloidal suspension (0.2 $molL^{-1}$) was added into 20mL of $CoCl_2$ (0.05 $molL^{-1}$) aqueous solution and stirred for 3h at room temperature to form the $CoGa_2O_4$, then the sedimentation was separated by centrifugation and dried at 60 ^oC for 2h.

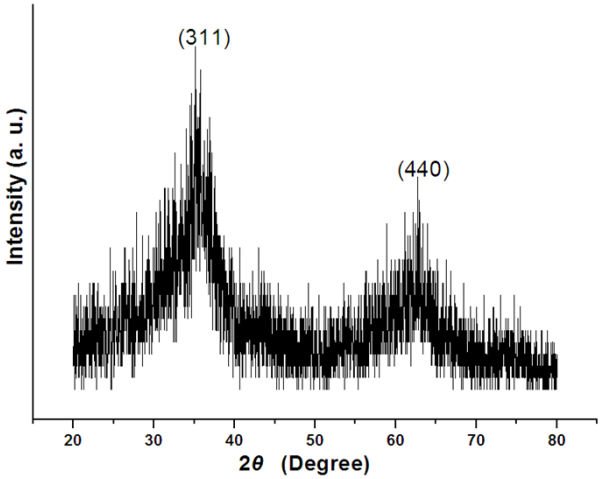


Figure S8 XRD pattern for the $CoGa_2O_4$. Two broadening peaks can be observed in the XRD pattern, indicating that the as-prepared $CoGa_2O_4$ has the low crystallinity.

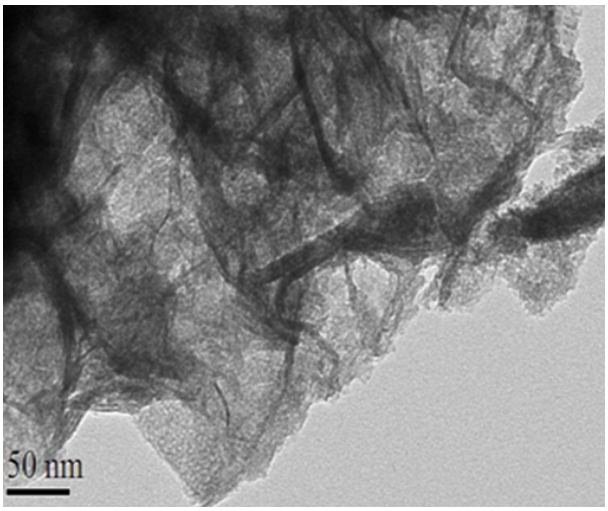


Figure S9 TEM image for the as-prepared $CoGa_2O_4$. The TEM image shows that the as-prepared $CoGa_2O_4$ presents a porous structure.

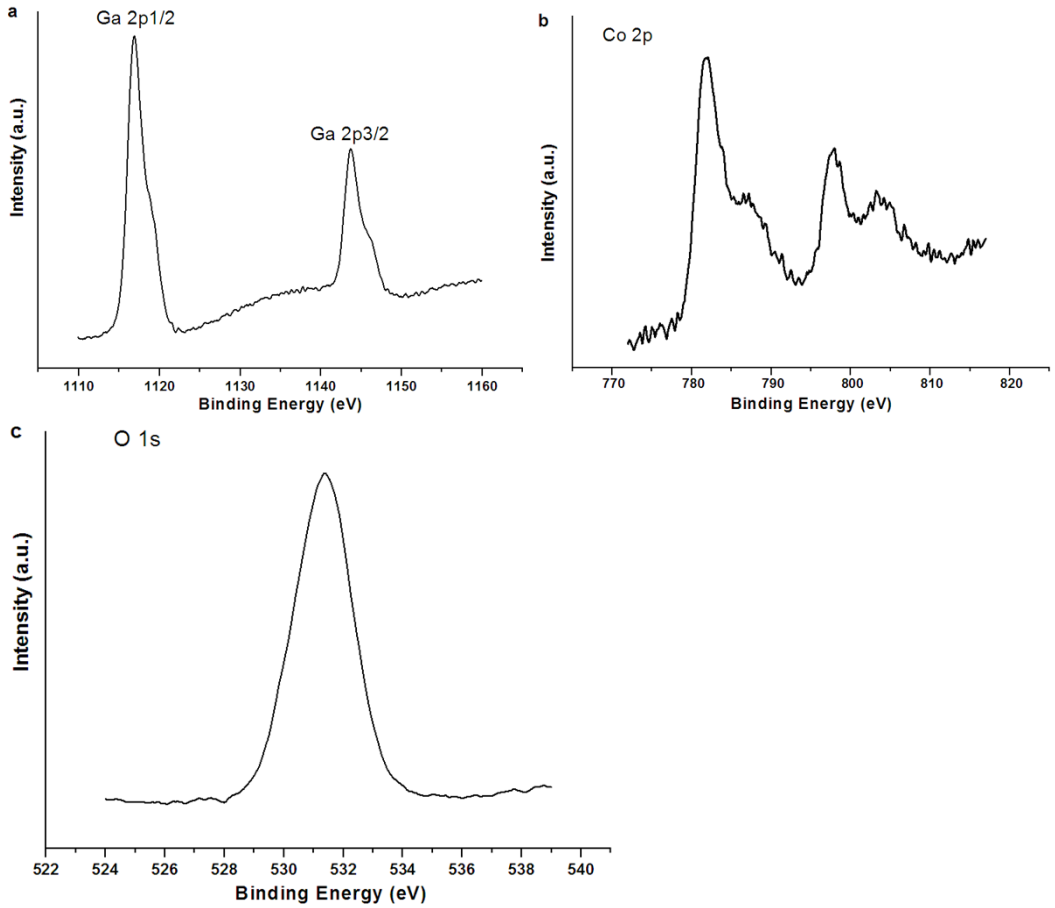


Figure S10 XPS spectra for the as-prepared $CoGa_2O_4$. a) Ga2p. b) Co2p. c) O1s. The composition of as-prepared $CoGa_2O_4$ is confirmed by XPS to be Co:Ga:O=1:2:4.

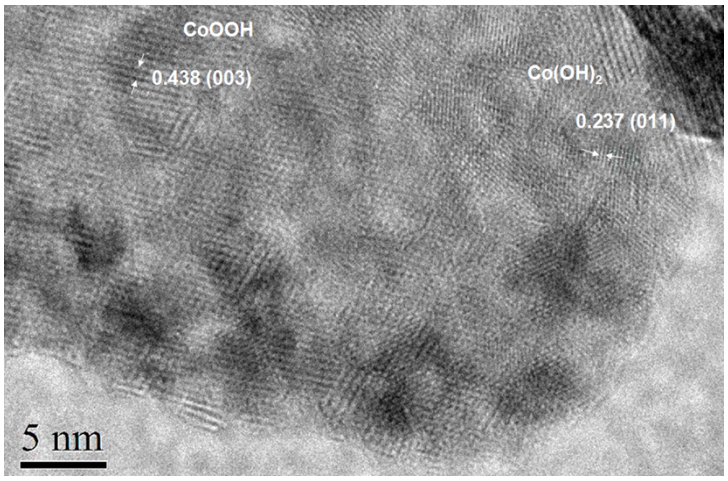


Figure S11 High-resolution TEM image for the $CoGa_2O_4$ after current-time scan at 1.72 V vs RHE in 1M NaOH electrolyte for 10h

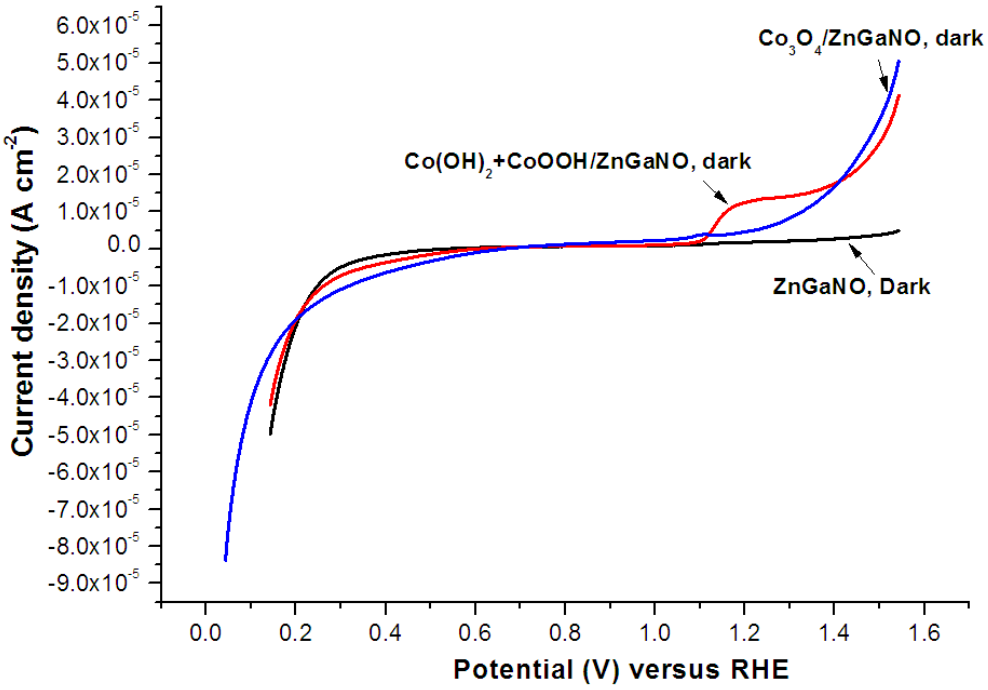


Figure S12 The dark current for the porous ZnGaNO without or with $Co(OH)_2$+CoOOH or Co_3O_4.

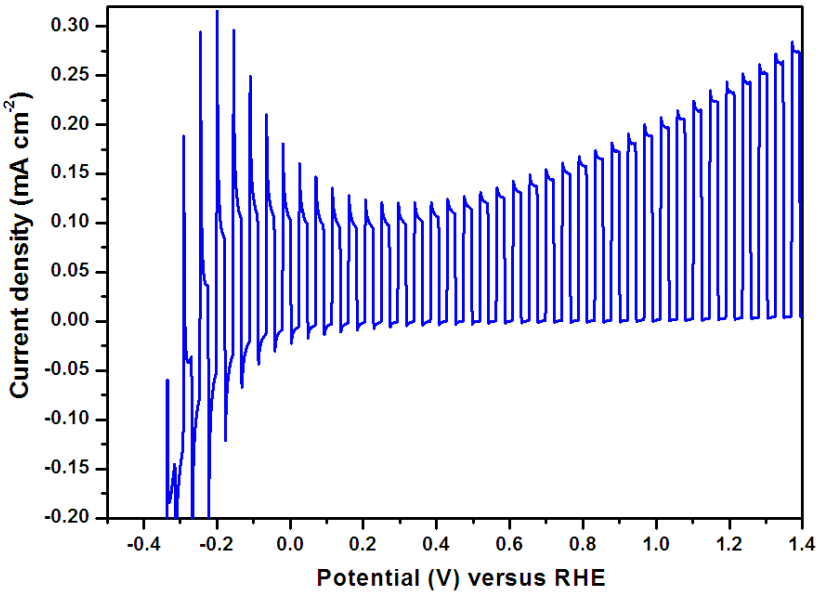


Figure S13 The photocurrent for the ZnGaNO microrod photoanode with dense $Co(OH)_2$+CoOOH electrocatalytic layer.