Supporting Information

Simultaneous Reduction of Surface, Bulk, and Interface Recombination for Au Nanoparticles Embedded Hematite Nanorod Photoanodes toward Efficient Water Splitting

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Figure S1. EDX scanning of Au/Fe$_2$O$_3$ NRs.
Figure S2. (a) XRD pattern, (b) Raman spectrum, and (c) UV-vis diffuse reflectance spectrum of Au/Fe$_2$O$_3$ NFs. The results of Fe$_2$O$_3$ NFs were shown for comparison. H: Fe$_2$O$_3$; M: Fe$_3$O$_4$; F: Fe; A: Au.
**Figure S3.** Comparison of 2D XRD patterns of Fe$_2$O$_3$ NFs (NFs) and Au/Fe$_2$O$_3$ NRs (NRs).
Figure S4. (a) XPS survey spectra, and (b) high resolution Fe 2p of Fe$_2$O$_3$ NFs, Au/Fe$_2$O$_3$ NFs, and Au/Fe$_2$O$_3$ NRs.
Figure S5. SEM images of Au/Fe$_2$O$_3$ NRs. The Au/Fe$_2$O$_3$ NFs were annealed in Ar atmosphere at various temperatures. (a) 500 °C; (b) 550 °C; (c) 600 °C; (d) 650 °C; (e) 700 °C.
Figure S6. XRD patterns of Au/Fe$_2$O$_3$ NRs annealing in Ar atmosphere at various temperatures. H: Fe$_2$O$_3$; M: Fe$_3$O$_4$; W: FeO; A: Au.
Figure S7. SEM images of (a) Au/Fe$_2$O$_3$ NRs, (b) Ti/Fe$_2$O$_3$ NRs, and (c) P/Fe$_2$O$_3$ NRs.
Figure S8. (a) UV-vis diffuse reflectance spectra and (b) calculation of band gaps of Au/Fe\(_2\)O\(_3\) NRs. The Au/Fe\(_2\)O\(_3\) NFs were annealed in Ar atmosphere at various temperatures.
Figure S9. Stability of Au/Fe₂O₃ NRs applied at 1.5 Vₚₐₖₑ."
Figure S10. (a-c) Cyclic voltammetry curves and (d) relative electrochemical surface areas of Fe$_2$O$_3$ NFs and Au/Fe$_2$O$_3$ NRs.

As scan rate increases from 20 to 100 mV sec$^{-1}$, the current increases while a small positive shift of the oxidation peak potential and a negative shift of the reduction peak potential have been observed with the increased scan rate. It should be related to the reaction capability and the OH$^-$ concentration at the interface between the electrode and electrolyte.
**Figure S11.** Linear sweep voltammogram (LSV) curves of (a) Fe$_2$O$_3$ NFs and (b) Au/Fe$_2$O$_3$ NRs in 1 M KOH electrolytes without and with H$_2$O$_2$. 
Figure S12. (a) UV-vis diffuse reflectance spectra, and (b) XRD patterns of Au/Fe$_2$O$_3$ NRs, Ti/Fe$_2$O$_3$ NRs, and P/Fe$_2$O$_3$ NRs. H: Fe$_2$O$_3$; M: Fe$_3$O$_4$; W: FeO; F: Fe; A: Au.
Table S1  Comparison of photoresponses of recent hematite electrodes in solar water splitting under AM 1.5G illumination.1-6

<table>
<thead>
<tr>
<th>Photoanodes</th>
<th>$i@1.23 \text{ V}_{\text{RHE}}$</th>
<th>Onset potential</th>
<th>Electrolyte</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITO/Fe$_2$O$_3$ nanowires/Fe$_3$TiO$_2$/FeNiOOH on FTO</td>
<td>2.2 mA cm$^{-2}$</td>
<td>~0.95 V$_{\text{RHE}}$</td>
<td>1 M NaOH</td>
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<td>Gradient P doped Fe$_2$O$_3$ nanobundles on FTO</td>
<td>~1.48 mA cm$^{-2}$</td>
<td>0.8 V$_{\text{RHE}}$</td>
<td>1 M KOH</td>
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<tr>
<td>CoFeO$_x$/Fe$_2$O$_3$ NRs on FTO</td>
<td>1.2 mA cm$^{-2}$</td>
<td>~0.6 V$_{\text{RHE}}$</td>
<td>1 M NaOH</td>
</tr>
<tr>
<td>Zr induced Fe$_2$O$_3$ nanotubes on FTO</td>
<td>1.5 mA cm$^{-2}$</td>
<td>~0.85 V$_{\text{RHE}}$</td>
<td>1 M NaOH</td>
</tr>
<tr>
<td>Ti doped Fe$_2$O$_3$ NRs on FTO</td>
<td>2.5 mA cm$^{-2}$</td>
<td>~0.85 V$_{\text{RHE}}$</td>
<td>1 M KOH</td>
</tr>
<tr>
<td>Ti doped Fe$_2$O$_3$ NRs on FTO</td>
<td>2.4 mA cm$^{-2}$</td>
<td>~0.95 V$_{\text{RHE}}$</td>
<td>1 M NaOH</td>
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<tr>
<td><strong>Au/Fe$_2$O$_3$ on Fe substrate in this work</strong></td>
<td><strong>2.0 mA cm$^{-2}$</strong></td>
<td><strong>0.6 V$_{\text{RHE}}$</strong></td>
<td>1 M KOH</td>
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</table>

Table S1 compared the photocurrent densities for the hematite nanostructures in more recent years. Compared to the hematite nanostructures grown on FTO substrates, the Au/Fe$_2$O$_3$ nanorods on iron substrate shows a relatively higher photoresponse, especially for a lower onset potential. A higher temperature annealing (700-800 °C) is introduced to activate the Fe$_2$O$_3$ on FTO substrates, and Sn doping in the Fe$_2$O$_3$ nanostructures.

References