Electronic supplementary information (ESI)

Fig. S1 TEM images of CdS-TiO_2 nanotubes.

Fig. S2 Photocurrent output-potential curves of reference heterogeneous 2-D arrays under (a) NR model (no reflector) and (b) WR model (with reflector). An 11% enhancement in photocurrent output under 0 V potential (vs. Ag/AgCl) was obtained by the artificial reflection light.

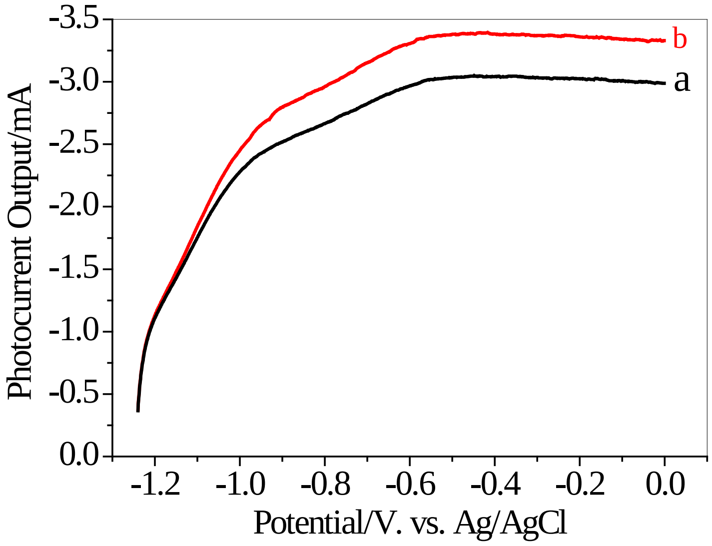


Fig. S3 Photocurrent output-potential curves of heterogeneous 3-D arrays irradiated by (a) only directly incident light and (b) only mimetic reflection light with a light intensity of 100 mW/cm^2. An almost identical photocurrent output of ~3.9 mA was obtained.

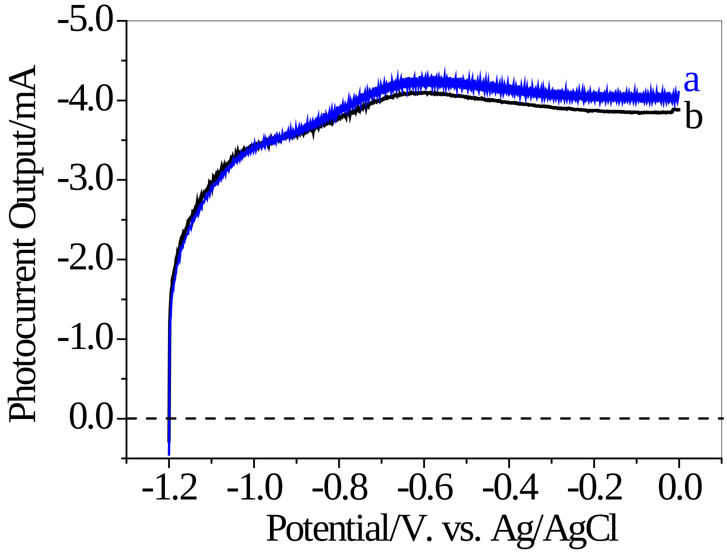


Fig. S4 Photocurrent output-potential curves of heterogeneous 3-D arrays irradiated by only mimetic reflection light with a light intensity of (a) 50 mW/cm^2 (b) 100 mW/cm^2 and (c) 150 mW/cm^2. The photocurrent output of 3-D arrays behaved a linear increase with the intensity of mimetic reflection light between 50-150 mW/cm^2.

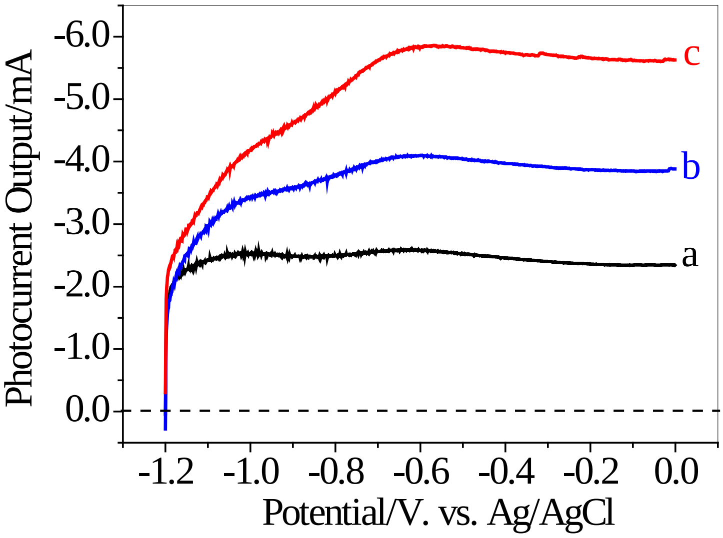


Fig. S5 The function of photocurrent output (*J*) at 0 V (vs. Ag/AgCl) of 3-D arrays with the total irradiation intensity (*I*) including the directly incident light and mimetic reflection light. The photocurrent output of 3-D arrays behaved a linear increase with the total irradiation intensity between 150-250 mW/cm^2.

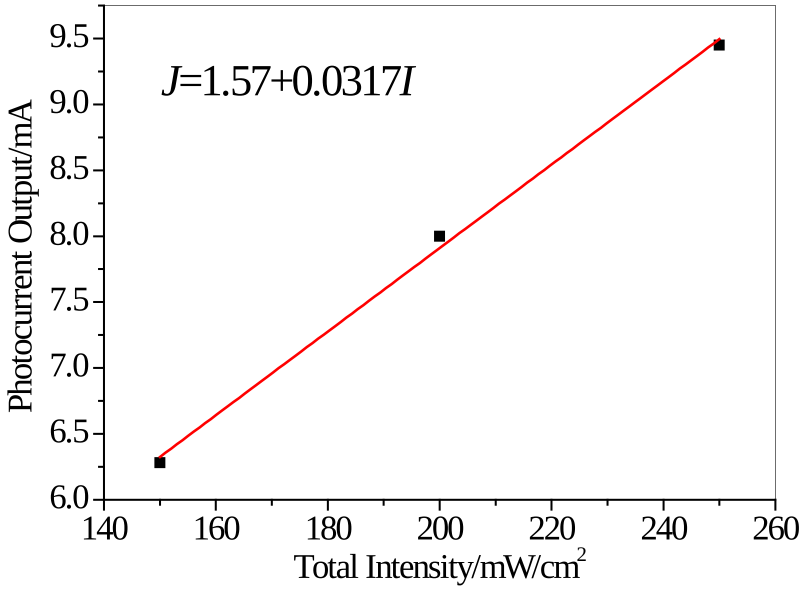
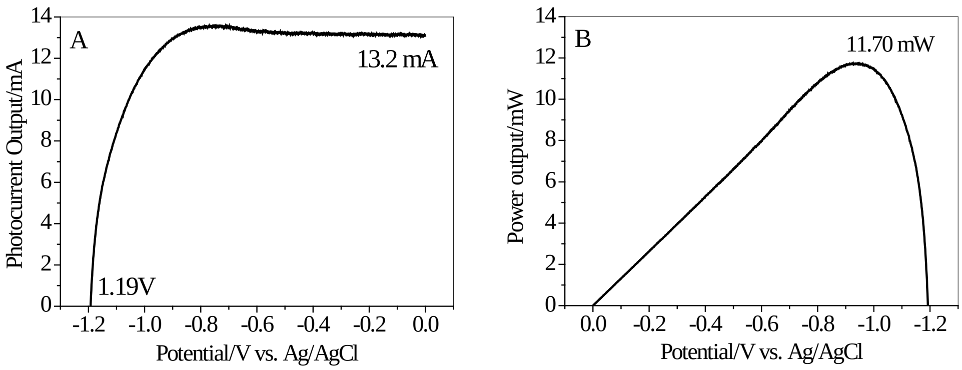


Fig. S6. (A) The photocurrent output-potential curve (WR model) of 3-D arrays with an optimal photoelectric output when the direct irradiation area of 3-D arrays is 1 cm^2. The length of TiO_2 nanotubes is 85 μm. The cycles of CdS nanoparticles deposition is 25. (B) The corresponding power output. J_{sc}=13.2 mA; V_{ocp}=1.19 V; P_{max}=11.70 mW.



We calculated the photoelectrode efficiency (not cell efficiency) based on the photocurrent output-potential curves measured in three-electrode system when the direct irradiation area of 3-D arrays is 1 cm^2 (Fig. S6). The photoelectrode efficiency (η_{ele}) was calculated using following equation:

$$\eta_{ele}(\%) = \frac{P_{\max}}{I_0} = \frac{J_{sc}V_{ocp}FF}{I_0} \times 100 \qquad FF = \frac{P_{\max}}{J_{sc}V_{ocp}}$$

Here,

J_{sc}=photocurrent output at 0 V potential vs. Ag/AgCl

V_{ocp}= open-circuit photopotential

FF=Fill Factor

P_{max}= maximal overall power output

I_0=Intensity of overall incident light (including directly incident light and artificial reflection light)

The photoelectrode efficiency was calculated be 7.4% when the photocurrent output was 13.2 mA (J_{sc}=13.2 mA; V_{ocp}=1.19 V; P_{max}=11.70 mW; FF=0.74).

Fig. S7 Photocurrent output-potential curves of heterogeneous 3-D arrays under WR model when the electrode was rotated in z-axis from 0 ° to 360° in clockwise directions. The photocurrent output-potential curves at 0° (black), 90° (red), 180° (blue), 270° (magenta) and 360° (green) were almost same, indicating an angle-independent photocurrent output.