Electronic Supplementary Information

Multiple bands light trapping in ultraviolet, visible, and near infrared regions with TiO$_2$ based photonic materials

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Experimental Section

Chemicals and Materials

A 2 mm thick titanium foil (99.6%, Strem Chemicals) was cut into pieces of 25 $\times$ 10 mm$^2$. Ethylene glycol (EG), ammonia fluoride (NH$_4$F) were purchased from Acros Organics and used as received. All aqueous solutions were prepared using deionized (DI) water with a resistivity of 18.2 M$\Omega$ cm prepared by Millipore system.

Preparation of TiO$_2$ PMs

The TiO$_2$ PMs were fabricated by a two-step anodization process. Prior to anodization, the Ti sheets were first degreased by sonicating in ethanol and room-temperature DI water, followed by drying in pure nitrogen stream. The anodization was carried out using a conventional two-electrode system with the Ti sheet as an
anode and a Pt gauze (Aldrich, 100 mesh) as a cathode respectively. All electrolytes consisted of 0.5 wt% NH$_4$F in EG solution with 2 vol% water. All the anodization was carried out at room temperature. In the first-step anodization, the Ti sheet was anodized at 70 V for 60 min, and then the as-grown nanotube layer was ultrasonically removed in DI water. The same Ti sheet then underwent the second anodization at different potential with progressive increasing voltages from 10 V to 30 V for 180 min. After the two-step anodization, the prepared TiO$_2$ PMs were cleaned with DI water and dried off with N$_2$ gas. The one step anodized TiO$_2$ NTs were also prepared in 70 V, and the two-step anodized TiO$_2$ NTs with constant voltages at 30 V and 60 V were prepared either. The as-anodized TiO$_2$ PMs and NTs were annealed in air at 450 °C for 1 h with a heating rate of 5 °C/min.

**Characterization of TiO$_2$ PMs**

The morphology of the hierarchical TiO$_2$ PMs was determined by filed-emission scanning electron microscope (FESEM, FEI Quanta 600). The crystalline structure was analyzed by X-ray diffraction (XRD, Bruker D8 Discover diffractometer, using Cu Kα radiation, $\lambda = 1.540598$ Å). The diffuse reflectance UV-vis adsorption spectra were recorded on spectrophotometer (Shimadzu, UV 3600), with fine BaSO$_4$ powder as reference. Photoelectron Spectroscopy (XPS) data were collected by an Axis Ultra instrument (Kratos Analytical) under ultrahigh vacuum ($<10^{-8}$ torr) and using a monochromatic Al Kα X-ray source operating at 150 W. The survey and high-resolution spectra were collected at fixed analyzer pass energies of 160 and 20 eV, respectively. Samples were mounted in floating mode in order to avoid differential
charging. Charge neutralization was required for all samples. Binding energies were referenced to the C 1s binding energy of adventitious carbon contamination which was set at 284.8 eV.

Fig. S1 SEM image of Ti foil surface after ultrasonic removal of the NTs layer.

Fig. S2 XRD pattern of TiO$_2$ PMs (the asterisk denoted as Ti patterns).

Fig. S3 SEM image of TiO$_2$ NTs prepared with one step anodization method.
**Fig. S4** SEM image of TiO$_2$ NTs prepared with two-step anodization method, the Ti was anodized in the second step with constant voltage of 30 V.

**Fig. S5** SEM image of TiO$_2$ NTs prepared with two-step anodization method, the Ti was anodized in the second step with constant voltage of 60 V.
Fig. S6 XPS survey (a), core level of Ti 2p (b) and O 1s (c) of the TiO₂ PMs.
**Fig. S7** Diffuse reflectance UV-vis absorption spectra of one step anodized TiO$_2$ NTs

**Fig. S8** Diffuse reflectance UV-vis absorption spectra of TiO$_2$ NTs prepared in two-step anodization method, the Ti was anodized in the second step with constant voltage of 30 V.
**Fig. S9** Diffuse reflectance UV-vis absorption spectra of TiO$_2$ NTs prepared in two-step anodization method, the Ti was anodized in the second step with constant voltage of 60 V.

**Fig. S10** SEM image of TiO$_2$ PMs with anodization time of 15 min.