Electronic Supplementary Information

Multiple bands light trapping in ultraviolet, visible, and near infrared regions with TiO_2 based photonic materials

Zhonghai Zhang,[a,*] and Hongjun Wu [b]

[a]*Department of Chemistry, East China Normal University, 500 Dongchuan Road, Shanghai 200241, China.*

Address correspondence to zhzhang@chem.ecnu.edu.cn

[b]*Provincial Key Laboratory of Oil & Gas Chemical Technology, College of Chemistry & Chemical Engineering, Northeast Petroleum University, Daqing 163318, China.*

Experimental Section

Chemicals and Materials

A 2 mm thick titanium foil (99.6%, Strem Chemicals) was cut into pieces of 25 × 10 mm^2. Ethylene glycol (EG), ammonia fluoride (NH_4F) were purchased from Acros Organics and used as received. All aqueous solutions were prepared using deionized (DI) water with a resistivity of 18.2 MΩ 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_4F 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, λ = 1.540598 Å). The diffuse reflectance UV-vis adsorption spectra were recorded on spectrophotometer (Shimadazu, 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.

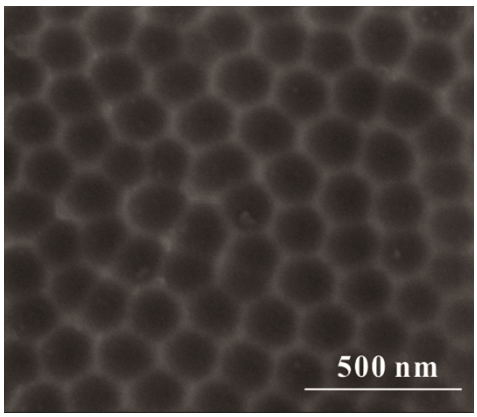

Fig. S1 SEM image of Ti foil surface after ultrasonic removal of the NTs layer.

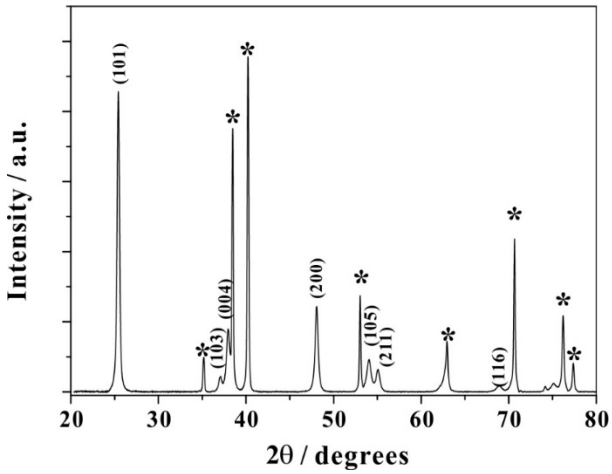

Fig. S2 XRD pattern of TiO_2 PMs (the asterisk denoted as Ti patterns).

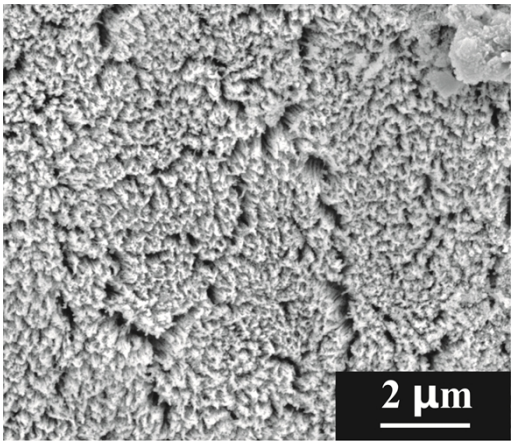

Fig. S3 SEM image of TiO_2 NTs prepared with one step anodization method.

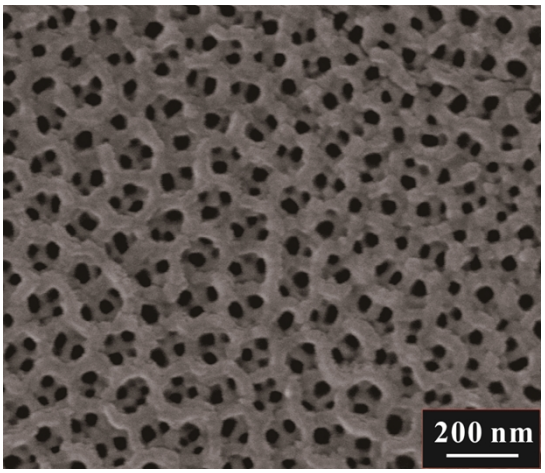

Fig. S4 SEM image of TiO_2 NTs prepared with two-step anodization method, the Ti was anodized in the second step with constant voltage of 30 V.

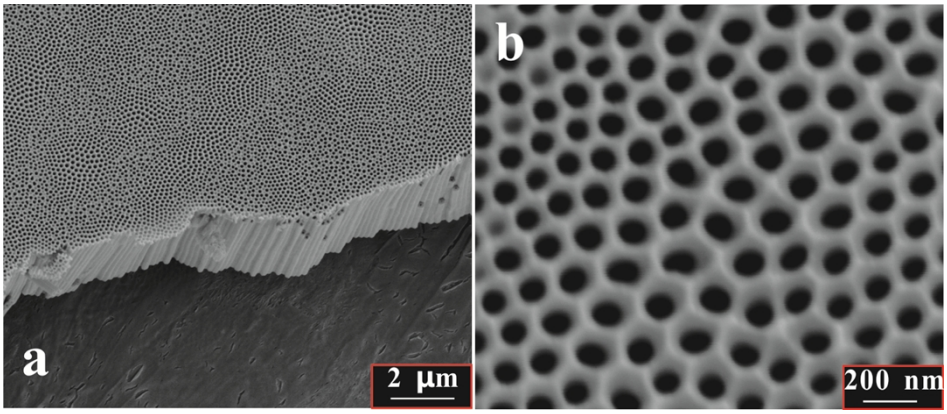

Fig. S5 SEM image of TiO_2 NTs prepared with two-step anodization method, the Ti was anodized in the second step with constant voltage of 60 V.

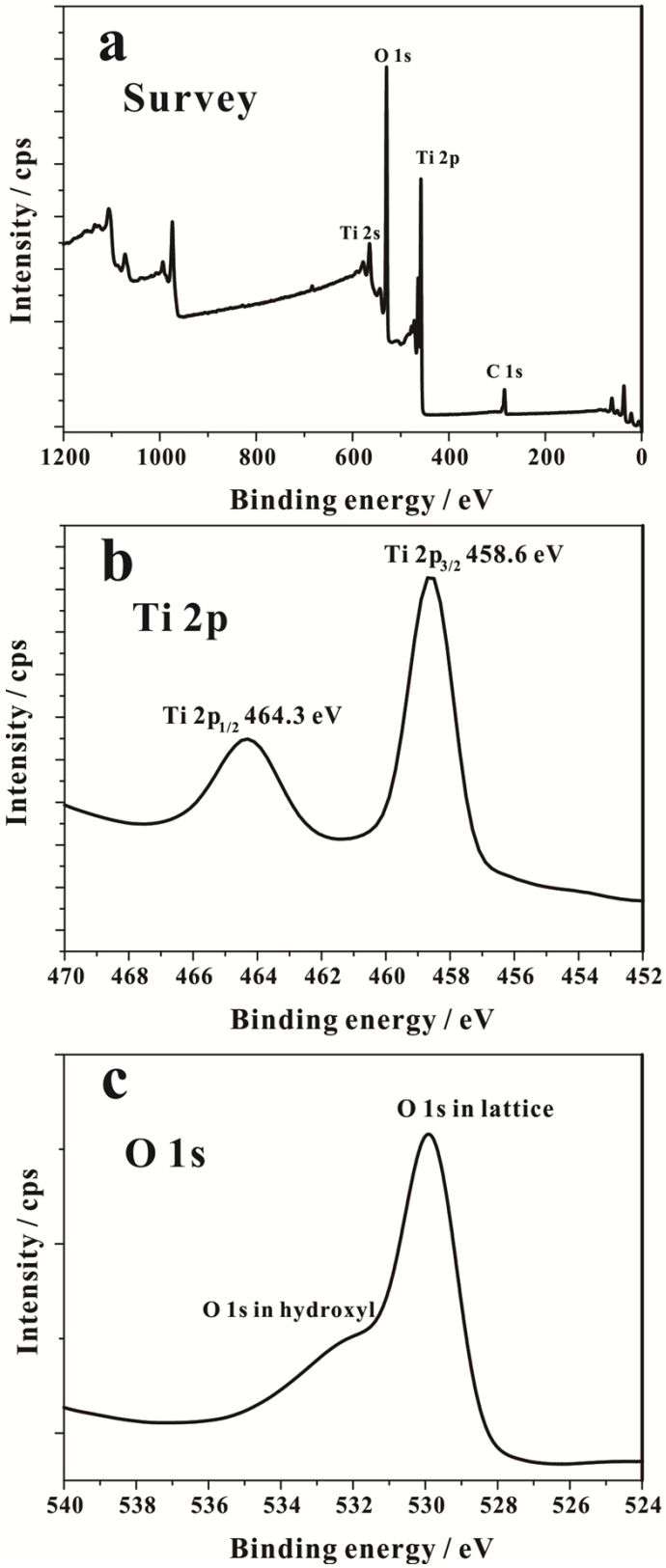

Fig. S6 XPS survey (a), core level of Ti 2p (b) and O 1s (c) of the TiO_2 PMs.

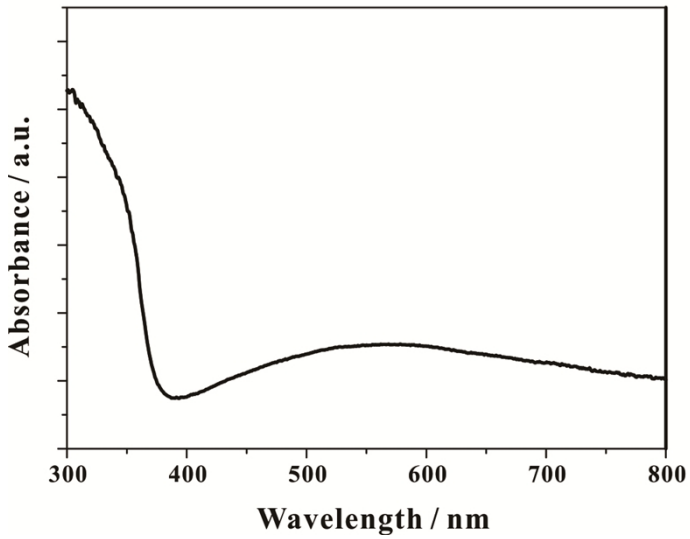

Fig. S7 Diffuse reflectance UV-vis absorption spectra of one step anodized TiO_2 NTs

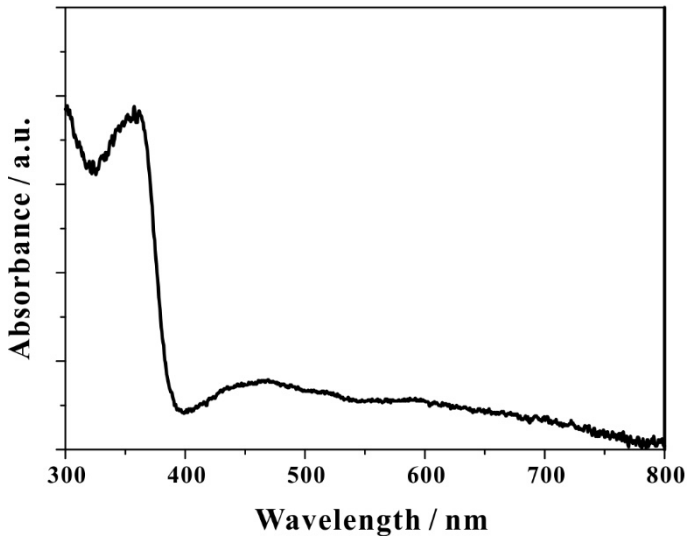

Fig. S8 Diffuse reflectance UV-vis absorption spectra of TiO_2 NTs prepared in two-step anodization method, the Ti was anodized in the second step with constant voltage of 30 V.

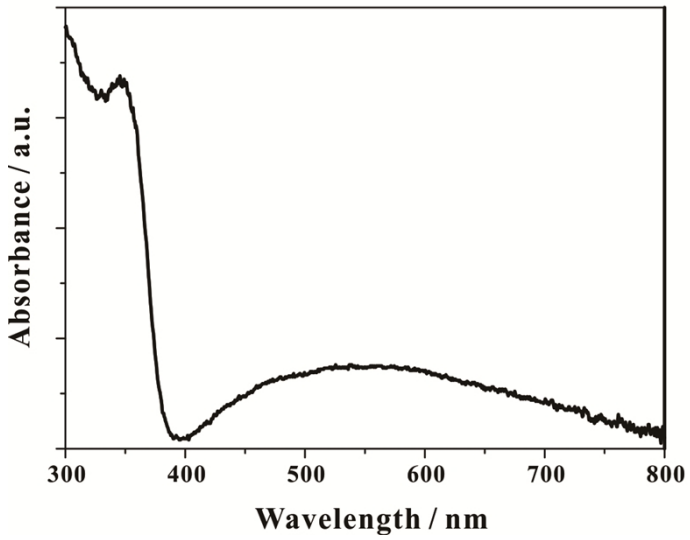

Fig. S9 Diffuse reflectance UV-vis absorption spectra of TiO_2 NTs prepared in two-step anodization method, the Ti was anodized in the second step with constant voltage of 60 V.

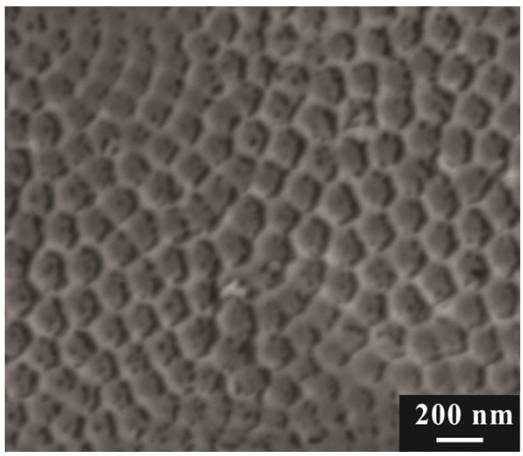

Fig. S10 SEM image of TiO_2 PMs with anodization time of 15 min.