Supporting materials

Section S1 TiO_2 thin film preparation by sputtering

The TiO_2 films were deposited on Si (100) substrates using RF magnetron sputtering (Magest S200, ULVAC, Germany) at ambient temperature. A TiO_2 target with 99.99% purity was used. The applied RF power was 150 W and the base chamber pressure was about 1.6×10^{-5} Pa. Argon gas at a flow rate of 20 sccm was introduced into the main chamber and via the same feed-through, oxygen could be added to the system. While the samples were rotating on non-heated substrates, the target-substrate distance was maintained at 40 cm. The average deposition rate was 566 Å per minute. Subsequently, the samples were annealed by rapid thermal annealing (RTA) in a nitrogen atmosphere for 2 min at 300℃ (T300) and 650℃ (T650).

Section S2 Flat plate photoreactor (FPR) set up

The experimental setup (photocatalytic reactor) was made out of plexiglass; the size of this photocatalytic reactor is indicated in Fig. S1(a). The image of the reactor is shown in Fig. S1(b). The photocatalytic reactor includes a tank (with one inlet and one outlet), a UVC lamp (with the power of 15 W and with a distance of 10 cm from the bottom of the tank), and a peristaltic pump for ACE solution circulation. The TiO_2 samples (as-deposited, T300 or T650) were placed at the reactor as shown in Fig. S1(a).

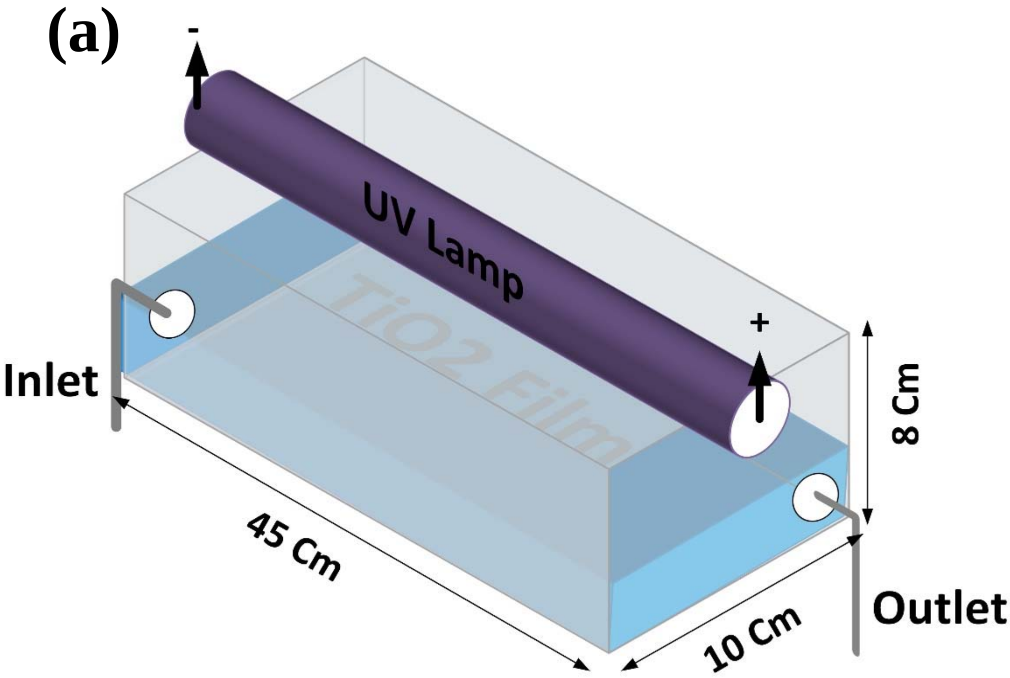
Section S3 Charactrizations and XPS analysis

The FESEM and TEM are shown in Figs. S2 and S3 respectively.

The chemical states of the deposited films were studied by X-ray photoelectron spectroscopy (XPS), as shown in Figs. S4 and S5. Survey scans for all of the samples contained the main peaks at a binding energy of 458 eV, 531 eV, and 285 eV that correspond to Ti (Ti2p), O (O1s), and C (C1s) elements, respectively. Figures S5(a) and S5(b) show high-resolution scan spectra for the Ti2s and O1s, respectively. Two clear peaks at binding energies of 458.6 and 464.2 eV related to the spin-orbit splitting of Ti 2P3/2 and 2P1/2 states, respectively (Xie et al., 2011; Katal et al., 2018b, 2020a). In O 1s spectrum (Fig. S5(b)), a strong peak at 529.6 eV was observed, which is assigned to the lattice oxygen (Xie et al., 2011; Katal et al., 2018b, 2020a).

Section S4 EIS Study

Electrochemical impedance spectroscopy (EIS) can be introduced as a suitable technology to examine the interfacial charge transfer between photocatalyst and electrolyte. The Nyquist plots of TiO_2 samples are shown in Fig. S6. The Nyquist curves at high frequencies (with the shape of the semicircle) indicate the charge transfer between solution and photocatalyst; meanwhile, charge transfer resistance (R_{ct}) is indicated with the diameter of the semicircle (lower diameter indicates the lower resistance) (Katal et al., 2018a, 2020b). As can be seen, the lowest and highest R_{ct} belong to the T650 and As-deposited samples, indicating the positive effect of the crystallinity enhancement on the reduction of carrier recombination and improvement of charge transfer. Figures S7 and S8 show the stability and FESEM after the photocatalytic process, respectively.



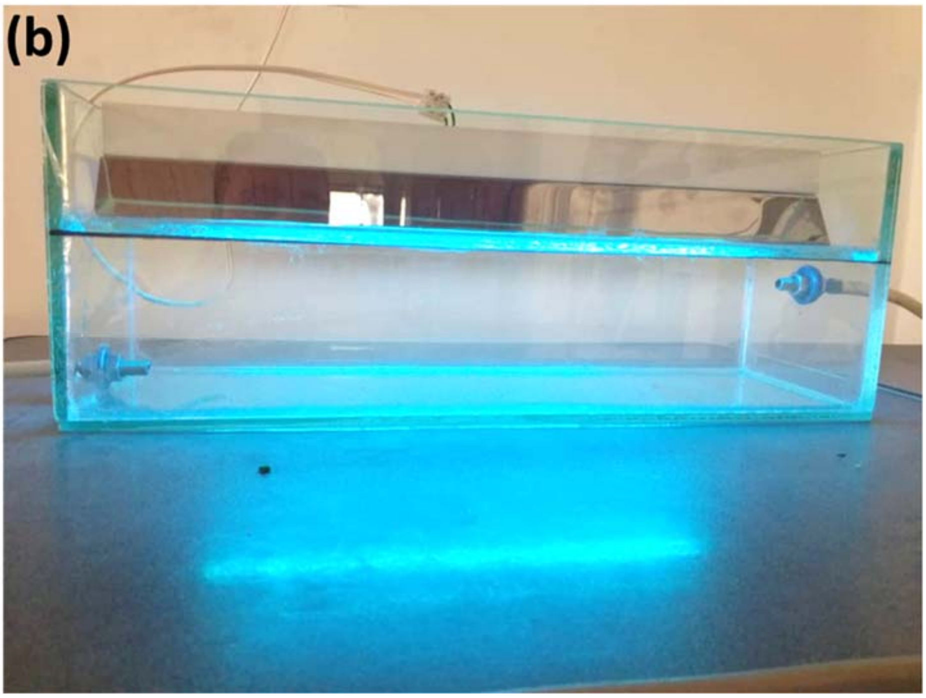


Fig. S1 **(a)** Scheme of the experimental set up **(b)** image of FPR

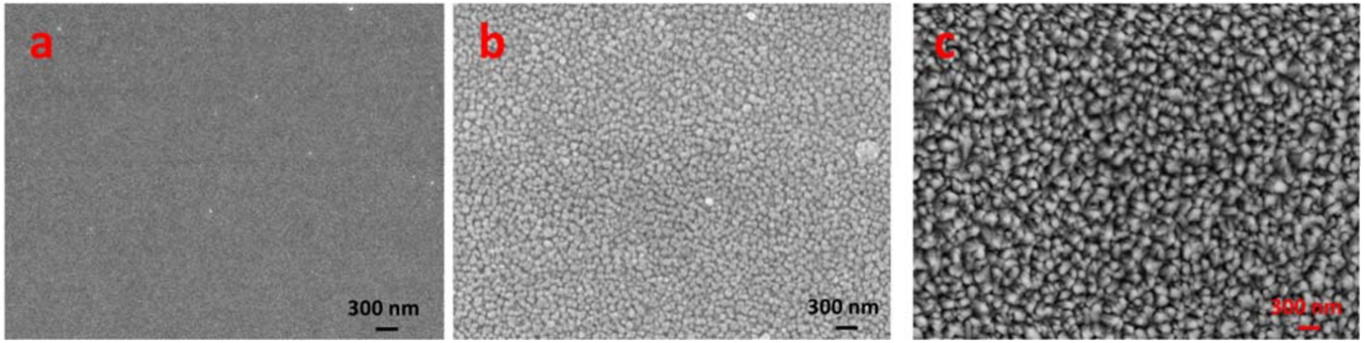


Fig. S2 FESEM of (a) As-deposited, (b) T300℃ and (c) T650℃

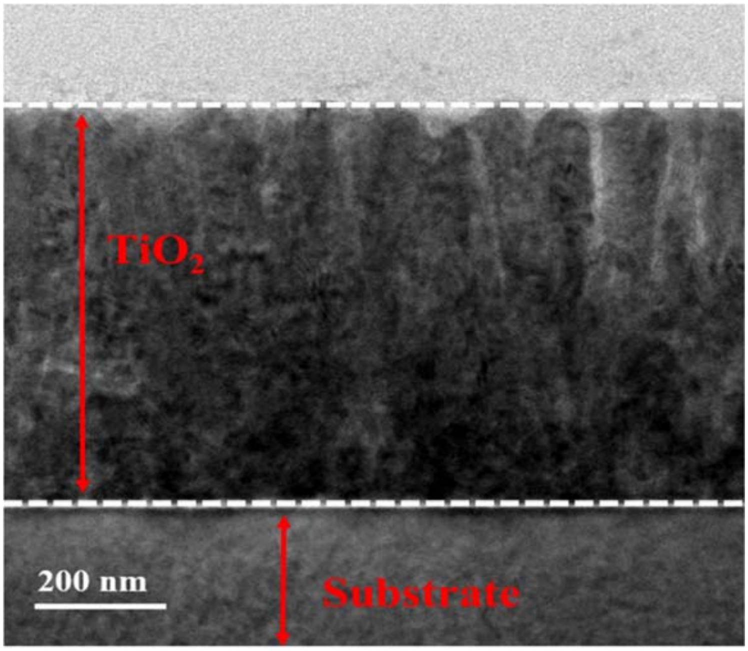


Fig. S3 Cross-sectional TEM images of T650

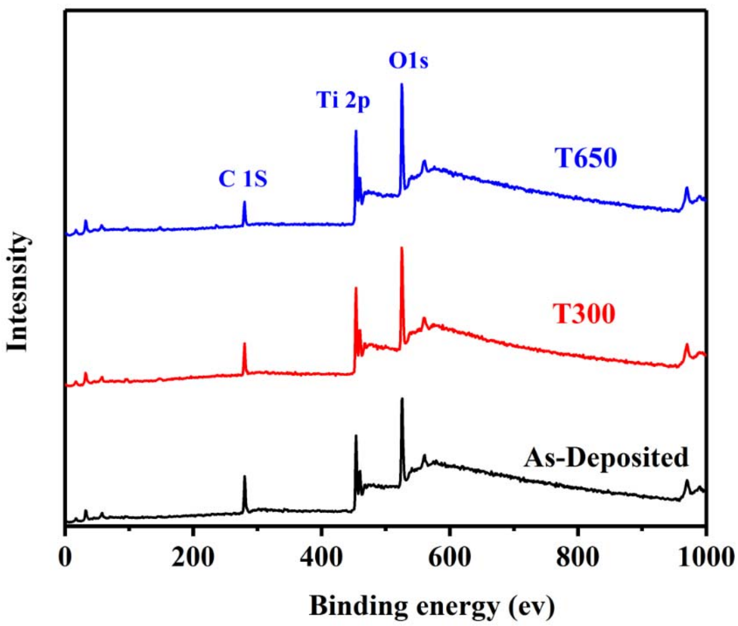


Fig. S4 XPS survey spectra of samples

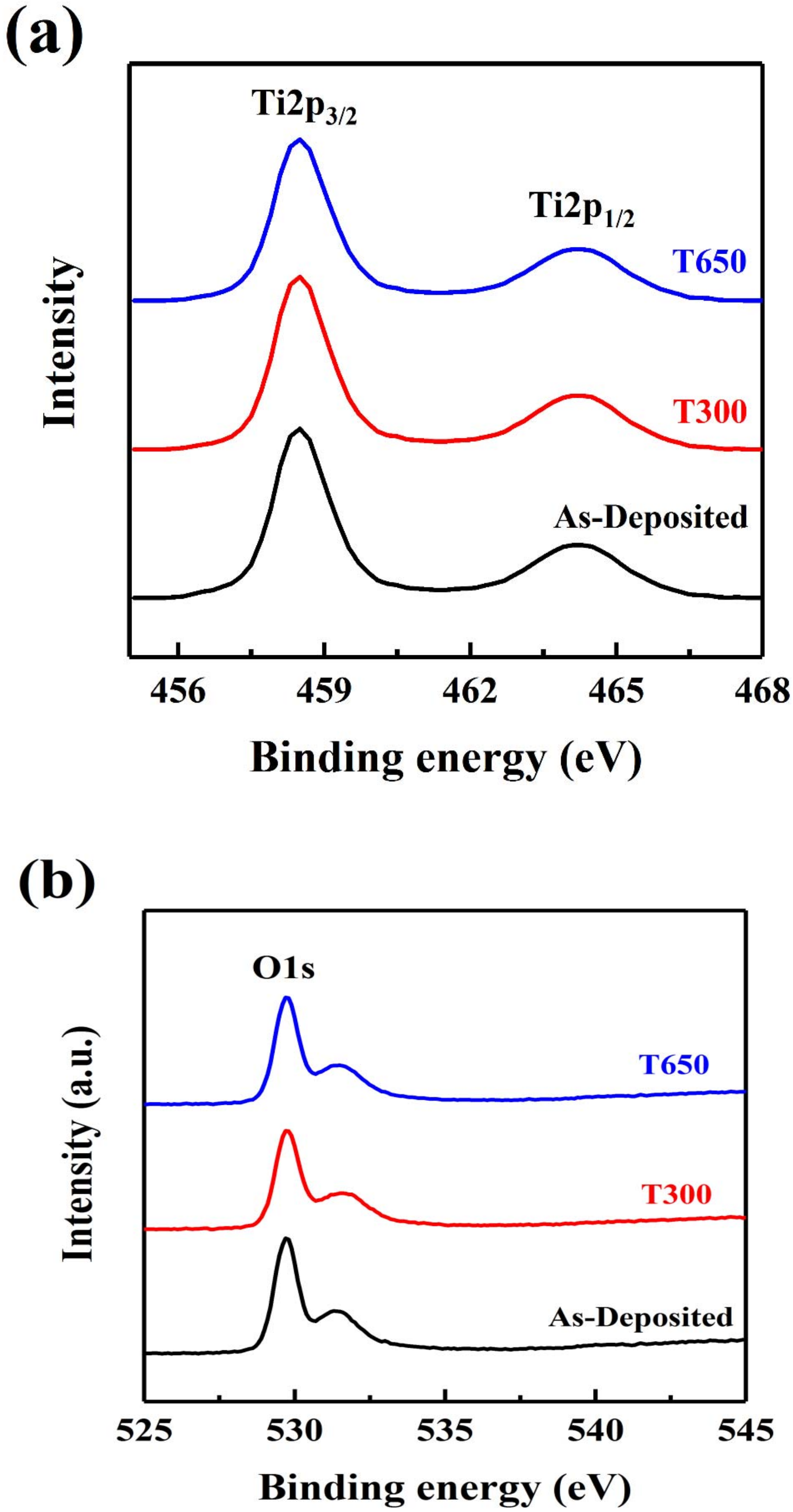


Fig. S5 XPS spectra of Ti 2p peaks (a) and O 1s peaks (b) for the samples

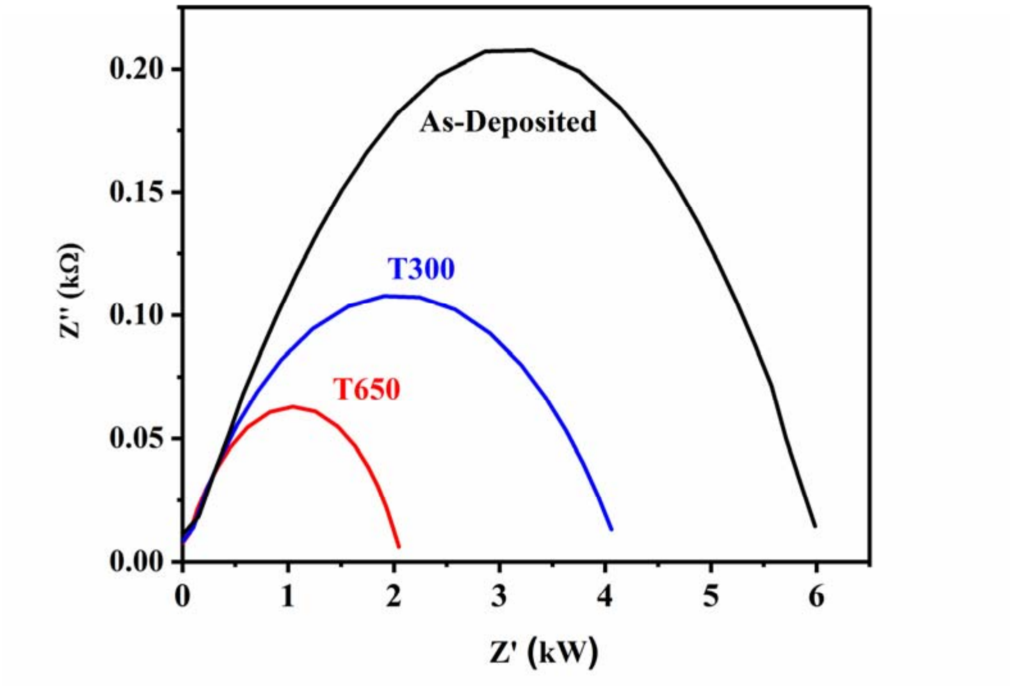


Fig. S6 Nyquist plot of the TiO_2 samples

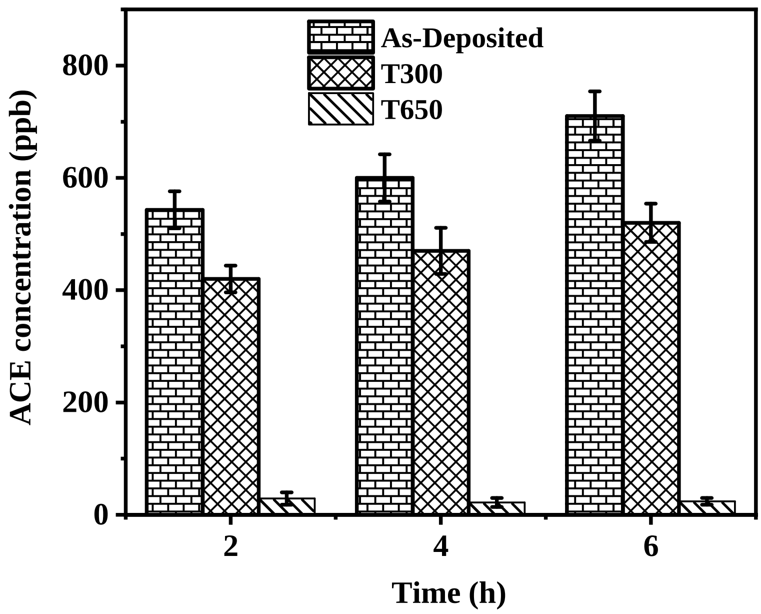


Fig. S7 Application of the samples for photocatalytic degradation of ACE

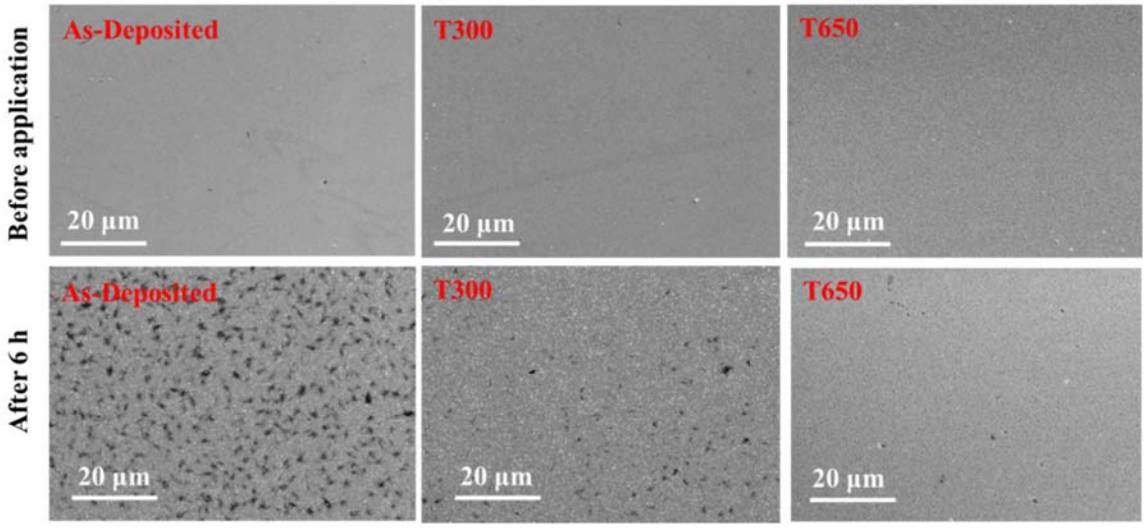
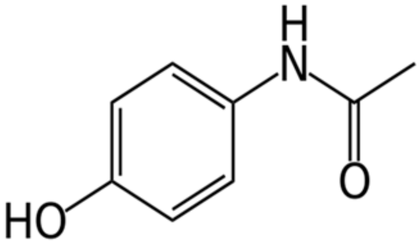


Fig. S8 FESEM images of photocatalysts before and after application

Table S1 Characteristics and structure of ACE

Molecular formula	Molecular mass	pKa	Structure
$C_8H_9NO_2$	151.163 g/mol	9.5	

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