Co-assembly of Heterojunction WO$_3$/TiO$_2$ Inverse Opal Films for Photoinduced Applications

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Photonic crystals (PCs) offer a macroporous periodic structure that activates slow light propagation at spectral regions of weak electronic absorption and enables photochemical enhancement by the synergy of light trapping and material’s composition [1]. Mixed WO$_3$/TiO$_2$ photonic crystal films in the form of 3D ordered inverse opals were deposited via the co-assembly of monodisperse 211, 261 and 287 nm polymer spheres with Ti(IV) bis(ammonium lactato) dihydroxide [2] and ammonium metatungstate [3] aqueous precursors on FTO substrates at nominal W/Ti molar ratios of 1:0.25, 1:1, 1:2 and 1:5. The structural and optical properties of the heterojunction PC photoelectrodes were investigated as a function of the W/Ti molar ratio and photonic band gap in order to explore synergistic effects between photonic amplification and charge separation in the photochemical performance of the PC films.

SEM and TEM images for the mixed PC films display a 3D network of uniform interconnected void macropores consisting of both metal oxides according to Ti and W EDX elemental maps (Figure 1). The presence of the anatase and monoclinic phases was identified for the single-phase TiO$_2$ and WO$_3$ inverse opals, respectively, whereas the relative Raman peaks intensity varied with the TiO$_2$ content in WO$_3$/TiO$_2$ films (Figure 2). Photocurrent generation was evaluated in 0.1 M Na$_2$SO$_4$ aqueous electrolyte under UV–visible irradiation, which excites electrons in both semiconductors. Films with high WO$_3$ content present the highest photocurrent due to the combination of reduced charge carrier recombination and optimal light trapping (Figure 2).

**Figure 1:** (Upper) SEM images and (Bottom) TEM image and elemental EDX maps of W and Ti for PC261 1:0.25.

**Figure 2:** (left) Raman spectra for PC211 films and (right) photocurrent density-potential curves under chopped UV-Vis light illumination for PC211 and PC287 WO$_3$/TiO$_2$ films.

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**References**

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