Co-assembly of Heterojunction WO_3/TiO_2 Inverse Opal Films for Photoinduced Applications

M.-A. Apostolaki*, S. Gardelis, V. Likodimos
Section of Condensed Matter Physics, Department of Physics, National and Kapodistrian University of Athens, Athens, Greece

E. Sakellis, P. Tsipas, N. Boukos, A. Dimoulas
Institute of Nanoscience and Nanotechnology, National Centre for Scientific Research "Demokritos", Athens, Greece

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.

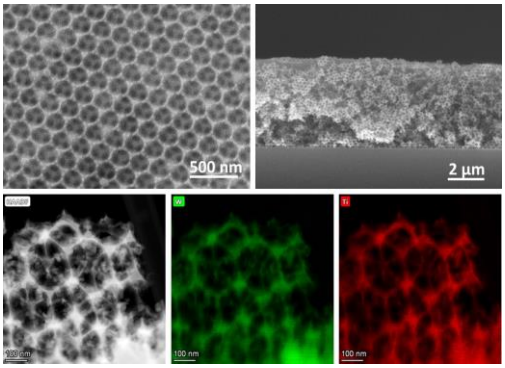

Figure 1: (Upper) SEM images and (Bottom) TEM image and elemental EDX maps of W and Ti for PC261 1:0.25.

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_2SO_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).

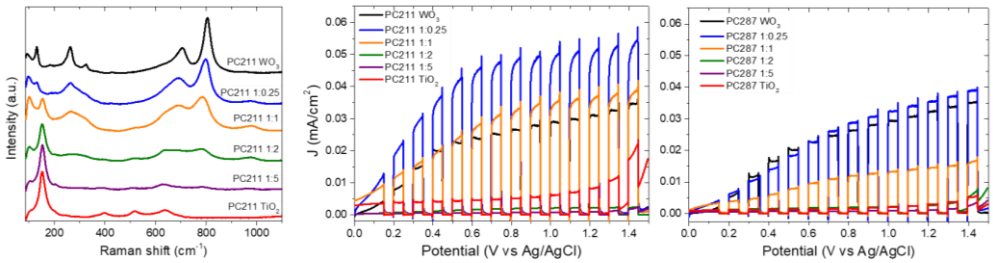

Figure 2: (left) Raman spectra for PC211 films and (right) photocurrent density-potential curves under chopped UV-Vis light illumination for PC211 and PC287 WO_3/TiO_2 films.

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* marapos@phys.uoa.gr