Tuning the density distribution of deep localized states of TiO₂ nanotube arrays through decoration with Pt and Pt@DLC

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Abstract

We demonstrate the possibility to tune the distribution of deep localized states and electronic transport properties of TiO₂ nanotube arrays (TNA) through decoration its surface with Pt or Pt@DLC (Diamond-like carbon). A quantitative calculation of the position of the deep trap states in the band gap and the amount of accumulated charge in deep traps of Pt/TNA and Pt-DLC/TNA electrodes are presented and compared based on photocurrent-voltage curves. Our findings demonstrate that both Pt NPs and Pt@DLC depositions could decrease the quantity of deep localized states in the band gap by saturating the dangling bonds on the surface of TNA. A decline in photoluminescence intensity in platinized samples confirmed the density of deep trap states acting as recombination centers reduced by these surface modifications. Also, the deep localized states in Pt/TNA and Pt-DLC/TNA electrodes shift down towards valence band, in comparison with pure TNA. The neighborhood of the trapped electrons in deep states to the hole sites (VB) in platinized samples leads to the reduction of the electron- hole life time in these samples. Moreover, higher anodic photocurrent density was observed for pure TNA, revealed that in pure TNA the free photoexcited electrons reached to the conduction band will transport to the external circuit whereas, in Pt/TNAs and Pt-DLC/TNAs some free electrons would transfer to Pt NPs via Schottky junction at the semiconductor/electrolyte interface or via hopping or tunneling of pi-electrons existing in the sp² nanoregions of DLC. Finally, Pt- and Pt@DLC-modified TNA electrodes absorbing light in the visible range and suppressing photoelectron recombination are worthy photocatalysts. In contrast, the deposition of Pt or Pt@DLC on TiO₂ nanotubes resulted in lower PEC response.

Keywords: TiO₂ nanotube arrays, Diamond-like carbon, Pt@DLC, Photoelectrochemical, Deep trap states, Electron transfer.