Influence of the dopant concentration on photoelectrochemical behavior of Al-doped TiO_2

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Titanium dioxide is the most extensively studied photoactive material since the discovery of water photo-assisted electrolysis with titanium dioxide photo-anode. Materials based on titanium dioxide can be used in photocatalytic systems for water and air purification, formation of self-cleaning and antibacterial coatings, in solar cells and sensors. Titanium dioxide possesses a sufficiently high photochemical (photocatalytic) activity, good chemical stability and non-toxicity and low cost of its production. In the present study we explored the effect of Al dopant concentration within the range <1.1 wt.% on the photoelectrochemical activity of Al doped TiO_2 photo-anode. The experimental dependencies of photoelectrochemical efficiency on Al dopant concentration indicate that there is an optimal Al concentration 0.5 wt.% corresponding to the highest photo-activity. The analysis of the spectral dependencies of the photocurrent confirms that 0.5 wt.% of Al provides the highest activity at photoexcitation in both intrinsic and extrinsic absorption spectral range. It was also shown that Al doping does not affect the optical band gap of TiO_2. The dependence of photoelectrochemical activity on Al concentration correlates with the corresponding dependencies of the flat band potential and work function indicating the shift of the Fermi level toward the conduction band for the Al concentration <0.5 wt.% and toward the valence band for the Al concentration >0.5 wt.%. Such alteration of the Fermi level position is explained in terms of alteration of the type of major compensating intrinsic defects for Al concentration <0.5 wt.% acting as shallow traps, to Al concentration >0.5 wt.% acting as deep traps. Transformation of compensating defects from shallow traps which are ineffective in charge recombination processes to deep traps which act as effective recombination centers is responsible for the optimal dopant concentration, 0.5 wt.%, to achieve the higher photoelectrochemical activity of Al-doped TiO_2.

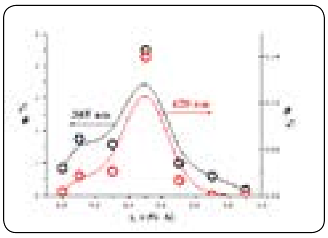

Figure 1: The dependence of IPCE on Al-dopant concentration at 365 and 420 nm.

Recent Publications:

1. Nakata K, Ochiai T, Murakami T and Fujishima A (2012) Photoenergy conversion with TiO_2 photocatalysis: New materials and recent applications. Electrochimica Acta 84:103-111.
2. Fujishima A, Zhang X and Tryk D A (2008) TiO_2 photocatalysis and related surface phenomena. Surf. Sci. Rep. 63:516-582.
3. Henderson M A (2011) A surface science perspective on TiO_2 photocatalysis. Surface Science Reports 66:185-29.
4. Robertson P, Robertson J and Bahnemann D (2012) Removal of microorganisms and their chemical metabolites from water using semiconductor photocatalysis. Journal of Hazardous Materials 211– 212:161–173.
5. Asahi R, Morikawa T, Ohwaki T, Aoki K and Taga Y (2001) Visible-light photocatalysis in nitrogen-doped titanium oxides. Science 293:269-271.

Biography

Anna A Murashkina has her expertise in the development and investigation of semiconductors for the solar energy conversion into the chemical energy. These semiconductor materials can be used in photocatalytic systems for water and air purification, formation of self-cleaning and antibacterial coatings, in solar cells and sensors.

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