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Processing-induced modification of photo- and cathodoluminescence spectra of TiO_2 nanotubes

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Cathodoluminescence and photoluminecsence are investigated in titanium dioxide nanotubes (TiO_2 NTs) produced in an ethylene glycol based electrolyte with the variation of the temperature of the electrolyte which allows the control of the inner diameter of nanotubes. The crystal structure of the produced nanotubes is controlled by the post-anodization thermal treatment. A new fast and cost-effective method for the fabrication of anatase TiO_2 NTs is proposed. The cathodoluminescence spectra and panchromatic images from the produced TiO_2 nanotubes suggest the formation of resonator modes in clusters of nanotubes. The enhancement of the ultraviolet near-bandgap or the green photoluminescence is demonstrated by means of coating the anatase TiO_2 nanotubes with thin Ag or Au films, respectively.

Introduction

Titanium oxide nanotubes (TiO_2 NTs) are of interest for many applications, e.g. in Grätzel-type solar cells, catalysis for decomposition of organic compounds and electrochemical water splitting, hydrogen sensor development etc. (1). Ordered spatial distribution of TiO_2 nanotubes promises to widen the potential applications of titania nanotubular structures even further, in particular in photonics, opening the possibility for the development of cost-effective photonic elements based on negative refractive index materials, e.g. of flat and concave focusing devices with super-resolution (2,3). Ordered arrays of TiO_2 nanotubes can be produced by electrochemical anodization of titanium foils. The self-organization process for the fabrication of ordered TiO_2 NTs depends on a series of factors such as solution concentration, temperature, pH, applied potential during anodic etching of Ti foils etc. Most of technological methods for the preparation of TiO_2 NTs employ fluorine containing electrolytes. With aqueous electrolytes, usually short nanotubes with diameters up to 100 nm are produced. On the other hand, using non-aqueous electrolytes, for instance ethylene glycol containing electrolytes, allows one to produce longer TiO_2 NTs with larger diameters. By tailoring the anodization voltage and the electrolyte composition one can produce TiO_2 NTs with different inner and outer diameters. However, the density of nanotube arrays is also changed in these processes.