Growth and morphological study of zinc oxide nanoneedles grown on the annealed titanate nanotubes using hydrothermal method

I. INTRODUCTION

Controlled synthesis of semiconductor (particularly ZnO) nanostructures in terms of size and shape is strongly motivated for expanding/investigating the application to various fields, since the properties can be tailored for desired applications dependent on their structural properties. ZnO, with wurtzite hexagonal phase and known properties, possesses a wide range of applications such as in transparent conducting electrodes of solar cells. fiat panel displays, surface acoustic devices, UV lasers, chemical and biological sensors, etc. The intriguing size effects and quantum confinement of ZnO have attracted researcher to concentrate on the growth and application of nanostructures of this material. Especially for titania based solar cells,owing to its band gap energy close to TiO2. Even though nanocrystalline TiO_2 reduces the recombination rate by forming an energy barrier at the electrode/electrolyte interface, the conversion efficiency still needs to be improved. Use of bilayer electrode and/or composite semiconductor electrode can resolve the problem to some extent. The recent trend focuses on the use of composite materials such as ZnO/TiO_2, ZnO/SnO_2, CdS/MgO, etc. For example, Mane et al. have studied the composite TiO_2/ZnO using layer-by-layer method for dye sensitized solar cells (DSSCs), where they observed that this composite further reduces the recombination rate. The material parameters, such as grain size, porosity, surface area. amount of dye absorption, etc., are known to affect the overall cell performance. Therefore, the synthesis of composite becomes the key issue in such DSSC based on composites.

The hydrothermal method is found simpler for synthesis of ZnO nanostructures among the few reported synthesis methods such as vapor deposition, template-assisted method, sol gel, etc. There are few reports on growing ZnO nanomaterials (random or nonaligned growth) in the hydrothermal route using aqueous solution containing zinc salts and/or organic amines. For the growth of aligned ZnO nanoneedles, seed layers of

the Zn-derived thin films, such Zn and ZnO films and textured ZnO nanocrystal. are used. Although many reports are available for the growth of ZnO nanostructure on the seeds of Zn-derived thin film, very few reports are available for direct growth of ZnO nanoneedles on titania (TiO_2) film However, the growth process and/or the role of seeds are/is elusive and not discussed well.

An understanding of this can be advantageous to further tune the morphology and size of these nanostructurcs for practical applications. Here, we present the systematic growth of ZnO nanoneedles on annealed titanate nanotubes as a function of time and their effect on the structure and morphology. Based on the growth characteristics, a growth model is presented with three-step growth mode.