ZnO- and TiO2-based nanostructures

Original
ZnO- and TiO2-based nanostructures / Lamberti, A.. - In: NANOMATERIALS. - ISSN 2079-4991. - 8:5(2018), p. 325.

Availability:
This version is available at: 11583/2836101 since: 2020-06-16T17:21:16Z

Publisher:
MDPI AG

Published
DOI:10.3390/nano8050325

nanomaterials

MDPI

Editorial

ZnO- and TiO_2-Based Nanostructures

Andrea Lamberti [1,2]

[1] Department of Applied Science and Technology, Politecnico di Torino, C.so Duca degli Abruzzi 24, 10129 Turin, Italy; andrea.lamberti@polito.it
[2] Center for Sustainable Future Technologies, Istituto Italiano di Tecnologia (IIT@Polito), C.so Trento 21, 10129 Turin, Italy

Received: 8 May 2018; Accepted: 10 May 2018; Published: 14 May 2018

Keywords: ZnO; TiO_2; nanostructures; smart materials

Transition-metal oxide (TMO) nanostructures are the focus of current research efforts in nanotechnology since they are the most common minerals on Earth, and also thanks to their special shapes, compositions, and chemical and physical properties. They have now been widely used in the design of energy saving and harvesting devices, such as lithium-ion batteries, fuel cells, solar cells, and even transistors, light emitting devices (LEDs), hydrogen production by water photolysis and its storage, water and air purification by degradation of organic/inorganic pollutants, bio-sensing devices, environmental monitoring by their applications in the fabrication of gas, humidity, and temperature sensors, and photodetectors. TMOs can overcome the limitation imposed by the relatively poor properties of standard electrodes, showing high carrier mobility and significantly low charge recombination rates.

In addition to the great application potentials, TMO-based nanomaterials, such as ZnO and TiO_2, have recently revolutionized nanomaterial research thanks to their outstanding smart properties. They can be produced in different shapes (such as nanowires, nanobelts, nanorods, nanotubes, nanocombs, nanorings, nanohelixes/nanosprings, nanocages and nanosheets, and nanostars) depending on the synthesis routes, resulting in different physicochemical properties.

The present Special Issue covers the most recent advances in ZnO and TiO_2 nanostructures, concerning not only their synthesis and characterization, but also reports of the manner(s) in which their functional and smart properties can be applied in working devices. Applications of nanosized ZnO and TiO_2 can range widely, from biomedical and drug delivery devices to piezoelectric and chemical sensors, and energy harvesting, conversion, and storage devices.

Twenty-seven papers compose this issue, with invited contributions and regular original papers, and both reviews and research articles.

The two first reviews address the application of ZnO nanostructures to chemoresistive sensing (Rackauskas and coworkers [1], invited contribution) and Surface Enhanced Raman Scattering (by Yang et al. [2]).

The last two reviews focus on TiO_2 nanostructures: Wang et al. [3] describe the engineering of the surface/interface structures of titanium dioxide micro- and nano-architectures towards environmental and electrochemical applications while the wet chemical preparation of TiO_2-based composites with different morphologies and their photocatalytic properties are reported by Xiang and Zhao [4].

Several research articles focus on the synthesis and deposition of ZnO and TiO_2 nanostructures. Hsu et al. [5] discuss the effect of process parameters on the sputtering deposition of indium titanium zinc oxide thin film for transistor fabrication. Shih and Wu [6] investigate the growth mechanism of ZnO nanowires, providing experimental observation and providing a short-circuit diffusion analysis. The sol-gel synthesis of ZnO/ZnS heterostructures is discussed by Berbel Manaia et al. [7], focusing on the critical role of thioacetamide concentration. Chen et al. [8] report on the preparation and characterization of ZnO nanoparticles supported on amorphous SiO_2. Rana and coworkers [9] discuss how the growth method and process parameters influence the optical, conductive, and physical properties of solution-grown ZnO nanostructures. Folger and coworkers [10] show how the heat treatments in different environments allow electronic conductivity to be tuned in hydrothermally grown rutile TiO_2 nanowires. Jin et al. [11] present a simple and novel strategy to obtain TiO_2 nanowire networks by titanium substrate corrosion and their application in third generation solar cells. Berthod et al. [12] show the improvement achieved in the fabrication of periodic TiO_2 nanostructures by colloidal lithography approach. Liang and coworkers [13] describe the synthesis and characterization of organozinc precursor-derived crystalline ZnO nanoparticles.

Some contributions discuss the photo-induced smart properties of metal-oxide nanostructures: Hu et al. [14] show how via constructing appropriate heterostructures between mesopore TiO_2 nanospheres and Sn_3O_4 nanoparticles it is possible to enhanced their ultraviolet-visible light photocatalytic activity. The study of the photodynamic activity of N-doped TiO_2 nanoparticles conjugated with aluminum phthalocyanine is reported by Pan et al. [15] Li and coworkers investigate the photoelectrochemical water splitting properties of Ti-Ni-Si-O nanostructures grown on Ti-Ni-Si alloy substrate [16]. The visible light response of mesoporous titania films loaded with silver salts is reported by Crespo-Monteiro et al. [17] for the degradation of methyl blue.

Other functional properties of ZnO and TiO_2 nanostructures are described: the piezoelectric potential in single-crystalline ZnO nanohelices is studied by finite element analysis by Hao et al. [18] (invited contribution) while the self-cleaning behavior of a nano-TiO_2-coated SiO_2 microsphere composite is reported by Sun et al. [19].

The electrical properties are also analyzed: the memristive response of TiO_2 nanoparticle is investigated by Schmidt et al. [20] while Bruzzi and coworkers [21] report the thermally stimulated current in nanocrystalline titania.

Other contributions addressed biological issues: Yamamoto et al. [22] show novel results on the in vitro sonodynamic therapeutic effect of polyion complex micelles incorporating titanium dioxide nanoparticles. Ancona et al. [23] (invited contribution) report a novel strategy for photodynamic cancer therapy exploiting lipid-coated ZnO nanoparticles. Zhang and coworkers [24] demonstrate the duplex bioactivity of titanium-based materials achieved by oxidation and nitrogen implantation. McCall et al. [25] reported the protective effect of ZnO nanoparticle for RNA, while the interaction of ZnO surface with biomatrices is discussed by Yu et al. [26].

Finally, Casu et al. [27] (invited contribution) showed how heating anodically grown TiO_2 nanotubes in situ in a transmission electron microscope allows for the monitoring of their crystallization from amorphous to polycrystalline with polymorphs dependent on the selected temperature.

I would like to gratefully acknowledge all the authors for their valuable contributions and expertise, as well as the reviewers for their comments and suggestions and the assistant editors for the constant support: all have contributed to the success of this special issue.

Hoping that the special issue contents provide an actual overview of the TiO_2 and ZnO nanostructures synthesis and applications, even if not exhaustive of this huge research field, I wish you a good reading.

References

1. Rackauskas, S.; Barbero, N.; Barolo, C.; Viscardi, G. Zno nanowire application in chemoresistive sensing: A review. *Nanomaterials* **2017**, *7*, 381. [CrossRef] [PubMed]
2. Yang, L.; Yang, Y.; Ma, Y.; Li, S.; Wei, Y.; Huang, Z.; Long, N. Fabrication of semiconductor ZnO nanostructures for versatile SERS application. *Nanomaterials* **2017**, *7*, 398. [CrossRef] [PubMed]
3. Wang, X.; Zhao, Y.; Mølhave, K.; Sun, H. Engineering the surface/interface structures of titanium dioxide micro and nano architectures towards environmental and electrochemical applications. *Nanomaterials* **2017**, *7*, 382. [CrossRef] [PubMed]

4. Xiang, L.; Zhao, X. Wet-chemical preparation of TiO_2-based composites with different morphologies and photocatalytic properties. *Nanomaterials* **2017**, *7*, 310. [CrossRef] [PubMed]
5. Hsu, M.-H.; Chang, S.-P.; Chang, S.-J.; Wu, W.-T.; Li, J.-Y. Oxygen partial pressure impact on characteristics of indium titanium zinc oxide thin film transistor fabricated via RF sputtering. *Nanomaterials* **2017**, *7*, 156. [CrossRef] [PubMed]
6. Shih, P.-H.; Wu, S. Growth mechanism studies of ZnO nanowires: Experimental observations and short-circuit diffusion analysis. *Nanomaterials* **2017**, *7*, 188. [CrossRef] [PubMed]
7. Berbel Manaia, E.; Kiatkoski Kaminski, R.; Caetano, B.; Magnani, M.; Meneau, F.; Rochet, A.; Santilli, C.; Briois, V.; Bourgaux, C.; Chiavacci, L. The critical role of thioacetamide concentration in the formation of zno/zns heterostructures by sol-gel process. *Nanomaterials* **2018**, *8*, 55. [CrossRef] [PubMed]
8. Chen, Y.; Ding, H.; Sun, S. Preparation and characterization of ZnO nanoparticles supported on amorphous SiO_2. *Nanomaterials* **2017**, *7*, 217. [CrossRef] [PubMed]
9. Rana, A.; Lee, J.; Shahid, A.; Kim, H.-S. Growth method-dependent and defect density-oriented structural, optical, conductive, and physical properties of solution-grown ZnO nanostructures. *Nanomaterials* **2017**, *7*, 266. [CrossRef] [PubMed]
10. Folger, A.; Kalb, J.; Schmidt-Mende, L.; Scheu, C. Tuning the electronic conductivity in hydrothermally grown rutile TiO_2 nanowires: Effect of heat treatment in different environments. *Nanomaterials* **2017**, *7*, 289. [CrossRef] [PubMed]
11. Jin, S.; Shin, E.; Hong, J. TiO_2 nanowire networks prepared by titanium corrosion and their application to bendable dye-sensitized solar cells. *Nanomaterials* **2017**, *7*, 315. [CrossRef] [PubMed]
12. Berthod, L.; Shavdina, O.; Verrier, I.; Kämpfe, T.; Dellea, O.; Vocanson, F.; Bichotte, M.; Jamon, D.; Jourlin, Y. Periodic TiO_2 nanostructures with improved aspect and line/space ratio realized by colloidal photolithography technique. *Nanomaterials* **2017**, *7*, 316. [CrossRef] [PubMed]
13. Liang, Y.; Wicker, S.; Wang, X.; Erichsen, E.; Fu, F. Organozinc precursor-derived crystalline ZnO nanoparticles: Synthesis, characterization and their spectroscopic properties. *Nanomaterials* **2018**, *8*, 22. [CrossRef] [PubMed]
14. Hu, J.; Tu, J.; Li, X.; Wang, Z.; Li, Y.; Li, Q.; Wang, F. Enhanced UV-visible light photocatalytic activity by constructing appropriate heterostructures between mesopore TiO_2 nanospheres and Sn_3O_4 nanoparticles. *Nanomaterials* **2017**, *7*, 336. [CrossRef] [PubMed]
15. Pan, X.; Liang, X.; Yao, L.; Wang, X.; Jing, Y.; Ma, J.; Fei, Y.; Chen, L.; Mi, L. Study of the photodynamic activity of N-doped TiO_2 nanoparticles conjugated with aluminum phthalocyanine. *Nanomaterials* **2017**, *7*, 338. [CrossRef] [PubMed]
16. Li, T.; Ding, D.; Dong, Z.; Ning, C. Photoelectrochemical water splitting properties of Ti-Ni-Si-O nanostructures on Ti-Ni-Si alloy. *Nanomaterials* **2017**, *7*, 359. [CrossRef] [PubMed]
17. Crespo-Monteiro, N.; Cazier, A.; Vocanson, F.; Lefkir, Y.; Reynaud, S.; Michalon, J.-Y.; Kämpfe, T.; Destouches, N.; Jourlin, Y. Microstructuring of mesoporous titania films loaded with silver salts to enhance the photocatalytic degradation of methyl blue under visible light. *Nanomaterials* **2017**, *7*, 334. [CrossRef] [PubMed]
18. Hao, H.; Jenkins, K.; Huang, X.; Xu, Y.; Huang, J.; Yang, R. Piezoelectric potential in single-crystalline ZnO nanohelices based on finite element analysis. *Nanomaterials* **2017**, *7*, 430. [CrossRef] [PubMed]
19. Sun, S.; Deng, T.; Ding, H.; Chen, Y.; Chen, W. Preparation of nano-TiO_2-coated SiO_2 microsphere composite material and evaluation of its self-cleaning property. *Nanomaterials* **2017**, *7*, 367. [CrossRef] [PubMed]
20. Schmidt, D.; Raab, N.; Noyong, M.; Santhanam, V.; Dittmann, R.; Simon, U. Resistive switching of sub-10 nm TiO_2 nanoparticle self-assembled monolayers. *Nanomaterials* **2017**, *7*, 370. [CrossRef] [PubMed]
21. Bruzzi, M.; Mori, R.; Baldi, A.; Carnevale, E.; Cavallaro, A.; Scaringella, M. Thermally stimulated currents in Nanocrystalline titania. *Nanomaterials* **2018**, *8*, 13. [CrossRef] [PubMed]
22. Yamamoto, S.; Ono, M.; Yuba, E.; Harada, A. In Vitro sonodynamic therapeutic effect of polyion complex micelles incorporating titanium dioxide nanoparticles. *Nanomaterials* **2017**, *7*, 268. [CrossRef] [PubMed]
23. Ancona, A.; Dumontel, B.; Garino, N.; Demarco, B.; Chatzitheodoridou, D.; Fazzini, W.; Engelke, H.; Cauda, V. Lipid-coated zinc oxide nanoparticles as innovative ROS-generators for photodynamic therapy in cancer cells. *Nanomaterials* **2018**, *8*, 143. [CrossRef] [PubMed]

24. Zhang, P.; Wang, X.; Lin, Z.; Lin, H.; Zhang, Z.; Li, W.; Yang, X.; Cui, J. Ti-based biomedical material modified with TiO_x/TiN_x duplex bioactivity film via Micro-Arc oxidation and nitrogen ion implantation. *Nanomaterials* **2017**, *7*, 343. [CrossRef] [PubMed]
25. McCall, J.; Smith, J.; Marquardt, K.; Knight, K.; Bane, H.; Barber, A.; DeLong, R. ZnO nanoparticles protect RNA from degradation better than DNA. *Nanomaterials* **2017**, *7*, 378. [CrossRef] [PubMed]
26. Yu, J.; Kim, H.-J.; Go, M.-R.; Bae, S.-H.; Choi, S.-J. ZnO interactions with biomatrices: Effect of particle size on ZnO-protein corona. *Nanomaterials* **2017**, *7*, 377. [CrossRef] [PubMed]
27. Casu, A.; Lamberti, A.; Stassi, S.; Falqui, A. Crystallization of TiO_2 nanotubes by in situ heating TEM. *Nanomaterials* **2018**, *8*, 40. [CrossRef] [PubMed]