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## Nano-structured oxide platforms for chemical sensing and beyond: A materials design

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Recent work in the author's laboratory has led to the development of simple processes for the fabrication of ordered and self-assembled nanostructures by exploiting intrinsic material properties that are inexpensive, highly scalable and do not require use of lithography. These processes can be classified as "oxide nanostructures by materials design". One process creates nanofiber arrays of single crystal  $\text{TiO}_2$  by gas phase reaction in a  $\text{H}_2/\text{N}_2$  environment. As oxygen from  $\text{TiO}_2$  is taken out as  $\text{H}_2\text{O}$  (g), Ti diffuses from the surface to the bulk resulting in fibers oriented along the  $\langle 001 \rangle$  direction. Work on single crystal  $\text{TiO}_2$  shows that on Au-catalyzed (001) surface, oriented nano-fibers can be grown with  $\langle 001 \rangle$  and  $\langle 110 \rangle$  alignments using  $\text{H}_2/\text{N}_2$  heat treatment. The same gas heat treatment was also used to grow nanofibers on polycrystalline  $\text{SnO}_2$  in regions of the sample coated with gold, showing directional growth on grains with crystal facets. We have also developed a process to create nanofibers of  $\text{TiO}_2$  on Ti metal and Ti alloys via oxidation under a limited supply of oxygen (~10s of ppm). Lately, we have succeeded in converting the 1-D  $\text{TiO}_2$  nano-fiber grown by thermal oxidation to nano-dendritic titanates by a hydrothermal treatment. The conversion of  $\text{TiO}_2$  to barium (and other) titanates is a path to synthesizing materials in a different class of functionality because of their piezoelectric and ferroelectric responses. We developed yet another interesting nanostructure (nanoislands and nanobars) during thermal annealing of an oxide (GDC) on top of another oxide (YSZ) substrate that self-assembles along the softest elastic direction of the substrate. What is common about these structures is that they are fabricated without the use of lithographic techniques and involves simple processes such as gas-phase reactions and stress-driven process. These nano-structures can be used as platforms for chemical sensing, photo catalysis, electro emission and biomedical applications. Preliminary results of some of these applications are presented.

### Biography

Sheikh A. Akbar is a Professor of Materials Science and Engineering and Founder of the National Science Foundation (NSF) Center for Industrial Sensors and Measurements (CISM) at The Ohio State University in Columbus, OH, USA. His recent work deals with synthesis-microstructure-property relations of ceramic bulk, thin-film and nano-structures. Dr. Akbar was the Chair of the 12<sup>th</sup> International Conference on Chemical Sensors (IMCS-12) held in 2008. This meeting was attended by 330 participants from more than 30 countries. His sensors received three (3) R&D 100 Awards as part of the 100 best inventions of 2007 and 2005 selected by R&D Magazine and 2005 NASA TGIR (turning goal into reality) award. Dr. Akbar is the recipient of the 2012 Electrochemical Society Sensor Division Outstanding Achievement Award, the 2002 Tan Chin Tuan Fellow of Nanyang Technological University in Singapore, and the 2001 Fulrath Award and the 2002 W.E. Cramer Award of the American Ceramic Society. He was elected a Fellow of the American Ceramic Society in 2001. He also received the 1993 B.F. Goodrich Col-lege Inventors Award for the development of a rugged and durable CO/H<sub>2</sub> sensor; one of three national awards. Dr. Akbar served on the International Advisory Committee of CIMTEC conferences, Steering Committee of the International Conference on Engineering Education (ICEE), Technical Steering Committee of the US-DOE Sensor and Controls Program, and the Steering Committee of the US-Japan Conference on Sensor Systems for the 21st Century. He has co-organized sensor symposia for the American Ceramic Society, the Electrochemical Society, ICMAT (Singapore) and ICC3 (Japan). Dr. Akbar has co-edited 2 books on sensors. In 2003, he served as the Guest Editor for two special sections of the Journal of Materials Science, "Chemical Sensors for Pollution Monitoring and Control" and "Chemical and Bioceramics." Recently, he was the Principal Editor of special issues entitled, "Nano-structured Ceramic Oxides: Challenges and Opportunities" and "Energy and Environment: Role of Advanced Materials" published by the American Scientific Publisher in 2011 and 2014, respectively. He is also the Guest Editor of a special issue entitled, "Sensing at the Nano-scale: Chemical and Biosensing" published in 2012 in Sensors. Dr. Akbar is on the Editorial Board of the Journal of Nanoengineering and Nanomanufacturing, Materials Focus, Ceramics International, Journal of Nanomaterials and Sensor Letters. He has published more than 200 technical papers and holds 8 patents.

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