

AN AQUEOUS SOLUTION APPROACH TO ADVANCED METAL OXIDE ARRAYS ON SUBSTRATES

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Abstract

The ability to design one-dimensional building blocks with tailored aspect ratio and to order them into large 3-D arrays is an important challenge scientists have to face to create smart and functionalized nanodevices. Our approach to control the size and shape of nanoparticles as well as the overall texture of particulate thin films is to tune their direct aqueous hydrolysis-condensation growth onto substrates by monitoring the interfacial thermodynamics of nanocrystals as well as their kinetics of heteronucleation. This is achieved by minimizing the surface energy at the water/oxide interface according to a general quantitative model based on Gibbs adsorption equation. Indeed, growing materials at very low interfacial tension, i.e. at thermodynamically stable conditions, allows the experimental control of the extension and rate of the nucleation and growth stages. Thus, different sizes, shapes, and orientations can be generated onto a variety of substrates. Consequently, the design and fabrication of novel devices with tailored and engineered three-dimensional architecture can be obtained from aqueous solution without template, surfactant, applied field, or undercoating. Such ideas will be demonstrated on transition metal oxides materials at nano-, meso-, and micro-scale, and illustrated on their growth as 3-D arrays with controlled orientations onto various substrates as well as the characterization of their electronic structure, photoelectrochemical, and magnetic properties.

Biographical Notes



Born in 1968, he obtained a MSc. in Physical Chemistry in 1991 and a Ph.D. in Inorganic Chemistry in November 1995 from the Université Pierre et Marie Curie in Paris, France for his research work on the *Interfacial and thermodynamic growth control of metal oxide nanoparticles in aqueous solutions* with Prof. Jacques Livage at the CNRS Laboratoire de Chimie de la Matière Condensée. Thereafter, he joined Uppsala University, Sweden as a postdoctoral researcher for the Swedish Materials Consortium on Clusters and Ultrafine Particles to extend his concepts and develop *purpose-built metal oxide nanomaterials* for photoelectrochemical applications with Prof. Sten-Eric Lindquist as well as to characterize their electronic structure by x-ray spectroscopies at synchrotron radiation facilities with Profs. Hans Siegbahn & Joseph Nordgren.

He has been invited as a visiting scientist: at the department of Chemical Engineering at the University of Texas at Austin, USA on nanocomposite metallic oxides for biosensors by Prof. Adam Heller, at the UNESCO Centre for Macromolecules & Materials and at the department of Biochemistry, at Stellenbosch University, South Africa on bio-nanocomposite materials by Profs. Ron Sanderson & Pieter Swart, at the Glenn T. Seaborg Center, Chemical Sciences Division, at Lawrence Berkeley National Laboratory, USA on actinide nanomaterials by Dr. David Shuh, at the Texas Materials Institute on metal oxide-based nanomaterials for optical, magnetic, and energy storage and conversion devices by Profs. Arumugam Manthiram & Llewellyn Rabenberg, and at the Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland on metal oxide oriented arrays for photocatalytic devices by Prof. Michael Graetzel.

He has (co-)authored 50 refereed publications, 3 ISI highly cited papers for the last 10 years, 2nd in the Top 3 hot papers published in the last 2 years in Materials Science (Sep-Dec 05) and 1st in the Top 10 hot papers published in the last 2 years in Chemistry (Jan-Feb 06), in major international journals, refereed proceedings and book series, which have already generated over 750 citations. He has presented over 100 lectures at universities, research institutes and international conferences as well as acting as a session chairman, program committee and advisory member at major conferences worldwide.

He is a referee for *Angewandte Chemie International Edition*, *Advanced Materials*, *Journal of the American Chemical Society*, *Advanced Functional Materials*, *Chemistry A European Journal*, *Applied Physics Letters*, *Chemical Communications*, *Chemistry of Materials*, *Journal of Physical Chemistry B*, *Inorganic Chemistry*, *ChemPhysChem*, *Langmuir*, *Crystal Growth & Design*, *Electrochemical Solid State Letters*, *Journal of Materials Chemistry*, *Chemical Physics Letters*, *European Journal of Inorganic Chemistry*, *Nanotechnology*, *New Journal of Chemistry*, *Journal of the American Ceramic Society*, *Journal of Nanoscience & Nanotechnology*, *Applied Surface Science*, *Journal of Solid State Chemistry*, *Comptes Rendus Chimie*, *Materials Letters* and *Small*.


He is currently a senior scientist at the International Center for Young Scientists, National Institute for Materials Science (NIMS) in Tsukuba, Japan; a R&D consultant for Hydrogen Solar Ltd., UK; a guest scientist at the Chemical Sciences Division and the Advanced Light Source at Lawrence Berkeley National Laboratory, USA as well as at the Materials Chemistry Department at Ångström Laboratory, Uppsala University, Sweden. He is the conference chairman of the 1st SPIE conference dedicated to *Solar Hydrogen and Nanotechnology* to be held during the annual Optics and Photonics meeting in San Diego, CA August 13-17, 2006.


He is also the founder and the editor-in-chief of a new journal dedicated to reviews and accounts in nanotechnology and related fields, the *International Journal of Nanotechnology* (ISSN 1475-7435(Print); 7141-8151(Online)) published by Inderscience Enterprises Ltd, UK <https://www.inderscience.com/browse/index.php?journalID=54>

Selected Publications

L. Vayssieres, "On the thermodynamic stability of metal oxide nanoparticles in aqueous solutions", *Int. J. Nanotechnology* **2005**, 2(4), 411-439

L. Vayssieres, C. Sathe, S. M. Butorin, D. K. Shuh, J. Nordgren, J.-H. Guo, "1-D quantum confinement in α -Fe₂O₃ ultrafine nanorod arrays", *Adv. Mater.* **2005**, 17(19), 2320-2323




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C. L. Dong, C. Persson, L. Vayssieres, A. Augustsson, T. Schmitt, M. Mattesini, R. Ahuja, C. L. Chang and J.-H. Guo "The electronic structure of nanostructured ZnO from x-ray absorption and emission spectroscopy and the local density approximation", *Phys. Rev. B* **2004**, 70(19), 195325  top 10 %


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