Aqueous Design, Electronic Structure & Applications of Quantum-confined Metal Oxides for Solar Energy Conversion

Lionel Vayssieres
International Research Center for Renewable Energy, School of Energy & Power Engineering,
Xian Jiaotong University, Xian 710049, PR China

The demand of low cost functional and highly efficient materials has become a major challenge scientists face to answer crucial contemporary issues such as clean alternative energy sources and sensors for a safer and cleaner environment and for better health. For instance, one of the promising alternatives for the transition of energy resource from its fossil fuel-based beginning to a clean and renewable technology relies on the widespread implementation of solar-related energy systems, however the high cost of energy production and low-energy of currently used material combinations pose an intrinsic limitation. In this context, new materials development is required to achieve the necessary dramatic increases in power generation and conversion efficiency. The necessity of materials development which is not limited to materials that can achieve their theoretical limits, but makes it possible to raise these limits by changing the fundamental underlying physics and chemistry is crucial. Low cost purpose-built, functional materials with optimized geometry, orientation, and aspect ratio combined with inexpensive large scale manufacturing methods will play a decisive role in the success of materials for renewable energy. However, fabricating and manufacturing large area of such functional materials is a daunting challenge. Novel smarter and cheaper fabrication techniques and, just as important, better fundamental knowledge and comprehensive understanding of materials and their syntheses as well as their properties using nanoscale phenomena such as quantum confinements to create multi-functional structures and devices is the key to success. R&D exploiting Nanoscience and Nanotechnology has the greatest potential to reach such challenging goals. Such ideas will be demonstrated by the thermodynamic modeling, low-cost aqueous design and fabrication of highly oriented crystalline arrays of metal oxide quantum dots and rods-based structures and devices with controlled orientation, size and shape onto various substrates designed at multiple scales by aqueous chemical growth at low-temperature along with the in-depth study of their electronic structure and quantum confinement effects performed at synchrotron radiation facilities and their applications for solar hydrogen generation and photovoltaics.

Born in 1968, he obtained his high school diploma in Mathematics and Life Sciences in 1986 in the Academy of Grenoble. He then moved to Paris and studied at the Université Pierre et Marie Curie where he received a BSc. and a MSc in Chemical Physics and a postgraduate diploma in Inorganic Chemistry in 1989, 1990, and 1991 respectively as well as a PhD in Chemistry in 1995 for his research work on *the Interfacial & thermodynamic growth control of metal oxide nanoparticles in aqueous solutions*. 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* as well as to characterize their electronic structure by x-ray spectroscopies at synchrotron radiation facilities. He has been carried out his research work as a visiting scientist at: the University of Texas at Austin; the UNESCO Centre for Macromolecules & Materials, Stellenbosch University, and iThemba LABS, South Africa; the Glenn T. Seaborg Center, Chemical Sciences Division, at Lawrence Berkeley National Laboratory; Texas Materials Institute; The Ecole Polytechnique Fédérale de Lausanne, Switzerland; the University of Queensland, Australia, and Nanyang Technological University, Singapore. He has also been an independent scientist at the National Institute for Materials Science, Tsukuba, Japan for 8 years. He has (co-)authored 115 publications (75 SCI) in major international journals and book series which have already generated over 10200 citations since the year 2000 (4560 since 2012, Google Scholar); Top 1% scientist in Materials Science. All time 8 ISI highly cited papers (5 as first author). He has been interviewed by In-Cites and by ScienceWatch (Thomson Reuters) in 2006 for a single-author original research paper cited now over 2650 times and again in 2010 for another of his highly cited paper in Chemistry. Two other first-and-corresponding author 2001 papers have already been cited over 1000+ times and 10 others over 200 times. He has given over 362 lectures: 177 talks at international conferences (48 plenary, 106 invited, 21 contributed, 2 tutorials) and 185 seminars at universities, governmental and industrial research institutes in 31 countries and acted as an organizer, chairman, executive program committee and advisory member for major international conferences (MRS, ACS, SPIE, IUPAC, ACerS, IEEE). He is currently a full time 1000-talent scholar Professor at Xi'an Jiaotong University, P.R. China and the co-founder and co-director of the *International Research Center for Renewable Energy* (340 publications and 6300 citations since 2011, 14 ESI Highly Cited Papers) funded by the National Science Foundation of China. He is also, since 2003, the founding editor-in-chief of the *International Journal of Nanotechnology,* a referee for 80 SCI journals as well as major funding agencies in North and South America, Europe, Asia, and Africa and a guest scientist at Lawrence Berkeley National Laboratory, Chemical Sciences Division. He's the recipient of the 2016 Chinese Goverment Friendship Award and one of most cited researcher in China in Materials Science in 2014, 2015, and 2016 according to Scopus/Elsevier.