

Loucas Tsakalacos

General Electric - Global Research Center

Application of Nanostructures to Next Generation Photovoltaics – Opportunities & Challenges from an Industrial Research Perspective

Abstract:

In the last decade there has been a significant interest in renewable energy systems. Solar energy conversion is of particular interest owing to the abundance of the source. Approximately 85% of today's commercial solar cells are based on crystalline Si (mean module efficiencies of 14-16%). The cost Si has until recently been generally higher than that of other technologies, though in the past year the prices have fallen significantly to a level that is close to competing technologies. The other ~15% of the PV market is based on thin films, which provide lower cost (<\$0.8/W) though with lower module efficiencies (9-14%). CdTe is the dominant thin film materials system, though Cu(In,Ga)Se₂ (CIGS) technology is beginning to make inroads in the market. Concurrently, the intersection of solar energy and nanotechnology research has flourished in the last 5 or so years. The above discussion highlights three key questions facing the solar energy field: 1) how can the efficiency of solar cells be increased to competitive levels with other energy sources?; 2) how can the cost of solar cells be decreased to a level suitable first for high penetration primary power generation?; 3) how can both of these goals be achieved in a single solar cell device and related manufacturing process? These questions lead to yet another question that is the central theme of this talk: can nanotechnology be used to address either of the above three questions from an industrial perspective, and if so, how [1]?

The presentation will explore the recent literature in the application of various classes of nanostructures to photovoltaics. These are classified as: (a) nanocomposites & nanostructured materials, (b) quantum wells, (c) nanowires & nanotubes, (d) nanoparticles & quantum dots. Both the potential advantages of each nanostructure approach, as well as the disadvantages will be discussed from an industrial perspective, with an emphasis on possible future areas of research interest. Parameters that will be considered are the potential efficiency, cost, reliability, manufacturing scalability, yield, and related parameters critical to ultimate successful deployment of a PV technology. An example from our own work on Si and III-V nanowire solar cells will also be described [2-4]. Examples of nanotechnologies currently in use at a commercial level will be also be discussed. Throughout the talk, cases in which the use of nanostructures may address issues of cost or can enhance the performance of conventional solar cells will also be highlighted. Various generic scientific challenges facing the use of nanostructures in PV, e.g. charge transport phenomena, surface recombination, etc. will also be given. The talk will conclude with a summary of the future prospects of using nanostructures in commercial PV applications.

- [1] L. Tsakalakos, Ed., Nanotechnology for Photovoltaics (Taylor & Francis Press, Boca Raton, 2010).
- [2] L. Tsakalakos, J. Balch, J. Fronheiser, B.A. Korevaar, O. Sulima, J. Rand, "Silicon nanowire solar cells," *Applied Physics Letters* **91**, 233117 (2007). [also published in *Virtual Journal of Nanoscale Science & Technology*]
- [3] L. Tsakalakos, J. Balch, J. Fronheiser, B.A. Korevaar, O. Sulima, J. Rand, "Silicon nanowire solar cells: device physics, fabrication, and optoelectronic properties", *Proc. 23rd European Photovoltaic Solar Energy Conversion Conference*, 1AP.1.3 (2008).
- [4] L. Tsakalakos, J. Balch, A Byun, J. Fronheiser, T.C. Kreutz, O. Sulima, S.P. Rawal, , J.J. Likar, "HIGH EFFICIENCY III-V MICRO/NANO-PILLAR SOLAR CELLS: BULK DEVICES & GROWTH ON METAL FOILS" *Proc. 25th European Photovoltaic Solar Energy Conversion Conference & 5th World Conference on Photovoltaic Energy Conversion* (2010).

Bio:

Loucas Tsakalakos is currently a Senior Scientist and Project Leader at the General Electric – Global Research Center in Niskayuna, New York. He received his BS degree (1995) from Rutgers University, and his MS (1998) and PhD (2000) degrees in Materials Science & Engineering from the University of California, Berkeley. His expertise is in the integration of heterogeneous thin film and nanostructured materials systems for micro and nano device applications, and also has extensive experience in the characterization of materials. Since joining GE Global Research in 2000, Dr. Tsakalakos has designed and implemented integrated electronic and sensor systems for defense applications, studied cathode materials for lighting applications, and is a founding team member of GE's Nanotechnology Program. A significant part of his research has focused on development of nanostructured materials and devices, primarily using nanowires/tubes, working with multi-disciplinary teams both within GE and in collaboration with external partners. He is currently leading programs in the area of advanced photovoltaics within GE Global Research's Solar Technology Platform, with interests both in long-term research on next-generation photovoltaic materials/devices and shorter-term R&D related to engineering of PV modules. He is a member of Tau Beta Pi (The National Engineering Honor Society); the author or co-author of over 30 journal, conference proceedings, and book chapter publications, as well as over 30 internal GE publications; has edited one book (on the topic of nanotechnology for photovoltaics) and also holds ten U.S. patents. Dr. Tsakalakos is an Associate Editor of the *Journal of Photonics for Energy*, and has given over 30 invited presentations at various international conferences, workshops, and institutions.