PHYSICS
COLORADO STATE UNIVERSITY

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One-Sun Multijunction Photovoltaics

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January 29, 2018 at 4 p.m.
120 Engineering (Hammond Auditorium)

Abstract

Multijunction solar cells are the first photovoltaic technology to surpass single-junction Shockley-Queisser theoretical efficiency limits, and represent the highest efficiency of any solar cell technology. Multijunction cells have historically been developed with single-crystal III-V and group-IV semiconductors, for space and terrestrial concentrator applications which can tolerate high costs per unit cell area. However, the multijunction cell concept for dividing the broad solar spectrum into narrower ranges, each of which can be converted more efficiently, is just as elegant a solution for one-sun, flat-plate terrestrial photovoltaic modules as well, provided low-cost absorber materials with the appropriate bandgaps can be found. Semiconductor materials that are inherently tolerant to recombination at grain boundaries and other defects are particularly intriguing as they hold the promise to enable low-cost growth methods for flat-plate multijunction modules.

This talk surveys multijunction cell technologies developed to date, their (largely single-crystal) semiconductor combinations, processes of subcell integration, their successes, and their challenges. Experience with these high-efficiency, but also high-cost multijunction cells is

then extended to look at potential low-cost, flat-plate multijunction module architectures and materials. One-sun terrestrial multijunction cell modules with much higher efficiency than their single-junction counterparts could have a game changing effect on the economics of solar electricity.

Richard R. King received his Ph.D. and M.S. in electrical engineering from Stanford University, and his B.S. degree in physics, also from Stanford. Dr. King is presently Professor in the School of Electrical, Computer, and Energy Engineering (ECEE), at Arizona State University. His research on photovoltaics over the last 30 years has explored defects and recombination in compound semiconductors, silicon and compound semiconductor interface passivation, metamorphic III-V materials, dilute nitride GaInNAs, sublattice ordering, high-transparency tunnel junctions, and high-efficiency multijunction solar cells with 3 to 6 junctions. In 2006, this work led to the first solar cell of any type to reach over 40% efficiency. Dr. King is the recipient of the 2010 William R. Cherry Award given by the IEEE for "outstanding contributions to photovoltaic science and technology." He is a co-founding editor of the IEEE Journal of Photovoltaics, an IEEE Fellow, Research Director of the NSF-DOE Engineering Research Center on Quantum Energy and Sustainable Solar Technologies (QESST), and served as general chair for the 40th IEEE Photovoltaic Specialists Conference in 2014.