3 AU. Currently available solar cells have uncertain performance under LILT conditions. NASA Glenn Research Center has initiated a program to evaluate solar cells under LILT conditions and to look for ways of enhancing their performance.

10.6.2 Quantum Dot Solar Cells

A recent approach to increasing the efficiency of thin-film PV solar cells involve the incorporation of quantum dots [55]. Semiconductor quantum dots are currently a subject of great interest mainly due to their size-dependent electronic structures, in particular the increased band gap and therefore tunable optoelectronic properties. To date these nanostructures have been primarily limited to sensors, lasers, LEDs, and other optoelectronic devices. However, the unique properties of the size-dependent increase in oscillator strength due to the strong confinement exhibited in quantum dots and the blue shift in the band gap energy of quantum dots are properties that can be exploited for developing PV devices that offer advantages over conventional photovoltaics. Theoretical studies predict a potential efficiency of 63.2%, for a single size quantum dot, which is approximately a factor of 2 better than any SOA device available today. For the most general case, a system with an infinite number of sizes of quantum dots has the same theoretical efficiency as an infinite number of band gaps or 86.5%. See Chapter 4 for a more complete discussion of quantum dots and theoretical efficiencies.

A collection of different size quantum dots can be regarded as an array of semiconductors that are individually size-tuned for optimal absorption at their band gaps throughout the solar energy emission spectrum. This is in contrast with a bulk material in which all photons with $E > E_g$ are absorbed at the same energy, that is, the band gap. Their excess energy $E - E_g$ is wasted. In addition, bulk materials used in solar energy cells suffer from reflective losses at energies about the band gap, whereas for individual quantum dots reflective losses are minimized. Some recent work has shown that quantum dots may offer some additional radiation resistance and favorable temperature coefficients [56].

10.6.3 Integrated Power Systems

NASA has also been working to develop lightweight, integrated space power systems on small-area flexible substrates [57]. These systems generally consist of a high-efficiency thin-film solar cell, a high-energy density solid-state Li-ion battery, and the associated control electronics in a single monolithic package. These devices can be directly integrated into microelectronic or micro-electromechanical systems (MEMS) devices and are ideal for distributed power systems on satellites or even for the main power supply on a nanosatellite. These systems have the ability to produce constant power output throughout a varying or intermittent illumination schedule as would be experienced by a rotating satellite or "spinner" and by satellites in a LEO by combining both generation and storage.

An integrated thin-film power system has the potential to provide a low-mass and low-cost alternative to the current SOA power systems for small spacecraft. Integrated thin-film power supplies simplify spacecraft bus design and reduce losses incurred through energy transfer to and from conversion and storage devices. It is hoped that this simplification will also result in improved reliability.