Table 10.1 Summary of existing space solar cell performance [15] obtained at AM0

Parameter	Silicon	High-efficiency silicon	Single-junction GaAs	Dual-junction III-V	Triple-junction III-V
Status	Obsolete	SOA	Obsolete	Nearly obsolete	SOA
Efficiency (%)	12.7–14.8	16.6	19	22	26.8
Operating voltage (V)	0.5	0.53	0.90	2.06	2.26
Cell weight (kg/m^2)	0.13–0.50	0.13–0.50	0.80–1.0	0.80–1.0	0.80–1.0
Normalized efficiency temperature coefficient at 28°C	−0.55%/C	−0.35%/C	−0.21%/C	−0.25%/C	−0.19%/C
Cell thickness (μm)	50–200	76	140–175	140–175	140–175
Radiation tolerance	0.66–0.77	0.79	0.75	0.80	0.84
Absorptance (ratio of absorbed radiant flux to the incident AM0 flux)	0.75	0.85	0.89	0.91	0.92

The ISS will have the largest PV power system ever present in space. It will be powered by 262 400 (8 cm × 8 cm) silicon solar cells with an average efficiency of 14.2% on 8 US solar arrays (each ∼34 m × 12 m) [13]. This will generate about 110 kW of average power, which after battery charging, life support, and distribution, will supply 46 kW of continuous power for research experiments. The Russians also supply an additional 20 kW of solar power to ISS.

Space solar cell research in the 1990s focused on the III-V and multijunction (MJ) solar cells that had higher efficiencies and were more tolerant of the radiation environment. Satellites continued to grow in both size and power requirements and structures were designed to deploy large solar arrays. The mass and fuel penalty for attitude control of these large arrays continued to drive the space photovoltaics community to develop more efficient cells. Costs for satellite power systems remained at about a $1000/W.

The Deep Space 1 spacecraft, launched in October 1998, was the first spacecraft to rely upon SCARLET concentrator arrays to provide power for its ion propulsion engines [14]. Concentrator arrays use either refractive or reflective optics to direct concentrated sunlight onto a smaller active area of solar cells. Deep Space 1 had two such arrays and each was capable of producing 2.5 kW at 100 V (DC). The SCARLET arrays were developed by AEC-ABLE Engineering, Inc., under a program sponsored by the Ballistic Missile Defence Organization (BMDO). These arrays performed flawlessly under this inaugural demonstration.

The state-of-the-art (SOA) space solar cells available today are triple-junction III-V semiconductor cells. However, high-efficiency Si cells are still utilized in a number of space applications. Table 10.1 summarizes the SOA in space solar cells [15].

10.2 THE CHALLENGE FOR SPACE SOLAR CELLS

A team from NASA, Department of Energy (DOE), and the Airforce Research Laboratory (AFRL) engineers recently reviewed the power technology needs of mid- and