9.9.3 Terrestrial Spectrum

The GaInP/GaAs/Ge cells that are currently produced in high volume for space applications require only minor modifications for terrestrial use. Specifically, under concentrated sunlight, the series resistance must be reduced (as discussed above). And because the direct terrestrial spectrum includes less blue light than the AM0 spectrum, the GaInP cell should be thicker so that it generates a photocurrent that approximately equals that generated by the GaAs junction. There is evidence that the AM1.5 direct reference spectrum is seldom observed in locations that are well suited for concentrators [152]. The AM1.5 global reference spectrum is sometimes observed, but more frequently the spectra lie between these two.

The direct spectrum observed at solar noon is usually richer in short-wavelength light, especially when compared with the AM1.5 direct reference spectrum. Therefore, optimization of the performance at solar noon is slightly different than the optimization for annual electricity production. The Module Energy Rating (MER) Procedure (Chapter 16) addresses this question by defining hourly data for different types of days. The highest performance over a day depends on the location, but may be found when cells are optimized for a spectrum between the AM1.5 global and AM1.5 direct spectra [153]. If the performance early and late in the day is the most important, then thicker top cells are better. However, the increased performance late in the day will reduce the power generated at the times when the most power is available; so this is a trade-off that must be evaluated relative to the application.

The sensitivity of the multijunction structures to variable spectrum has been studied theoretically [21, 29], but not yet experimentally. Modeling of the system performance for concentrators using multijunction cells will be more difficult than modeling Si-based modules because of the spectral sensitivity, but the temperature sensitivity is reduced.

Fundamentally, there should be no difficulty with the lifetime of the cells, but in practice, the need for encapsulation and the complexity of the device structure (tunnel junctions and/or use of Ge substrate, which can cause a higher defect density) could lead to challenges in achieving reliable, manufacturable modules.

REFERENCES

1. Olson J, Gessert T, Al-Jassim M, *Proc. 18th IEEE Photovoltaic Specialists Conference*, 552–555 (1985).
2. Fan J, Tsaur B, Palm B, *Proc. 16th IEEE Photovoltaic Specialist Conf.*, 692 (1982).
3. Olson J, Kurtz S, Kibbler A, *Proc. 18th IEEE Photovoltaic Specialists Conference*, 777 (1988).
4. Kurtz S, Olson J, Kibbler A, *Sol. Cells* **24**, 307 (1988).
5. Kurtz S, Olson J, Kibbler A, *Appl. Phys. Lett.* **57**, 1922–1924 (1990).
6. Olson J, Kurtz S, Kibbler A, Faine P, *Appl. Phys. Lett.* **56**, 623–625 (1990).
7. Kurtz S, Faine P, Olson J, *J. Appl. Phys.* **68**, 1890 (1990).
8. Bertness K *et al*., *Appl. Phys. Lett.* **65**, 989–991 (1994).
9. Friedman D *et al*., *Prog. Photovolt.: Res. Appl.* **3**, 47–50 (1995).
10. Kurtz S *et al*., *Proc. 1st World Conference on PV Energy Conversion*, 2108 (1994).
11. Yamaguchi M, Wakamatsu S, *Proc. 25th IEEE Photovoltaic Specialists Conference*, 9–11 (1996).