N89-24720

Deployable Aerospace PV Array Based on Amorphous Silicon Alloys

Joseph J. Hanak, Lee Walter, David Dobias and Harvey Flaisher
Sovonics Solar Systems, Inc.
a Subsidiary of Energy Conversion Devices, Inc.
1100 West Maple Road
Troy, MI 48084

Summary

We report the development of the first commercial, ultralight, flexible, deployable, PV array for aerospace applications. It is based on thin-film, amorphous silicon alloy, multijunction, solar cells deposited on a thin metal or polymer by a proprietary, roll-to-roll process. The array generates over 200 W at AM0 and is made of 20 giant cells, each 54 cm x 29 cm (1566 cm^2 in area). Each cell is protected with bypass diodes. Fully encapsulated array blanket and the deployment mechanism weigh about 800 g and 500 g, respectively. These data yield power per area ratio of over 60 W/m^2, specific power of over 250 W/kg (4kg/kW) for the blanket and 154 W/kg (6.5 kg/kW) for the power system. When stowed, the array is rolled up to a diameter of 7 cm and a length of 1.11 m. It is deployed quickly to its full area of 2.92 m x 1.11 m, for instant power. Potential applications include power for lightweight space vehicles, high altitude balloons, remotely piloted and tethered vehicles. These developments signal the dawning of a new age of lightweight, deployable, low-cost space arrays in the range from tens to tens of thousands of watts for near-term applications and the feasibility of multi-100 kW to MW arrays for future needs.

Extended Abstract

This report describes the development of an ultralight, deployable, photovoltaic (PV) array for aerospace applications, having performance capabilities one order of magnitude beyond the state of the art. Sovonics' approach in the design of this commercially available array is to use proprietary Ultralight^{TM} monolithic modules which are extremely lightweight, flexible, stowable and damage tolerant [ref.1]. They are based on thin-film, amorphous silicon alloy, tandem-junction solar cells deposited on a thin metal or polymer by a roll-to-roll process. The array structure is formed by patterning of continuous sheets of the solar cell material into a matrix of cells interconnected in series and parallel.

The specific objective was to design and fabricate a commercial PV array generating 200 W at AM0 for applications in lightweight space vehicles and high altitude balloons. The array design which was used in successful fabrication consisted of 20 giant solar cells, each measuring 54 cm x 29 cm (1566 cm^2 in area). Each cell is fully protected with bypass diodes to prevent damage upon partial shading or cell mismatch. The array is stowable, deployable and self-supporting upon deployment. Fully encapsulated array blanket and the deployment mechanism weigh 800 g and 500 g, respectively. These performance characteristics include a power per area ratio of 60 W/m^2, specific power of 250 W/kg (4kg/kW) for the blanket and 154 W/kg (6.5 kg/kW) for the power system, including the array and the deployment and support mechanism. This system performance is at least one order of magnitude higher than any known aerospace PV power system. The use of the giant cells has been made possible by the recent Sovonics development of a novel means of eliminating all shorting defects between the top and bottom electrodes, which makes possible the fabrication of single cells of virtually unlimited area.

When stowed, the array is rolled up to a diameter of less than 7 cm and a length of 1.11 m. It can be deployed quickly to its full area of 2.92 m x 1.11 m. The array is suitable for applications such as lightweight space vehicles, high altitude balloons, remotely piloted vehicles and tethered vehicles. Extension to higher power arrays is readily achievable.

Higher array power density can be anticipated for future arrays by utilizing other technological achievements which have been reported by Sovonics. These include active area conversion efficiency of 13% at AM1.5 and 10% at AM0 for triple-junction, dual-gap test cells, and a specific power of 2.4 kW/kg and power-to-volume ratio of 6.4 MW/m^3 for 10-watt unencapsulated modules. These devices are well suited to a space environment since it has also been shown that they have a 50 to 100 times higher resistance to MeV proton radiation for a-Si alloy cells than for silicon and GaAs crystalline cells.

The development of this first commercial amorphous silicon alloy aerospace PV array signals the arrival of a new generation of very lightweight, deployable, low-cost arrays in the range from tens to tens of thousands of watts for near-term applications and the feasibility of PV arrays in the multi-100 kW to MW range for future space needs.

One such array had the following AM0 performance data calculated from results measured at AM1.5 and temperature of ca. 35°C: Power = 207 watt

V_{mp} = 25 V
I_{mp} = 8.3 A
Fill factor = 0.57

where mp denotes the maximum power point.

* This work was sponsored in part by the Defense Nuclear Agency under RDT&E RMSS Code B 4693 C RL RB 00046 RAEV 3230 A B 7660 D SF SB 00043 RAEV 3230 A.

References

[1] J. J. Hanak, Englade Chen, C. Fulton A. Myatt, and James R. Woodyard, "Ultralight Amorphous Silicon Alloy Photovoltaic Modules for Space Applications", NASA Conference Publication 2475, *Space Photovoltaic Research and Technology (SPRAT)*, (1986).