RECENT DEVELOPMENTS IN LIGHTWEIGHT SOLAR CELL MODULES

J. D. Broder and A. F. Forestieri
NASA Lewis Research Center
Cleveland, Ohio

SUMMARY

Two types of lightweight solar cell modules have been prepared. The goal is to achieve a module with a power to weight ratio of 350 watts per kilogram. Both structures use thin cells approximately 50 micrometers thick and glass covers approximately 75 micrometers thick. In one structure the glass is bonded to the module using 93-500 silicone adhesive; while the other relies on heat and pressure bonding using FEP as the adhesive. Specific powers of about 335 watts per kilogram have been achieved.

INTRODUCTION

Some future space missions will require solar cell modules with high power to weight ratios. The use of lightweight materials is necessary to achieve this goal. The 50-micrometer-thick cell forms the basis of the modules prepared in this program. These cells still require a protective cover to reduce the harmful effects of trapped electrons and protons. To minimize the weight and still protect the cells, only the thinnest available cover glasses were considered. In this program the recently available 50- to 75-micrometer-thick 7070 glass was used. Substrate and support materials were also chosen from among the thinnest available and included 7.5-micrometer-thick Kapton, 25-micrometer-thick fiberglass, and 12.5- and 25-micrometer-thick FEP. Also of importance towards achieving the high specific power goal is the use of thin interconnect material, in this case, 12.5-micrometer silver (ref. 1). The two structures will be discussed in this paper.

The 93-500 Bonded Module

The first attempt to prepare a lightweight module made use of 93-500 as the glass-to-cell adhesive. The module was prepared using parallel-gap welding to interconnect thin cells into a three-by three configuration and available 50-micrometer silver plated Invar interconnects. Gently abraded 25-micrometer Kapton was used as the substrate. A one piece 65- by 65-millimeter 7070 glass cover was attached to the nine cells using 93-500 adhesive. Standard aerospace technology was used in fabricating the module.

Since mechanical sample cells were used for the module, no electrical measurements were made. However, the module weighed 2 grams, and the thickness in the central portion was about 215 micrometers. The thickness at the interconnect was 265 micrometers. It is expected that a module using 12.5-micrometer silver interconnects instead of the 50-micrometer Invar would be more uniform in thickness across the whole module. A schematic of a structure using thin interconnects is shown in figure 1.

FEP Bonded Module

This module was assembled by parallel-gap welding 12.5-micrometer silver interconnects to 50-micrometer cells in a three-by-three configuration. 25-micrometer-thick fiberglass cloth and 7.5-micrometer-thick Kapton together with 12.5 micrometer thick FEP-C formed the substrate of this module. The remaining components included a 25-micrometer layer of FEP-A, another layer of 12.5-micrometer-thick FEP-C, and a one-piece 75-micrometer-thick, 65- by 65-millimeter 7070 cover glass. A schematic of this structure is shown in figure 2. The technique for preparing this module is substantially the same as described in reference 2. After fabrication, the module was trimmed, weighed, and its electrical performance measured. Figure 3 shows the module and its current-voltage (I-V) characteristic. The module weighs approximately 2.07 grams and has a power to weight ratio of 335 watts per kilogram. It is noteworthy that the interconnected module efficiency was over 14 percent based on solar cell active area. The average thickness of the module between contacted areas is about 222.5 micrometers and at the contacts about 232.5 micrometers.

In addition to the advantage in weight saving gained by using the 12.5-micrometer silver interconnect, another advantage is in reduced glass breakage at the top contact areas. Before the use of 12.5-micrometer silver interconnects, the glass cover would break at the top contact. Since the 12.5-micrometer silver interconnect was introducted, several modules have been prepared with no cracking whatsoever.

CONCLUDING REMARKS

Two methods of preparing lightweight solar cell modules capable of achieving a specific power of 350 watts per kilogram have been demonstrated. Both methods use the new approach of covering several cells (nine) with a single large piece of thin glass. This approach also demonstrates that there should be no difficultly in covering the new large area solar cells, currently under development, with a single piece of thin glass.

Another key technique for achieving the high power to weight ratios is the use of 12.5-micrometer silver interconnect material. Considerable testing has yet to be done to prove that the methods, materials, and techniques described here are space qualified. However, the materials and technologies used in this program were chosen because of their past good performance in space arrays.

The advent of high specific power modules should now lead to high specific power solar cell blankets and thence to arrays. Several of the techniques described (single large piece of glass and FEP adhesive) should also be instrumental in reducing the cost of future solar cell arrays.

REFERENCES

1. LaRoche, Guenther J.: Ultrathin Cell Module Technology. Photovoltaic Generators in Space. ESA SP-147, European Space Agency, 1980, pp. 21-27.
2. Forestieri, A. F.; and Broder, J. D.: Improvements in Silicon Solar Cell Cover Glass Assembly and Packaging Using FEP Teflon. NASA TM X-52875, 1970.

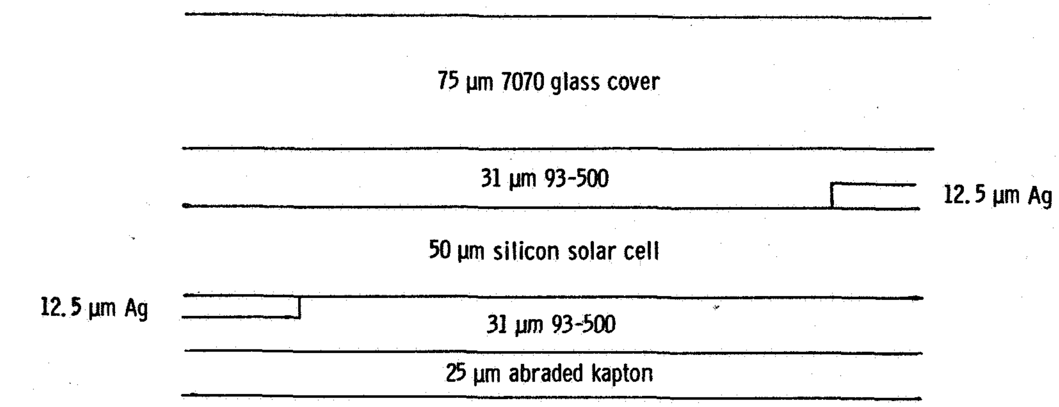

Figure 1. - Thin module build-up with 93-500.

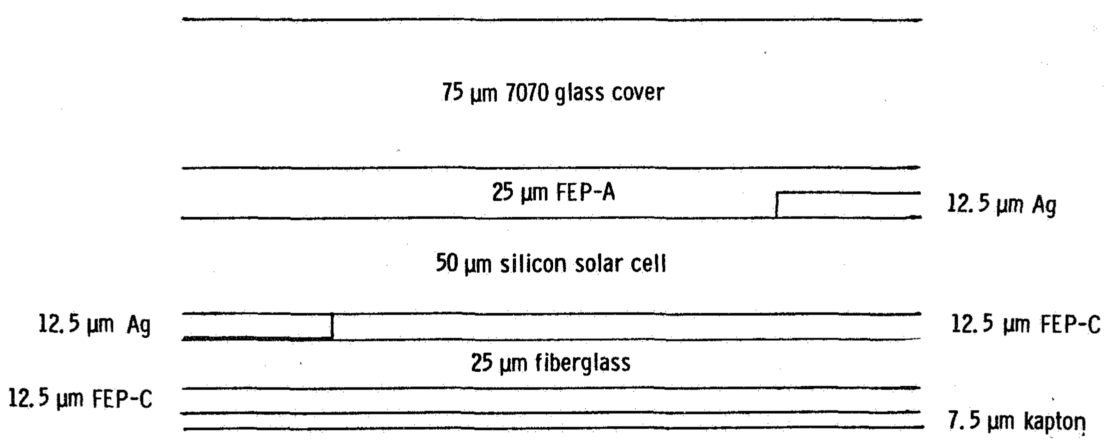

Figure 2. - Thin module build-up with FEP.

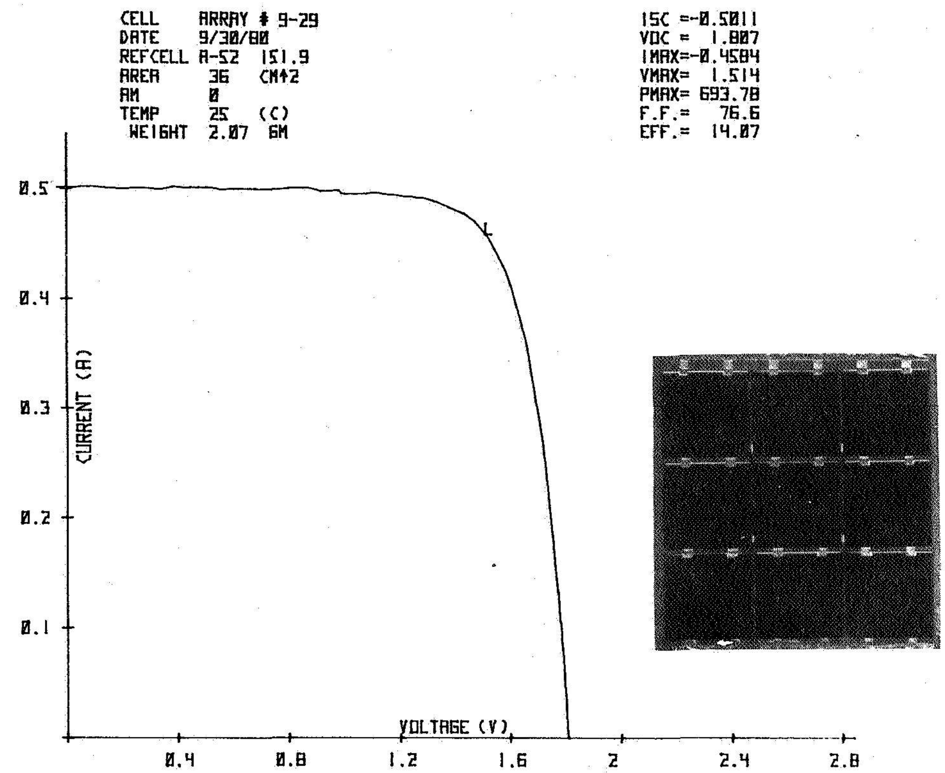

Figure 3. - 335-watt-per-kilogram module.