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Spaceflight Performance of Several Types of Silicon Solar Cells on the LIPS III Satellite

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Results from exposure of several types of Solarex silicon solar cells to a space environment for nearly two years on the LIPS III satellite are presented. Experiments include standard thickness (10 mil) cells with and without back surface fields, and ultrathin (2 mil) cells also with and without back surface fields. A comparison between a widely used coverslide adhesive, DC 93-500, and a potential alternate is also presented.

The major findings from the data are that the 2 mil cells without a back surface field show the smallest normalized short circuit current degradation and that the 10 mil back surface field cells show the greatest absolute power output for the radiation exposures and temperatures encountered. The new encapsulant (McGhan Nusil CV-2500) exhibits a degradation comparable to DC 93500.

A comparison is made with each of the cell types in this experiment with expectations based on JPL Radiation Handbook data.

Description of Experiments

Ten 2 x 2 cm Solarex silicon solar cells were launched on the LIPS III spacecraft into a nearly circular 1100 km orbit in the spring of 1987, reference 1. Two cells from each of the following groups were included: a) 10 mil BSF (with DC 93-500 adhesive); b) 10 mil BSFR (with McGhan Nusil CV-2500 adhesive); c) 10 mil BSR; d) 2 mil BSFR; e) 2 mil BSR. All of the cells had dual layer antireflective coatings, 12 mil coverslides attached to the cell using DC 93-500 except for b), and titanium/palladium/silver contacts. Each of the cells were fabricated using silicon with 10 ohm-cm bulk resistivity and had an aluminum reflector on the back surface.

Current-voltage characteristics for each of the cells were monitored throughout a 650 day period along with cell temperature and solar constant correction factors. As has been reported for other LIPS III data, reference 2, anomalous fluctuations in current were observed for each of the groups. However, relative comparisons between each of the groups and expectations for each of the groups can be made.

Results

Measured short circuit current degradation with time in orbit is shown in Figures 1-4. The data is corrected for variations in solar constant and temperature. Expected

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degradation curves based on a fluence of 2.28 x 1013 equivalent 1 MeV electron/cm2 fluence per year are shown for each cell type (except for the 2 mil BSR for which no data was available).

As expected, the 2 mil cells show the smallest normalized short circuit current degradation. The 10 mil BSF cells show the greatest relative power degradation. However, for the radiation levels and temperatures encountered in orbit, the 10 mil BSFR cells still maintain the highest total power output. Since the 10 mil BSR cells do not have a back surface field, their relative current output degraded more slowly than the BSFR cells. Both solar cell/coverslide adhesives used for the 10 mil BSFR cells performed comparably.

Solarex vertical junction cells were also present on this spacecraft. This carries special significance as it is the first successful flight test of covered vertical junction cells and demonstrates the effectiveness of a new covering technique. As reported previously, reference 3, these cells showed comparable degradation to planar 10 mil BSFR cells for the environmental conditions seen to date. The vertical junction cells, however, are expected to be capable of improved relative power output as radiation fluence levels increase.

All of the Solarex cells in this experiment have survived 9599 thermal cycles as of this writing with no observed failures.

References

J. G. Severns, R. M. Hobbs, N. P. Elliott, R. H. Towsley, R. W. Conway and G. F. Virshup, "LIPS III-A Solar Cell Test Bed in Space", 19th IEEE Photovoltaic Specialist Conference, 1988, p. 801.

J. G. Severns, R. W. Conway, B. J. Faraday and R. M. Hobbs, "Flight Experience with LIPS-III", 24th IECEC Proceedings, 1989, p. 399

R. L. Statler, "The Effects of Space Environment on Silicon Vertical Junction Solar Cells on the LIPS-III Satellite", 24th IECEC Proceedings, 1989, p. 405.

Fig. 1

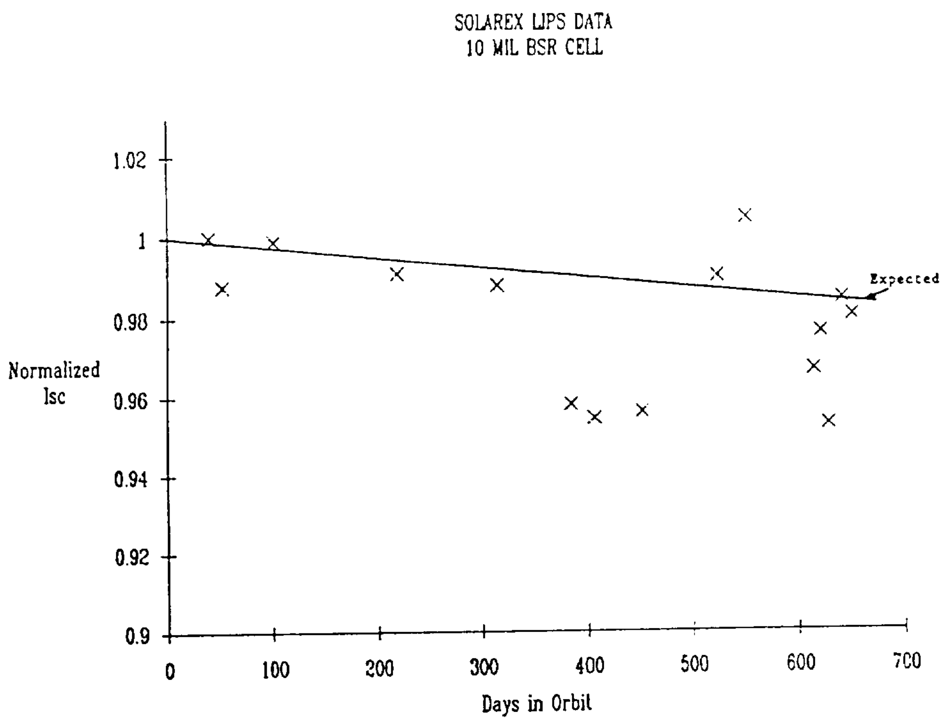

SOLAREX LIPS DATA
10 MIL BSR CELL
Normalized
Isc
1.02
1
0.98
0.96
0.94
0.92
0.9
0
100
200
300
400
500
600
700
Days in Orbit
Expected

Fig. 2

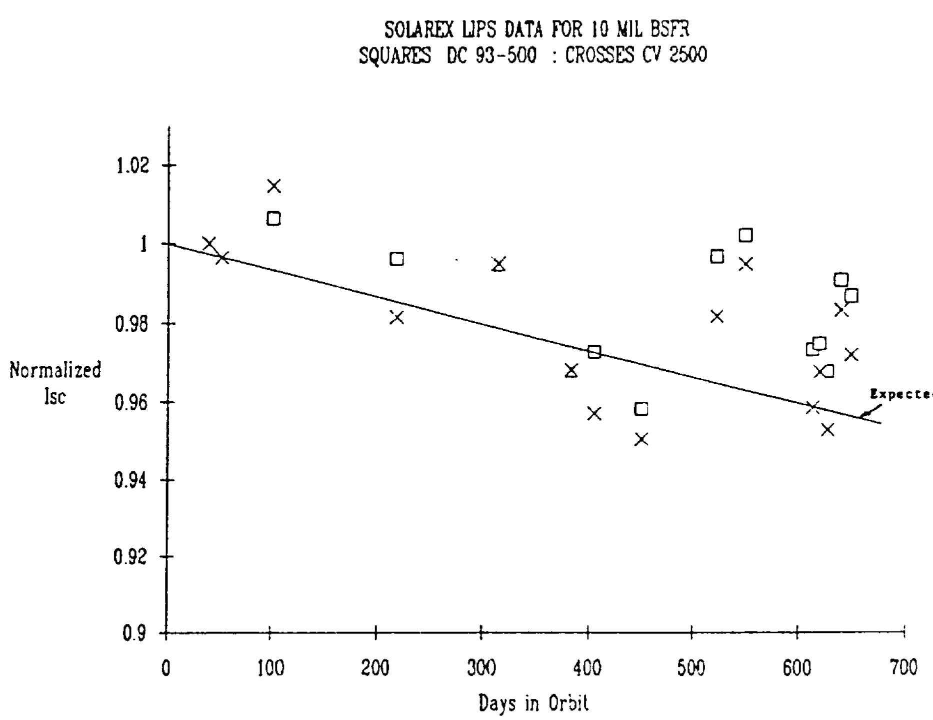
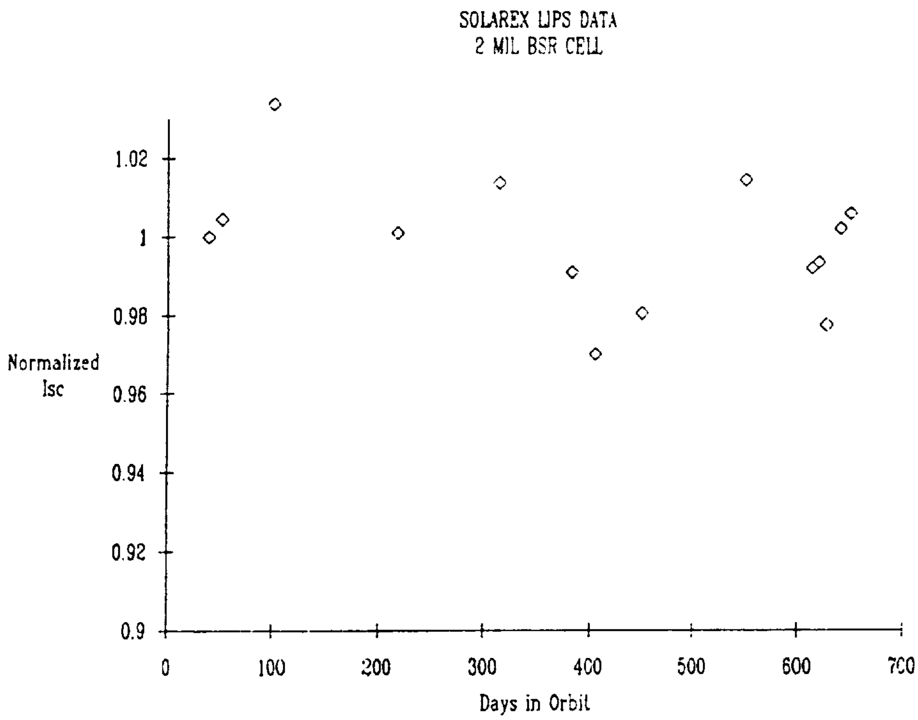

SOLAREX LIPS DATA FOR 10 MIL BSFR
SQUARES DC 93-500 : CROSSES CV 2500
Normalized
Isc
1.02
1
0.98
0.96
0.94
0.92
0.9
0
100
200
300
400
500
600
700
Days in Orbit
Expected

Fig. 3


SOLAREX LIPS DATA
2 MIL BSR CELL
Normalized Isc
1.02
1
0.98
0.96
0.94
0.92
0.9
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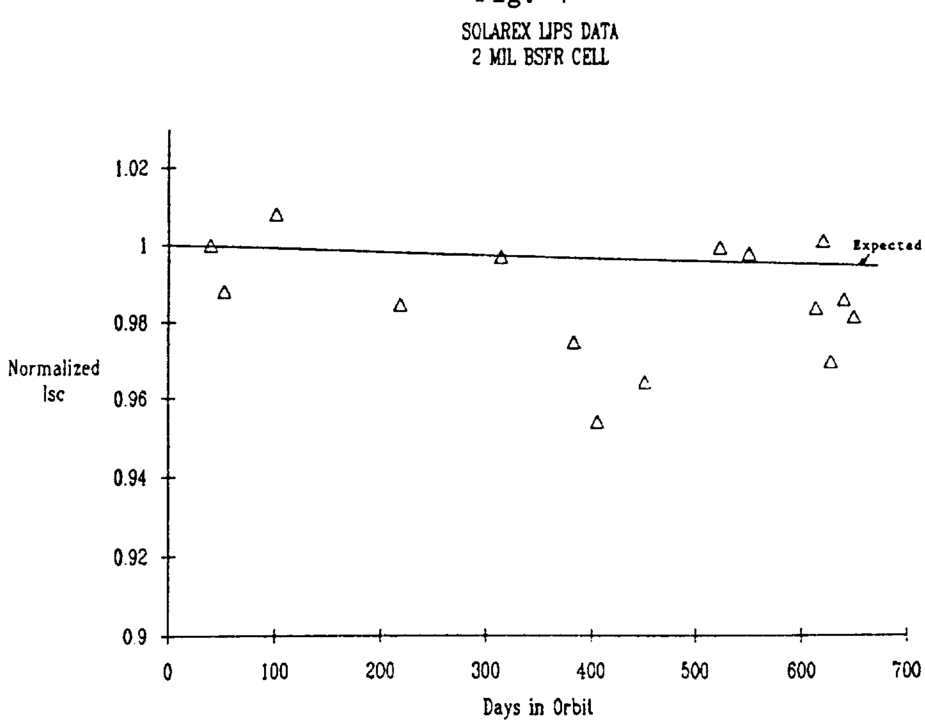
100
200
300
400
500
600
700
Days in Orbit

Fig. 4


SOLAREX LIPS DATA
2 MIL BSFR CELL
Normalized Isc
1.02
1
0.98
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Expected
0
100
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