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SPACE ENVIRONMENT WORKSHOP

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The Space Environment Workshop started its deliberations by ranking the various environmental effects according to their perceived importance. Figure 1 is a semi-quantitative summary of the result. Obviously, the relative importance of any particular environmental component listed must be viewed within the context of the anticipated mission environment. Nonetheless, the chart does serve as an indication of what have historically been the major environmental concerns for operating space power systems. The workshop presented its findings in a question and answer format, which is reproduced here with minimal editing.

RADIATION EFFECTS:

Silicon Technology-

Are high-efficiency, low-resistivity silicon cells suitable for high-radiation orbits?

Conclusion:

They are not suitable in their present state.

Recommendation:

The silicon cells are promising enough to warrant further research.

Areas to investigate:

(1) New base dopants
(2) Base thickness
(3) Dopant (p^+) profiles
(4) Low-resistivity MVJ cell (perhaps)

Is the BOL efficiency of back-illuminated, high-resistivity cells ($\rho \geq 500$ Ω-cm) high enough?

Conclusion:

No, but if the BOL performance can be raised to 14 to 15 percent, then its radiation resistance makes it very competitive.

Recommendation:

Improve fabrication techniques and make cells thinner.

Gallium Arsenide Technology-

What environmental considerations are important in GaAs structures?

Conclusions:

(1) Radiation resistance of n on p versus p on n GaAs cells needs to be explored on cells of both type that are optimized for radiation resistance.

(2) 1-MeV electron data are suitable for evaluating GaAs cells, but more electron energy dependence data are needed in order to define cell limitations.
(3) More work is needed in omnidirectional proton environments (at variable energies).

Area of concern:
As the efficiency of GaAs cells is optimized, will new radiation damage mechanisms dominate their low fluence response?

Multibandgap Cells-
What is the radiation performance of multibandgap cells?

Conclusion:
Since relatively little is known, we urge the community to make available state-of-the-art samples for testing and evaluation.

Other Cell Technologies-

Areas to investigate:

Thin films
(1) Amorphous silicon cells
(2) $CuInSe_2$ cells
Geometries
(1) Superlattice structures
(2) Ultrathin cells
Other materials
(1) Lithium counterdoping
(2) Indium phosphide
(3) Other high absorption materials

What other methods can improve power system performance in high radiation orbits?

Conclusions:
(1) Annealing is an acceptable approach if temperatures can be kept compatible with array materials.
(2) Concentrators help by shielding cells if optical surfaces are hard.
Recommendation:
NASA should look at ultralightweight radiation resistant concentrators.

UV RADIATION:

What problems does UV pose for power systems?

Conclusions:
(1) UV still presents problems for some coverglass/adhesive systems.
(2) UV may be a problem for coatings that may be required to harden dielectric surfaces against atomic oxygen and charging/arcing phenomena in plasma.

ATOMIC OXYGEN:

Conclusion:
Atomic oxygen is potentially a severe problem for array materials in LEO.

Recommendations:
(1) A basic materials studies approach is needed to understand the nature and extent of the problem.
(2) Develop better ground simulation techniques.

PLASMA EFFECTS:

Conclusion:
Plasma effects (leakage, arcing, EMI) are a serious power system problem.

Area of concern:
Size of test articles being flown may lead to different conclusions than would be the case if large arrays were flown.

Recommendation:
Prepare an experiment to fly a large test sample (>10 m^2) in order to determine scalability of small specimen results.

THERMAL CYCLING:

Area of concern:
What are the effects of mismatched intersections of multiple bandgap cells?

Recommendation:
Photovoltaic community should make state-of-the-art specimens available for evaluation.

ADDITIONAL RECOMMENDATIONS IN AREAS OF UV RADIATION, ATOMIC OXYGEN, PLASMA EFFECTS, AND THERMAL CYCLING:

Recommendations:
Begin development of coatings/materials with following properties:
(1) Good thermal emittance
(2) Resistant to UV
(3) Resistant to atomic oxygen
(4) Conductive

Approach should be more basic than simply a quick fix for existing materials if 20-year lifetime is to be achieved.

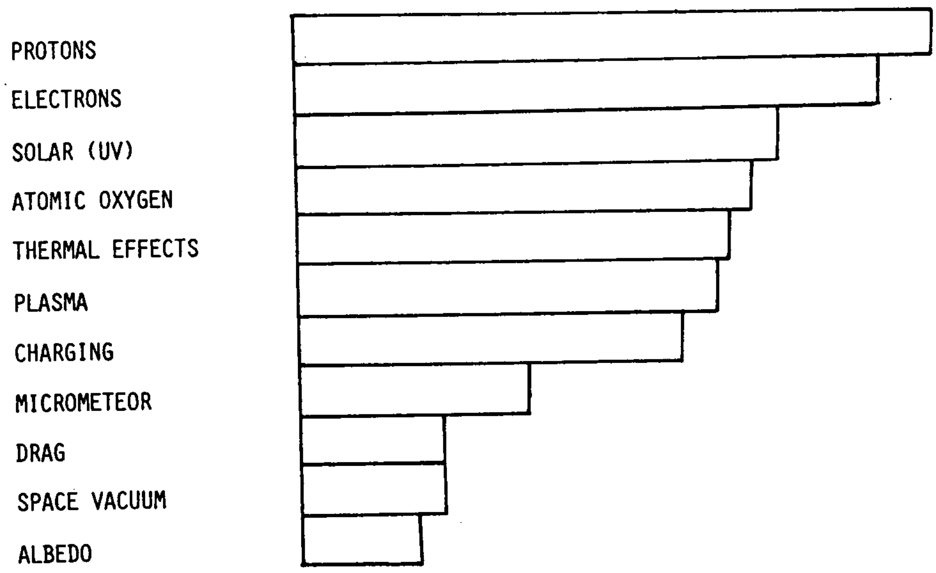

Figure 1. - Environment importance survey.