NASA TECH BRIEF

NASA Pasadena Office

Performance of Silicon Solar Cell Assemblies

The results of a comprehensive investigation of the actual performance of solar panels have been compiled in report form. The program of investigation was designed to assess the performance of three solar panel design approaches suitable for use at high solar intensities (Venus-Mercury flyby), but voluminous data in the report is of value to all users of solar cells, especially for design of terrestrial standby power systems which employ flat panels.

Six types of solar cells and nine types of coverglass assemblies were selected for study of their electrical and thermal-optical properties. The solar cells were arranged in two major groups: (1) standard 2- and 10-ohm-cm production cells, (2) experimental 2- and 10-ohm-cm wide-grid cells with enlarged grid lines designed to serve as second-surface mirrors. The cover glasses were arranged in three groups: (1) standard blue and blue-red interference filters and antireflective coatings on fused silica flats; (2) experimental selective-bandpass interference filters on fused silica; (3) experimental partially-mirrored coverglasses with blue filters and antireflective coatings. Assemblies were fabricated by cementing the glass covers to the cells with room-temperature-vulcanizable adhesive of the kind used in earlier space missions.

The current-voltage characteristics of fourteen silicon cell—cover glass combinations were determined at 25 temperature—incident energy combinations ranging from —40° to 160°C (in 20-degree increments) and 140 to 850 mW/cm^2; the high temperatures were used with high fluxes of incident energy to simulate conditions of operation when solar panels are within 0.4 AU of the sun. The short-circuit current, open-circuit voltage, and maximum power point were extracted and reduced with the aid of a computer programmed to average the data for each cell assembly type. In addition, the standard deviations and 95% confidence limits were determined. For each cell type, plots are given in the report to show the dependence of cell efficiency on temperature and intensity of illumination and a curve shape factor which expresses the "squareness" of the current-voltage (I-V) curve as a function of temperature and intensity.

The functions of ϕ (T) and ψ (S), which represent the dependence of cell efficiency on temperature T and intensity S, respectively, were determined by minimizing, in a weighted least squares sense, the difference between the maximum power measurements and the power defined by the function:

$$P(S, T) = P(1 \text{ sun}, 60°C)\, \phi(T)\, \psi(S)\, S.$$

This procedure results in uncoupling the effects of temperature and intensity on maximum power and allows them to be examined separately. Thus, characteristics such as a decrease in cell efficiency at high solar intensity due to a high series resistance are clearly displayed.

The curve shape factor which depicts the "squareness" of the I-V curve is defined as the ratio of maximum power to the product of short-circuit current and open-circuit voltage. Ideally, with a rectangular I-V curve, the curve shape factor will be one. Thus, the extent to which the curve shape factor is less than one indicates the degree of rounding of the knee of the I-V curve.

The thermal radiation properties of solar cell-coverglass combinations and solar cell modules were also measured to obtain data useful for correlation of observed performance and as design data for thermal

(continued overleaf)

control of spacecraft solar panels. The effects of ultraviolet and particulate irradiation (predominantly protons with a mixture of alpha particles) were also determined in 500- and 2400-hour tests. The results of a brief study of adhesives for solar cell fabrication are included in the report.

Note:

The following documentation may be obtained from:

National Technical Information Service
Springfield, Virginia 22151
Single document price $3.00
(or microfiche $0.95)

Reference:

JPL Technical Memorandum 33-473 (N71-23780), Measured Performance of Silicon Solar Cell Assemblies Designed for Use at High Solar Intensities.

Source: Ronald G. Ross, Jr., Robert K. Yasui, Wiktor Jaworski, Liang-Chi Wen, and Edward L. Cleland of Caltech/JPL under contract to NASA Pasadena Office (NPO-11847)