February 1975 B74-10301

NASA TECH BRIEF

NASA Pasadena Office

Thermoelastic Analysis of Solar Cell Arrays and Their Material Properties

An analytical procedure has been developed for predicting failures resulting from thermally induced stresses in silicon solar cell arrays. The work is published in a report entitled "Thermoelastic Analysis of Solar Cell Arrays and Their Material Properties". Using this procedure, designers can predict potential cell failures and correct them prior to proceeding with costly and elaborate test programs.

The report begins with a discussion of an experimental test program in which five different solar cell array designs were evaluated by subjecting them to 60 thermal cycles from -190° C to 0.0° C. The purpose of the test was to: (a) determine the capability of various adhesives, interconnector geometries and materials for both solderless and solder-coated cells to meet extreme thermal environments; and (b) verify the analytical approach.

Test results indicate that certain failures are associated with specific configurations. In solder-coated cells, the most prevalent failure is due to hairline fractures developed between the n-interconnector and the solder joint fillets. These fractures cause poor electrical performance. Another failure is delamination that is characteristic of configurations in which dimethyl-silicone adhesive is used between the filter cover and the silicon cell. The delamination is accompanied by extensive deformation of the adhesive.

Next, the analytical approach is carried out by making extensive measurements of the temperature-dependent thermal and mechanical properties of the solar cell materials. Results of these measurements are included in the report for the temperature ranges -200° C to +200° C for the filter glass, p- and n-type silicon, interconnector metals, solder, and several silicone rubber adhesives. With these material properties, a general purpose computer program is used to calculate the stress distribution in the cell components as a function of temperature. A number of illustrations are included in the text to indicate cell configurations and behaviors of various materials under thermal stresses.

Results of the analysis indicate that solder-coated cells combined with Kovar n-interconnectors and p-interconnectors are more durable under thermal loading than the other configurations. Additional findings are that at low temperatures methyl-phenyl-type, RTV (room-temperature-vulcanizing) silicone adhesives are more durable than the dimethyl type. Good agreement was found between the type of failures predicted by the analysis and those found from the test program.

There are two appendix sections: One presents the computer program, and the other discusses mechanical property specimen preparation and the test procedure for single-crystal silicon.

(continued overleaf)

Notes:

1. The following documentation may be obtained from:
   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $5.25
   (or microfiche $2.25)
   Reference: NASA CR-135713 (N73-31993), Thermoelastic Analysis of Solar Cell Arrays and Their Material Properties
2. Technical questions may be directed to:
   Technology Utilization Officer
   NASA Pasadena Office
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B74-10301

Patent status:

NASA has decided not to apply for a patent.

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NASA Pasadena Office
(NPO-13458)

Categories: 03 (Physical Sciences)
02 (Electronics - Components and Circuitry)
04 (Materials)
06 (Mechanics)