SUMMARY OF GaAs SOLAR CELL PERFORMANCE AND RADIATION DAMAGE WORKSHOP

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The workshop considered the GaAs solar cell capability and promise in several steps:

(1) Maximum efficiency
(2) Space application
(3) Major technology problems
  (a) AR coating optimization
  (b) Contacts
(4) Radiation resistance
(5) Cost and availability
(6) Alternatives

The workshop believes that GaAs solar cells are fast approaching the fulfillment of their potential as candidates for space cells. A maximum efficiency of 20 to 31 percent AMO can be reasonably expected from GaAs based cells, and this may go a little higher with concentration. The use of concentration in space needs to be more carefully evaluated.

The space application of the cells seems quite justified in view of the high efficiency and the good radiation damage data obtained to date. However, more extensive testing of the cells is necessary before they can be space qualified for use in actual space missions. Some small-scale flight tests have to be conducted following a rigorous qualification scheme before the cells will be easily accepted by the space system community. The exact way to achieve this desirable result has to be developed.

The major technological problems that need to be solved are the electrical contacts to the cells (metallurgy, bonding, and interconnect problems) and the optimization of AR coating. The reliability of both the contacts and the AR coating under all possible environmental conditions likely to be encountered in actual missions (humidity, temperature, shelf life) and their acceptability for all process variables (especially bonding and panel interconnect and panel deployment during launch and life in space) are still a serious concern and need to be evaluated. Some of these are engineering problems and would need a supply of cells made under well-controlled conditions to ensure the cell's uniformity and reproducibility."Research" cells would not be adequate to meet this need.

The AR coating problem is still somewhat open. The best known candidate that has been most in use is Ta_2O_5. This material has been space qualified for Si cells and is reasonably satisfactory for the heterostructure cells with (AlGa)As as a window layer. However, an oxide, even though refractory, may have limitations in (AlGa)As and needs to be looked at more carefully. Alternatives, such as Si_3N_4 and TiO_x are still to be fully evaluated. Silicon nitride may have special value and has been used on a research basis, especially with the homojunction cells developed by Lincoln Laboratory, MIT.

The homojunction cells produced by CVD have several attractive features and need to be examined carefully for their potential. They offer the n on p structure, and, since they are being produced by CVD, can be fabricated on Ge and possibly on other substrates. The CVD approach is thus an alternative and complement to the presently developed LPE capability and should be developed in parallel with the full realization of the LPE GaAs cells.

While there is a considerable amount of scattered data on GaAs cells with respect to their radiation damage characteristics, the scatter in them is considerable. This arises largely because the cells are made by a variety of methods with little control on the structural properties that play a major role in controlling the radiation damage characteristics. There are still uncertainties even about basic considerations such as the relative resistance of n on p versus p on n structures. The reliability of various models which predict cell behavior needs to be evaluated more carefully, especially in terms of defining relevant material parameters more carefully. The situation is rapidly improving, however, and in view of the short history of the heterostructure GaAs cell compared to Si, is very encouraging.

The susceptibility of the GaAs cell to damage by low-energy protons is a concern. However, this region is fortunately the one for which the coverglass offers the maximum protection. The thickness of the coverglass has to be chosen carefully for each mission to minimize weight-to-power ratio for the panel without jeopardizing the radiation resistance. The damage equivalence (protons to electrons) is not too well known and needs to be defined to permit space optimization of the cell and coverglass for various missions. It is especially important in this respect to work with cells with very similar properties and parameters so that the random structural properties of the cells do not affect the data.

The last topic discussed was the cost and availability of the cells. The availability of Ga was not considered a primary problem, at least for any forseeable period of time if space missions are considered. The possibility of using Ge as a substrate has some short-term attraction because of the highly developed Ge technology which makes large area Ge substrates readily available. However, the sources of Ge are few and its cost has been recently rising. The cost of Ga has been, on the other hand, falling. The possibility exists of using Si as a substrate. That will certainly be extremely attractive, especially if thin film cells can be developed. A large number of problems, however, need to be solved and a new technique such as the Mo-CVD fully developed before a practical realization of this attractive alternative can be fully evaluated.

The advantages of CVD versus LPE were discussed briefly. The important point is that LPE is here, fully developed and producing space-quailty cells on a cost competitive basis with the present-day Si cells. The application of these cells to space missions, to a degree, will only strengthen the GaAs cell acceptance in the systems area and allow further development of GaAs cells for future expanded application. Without such acceptibility, GaAs cells may stay as a curiosity with promise for a long time to come.