N86-17852

EXPERIENCE WITH OMCVD PRODUCTION OF GaAS SOLAR CELLS

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Update 1983 SPRAT paper with experience accumulated running at 1200 2x2cm GaAs cells per week. Show results on best cell performance achieved under production conditions, and uniformity achievable for successive cell runs. Also some production topics will be addressed.

Results of typical space-environmental tests and discussion of critical areas, including substrate supply and specification will be presented.

INTRODUCTION

This paper updates the report given at the 1983 SPRAT Conference. It describes the experience gained in operating a production-level OMCVD reactor and in processing cells made from layers grown in the reactor.

We have improved the uniformity in thickness and doping of deposited layers, by improved susceptor design and by modification of gas injection and flow conditions.

The throughput to date was slightly below that originally planned (is now at about 1200 2x2cm cells/week per machine) but this level was sufficient to show the potential of the approach and has indicated areas for further increase in throughput.

RUNNING EXPERIENCE

A wide range of substrates have been processed through to finished cells, and the space-worthiness of the cells produced has been confirmed. The experience is summarized in the following areas:

Substrates

The suppliers have cooperated well, to provide large (about 11.3cm^2), near-rectangular substrates of good quality. The control of wafer processing and cell fabrication is sufficient to show that over a wide sample range, there have been variations in bulk crystal defects and in surface quality, although the average quality has been sufficient to provide good cell efficiency (greater than 16%).

The suppliers continue to improve their product, and with stronger conviction that the potential solar cell market is significantly large, have continued a trend of reduced costs per square inch.

OMCVD Deposition

Continuous operation at realistic production levels has shown apparently mundane but essential needs, in housekeeping and maintenance, especially preventive maintenance to cope with typical performance specifications, critical spare parts, safety concerns and waste disposal.

This experience has been applied to include improved features, in later models of the reactor.

Sources

The suppliers have increased the delivery capacity of key elements, especially TMG and AsH_3, without apparent adverse effects from impurities. The larger bottles and cooling means were made readily by the suppliers. We have added monitoring to ensure that the carrier gas (H_2) has low water content.

Cell Processing

The post layer processing has been simplified and consolidated to give reproducible cell properties and acceptable performance in space. The test data manipulation has been expanded to display yields and detailed PV parameters.

Diagnostics

The cell line is supported by a systematic diagnostic effort, to determine the allowable range of properties which still give good cells and to trace the effects of variations (intentional or unplanned) in the substrate or layer properties.

Sample Results

To illustrate the present level of performance, we present data for six consecutive runs made in the past month. These runs include several different substrates and different geometry cells (2x2, 2x4cm^2). The "best" cells resulting from production runs have been steadily improving.

CONCLUSIONS

The projected promise of the OMCVD approach, to make high efficiency GaAs space cells has been demonstrated. The properties and control of the deposited GaAs and AlGaAs layers and the uniformity of the post layer processing have been most satisfactory. In particular the control of the critical thin layers (p-GaAs, p-AlGaAs) has been impressive.

Experience has also been gained in routine areas, connected with continuous operation at high capacity.

There are still a few areas for improvement, to further increase capacity, and to anticipate and prevent mechanical equipment problems.

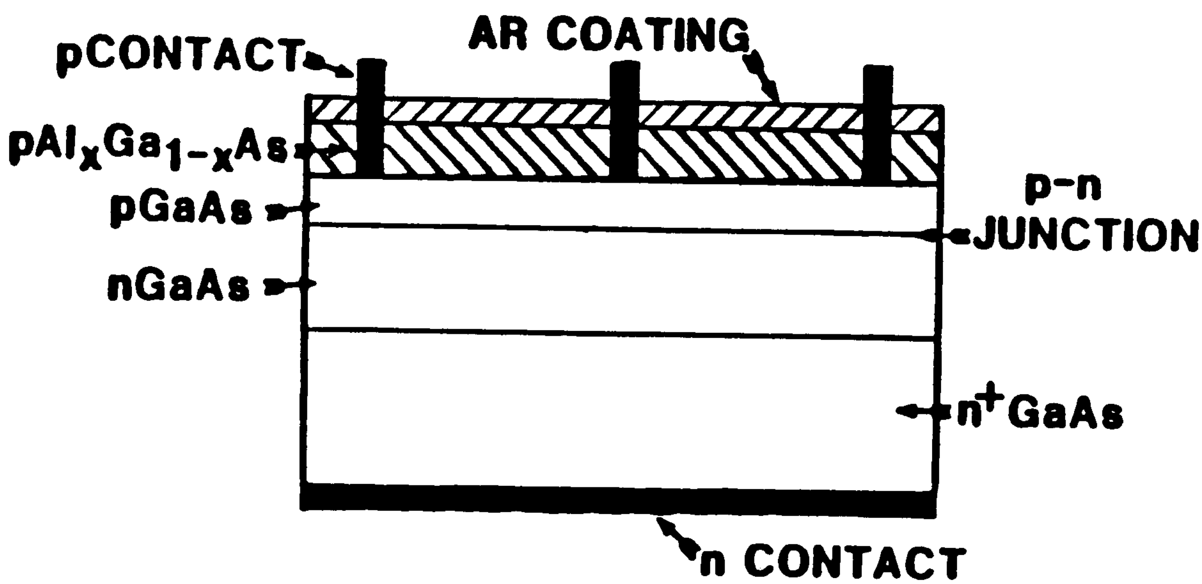

FIGURE 1: AlGaAs/GaAs HETEROFACE SOLAR CELL STRUCTURE

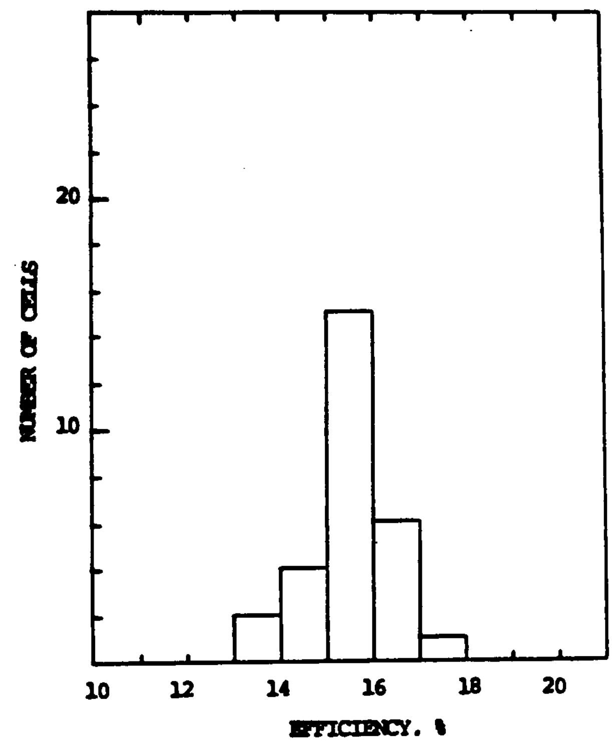

FIGURE 2: HISTOGRAM OF AMO EFFICIENCY FOR LOT 233

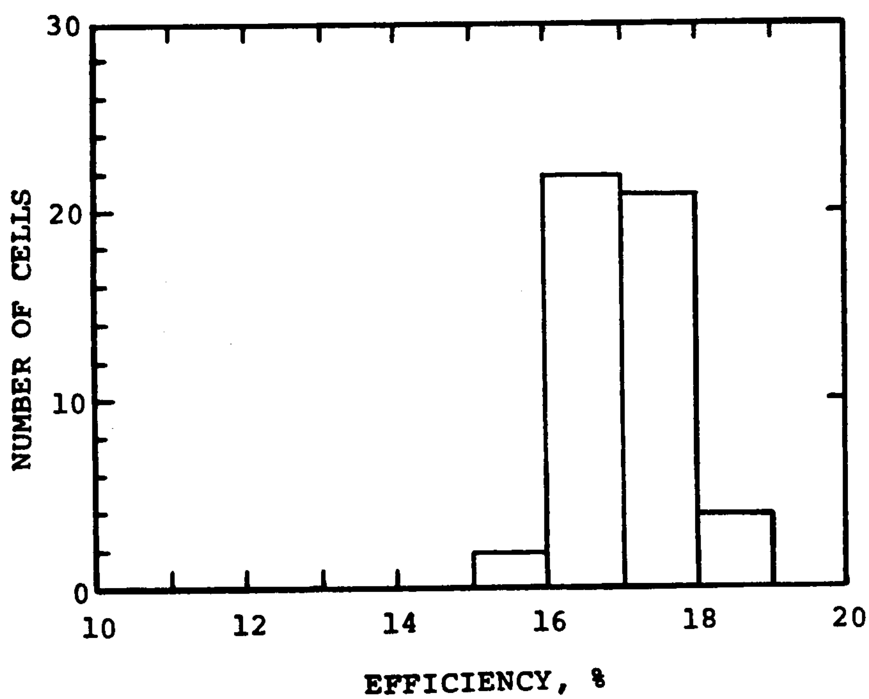

FIGURE 3: HISTOGRAM OF AMO EFFICIENCY FOR LOT 692

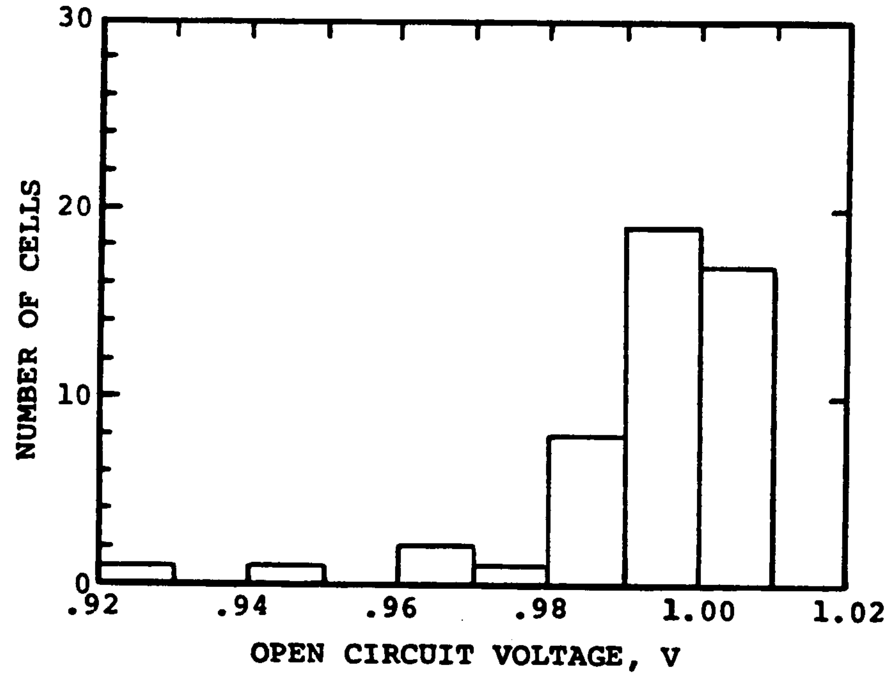

FIGURE 4: HISTOGRAM OF OPEN CIRCUIT VOLTAGE FOR LOT 692

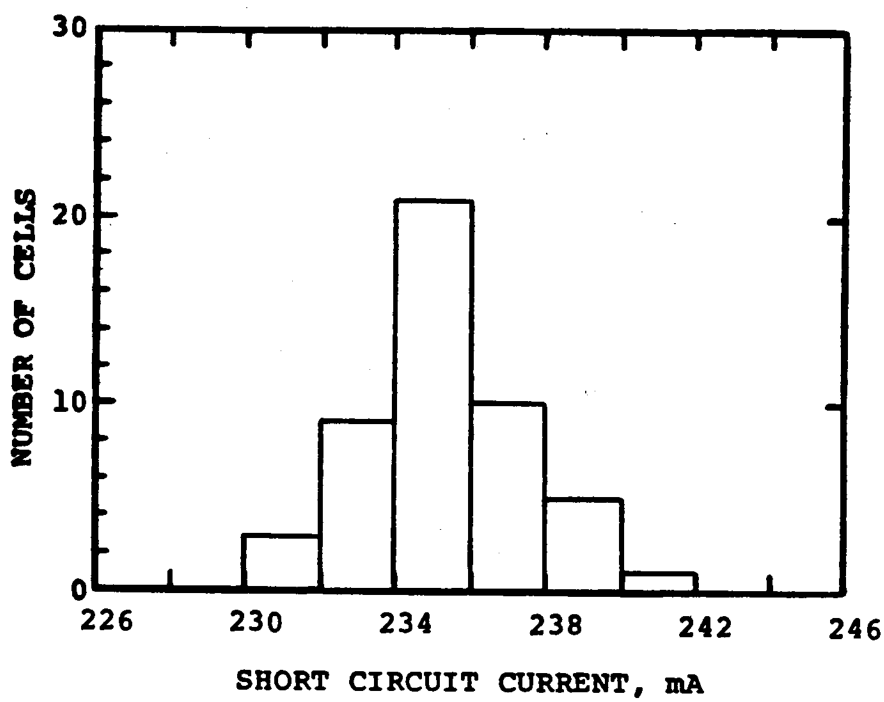

FIGURE 5: HISTOGRAM OF SHORT CIRCUIT CURRENT FOR LOT 692

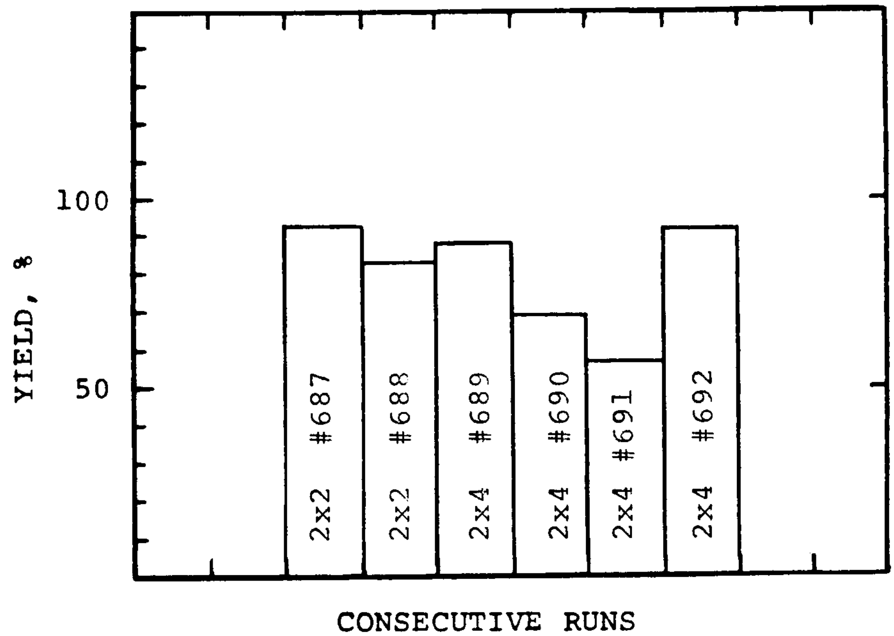

FIGURE 6: HISTOGRAM OF YIELD IN SIX CONSECUTIVE RUNS FOR AMO EFFICIENCY GREATER OR EQUAL TO 16%

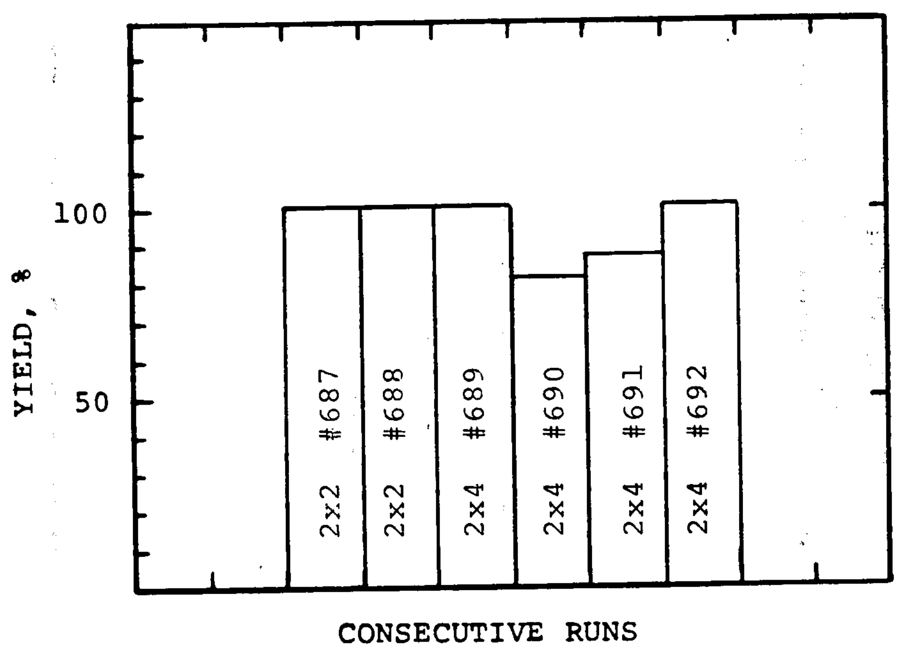

FIGURE 7: HISTOGRAM OF YIELD IN SIX CONSECUTIVE RUNS FOR AMO EFFICIENCY 16% AVERAGE OR GREATER AND 15% MINIMUM

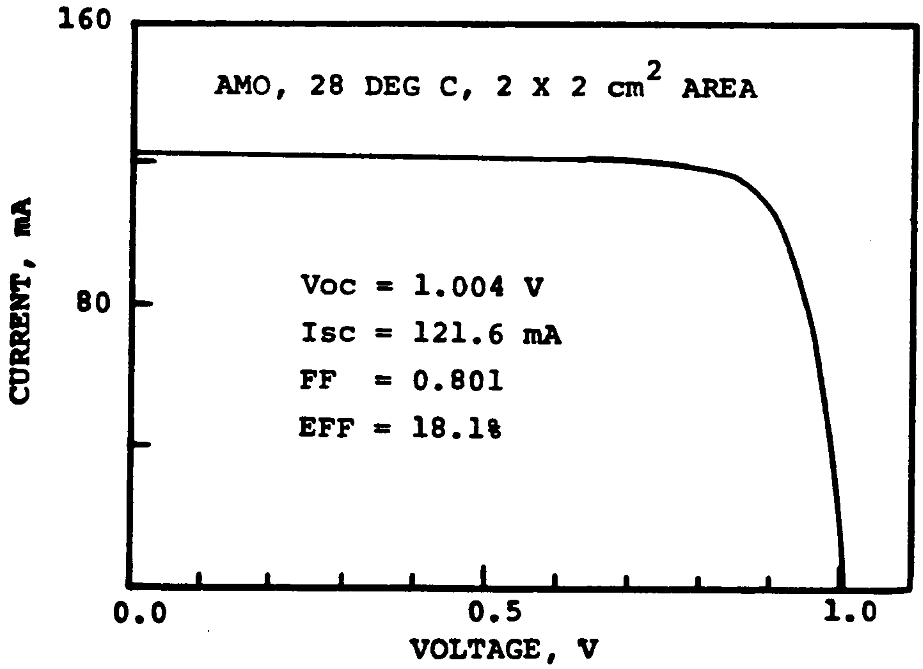

FIGURE 8: LIGHT I-V CHARACTERISTICS OF AN AlGaAs/GaAs SOLAR CELL