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DEVELOPMENT AND FABRICATION OF A SOLAR CELL JUNCTION PROCESSING SYSTEM

Quarterly Report

By
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January 1981

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DEVELOPMENT AND FABRICATION OF A
SOLAR CELL JUNCTION PROCESSING SYSTEM

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Quarterly Report

January 1981

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SECTION 1

CONTRACT OBJECTIVES

The basic objectives of the program are the following:

1. To design, develop, construct and deliver a junction processing system which will be capable of producing solar cell junctions by means of ion implantation followed by pulsed electron beam annealing.
2. To include in the system a wafer transport mechanism capable of transferring 4-inch-diameter wafers into and out of the vacuum chamber where the ion implantation and pulsed electron beam annealing processes take place.
3. To integrate, test and demonstrate the system prior to its delivery to JPL along with detailed operating and maintenance manuals.
4. To estimate component lifetimes and costs, as necessary for the contract, for the performance of comprehensive analyses in accordance with the Solar Array Manufacturing Industry Costing Standards (SAMICS).

In achieving these objectives, Spire will perform five tasks:

Task 1 - Pulsed Electron Beam Subsystem Development

Task 2 - Wafer Transport System Development

Task 3 - Ion Implanter Development

Task 4 - Junction Processing System Integration

Task 5 - Junction Processing System Cost Analyses

Under this contract the automated junction formation equipment to be developed involves a new system design incorporating a modified, government-owned, JPL-controlled ion implanter into a Spire-developed pulsed electron beam annealer and wafer transport system. Figure 1 presents a conceptual drawing of the junction processing system. When modified, the ion implanter will deliver a 16 mA beam of $^{31}\text{P}^+$ ions with a fluence of 2.5×10^{15} ions per square centimeter at an energy of 10 keV. The throughput design goal rate for the junction processor is 10^7 four-inch-diameter wafers per year.

FIGURE 1. SPIRE/JPL JUNCTION PROCESSOR

At the present time, authorization has been given to perform work only on Tasks 1 and 2. The performance of Tasks 3, 4 and 5 has been deferred until a written "Notice to Proceed" with one or more of these deferred tasks is received from JPL.

SECTION 2

SUMMARY OF WORK PERFORMED

2.1 INTRODUCTION

This Quarterly Report covers the work performed during the period from 1 October through 31 December 1980 on Tasks 1 and 2 of a contract for the development and fabrication of a solar cell junction processing system. The engineering design and major component fabrication program is nearly complete for Task 1. Final assembly and debugging is now underway for the development of the pulsed electron beam annealing machine. The design phase for the Task 2 transport system was initiated at the beginning of December.

2.2 PULSER DESIGN

In order to assemble the grid of energy storage lines within the upper and lower capacitor support plates, additional handling fixtures were designed for vertical loading and alignment with respect to the high voltage accumulation spinning.

The trigger assembly piston clearance design was changed to further minimize contact resistance during the charge/discharge cycling.

2.3 PULSER FABRICATION

All major components such as the collimating magnet, pressure vessel, vacuum chamber and the first production run of energy storage lines have been received. Some component rework problems have hampered the assembly schedule.

2.4 TASK 2. TRANSPORT DESIGN

The engineering design effort on the required transport system has been started, with the first area of concentration being that of the entrance and exit cassette load locks and their associated elevator mechanisms.

SECTION 3
PROGRESS ON TASK 1 - DEVELOPMENT OF PULSED
ELECTRON BEAM SUBSYSTEM

3.1 PULSER DESIGN

3.1.1 Energy Storage Line Terminations

For the efficient operation of the PEBA machine, the problem of contact resistance must be minimized. This problem arises at each mechanical connection between the high voltage accumulation spinning and the energy storage lines as well as all the ground plane mechanical contacts. Since servicing and assembly requirements necessitated nonpermanent, separable joints, a specially designed connector was needed to solve this basic problem of high current transfer from one conductor to another. The design chosen features machined collars for the liner insert stems which incorporate Multilam bands* made of silver plated beryllium copper. These bands with their large number of parallel contacts provide a high density of contact points.

The chosen Multilam band type LAI a/.15/15⁰ has 10 louvers per inch and for the 2" diameter has a joint calculated current rating of 157 kiloamperes for a 1 millisecond duration. Multilam catalog literature states that for a LAI a/.15 silverplated, 63 louver band making a 2" diameter sliding contact with a silver plated aluminum part, produces a resistance of 2 microhms.

A similar contact resistance design problem occurs at the energy storage line collar to ground plane support plate. A dependable low-impedance connection between the removable storage capacitor and its support ground plane was required to ensure good contact between two large electrical structures that do not necessarily mate mechanically, due to dimensional tolerances. This design problem is being solved with the use of a METEX** Monel EMI Mesh Strip gasket 1/8"x1/4" in cross section. The metal-to-metal contact, and the ability of this mesh to cut through films on the flange surfaces, reduces surface resistivity to microhm-centimeter levels. The continuity of the mesh gives it the required high internal conductivity as well.

*Multilam Corporation, Los Altos, CA 94022

**Metex Electronic Shielding Group, Edison, NJ 08817

3.1.2 Collimating Magnet

The SPI-PULSE 7000 electromagnet shown in Figure 2 was fabricated by ANAC, Inc. of Santa Clara, California and received at Spire on 3 December 1980. This Spire specified custom magnet was constructed using a modular coil structure. The coils are strip wound from copper tape, have Mylar interturn insulation and are sealed by wrapping in epoxy impregnated fiberglass tape. Cooling is by means of water cooled aluminum plates integrated into the coil structures. The aluminum plate is electrically isolated from the coils, eliminating electrochemical corrosion effects. A series of temperature sensors will shut down the magnet coil power if overheating occurs.

The magnet excitation curve supplied by ANAC, Inc. is shown in Figure 3. With the Spire 50 ampere 40 volt Hewlett Packard Model 6269B power supply, the maximum field achievable will be 4370 gauss. Using a higher current rated power supply, ANAC measured a nominal maximum field of 4550 gauss at 65 amperes. Figure 4 presents an ANAC data plot of the fringing field, measured along the median plane at a magnet coil current of 65 amperes.

3.2 PULSER FABRICATION

3.2.1 Pressure Vessel, Energy Store Lines and Support Structure

On 23 December 1980 the pressure vessel from the Buffalo Tank Company was received at Spire. Upon incoming Q.C. inspection, a number of unacceptable fabrication discrepancies were determined. Representatives from Buffalo Tank Company are scheduled to visit Spire to review and initiate steps to rework the rejected components.

The final process steps are being completed in the fabrication of the first production lot of dielectric storage lines. These steps include zinc arc spray metallizing and the attachment of electrical and mechanical support collars.

For installation of the magnet subsystem, support brackets have been fabricated to attach and center the magnet pole pieces to align with the electron beam axis. Power, dry nitrogen, air and water cooling lines are being installed to service the SPI-PULSE 7000 machine and its support equipment and instrumentation.

FIGURE 2. SPI-PULSE 7000 COLLIMATING MAGNET

CURRENT FIELD (AMPS) (GAUSS)	
10	1580
20	2900
30	3743
40	4142
50	4370
60	4512
70	4600

SCALE:	DATE: 9/25/80
DRAWN: DV	REF: 538-80
DRAWING NUMBER	
FINAL EXCITATION	

ANAC

FIGURE 3. MAGNET EXCITATION CURVE

OCT 06 1980

SCALE:	DATE: 9/26/80
DRAWN: J.V	REF: 538-80
DRAWING NUMBER

FIGURE 4. FRINGING FIELD ALONG MEDIAN PLANE AT I = 65 AMPERES

3.2.2 Vacuum Chamber and Interim Wafer-Handling System

Full operation of the vacuum system after leak testing was accomplished with an average indicated pressure reading in the cryopumped process chamber of 2×10^{-6} torr. The wafer process region and magnet pole pieces are shown in Figure 5. Integration of the interim wafer-handling system with the vacuum system was completed during the first week in December. The configuration of the interim wafer transport "Y" track section is given in Figure 6. After debugging the interface electronics and cabling to the microprocessor controller, the interim wafer-handling system became completely operational on 22 December 1980.

3.2.3 Electronic Control

The software programming of the microprocessor system controller has been completed and tested. Process control sequencing is now available for the interim wafer-handling system and trigger control circuit. The documentation package for the microprocessor controller should be completed in early January 1981. Figure 7 shows the control console with microprocessor for the SPI-PULSE 7000.

FIGURE 5. SPI-PULSE 7000 WAFER PROCESS
REGION — INTERIOR VIEW

**FIGURE 6. INTERIM WAFER TRANSPORT
"Y" TRACK SECTION**

FIGURE 7. SPI-PULSE 7000 CONSOLE

SECTION 4

PLANS

During the next reporting period efforts will continue to complete the overall system assembly and to initiate the pulser test program as outlined in Figure 8.

FIGURE 8. SPI-PULSE 7000 ASSEMBLY AND TEST SCHEDULE

SECTION 5

SCHEDULE

Figure 9 shows the projected schedule for Task 1, "Pulsed Electron Beam Subsystem Development".

FIGURE 9. TASK 1 SCHEDULE

SECTION 6

PROGRESS ON TASK 2 — WAFER TRANSPORT SYSTEM DEVELOPMENT

6.1 TRANSPORT DESIGN

The chosen mode of wafer transport is a three-phase "Orbitrac" walking beam system. Typically comprised of three rails that describe oscillatory motion, the walking beam transport moves wafers by an alternating movement of the center and side rails. The motion describes a series of arcs which carry the wafer forward along the walking beam. The design effort so far has been concerned with the entrance and exit locks and their associated mechanisms to permit wafer/holder transfer from the cassettes to the transport tracks. The initial design is that of a "Y" track, with an additional straight section of approximately 3 feet in length to provide for "bunching up" and slowing down the speed of the wafers and then debunching before entering the standard track between the ion implanter and the pulsed electron beam machine.

SECTION 7

PLANS

Design efforts will continue based on overall system requirements such as rates of track speed, timing sequence of events and vacuum system valves and pump sizes. Long lead time hardware will be identified and procurement initiated.

SECTION 8

SCHEDULE

Figure 10 shows the projected schedule for Task 2, "Wafer Transport System Development".

FIGURE 10. TASK 2 SCHEDULE