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LSSA LARGE AREA SILICON SHEET TASK CONTINUOUS
LIQUID FEED CZOCHRALSKI GROWTH

Quarterly Report No. 2, January—March 1978

By
Walter Torbet

March 1978

Work Performed Under Contract No. NAS-7-100-954886

Siltec Corporation
Menlo Park, California

MASTER

U.S. Department of Energy

Solar Energy

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CONTINUOUS LIQUID FEED CZOCHRALSKI GROWTH

Siltec Report No. 0140-2094

QUARTERLY REPORT #2
January - March 1978

By
Walter Torbet

March 1978

SILTEC CORPORATION
Menlo Park, California

The JPL Low-Cost Silicon Solar Array Project is sponsored by the U.S. Department of Energy and forms part of the Solar Photovoltaic Conversion Program to initiate a major effort toward the development of low-cost solar arrays. This work was performed for the Jet Propulsion Laboratory, California Institute of Technology by agreement between NASA and DoE.

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ABSTRACT

Siltec Corporation's contract with JPL is for the process development of Czochralski growth with continuous liquid replenishment of the growth crucible. A necessary ancillary of this work is the design and construction of a suitable furnace. This quarter's effort has been on this task.

A workable method of melt-level monitoring has been demonstrated using a reflected laser-beam. A method that may yield a satisfactory throttle valve for the molten silicon flow is being investigated.

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INTRODUCTION

Siltec Corporation's contract with JPL is for the process development of Czochralski growth with continuous liquid replenishment of the growth crucible. A necessary ancillary of this work is the design and construction of a suitable furnace. This quarter's effort has been on this task.

The design of the furnace can be considered in parts:

- A. A basic CZ furnace with a second chamber to be used for the melting of the polysilicon
- B. The molten silicon transport apparatus
- C. Controls for the flow of the molten silicon

A discussion of each of these follows.

TECHNICAL DISCUSSION

Furnace

Many of the components from the Siltec 860-C furnace have been adapted for incorporation into the Continuous Liquid Feed (CLF) Furnace. These include both major and minor mechanical parts and the majority of the system controls. The use of these items will not only short-cut the design cycle but will also do the same for the debugging cycle. The specific progress is:

- . The electrical hardware has been ordered, and the majority has been received
- . The system controls have been flow-charted, and the schematics are in process
- . Half of the long-lead-time mechanical items have gone out for quotation, and many of the minor parts are on order

Transport Apparatus

The conceptual design of a tube and supporting elements to transport molten silicon was described in last quarter's report. There has been no progress in this design area due to non-receipt of test elements.

Flow Controls

The Siltec proposal to JPL was to control the flow of molten silicon from the melt-down crucible to the growth crucible by the control of the differential pressure of the two chambers. Calculations indicate that for such a control to be workable, a restrictive orifice on the order of .3 mm diameter would be required. Such an orifice

might be subject to significant size changes from dissolution. An alternate method of flow control would be to use constant differential pressure as the motive force, with a throttling valve.

To this end, Siltec is working on an electro-magnetic valve which uses the same principle as the electro-magnetic pumps of the metalurgical industry. As depicted in Figure 1, Appendix B, three-phase voltage is applied to staged coils providing a traveling flux field. The induced eddy-currents in the silicon will try to follow the field, and the generated force will be directed to oppose the pressure-induced flow. If this scheme proves workable, the resultant valve could be used to give either restricted flow or pulsed flow.

A necessary part of a flow control is a rate parameter. This can be provided in several ways; the one selected by Siltec is a monitoring of the melt level with the in-flow of molten silicon controlled to maintain a constant level. A monitoring scheme, similar to the one used in the chemical industry, has been successfully demonstrated with molten silicon and is depicted in Figure 2, Appendix B. An oblique laser beam is reflected from the melt-level and the deflections in the reflected beam caused by surface ripples are re-focused by a convex lens. This scheme will be incorporated into the CLF furnace.

CONCLUSIONS AND RECOMMENDATIONS

No conclusions or recommendations may be drawn from the work in the second quarter.

NEW TECHNOLOGY

No new technology has been developed on this program during this quarter.

PROJECTION OF ACTIVITIES

The fabrication drawings of the CLF furnace will be completed and all items ordered. The system control schematics will be finished and the control console assembled. The crucible/heater set-up will be checked out in a standard furnace.

Tests will begin on the various elements of the molten silicon transport tube.

APPENDIX A

Summary of Characterization, Design, and Economic Analysis Data

There was no data generated during this quarter to analyze.

APPENDIX B

Figure 1: Electro-magnetic Throttle Valve

APPENDIX B

Figure 2: Melt-Level Monitoring Scheme CLF Furnace

CALIFORNIA INSTITUTE OF TECHNOLOGY
Jet Propulsion Laboratory

ISS7 LARGE AREA SILICON SHEET TASK
CONTINUOUS LIQUID FEED CZOCHRALSKI GROWTH

Contract No. 954886
Modification No. 1
DRL 61/DRD Line Item SC2
Siltec Doc. No. 0140-0280

PROGRAM PLAN

Revised: 12-14-77

Milestone Ledger:

⊙ = Due Date
▼/⊙ = Start/Finish

APPENDIX C