# SILICON DENDRITIC WEB GROWTH

**WESTINGHOUSE ELECTRIC CORP.**

S. Duncan

<table>
<thead>
<tr>
<th>Technology</th>
<th>Report Date</th>
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<tbody>
<tr>
<td>Single crystal ribbon growth</td>
<td>10/3/84</td>
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<thead>
<tr>
<th>Approach</th>
<th>Status</th>
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<tbody>
<tr>
<td>Silicon dendritic web growth</td>
<td>• 6 ¼ meters of uninterruped, continuously melt replenished web growth has been achieved with three different growth configurations</td>
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<td>Contractor</td>
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<td>Westinghouse Electric Corp., Advanced Energy Systems Division</td>
<td>• Steady-state web growth of 8 cm²/min has been achieved</td>
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<tr>
<td>JPL Contract 955843</td>
<td>• Major improvement in web growth reproducibility has been achieved</td>
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<td>• Concepts for higher growth rate have been developed</td>
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### Goals

**For 1984**

- Demonstrate 10 meter length of continuously melt replenished web crystal growth
- Demonstrate 10 square centimeters per minute steady-state web growth

### Principal Activities This Period

- Grow Long Web Crystals From Continuously Replenished Melt
- Develop Temperature Distribution In Web And Melt
- Improve Reproducibility Of Growth
- Develop Configurations For Increased Growth Rates (Width And Speed)
- Develop New Growth System Components As Required For Improved Growth
- Evaluate Quality Of Web Grown
Continuously Melt-Replenished Web Growth

Three Web Growth Configurations Have Achieved Long Growth (Approx. 6 Meters)

- J435 (3.3 cm width)
- J460L (4.1 cm width)
- J460LS (5.1 cm width)

Critical Regions of Temperature Distribution in Silicon Web Growth

- Between Crucible Compartments (Growth And Melt Replenishment Compartments)
- Within The Growth Compartment
- Vertical Profile Within The Growing Web
- Horizontal Profile Within The Growing Web
Melt Temperature Distribution

\[ T_M + 14 \]
\[ T_M + 4 \]
\[ T_M \]

\[ \Delta T \]

Required

\[ \Delta T = 0.4 \pm 0.2^\circ C \]
\[ \Delta T = 1.2^\circ C \]
\[ \Delta T = 2.5^\circ C \]

Principal Methods for Control of Melt Temperature Distribution

- Stationary Shield Configuration
- Dynamically Positionable Shield Configuration
- Dynamically Positionable Work Coil
- Design Of The Barrier Which Separates Crucible Compartments
Susceptor Shields

For Control Of Melt Temperature Distribution Includes
Both Fixed And Adjustable Shields

Temperature Distribution Within the Growing Web

- Determined By Design Of The Susceptor Lids And Top Shields
- Predicted By Computer Model
- Lid And Shield Temperatures Measured In Growth System
Reproducibility of Web Growth

Improvements This Period

- Crucible Re-Designed For Better Susceptor Fit And Improved Thermal Transfer
- Rectangular Work Coil Fabricated With Precision Dimensions
- Perimeter Shields Re-Designed For Reproducible Spacing
- Mated Parts Fitted For Uniform Thermal Transfer

Configurations for Increased Growth Rates
(Width and Speed)

- Concepts Are Generated Through Computer Modeling
- Initial Design Specification Derived From Models
- Design Is Verified Through Experimental Web Growth
- Experimental Web Growth And Measurements Provide Data For Additional Input To Model

Growth System Component Development

Major Examples Of Component Development In This Reporting Period:
- New Crucibles
- Improved Crucible Barriers
- New Induction Heating Work Coils
- New Furnace Cover Plate For Higher Growth Rate
- Improved Feeder For Polysilicon Pellets
- Thermal Elements For New Growth System Designs
- Instrumentation For Monitoring Dendrite Thickness (Incomplete)
Web Quality Evaluation

Sources

From This Program
- Residual Stress Via Web Split Width Measurements
- Dislocation Density Via Etch Pit Counting
- Defect Type, Distribution And Structure Via X-Ray Topography

From Associated Programs
- Impurity Evaluation
- Electrical Properties
- Solar Cell Data

WEB SAMPLES FOR STRUCTURE ANALYSIS
J435 Lid Configuration

Etch Pit Density
$(10^3 \text{cm}^{-2})$

- Positions: ZC25-3, 2248-3

Residual Stress
$(\text{Mdyn/cm}^2)$

J460 Lid Configuration

Etch Pit Density
$(10^3 \text{cm}^{-2})$

- Positions: R461-5

Residual Stress
$(\text{Mdyn/cm}^2)$
Problems and Concerns

Calendar Schedule Of Goals Is Tight

Summary

- Technology And Direction Of Development Sufficient To Surpass Goals When Fully Developed
- Major Improvement Achieved In Length Of Continuously Melt Replenished Crystal Growth