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White Paper:

Specialty Materials and Evergreen Solar Light Up Strong Ribbon Solar Cell Technology

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The early 2000s signified a time of extensive growth for solar power usage in the United States. NASA's solar-powered aircraft development, Union Pacific Railroad's adoption of solar-powered, blue-signal, rail yard lanterns, and an overall increase in rooftop solar power systems installations are prime examples of this. Within the same timeframe, we also teamed up with Evergreen Solar, Inc. to help them take their technology to the next level. Our partnership generated massive improvements in their String Ribbon Solar Cell technology using our expertise in silicon fibers.

This solar cell technology offered the opportunity to manufacture panels in a way that was both cost effective and high yielding. The process used surface tension to create a thin silicon film between two heat-resistant wires that are pulled through a silicon melt. Upon cooling, the thin film solidified and then it was extracted with little to no waste. Further process optimizations and product development, from single-crucible dual-ribbon silicon growth to the realization of a monolithic module, resulted in fantastic improvements. The module realization, also known as Project Gemini, took place in four parts:

1. **Production Implementation of Multiple Ribbon Growth:** The name "Gemini" was coined for the process of growing twin silicon ribbons from a single crucible by taking advantage of the strings' edge stabilization. Our findings resulted in significant cost reductions by nearly half for ribbon growth. Further improvements led to a more refined process, termed "Gemini II", that boosted the production capacity of string ribbon by the end of 2004 to ca. 15 MW/yr. This project became one of the most successful in Evergreen Solar's history, which exceeded all first targets set for production yield and machine uptime.
2. **Growth of Low Surface-Oxide Content Gemini Ribbon:** Prior to the development of Gemini, silicon ribbons were grown using a "no-etch" process that allowed for direct movement of String Ribbon wafers from crystal growth to diffusion, without use of wet chemistry or etch steps of any kind. While the growth of a Gemini ribbon failed to fully exclude surface oxidation, the optimization of melt conditions significantly mitigated the oxide content thus enabling its compatibilization with the no-etch process.
3. **In-line Diagnostics:** For Gemini, several developments in measurement systems were introduced. These included improved methods to quantify and control ribbon thickness and melt depth, and techniques to produce uniform thickness between front and rear ribbons which massively affected overall throughput.
4. **Monolithic Module Developments:** The bond between the conductive adhesive bars printed onto the backskin material was further enhanced from 400 to well over 1,000 cycles on small (25 W size) monolithic modules with negligible power losses.

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Up until our engagement, no prior efforts at Evergreen Solar had yielded as flat a ribbon and with virtually no material losses or machine downtime! In addition, newly developed methods to control the as-grown silicon surface of the ribbon enabled its direct transfer to diffusion, thus avoiding any intermediate etching steps. This further enabled the development of in-line melt depth diagnostics tools that improved the thickness control of the silicon film. The consequences in direct manufacturing costs were of high impact, significantly reducing the use of raw materials and streamlining the production process.

Interested in exploring how we can help your solar business? Shoot us a line at info@specmaterials.com and we'll help your work in the solar industry shine.