PROJECT DATA

AVA Technologies, Inc. - 01GO11044

High Throughput Vacuum Processing for Innovative Uses of Glass

Recipient:	AVA Technologies, Inc.	Instrument Number:	DE-FG36-01GO11044
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Subcontractor(s):		B&R Number(s):	ED1906020
		PES Number(s):	01-2031
EERE Program:	Industrial Technologies	State Congressional District:	CO - 4

PROJECT SCOPE: The objective of this project is to develop and test a system with HPD sources and glass heaters for processing 1 x 1 foot substrates. Tasks include: 1) Design of system, 2) Finite Element computer simulation, 3) Assemble prototype, 4) Test and optimize prototype, 5) Deposition experiments, and 6) Data analysis. The remaining tasks include semi-annual and final reporting, attending the annual project reviews, and business activities. This technology is expected to provide energy savings of 5 million Btu per unit per year.

FINANCIAL ASSISTANCE

Approved DOE Budget	$200,000	Approved DOE Share	$200,000
Obligated DOE Funds	$200,000	Cost Share	$49,560
Remaining Obligation	$0		
Unpaid Balance	$0	**TOTAL PROJECT**	**$249,560**

Project Period: 3/1/01-3/1/04

TECHNICAL PERFORMANCE
DE-FG36-01GO11044
AVA Technologies
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PROJECT SYNOPSIS

In this work, a system with Heated Pocket Deposition (HPD) sources and glass heaters for processing one square foot substrates will be developed and tested. A belt arrangement similar to that used in the current AVA Technologies prototype will be used for transporting substrates from one process module to the next. There will be up to seven processing stations in the vacuum chamber. The processing of complete photovoltaic devices will also be tested. Tasks are categorized into six work tasks and seven tasks supporting the project. The work tasks are as follows; 1) Design of system, 2) Finite Element computer simulation, 3) Assemble prototype, 4) Test and optimize prototype, 5) Deposition experiments, and 6) Data analysis. The remaining tasks include activities such as semi-annual and final reporting, attending the annual project reviews, and business activities. Optimization of the processes used to manufacture the one square foot substrate is expected to provide energy savings of five million Btu per unit per year.

SUMMARY OF TECHNICAL PROGRESS

Over the past year, AVA has made significant progress and has completed this project. Through the support of the I&I Category 2 project, the feasibility of processing commercial size photovoltaic (PV) modules was demonstrated. Large area solar cell processing modules (process heads) for the deposition and processing of the semiconductor films have been designed. A significant advantage of AVA's technology is that the process modules are nearly identical for all vacuum process steps. Two stations have been constructed and installed. One has been tested for mechanical, electrical, and thermal performance with excellent results. Estimated film thickness uniformity ~ +/- 5% on the film except at the corners was demonstrated. The attributes of this system include:

- Process stations for designed production: continuous running for 40 hours or more without reloading.
- Six substrate positions (two installed).
- Phase angle SCR power control for longer lamp life and lower power line electrical transients.
- Tested in continuous eight hour runs.
- High thermal efficiency.
- Thermal uniformity of +/- 1.5 °C was measured for a temperature of 400 °C.

SUMMARY OF PLANNED WORK

An I&I Category 3 project which includes nearly 50% cost share from their industrial partner, National Starch and Chemical (NSC) is currently under review. Completing this addition and integrating it with the existing semiconductor subsystem will result in a full PV manufacturing production prototype system. When completed and operated in full production mode, the production prototype system will produce two million watts (2 MW) of PV a year. In addition, the final report is being produced for DOE review.

PROJECT ANALYSIS

The project appears to have a high level of interest based on the companies that have met with AVA and or inquired about the progress. As mentioned under Technical Progress, AVA continues to search for additional funds to scale up a demonstration unit. This project warrants continued attention by DOE.

ACTION REQUIRED BY DOE HEADQUARTERS

No action is required from DOE Headquarters at this time.

STATEMENT OF WORK
DE-FG36-01GO11044
AVA Technologies
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Detailed Task Description

Task 1. Design of the System

The prototype will be designed on AutoCad 2000. The members of the group have extensive experience in vacuum system development and design. They follow the systematic approach for vacuum systems design developed by the vacuum thin film industry: (a) design the process modules, (b) design the substrate transport, (c) optimize the vacuum chamber around the process modules and substrate transport, and (d) locate the feedthroughs. This will be done for one of the stations and duplicated for the other stations. System control will utilize a networked PC running the National Instrument software "Lookout".

Task 2. Finite Element Computer Simulation

In order to prevent glass substrate thermal cracking and obtain high performance PV devices, it is necessary to ensure a high degree of thermal uniformity (+/- 2 °C) at each process station. The design from step 1 will be analyzed using the Finite Element Method to ensure this level of thermal uniformity at each process station. Algor FEM software is available for analysis.

Tasks 4 & 9. Attend Annual Project Review

At the request of DOE, attend a project review and present project status and discuss upcoming goals and objectives.

Task 5. Assemble Prototype

The vacuum chamber and the support frame will be constructed. Then the process modules will be built. The system will be constructed at the machine shop in the Engineering Research Center at Colorado State University (CSU). The entire system will be assembled and tested for vacuum leaks in a specialized laboratory at CSU.

Task 7. Test and Optimize Prototype

Processing studies will be initiated. The system will be fine tuned and preliminary testing will be conducted. Initial inputs for a detailed study using statistical design of experiments (SDE) will be provided. Based on the development of AVA's current system, there are no anticipated difficulties in successfully completing the proposed new system.

Task 10. Film Deposition Experiments

A detailed SDE study will be conducted. The highest heating rate for the large glass substrates that will not cause cracking will be determined. Then 3000 Å CdS films will be deposited. These films will be tested for uniformity and optical properties (transmission, band gap, etc.). Then CdTe films of 2.5 microns thickness will be deposited on CdS and tested similarly. Complete PV modules will then be deposited and tested. The films will also be studied by Scanning Electron Microscopy (SEM) and X-Ray diffraction (XRD). These studies will enable the measurement of crystallinity, grain size, texture and other properties.

Task 11. Data Analysis

The data on the performance of PV devices on a statistically valid number of samples will be studied and the data will be analyzed for determining the capability of the process for producing large area devices. There is close interaction with the statistical laboratory at Colorado State University and their expertise will be utilized in the analysis.

Tasks 3, 6, 8, 12 & 13. Business Activities, Project Management and Reporting

The completed prototype will be demonstrated to potential licensees such as Libby Owens Ford, BP-Amoco, Royal Dutch Shell, Siemens and other producers of glass products. Due to the market growth and environmental concerns many large companies are pursuing PV manufacturing technologies. Pre-production activities will be pursued with resources from the licensees. However, the prototype to be developed in this program is needed before licensing will transpire. Reporting and documentation will be completed and submitted to DOE as required.

Overall project management and timely reporting and preparation of project results will be conducted. This includes project and financial status reports and the final project report due 90 days after completion of the project. This task also includes other DOE requirements for a market assessment, fact sheets, benefits analyses, market assessments, workshops, etc.

Project Cost Performance in DOE Dollars for Fiscal Year 2003

DE-FG36-01GO11044 **AVA Technologies, Inc.**

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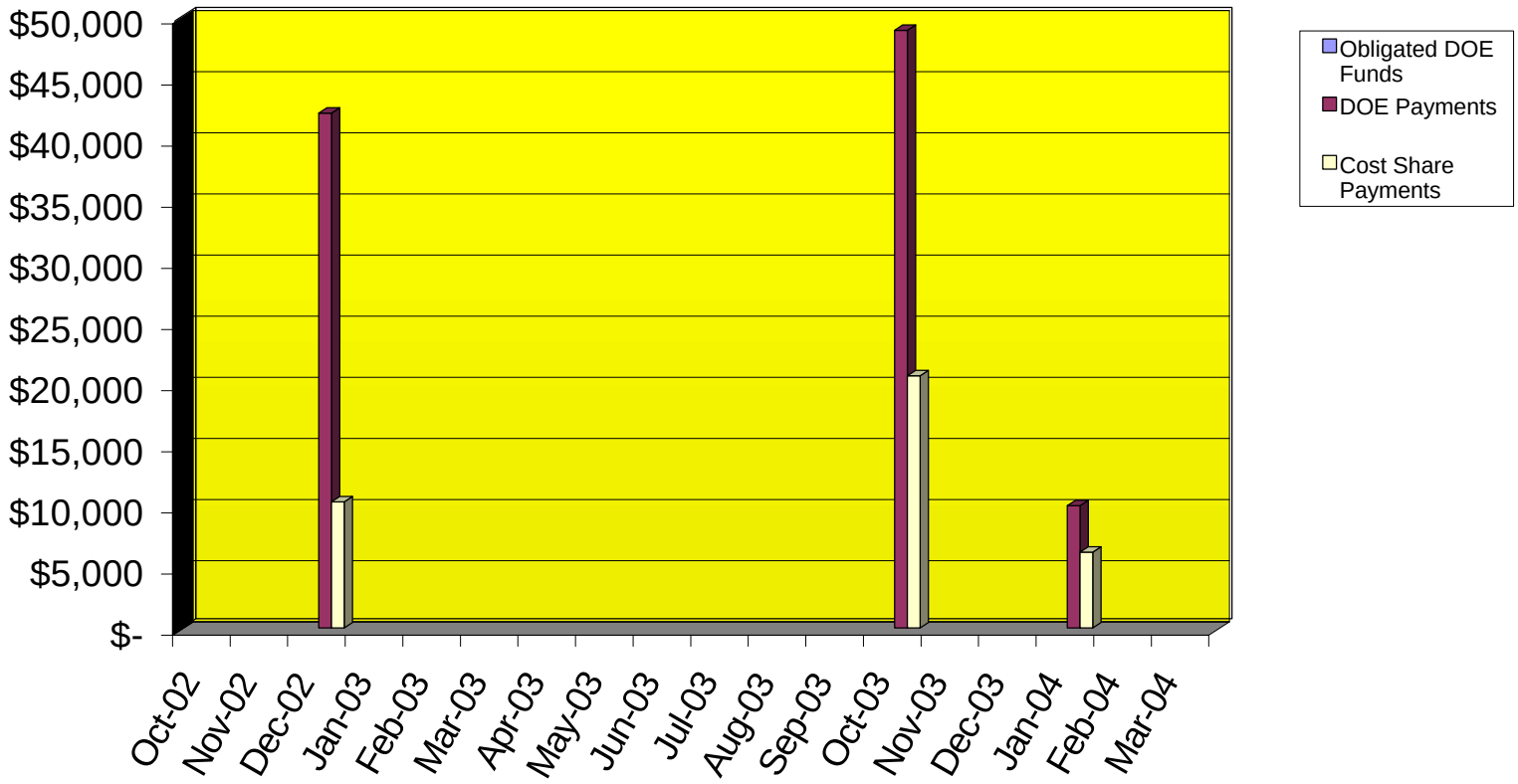

	Oct-02	Nov-02	Dec-02	Jan-03	Feb-03	Mar-03	Apr-03	May-03	Jun-03	Jul-03	Aug-03	Sep-03
Obligated DOE Funds	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
DOE Payment	$0	$0	$42,115	$0	$0	$0	$0	$0	$0	$0	$0	$0
Cost Share Payment	$0	$0	$10,325	$0	$0	$0	$0	$0	$0	$0	$0	$0

	Oct-03	Nov-03	Dec-03	Jan-04	Feb-04	Mar-04	PFY*	Cumulative
Obligated DOE Funds	$0	$0	$0	$0	$0	$0	$200,000	$200,000
DOE Payment	$48,896	$0	$0	$10,000	$0	$0	$98,989	$200,000
Cost Share Payment	$20,650	$0	$0	$6,195	$0	$0	$26,845	$64,015

Approved DOE Budget:	$200,000
Approved Cost Share Budget:	$49,560
Total Project Budget:	$249,560

* Prior Fiscal Years

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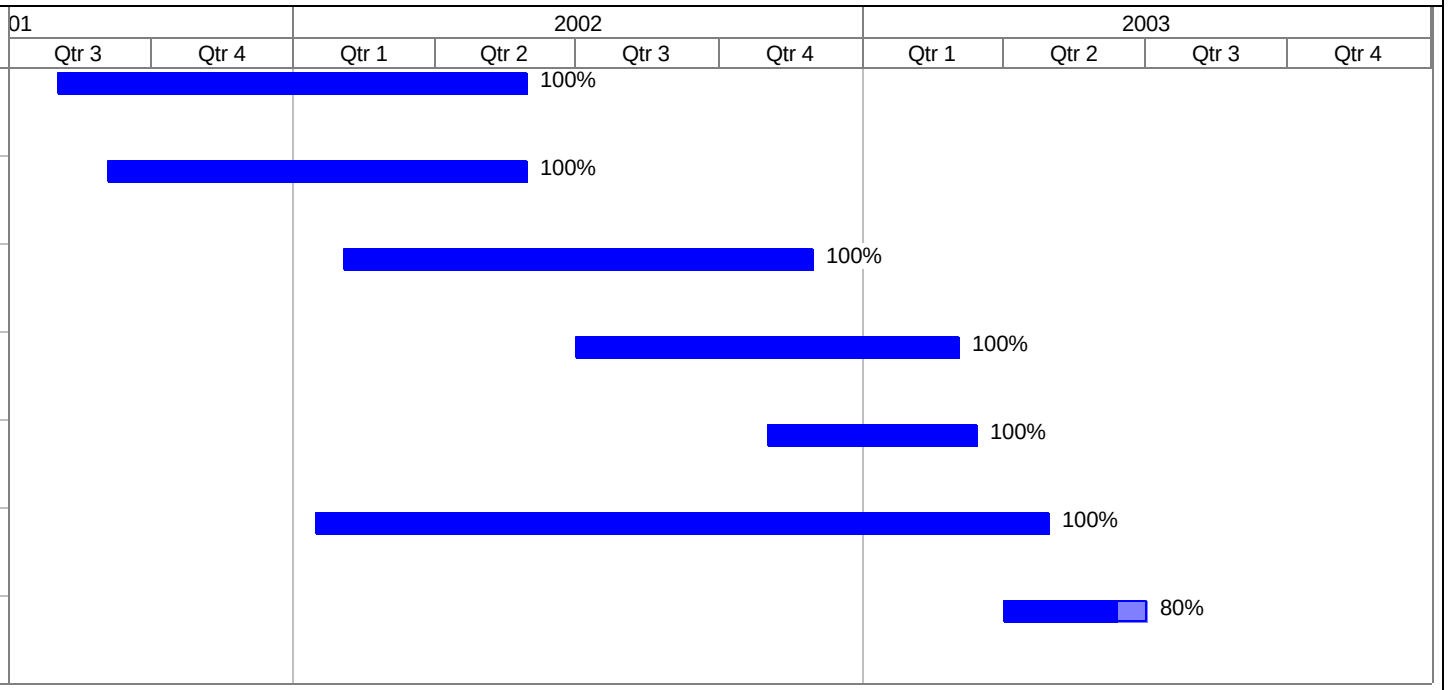
Task Name	Start	Finish
Task 1. Design of System	Wed 8/1/01	Thu 5/30/02
Task 2. Finite Element Computer Simulation	Mon 9/3/01	Thu 5/30/02
Task 3. Assemble Prototype	Fri 2/1/02	Fri 11/29/02
Task 4. Test and Optimize Prototype	Mon 7/1/02	Mon 3/3/03
Task 5. Film Deposition Experiments	Fri 11/1/02	Sat 3/15/03
Task 6. Data Analysis	Tue 1/15/02	Wed 4/30/03
Task 7. Gather Data; Preprare and Submit Final Report	Tue 4/1/03	Tue 7/1/03