Technical Assistance Request - Provide a two-page description of the areas where you need assistance to realize your solution. Consider the unique capabilities the national labs, a private facility, and/or members of the American-Made Network could provide to you to resolve these barriers. The Prize Administrator will make this request broadly available so members of the American-Made Network can understand your needs and assist you through the voucher program or otherwise

Introduction of the innovation

Approximately 80% of the incoming solar irradiation on a photovoltaic (PV) array is dissipated as heat. Effective rejection of this heat from the PV panel to the ambient is critical in order to maintain effective long-term operation of the panels. Higher cell temperatures result in decreased cell efficiency, and reduced cell lifetime due to increased propensity for failures. While several active cooling technologies including fan-assisted heat sinks, liquid-cooled cold plates and thermoelectric coolers have been investigated, increased costs of these approaches have resulted in limited commercial adoption in high volume applications. The thermal management problem is getting increasingly challenging in bifacial PV modules. Such modules can potentially generate 10%-15% more electricity due to being able to take advantage of both the direct solar radiation on the front face, as well as reflected radiation on the rear face. However, they are also more prone to temperature variations compared to mono-facial PV modules, due to the presence of front-side partial shading, and rear-side irradiance inhomogeneity. These temperature variations can result in hot spots, which are prone to failures. Additionally, both mono-facial and bi-facial panels utilize bypass diodes within junction boxes that require effective thermal management. The thin vapor chamber (VC) technology developed at Georgia Tech promises to be the answer for these challenges. When integrated with these hot spot locations, the VC technology can effectively spread the heat to a much larger area with near zero internal thermal resistance, thereby allowing a significant reduction of heat flux and its dissipation to the ambient environment entirely passively.

Georgia Tech Facilities

The thin VC technology was developed at Georgia Tech (GT). Extensive facilities are in place for performance optimization and developing volume manufacturing of this technology. Three sets of GT facilities will directly be utilized in support of the proposed application. The thin VC assembly, charging and thermal testing will be performed at the **Microelectronics and Emerging Technologies Thermal Laboratory (METTL)**, directed by Dr. Joshi. At METTL, VC samples will be hermetically sealed, charged with the working liquid (water) under partial vacuum conditions, and thermally evaluated by attaching resistance heaters, and in later phases actual diodes, and monitoring resulting temperatures and thermal resistances. This testing will demonstrate the laboratory-scale thermal performance at the individual bypass diode level. Using computational modeling, and laboratory-scale testing, we will be able to optimize VC parameters such as the capillary wick geometry. METTL has extensive thermal testing facilities, and also houses the necessary VC working fluid charging and sealing equipment. The sintered metal powder-based VC wick will be fabricated for laboratory-scale testing at the **Packaging Research Center (PRC)**. PRC is a world-class facility and has over a two-decade track record in microelectronics packaging technologies research and development. Originally established as a National Science Foundation Engineering Research Center, it operates on the industry consortium model, where each member company focuses on advanced packaging development on an emerging topic. The wick fabrication will utilize the high-temperature sintering furnace facility within the PRC Cleanroom. The sintering parameters will need to be optimized for the proposed application. PRC also has extensive knowhow and packaging-related laboratory facilities that we plan to use to develop the integration of the VC based bypass diode architecture, and integration of packaging. Georgia Tech has extensive machine shop facilities, with multiple computer numerical controlled machines which we plan to utilize on an as-needed basis.

National Renewable Energy Laboratory

We plan to actively engage with the National Renewable Energy Laboratory (NREL) as part of the proposed application. Our team has current collaborations with Dr. Sreekant Narumanchi's group in the area of power electronics thermal management. Dr. Narumanchi's group has extensive computer modeling and thermal characterization facilities for component and module-level assessment. We plan to collaborate with them in validating the thermal performance of the VC at the component level. Using their power electronics thermal testing capabilities such as the T3Ster, we plan to evaluate the VC integrated bypass diode electrical and thermal performance. In the later stages of the competition, we would plan to also the utilize larger scale PV testing facilities for photovoltaic research available at NREL (https://www.nrel.gov/pv/).

Technology Commercialization

For assistance with the commercialization of the technology, we will work with the VentureLab, a nationally acclaimed campus incubator program. Mr. Jonathan Goldman has extensive experience with the solar industry through participation in the campus spin-out solar cell company Suniva. Mr. Goldman served as the Director of Business Development for Suniva during 2007-2008. We plan to work with VentureLab in identification of the scale-up approach for cost-effective manufacturing, and following the anticipated formation of a start-up, in raising funds for its expansion. The Georgia Tech team also plans to collaborate with two America-made companies: Solar Inventions, and Resilient Power Systems. Both are prior winners of the Go! Competition and will provide consultation on product development, support on testing, and help with technology commercialization. Collaboration letters from these companies are attached. In addition, we will seek assistance in identifying commercialization opportunities from ADL Ventures, the Power Connector that made our team aware of the Go! Competition.

Needs for the Next Phase

For the Ready! Phase, we plan to successfully demonstrate the thermal performance benefits of integration of VC technology with bypass diodes in PV junction boxes. Specifically, we will need the following technical steps to be performed at the laboratories at GT:

- Fabrication of VC devices in form factors suitable for PV junction box integration
- Capillary wick fabrication for VC using metal sintering and patterning
- VC hermetic sealing
- VC charging with working fluid suitable for operating temperature range for PV modules
- VC testing with simulated thermal load
- VC thermal modeling for optimization of wick performance parameters
- Laboratory-scale thermal testing of optimized VC
- Identification of approach for VC packaging integration with bypass diode
- Conceptual design of new junction box topology

The anticipated technical assistance from the industry partners and NREL will include:

- Validation of thermal performance of VC samples fabricated at GT
- Combined thermal and electrical performance testing of VC integrated bypass diode
- Environmental chamber testing of VC integrated bypass diode to simulate ambient temperature and humidity ranges in various climatic regions
- Identification of design and performance requirement of new junction boxes
- Identification of scale-up and grid integration architectures of PV modules with new junction boxes