Funding Opportunity Title: Thermophotovoltaic (TPV) Cell Array Assembly Research
Funding Instrument Type: The Government anticipates awarding an Other Transaction Agreement (OTA), but reserves the right to award any instrument available for use under the Broad Agency Announcement W911NF-17-S-0003
Funding Opportunity Number in Grants.gov: W911NF-17-S-0003-SPECIALNOTICE-TPV-CELL

Background:
Dismounted soldiers and squads rely on rechargeable batteries for operations and require recharging capabilities to enable multiday missions. Current recharge capabilities are limited to portable generator technology based on internal combustion engines that are too loud, heavy, and are susceptible to failures or harvesting solar energy that is not always available. Army Research Laboratory (ARL) is researching the use of a compact multi-fuel combustion heat source paired with a thermophotovoltaic (TPV) cell array and Cavity designs on the ARL experimental test stand to produce electric output ranging from 50 to 150 W as part of Phase 1. The main generator components are a Burner/Emitter/Recuperator (BER), TPV cell array (TCA), and the Cavity design. The Cavity is the space between the Emitter and the TPV Cells and the Cavity design involves the interaction of the emitter surface, TPV surface, and possibly special reflectors, endcaps, and/or non-imaging optical filters. Other researchers have tried integrating the best performing individual components, but the performance does not match predictions and is not acceptable. The interaction of these components requires further research and development to reach optimal system performance. To refine the direction of the research, proof of concept of "coupling" of a BER, Cavity, and TPV Cells at relevant scales is critical. In addition as part of Phase 2, ARL is investigating the impact of system scale on the “coupling” of these components to reach electric outputs ranging from 150 to 500 W. The research, processes and components developed in this effort are part of the Compact Power research being conducted at ARL on thermophotovoltaic power sources.

Description:
The aim of this Special Notice under the ARL BAA (W911NF-17-S-0003), under Grants.gov Opportunity W911NF-17-S-0003-SPECIALNOTICE-TPV-CELL, is to fund an entity to collaborate with ARL to research Thermophotovoltaic (TPV) Cell Array assembly concepts for use on the ARL experimental test stand to produce electric output. ARL has assembled TCAs in-house in the past, but seeks entities with other approaches, more experience, and better equipment to collaborate with on this research. ARL will collaborate with the awardee on an improved design. The awardee will assemble proof of principle TCAs using TPV cells provided by ARL. The TCA will be tested by ARL on the ARL experimental test stand. ARL will then feedback the test data and work with the awardee to further improve the design. It is envisioned a few iterations of this process will lead to an optimized design to determine the limits of the TCA on overall ARL experimental test stand efficiency.

The primary components of the ARL experimental test stand include a BER, TPV cell array (TCA), and Cavity. The BER is made up of a cylindrical counter flow burner with a cylindrical emitter tube covering one end of the burner with a recuperator attached to the other end of the burner. One end of the emitter is closed off with a thermally insulating lid. The outer surface of the emitter is heated to ~1100 Celsius and the burner surfaces are also at high temperatures. The TCA is made up of TPV cells mounted on heat sinks that surround the outside of the emitter. The TPV cell array and heat sinks fits inside a

tubular housing with a cooling fan mounted on one end. Air from the cooling fan flows in the direction of the axis of the tubular housing through the heat sinks. The Cavity is the space between the Emitter and the TPV Cells and the Cavity design involves the interaction of the emitter surface, TPV surface, and possibly special reflectors, endcaps, and/or non-imaging optical filters. See Figure 1.

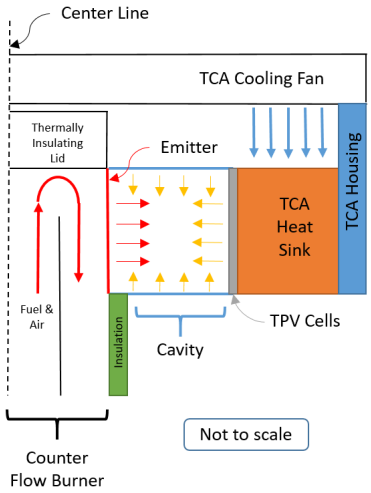

Figure 1- Cross section view of BER, TCA, and Cavity

The current ARL TCA design has 108 TPV cells with each cell measuring 0.87 cm x 0.85 cm. It also includes a -circuit board with score marks to allow the circuit board to bend to create a 9 facet 180 degree semicircle. This semicircle has 54 TPV cells attached using thermally conductive epoxy. Heat sink fins are epoxied to the backside of the circuit board (see Figure 2). The axial length of the area covered by TPV cells on each facet is 53.5 mm. The distance from the surface of the TPV cells on one facet to the surface of the TPV cells on the facet 180 degrees directly across is 54.5 mm. The TPV cells can be electrically connected in various series/parallel configurations. Two circuit boards bend into a semicircle to cover the 360 degree interior of a tubular Teflon housing. The outer diameter of the fins of the current design is 87.5 mm. The outer diameter of the Teflon housing is96 mm. There is a thermocouple epoxied to the heat sink base to monitor the cell temperature. The current design has an 80 x 80 mm low power fan mounted on one opening of tubular housing with the air flowing in the direction of the axis of the tubular housing through the heat sinks.

During operation of the current design on the ARL TPV Test Stand, TPV cell temperatures are controlled to less than 80 Celsius, but at the cost of more fan power which reduces the overall ARL experimental test stand efficiency. Low TPV cell temperatures are desired to ensure better TPV cell performance. Other ways to reduce the cell temperature might be improved heat sink design, integration, and attachment. Other areas of research that may be addressed include: improved circuit board design, TPV cell attachment methods; electrical connection methods and configurations; methods to reduce force air cooling required; methods to withstand high temperature and high radiation flux environments given the high emitter and burner temperatures; methods to improve view factor; methods to reduce inactive TPV cell areas; and methods to increase reflectivity for photon recycling.

The awardee may need to sign some type of non-disclosure agreement/license with the TPV cell manufacturers. This requirement will be negotiated prior to award.

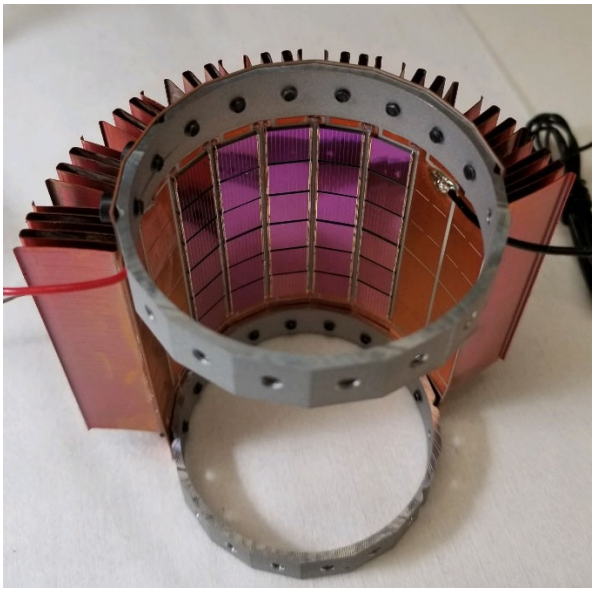

Figure 2: Current partial PCA design showing 9 facet board with heat sinks attached, 5 facets with 6 TPV cells on each facet

Schedule:

The program consists of two phases. Phase 1, will be the first year and involve 3 tasks. In Task 1, ARL will collaborate with the awardee on improving the current TCA design. The current design has 108 TPV cells with each cell measuring 0.87 cm x 0.85 cm; the area covered by TPV cells on each facet shall have an axial length of 53.5 mm; and the distance from the surface of the TPV cells on one facet to the surface of the TPV cells on the facet directly across is 54.5 mm. The cells in the current design are capable of being electrically connected in various series/parallel configurations. In the current design, the outer diameter of the heat sink fins is 87.5 mm; the outer diameter of the of the tubular Teflon housing is 96 mm; a thermocouple is connected to the heat sink base to monitor the cell temperature; and a low power fan is mounted on one end of the housing with the air flowing through the heat sinks. The awardee will assemble and deliver one proof of principle TCA (TCA 1) using 108 TPV cells provided by ARL. This awardee's TCA will be tested by ARL on the ARL experimental test stand. In Task 2, ARL will feedback the test data from Task 1 and work with the awardee to improve the design. The awardee will assemble and deliver one proof of principle TCA (TCA 2) using 108 TPV cells provided by ARL. In Task 3, ARL will feedback the test data from Task 2 and work with the awardee to improve the design. The awardee will assemble and deliver three proof of principle 108 TPV cell TCAs (TCA 3) using cells provided by ARL.

Phase 2, will be the second year and involve one task known as Task 4. In Task 4, ARL will feedback the test data from Task 3 and work with the awardee to improve and scale up the design. The awardee will assemble and deliver four scaled up proof of principle TCAs (TCA 4) using TPV cells provided by ARL. Each TCA in Task 4 is estimated to have 319 cm^2 of TPV cells.

Goals and Metrics:

Collaborate with ARL to research Thermophotovoltaic (TPV) Cell Array assembly concepts for use on the ARL experimental test stand. ARL will collaborate with the awardee on an improved design. The awardee will assemble proof of principle TCA using TPV cells provided by ARL. The TCA will be tested by ARL on the ARL experimental test stand. ARL will then feedback the test data and work with the awardee to improve the design. It is envisioned a few iterations of this process will lead to an optimized design to determine the limits of the TCA on overall system ARL experimental test stand efficiency.

Phase 1 (12 months; available Government funding not expected to exceed $150,000):

- Collaborate with ARL on an improved TCA design based in ARL current design.
- Assemble and deliver one proof of principle TCA (TCA 1) using 108 TPV cells provided by ARL.
- Analyze test data from ARL testing of TCA 1 on the ARL experimental test stand.
- Collaborate with ARL on an improved TCA design.
- Assemble and deliver one proof of principle TCA (TCA 2) using 108 TPV cells provided by ARL.
- Analyze test data from ARL testing of TCA 2 on the ARL experimental test stand.
- Collaborate with ARL on an improved TCA design.
- Assemble and deliver three proof of principle TCAs (TCA 3) using 108 TPV cells provided by ARL for each TCA.

Phase 2(12 month Option Period; available Government funding not expected to exceed $200,000):

- Analyze test data from ARL testing of TCA 3 on the ARL experimental test stand.
- Collaborate with ARL on an improved and scaled up TCA design.
- Assemble and deliver four scaled up proof of principle TCAs (TCA 4) using TPV cells provided by ARL.

Deliverables:

- Monthly technical report and review meeting
- Monthly financial reports
- Task 1, one proof of principle TCA (TCA 1) using 108 TPV cells provided by ARL delivered no later than 3 months after award.
- Task 2, one proof of principle TCA (TCA 2) using 108 TPV cells provided by delivered no later than 2 months after Task 1 delivery.
- Task 3, three proof of principle TCAs (TCA 3) using 108 TPV cells provided by ARL delivered no later than 3 months after Task 2 delivery.
- Task 4, four scaled up proof of principle TCAs (TCA 4) using TPV cells provided by ARL delivered no later than 10 months after Task 3 delivery.

Evaluation criteria:

Proposals will be evaluated using the following criteria, listed in descending order of importance: (a) Overall Scientific and Technical Merit; (b) Potential contribution to the Army mission; (c) Realism of Proposed Schedule; (d) Cost Realism; (e) and Offeror's Capabilities and/or Related Experience.

1. Overall Scientific and Technical Merit

The proposed technical approach is feasible, achievable, and complete. Task descriptions and associated technical elements provided are complete and in a logical sequence with all proposed deliverables clearly defined such that a final outcome that achieves the goal can be expected as a result of award. The proposal identifies major technical risks and planned mitigation efforts are clearly defined and feasible. Some factors to address may include: maintaining low cell temperature with minimal parasitic power to the cooling fan; improved circuit board design and TPV cell attachment methods; electrical connection methods and configurations; methods to withstand high temperature and high radiation flux environments given the high emitter and burner temperatures; methods to improve view factor; methods to reduce inactive area; and methods to increase reflectivity of inactive area for photon recycling.

2. Potential contribution to the Army mission
The offeror details the effort's potential contributions to the Army mission and the extent to which the research effort will contribute to balancing the overall ARL research program.

3. Realism of proposed schedule
The proposed schedule aggressively pursues performance metrics in the shortest timeframe and accurately accounts for that timeframe. The proposed schedule identifies and mitigates any potential schedule risk.

4. Cost Realism
The proposed costs are realistic for the technical and management approaches offered and demonstrates the offeror's practical understanding of the effort. The costs proposed are based on realistic assumptions, reflect a sufficient understanding of the technical goals and objectives of the special notice, and are consistent with the offeror's technical approach (to include the proposed Statement of Work). At a minimum, the prime offeror and proposed subawardees substantiate the proposed costs with the type and number of labor hours proposed per task as well as the types and kinds of materials, equipment and fabrication costs proposed (substantiated with quotes), and justification of any other proposed costs. It is expected that the effort will leverage all available relevant prior research in order to obtain the maximum benefit from the available funding.
ARL recognizes that undue emphasis on cost may motivate offerors to offer low-risk ideas with minimum uncertainty and to staff the effort with junior personnel in order to be in a more competitive posture. ARL discourages such cost strategies. Likewise, proposals that do not confine to the funding levels mentioned above may be deemed non-compliant.

5. Offeror's Capabilities and/or Related Experience
The offeror's prior experience in similar efforts clearly demonstrates an ability to deliver products that meet the proposed technical performance within the proposed budget and schedule. The proposed team has the expertise to manage the cost and schedule. Similar efforts completed/ongoing by the offeror in this area are fully described including identification of other Government sponsors.

Proposal submission:

White Papers will not be accepted under this Special Notice. Full proposal submissions must be submitted against Grants.gov Opportunity Announcement W911NF-17-S-0003-SPECIALNOTICE-TPV-CELL in accordance with the preparation and submissions instructions under BAA W911NF-17-S-0003, except as noted below. Proposals shall be submitted electronically through the www.grants.gov portal. A proposal sent by any other means (e.g., hand-carried, postal service mail, commercial carrier, fax or email) will not be considered. Proposals must be received no later than Friday, 11 June 2021 at 11:59 PM (EDT) to be considered for award under this Special Notice. The proposal content information is as specified under BAA W911NF-17-S-0003, except the technical proposal (project description) portion of the full proposal must not exceed thirty (30) pages. If the technical proposal exceeds 30 pages, only the first 30 pages will be reviewed and evaluated. As described in the BAA W911NF-17-S-0003, the proposal must also include a budget for each year of support requested. Proposals will be evaluated using the criteria listed in this Special Notice. Proposal evaluation is expected to be complete and any award selections made by late June 2021. An applicant whose proposal is selected for award will be contacted by a Contracting/Grants Specialist.

Clarifying questions regarding the intent or scope of this special notice may be submitted. Answers to non-proprietary questions will be sent to the points of contact from each eligible Applicant's proposal submission. All clarifying questions must be submitted to christopher.d.justice4.civ@mail.mil AND nikolaos.georgakopoulos.civ@mail.mil before
26 May 2021 at 11:59 PM (EDT). Should an Applicant have questions they believe are of a proprietary nature, the Applicant must clearly state so and identify and mark the proprietary information in the question when submitted. Answers to questions of a proprietary nature will be provided via email directly to the requestor of the question.

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