

CRADA Final Report Form

Date: ___ March 25, 2020 ___

PI: Vi Rapp

CRADA AWD No.: AWD00002981

CRADA FP No.:

FP00005626

LBNL Report Number: _____ (SPO to add)

OSTI Number: _____ (SPO to add)

1. Parties: Spark Thermionics. Inc. and Lawrence Berkeley National Laboratory
(Identify Parties to the CRADA)

2. Title of the Project: Thermionic emission and energy conversion

3. Summary of the specific research and project accomplishments:
(Were key major goals of the CRADA achieved?)

Note: Final Reports and Forms containing Protected CRADA Information are to be emailed directly to the SPO close out requestor, along with a confirmation of the public release date. Do not submit via eSRA. Also, please do not include any Proprietary Information (defined below) in CRADA Final Reports and Forms.*

The project team worked on development of a transformative heat-to-electricity conversion device based on thermionic energy conversion. Research was conducted to further development of a thermionic energy converter based on modern microfabrication and new low work function anode materials that can surpass all other forms of direct heat-to-electricity conversion. The research team completed the following:

- 1) Developed components for use in thermionic energy converters and electron emission devices, including electrode materials for electron emission and electron absorption with ultimate work functions below 5 eV;
- 2) Designed and fabricated thermionic devices for energy conversion and electron emission based on the components developed in (1);
- 3) Engineered test systems to characterize electronic, thermal, and mechanical properties of thermionic devices and electron emitters and their components, and test devices and components designed and fabricated in (1) and (2); and

- 4) Developed theoretical modeling capabilities in support of these technical objectives.

4. Deliverables:

Deliverables met	Party (LBNL, Participant, Both)	Delivered to Other Party?
Project mentorship and facility access	LBNL	complete
Development of electrode materials and components	Participant	complete
Design and fabricate devices	Participant	complete
Engineer test systems, test devices	Participant	complete
Theoretical modeling in support of Tasks 1-3	Participant	complete

5. Identify (list below) and attach all publications or presentations at conferences directly related to the CRADA: None
6. List of Subject Inventions and software developed under the CRADA: (Please provide identifying numbers or other information.) None
7. A final abstract suitable for public release:
(Very brief description of the project and accomplishments without inclusion of any proprietary information or protected CRADA information.)

This project worked on development of a transformative heat-to-electricity conversion device based on thermionic energy conversion. The research provided a unique opportunity to transform the thermionics technology of the 1950-1990s by applying modern materials and 21st century wafer-scale fabrication methods. Research was conducted to further development of a thermionic energy converter based on modern microfabrication and new low work function anode materials that can surpass all other forms of direct heat-to-electricity conversion. This project completed the following goals:

- 1) Developed components for use in thermionic energy converters and electron emission devices, including electrode materials for electron emission and electron absorption with ultimate work functions below 5 eV;
 - 2) Designed and fabricated thermionic devices for energy conversion and electron emission based on the components developed in (1);
 - 3) Engineered test systems to characterize electronic, thermal, and mechanical properties of thermionic devices and electron emitters and their components, and test devices and components designed and fabricated in (1) and (2); and
 - 4) Developed theoretical modeling capabilities in support of these technical objectives.
8. Benefits to DOE, LBNL, Participant and/or the U.S. economy.

The research project expanded the laboratory's core competencies by introducing a unique opportunity to transform thermionics technology, while it also enhanced and took advantage of the lab's existing core competencies in material science and combustion.

9. Financial Contributions to the CRADA:

DOE Funding to LBNL	\$0
Participant Funding to LBNL	\$0 (\$10,000 in royalty funds allocated)
Participant In-Kind Contribution Value	\$40,000
Total of all Contributions	\$40,000

** "Proprietary Information" means information, including data, which is developed at private expense outside of this CRADA, is marked as Proprietary Information, and embodies (i) trade secrets or (ii) commercial or financial information which is privileged or confidential under the Freedom of Information Act (5 U.S.C. 552 (b)(4)).*