NASA EPSCoR
Research Performance Progress Report (RPPR)
Seed Award

I. Collaborating Organizations

A. Academic Collaborators *(do not include names of minors)*

Name	Academic Affiliation	RID Project Role	Nearest person month worked	Contribution to Project	Funding Support
Joseph P Feser	University of Delaware	PI	5	Advisor (assisted with all Chowdhury tasks -below; advisor to Russell Purdue)	
Ongira Chowdhury	University of Delaware	Graduate Student	5	Designed & Assembled Oscillating Heat pipe prototypes, designed and assembled the refrigerant charging system. Executed TDTR experiments.	This project
Russell Purdue	University of Delaware	Undergraduate Researcher	3	Re-design of refrigerant charging/measuring system,	DE Spacegrant Summer Intern

				design of high speed camera integration and software, with laser system.	

B. NASA Collaborators

Name	Title	NASA Center	Nature of the Collaboration

C. Industry Collaborators

Name	Title	Industry/Company Name	Nature of the Collaboration

D. New non-EPSCoR grants

Funding Entity	Award Name	Value of New Grant

E. Other Organizations Involved as Partners

Organization	Nature of the Partnership	Benefit of the Partnership

II. Products

A. A. A. List Journal publications – Please only list papers that have been published. **Please do**

not remove the table; or alter columns, add additional rows as required.

Date Published	Published Paper (APA format)

A. A. B. List Conference Papers – Please only list papers that are included in conference proceeding. **Please do not remove the table; or alter columns, add additional rows as required.**

Conference Date	Conference Paper (APA format)

A. A. C. List Conference Presentation – Please list conference presentation. **Please do not remove the table; or alter columns, add additional rows as required.**

Conference Date	Presentation Topic (APA format)

A. A. D. List Books and/or other Publications – Please include explanations, help us to learn about your accomplishments. **Please do not remove the table; or alter columns, add additional rows as required.**

Date	Explanations (APA format -Book, Newspaper Op-Ed, …)

A. A. E. List talk/presentation/event/outreach activity – Please include explanations, help us to learn about your accomplishments. **Please do not remove the table; or alter columns, add additional rows as required.**

Date	List talk/presentation/event/outreach activity (APA format if applicable)

A. A. F. List of new or updated Website(s) or other Internet site(s). **Please do not remove the table; or alter columns, add additional rows as required.**

URL	Short description of purpose of site

A. A. G. Technology/Technique – **Please do not remove the table; or alter columns, add additional rows as required.**

Technology/Technique	Short description of technologies or techniques
TDTR observations of liquid water presence	**High Performance Oscillating Heat Pipes are generally optically opaque, making them difficult to observe, short of a neutron source. We have developed the ability thermally observe the presence of liquid water vs vapor on the non-visible side of an opaque metal using time domain thermoreflectance (TDTR). The basic idea is to use transient heating to probe the thermal response of the system on fast time scales. An example is shown in the Impact Section below.**

A. A. H. List patent – Please include Patent Number/Patent Title/ Patent Abstract (or link to it). **Please do not remove the table; or alter columns, add additional rows as required.**

Date	Patent Number/Patent Title/ Patent Abstract (or link to it)

Patent Issued	

A. A. I. List Inventions – Please include Invention Title, List of Inventor(s) and Description. **Please do not remove the table; or alter columns, add additional rows as required.**

Invention Title	List Inventor(s)	Invention Description

A. A. J. List Licenses – Please include license issued, Invention Title, List of Inventor(s) and Description. **Please do not remove the table; or alter columns, add additional rows as required.**

Date License Issued	License Assignees	License Title

A. A. K. List New/Revised Courses – Please include new/revised courses. **Please do not remove the table; or alter columns, add additional rows as required.**

Course Number	Course Name/Title	Offering Institution

A. A. L. Others: List Databases, Physical collections, Audio or video products, Software or NetWare, Models, Instruments or equipment, Data & Research Material (e.g., cell lines, DNA probes, animal models) related to your EPSCoR research. **Please do not remove the table; or alter columns, add additional rows as required.**

Accomplishments title	Short Description of accomplishments

III. Changes/Problems

A. Actual or anticipated problems or delays and actions or plans to resolve them

We executed the activities as stated in the proposal. Ongira Chowdhury worked for 5 months and successfully completed an initial prototype OHP, refrigerant charging system, and did initial experiments demonstrating we could detect phase change fronts thermally with TDTR– beyond an optically opaque wall (see Impact section below). That work was completed in late January 2024. Work is ongoing (by the PI now that Chowdhury is no longer funded) to accomplish the same thermal detection within the OHP itself; it will take several more months to polish our execution data before we are able publish and compete for proposals.

B. Changes that have a significant impact on expenditures

None.

IV. Impact

Graduate student, Ongira Chowdhury, and undergraduate researcher Russell Purdue are developing new tools to understand a promising thermal management technology called Oscillating Heat Pipes (usually called OHP's). Like their conventional heat pipe counterparts, the goal of an OHP is move heat from one location to another without using a pump – the heat itself provides the pumping action. In an OHP, the way this happens is complicated: Heat boils liquid inside of a partially filled liquid-tubing system pressurizing vapor bubbles that push other "slugs" of liquid toward a colder section, where the vapor begins to compress and condense. This creates a backpressure that acts as a spring and sends liquid slugs back towards the boiling section. Under some conditions, this causes a back-and-forth movement of the liquid between the hot and cold ends. This is extremely useful in a wide variety of applications, like thermal management in space, because passive heat transfer devices have are fewer parts to break and because the technology might handle larger heat loads than normal heat pipes.

Unfortunately, the mechanisms of the movement of liquid/vapor in OHP's are not well understood and under some conditions, they don't oscillate at all! Making things worse is that their exterior is made of copper, so that scientists cannot easily observe the fluid movement inside. That's where Chowdhury's work comes in.

Through the NASA EPSCoR seed grant, they are developing a new technique allowing the ability to "see" beyond the OHP's walls by probing thermal waves generated by a pulse laser – a variant of time domain thermoreflectance (or TDTR). This allows observation of whether liquid or vapor is passing by the wall at any given instant. So far, things are looking good. Chowdhury and Purdue have successfully built a plate-style OHP and refrigerant filling system. In a proof-of-concept experiment, Chowdhury used TDTR to detect transitions from liquid to vapor in metallic coated "windows".

More generally, NASA funding of the project is enabling the University of Delaware to build infrastructure and experience in two-phase flow thermal management technologies that will enable it to contribute to NASA mission goals in the future in the areas of adiabatic two-phase flow, boiling and condensation, capillary flow, and interfacial phenomena.

(*this Impact statement is not published online currently*)

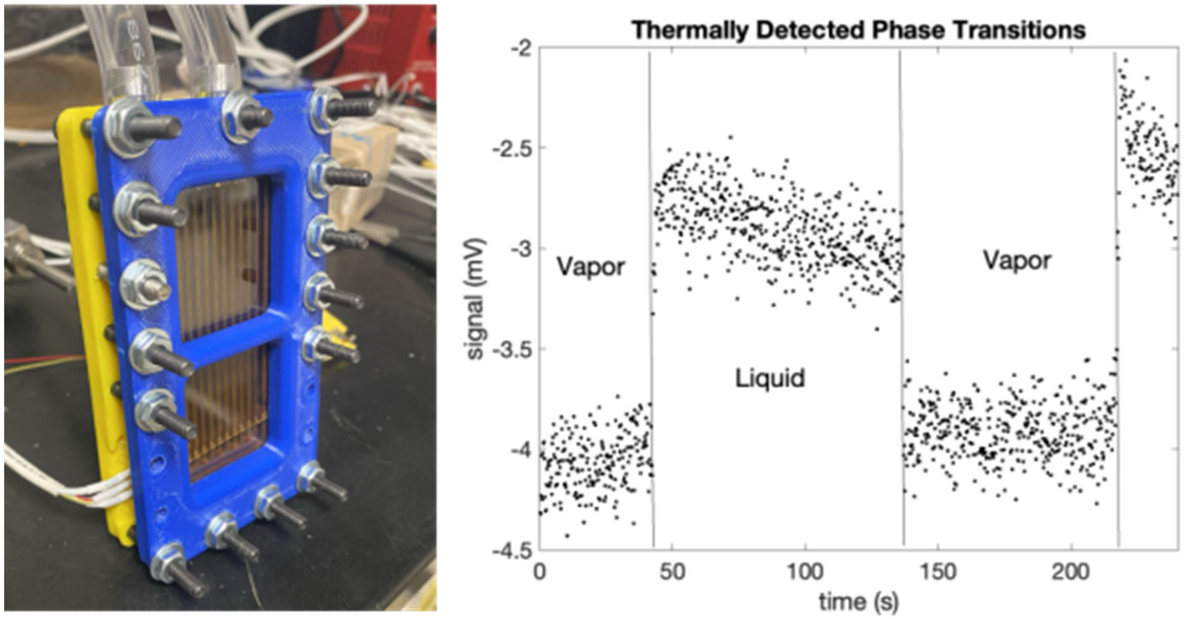

Figure 1. *UD 's first operational oscillating heat pipe (left) and time domain thermoreflectance data detecting fluid/vapor phases flowing past a gold coated window (right)*