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14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UU	15. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON David Cahill
a. REPORT UU	b. ABSTRACT UU	c. THIS PAGE UU			19b. TELEPHONE NUMBER 217-333-6753

RPPR Final Report
as of 01-Sep-2021

Agency Code: 21XD

Proposal Number: 75672MSRIP

Agreement Number: W911NF-20-1-0067

INVESTIGATOR(S):

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DUNS Number: 041544081

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Report Date: 14-Sep-2021

Date Received: 31-Aug-2021

Final Report for Period Beginning 15-Jun-2020 and Ending 14-Jun-2021

Title: GHz Frequency Optical Pump-Probe (GFOPP) Metrology Tool for High Sensitivity Measurements of Acoustic Dissipation and Elastic Constants

Begin Performance Period: 15-Jun-2020

End Performance Period: 14-Jun-2021

Report Term: 0-Other

Submitted By: David Cahill

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Distribution Statement: 1-Approved for public release; distribution is unlimited.

STEM Degrees: 1

STEM Participants: 1

Major Goals: The goal of the project was to purchase components and construct a non-contact metrology tool for studying GHz frequency acoustics of a wide range of bulk and thin film materials. Our GHz frequency optical pump-probe (GFOPP) metrology tool will enable experiments on the physics of acoustic dissipation in materials at frequencies comparable to thermal phonon relaxation rates.

Accomplishments: The components to construct the apparatus were purchased and assembled. A report on the expenditures and a picture of the apparatus are included in the "upload" section.

Training Opportunities: Unfortunately, the student who was intended to be trained in the construction of the apparatus was unable to travel to the US because of COVID. He will begin working on the instrument in fall 2021.

Results Dissemination: Nothing to Report

Honors and Awards: Professor Cahill was appointed the Grainger Distinguished Chair in Engineering at the University of Illinois.

Protocol Activity Status:

Technology Transfer: Nothing to Report

RPPR Final Report
as of 01-Sep-2021

Partners

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I certify that the information in the report is complete and accurate:

Signature: David Cahill

Signature Date: 8/31/21 5:52PM

Final Report: GHz frequency optical pump-probe (GFOPP) metrology tool for high sensitivity measurements of acoustic dissipation and elastic constants

David G. Cahill

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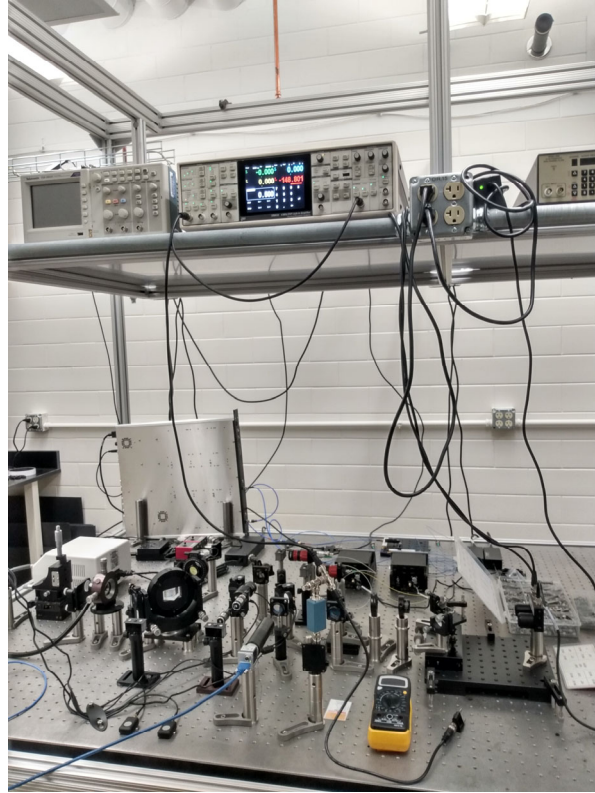
Program officer: Chakrapani (Pani) Varanasi
Branch Chief, Materials Science Branch
Program Manager-Physical Properties of Materials,
U.S. Army Research Office
email :chakrapani.v.varanasi.civ@army.mil

The funding of \$85,000 was used to purchase components for the construction of a GHz frequency optical metrology tool designed for measuring the dissipations of acoustic resonances in materials as a function of temperature. Due to covid restrictions on travel, the student that I intended to work on this project only arrived on campus at the end of August 2021. I purchased the equipment myself and assembled the components during the summer of 2021. The equipment is operational although the software to operate the system has not yet been written and the equipment is not fully debugged. We will start testing the system this fall using W/SiO₂ multilayers of the type conventionally used for acoustic Bragg reflectors and silicon nitride membranes. Initial experiments at low frequencies (20 MHz) produce the expected magnitudes of thermal signals for both thermorefectance and probe-beam deflection.

The GFOPP instrument is located in room 458 of the Materials Research Laboratory (MRL) and occupies one of the two optical tables in that room. The itemized list of expenditures is tabulated below in order of largest to smallest expenditure. A photo of the apparatus taken in July 2021 is included below the table of expenditures.

Amount	Vendor	Description
\$ 20,606.00	Berkeley Nucleonics Corp	Two-channel 20 GHz rf source.
\$ 8,919.04	Edmund Optics Inc	DSP lock-in amplifier for detecting the heterodyned signal. This includes a PID controller.
\$ 8,848.18	Olympus America Inc	Three microscope objectives
\$ 8,128.72	Thorlabs Incorporated	Optical fiber collimators
\$ 7,270.00	iXblue Inc	Optical modulator
\$ 6,770.00	Instec Incorporated	Temperature controlled microscope stage
\$ 6,550.00	iXblue Inc	Optical modulator and components
\$ 3,280.00	Q-Photonics LLC	Laser diodes
\$ 2,689.76	Thorlabs Incorporated	Flip mounts used to automate the positioning of mirrors and attenuators.
\$ 2,554.00	Newport Corporation	Gimbal mount for steering the pump probe beam separation
\$ 1,893.20	Thorlabs Incorporated	Positioners needed to scan the x-y position of

		the sample.
\$ 1,600.00	Sigatek	Directional couplers and mixers
\$ 1,335.08	Thorlabs Incorporated	Positioners needed to scan the x-y position of the sample.
\$ 919.44	Edmund Optics Inc	Illumination source, the light guide, and a mounting adapter for the imaging system.
\$ 869.00	Newport Corporation	xy positioner and rms-threaded objective mount to position the microscope objective.
\$ 638.68	Thorlabs Incorporated	Optical patch cables to connect the optical modulators to the fiber collimators.
\$ 516.66	Edmund Optics Inc	Camera and mounting adapter for imaging the sample and optical beams.
\$ 425.00	AVR Optics	Short pass optical filter, 950 nm edge.
\$ 393.00	Newport Corporation	Micrometers for xyz positioning stage.
\$ 272.72	Thorlabs Incorporated	Tube mounts for the fiber collimators.
\$ 223.00	Krytar	Rf 201B power detector
\$ 196.95	Thorlabs Incorporated	Optical patch cable
\$ 185.13	Thorlabs Incorporated	Misc optical mounts
\$ 105.00	SEKO Worldwide LLC	shipping cost for optical modulators
\$ 81.50	Thorlabs Incorporated	Misc optical mounts
\$ 66.49	Ted Pella Inc	Small vacuum pump to operate a vacuum chuck to mount samples for room temperature measurements.
\$ 40.72	United Parcel Service Inc (UPS)	shipping cost for rf source.
\$ 28.36	DKC DIGI KEY CORP: optical fiber connector	optical fiber connector
\$ 27.23	SEKO Worldwide LLC	shipping cost for optical modulators
\$ 16.78	United Parcel Service Inc (UPS)	Shipping cost for directional coupler
\$ 7.64	United Parcel Service Inc (UPS)	Shipping cost for laser diodes
\$ 5.70	United Parcel Service Inc (UPS)	Shipping cost gimbal mount
\$ 4.00	United Parcel Service Inc (UPS)	shipping rf power detector
\$ 3.87	United Parcel Service Inc (UPS)	Shipping cost for optical fiber connector
\$ 3.76	United Parcel Service Inc (UPS)	shipping cost for short-pass filter



Photograph of the GHz frequency optical pump probe apparatus installed on the optical table in room 458 of the Materials Research Laboratory at the University of Illinois. The sample mount is on the left side and two options for detection (thermoreflectance and probe-beam deflection) are on the right side.