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RPPR Final Report
as of 27-Mar-2019

Agency Code:

Proposal Number: 71231EGRI **Agreement Number: W911NF-17-1-0355**
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STEM Degrees: 0 **STEM Participants:** 0

Major Goals: Lightweight transparent armor structures are generally layered structures. The interface strength and toughness play a critical role in deflecting or promoting branching of growing cracks and effectively absorb energy. This helps in the development of failure resistant transparent armor alternatives to thick single layer designs. A mechanics-based research in this regard would require understanding how a dynamically growing crack interacts with one or more interfaces. This in turn demands development of new experimental techniques to perform full-field mechanical measurements at high spatial and temporal resolutions. The PI has an ongoing ARO grant (# W911NF-16-1-0093) entitled 'Dynamics of Crack-Interface Interaction in Layered Transparencies: An Experimental Investigation using Novel Optical Technique.' The present Research Instrumentation (RI) grant (# W911NF-17-1-0355) was to acquire instrumentation in support of the above effort. The specific items acquired were: (i) a high energy LED pulsed laser light source, (ii) a high-intensity flash illumination system, (iii) a long focal length zoom lens and accessories. Item (i) minimizes blur in the recorded images in the vicinity of a rapidly growing crack when used in conjunction with an ultrahigh-speed camera currently available in PI's lab. Item (ii) is a general purpose high energy solid-state flash lamps to replace/supplement aged ones currently used by the PI. Item (iii) is to perform paraxial imaging of fracture events at very high framing rates (> 1 million fps) from relatively long distance yet achieve the necessary 'exposure' during photography.

Accomplishments: The items purchased using this grant were: (i) a high energy LED pulsed laser light source, (ii) a high-intensity flash illumination system, (iii) a long focal length zoom lens and accessories.

Each of the above items have been purchased via market research and in-house demonstration of the equipment for their suitability/compatibility. The specifics of the purchase are as follows:

(I) Specialized Imaging, Inc. SI-LUX640-400 Pulsed Laser system with accessories (400 Watts peak power with 30 usec total light, pulse width from 10 ns to 30 usec)

(II) Specialized Imaging, Inc. SI-AD500-SYS-2, with one SI-AD500-CON controller including Fresnel lens assembly and control unit

(III-a) Cameragraphics, Inc. Nikon 400mm f/2.8 D II Lens with Nikon TC-20EIII

(III-b) Specialized Imaging, Inc. Lens mount accessories: tripod with translation stage and rails

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Training Opportunities: The purchase of different items listed have been market-researched, purchased, tested for their functionality and compatibility with the existing equipment to accomplish the tasks they were intended for. Market research and testing phases of this grant have been assisted by a graduate student in consultation with the sellers giving them hands-on training.

Results Dissemination: Preliminary results obtained using instrumentation purchased by this grant will be presented at national conference in June 2019.

Honors and Awards: The PI was appointed to the executive committee of ASME - Materials Division during 2018 for a 5-year term.

Protocol Activity Status:

Technology Transfer: Nothing to Report

PARTICIPANTS:

Participant Type: PD/PI
Participant: Hareesh V Tippur
Person Months Worked: 1.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

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Conference Location: Reno, Nevada
Paper Title: A comparative study of crack branching in glass using photoelasticity, digital image correlation and digital gradient sensing techniques
Authors: S. Dondeti, H.V. Tippur
Acknowledged Federal Support: **Y**

Final Report – Research Instrumentation Grant # W911NF1710355
(Reporting Period: Aug, 07 2017 to Dec, 31 2018)

Illumination and Recording Accessories for High-speed Photography to Study Dynamic Fracture of Brittle Solids

Hareesh Tippur (PI), Department of Mechanical Engineering, Auburn University, AL 36849

Objective

To acquire instrumentation to aid dynamic fracture characterization aspects of an ongoing ARO grant (# W911NF-16-1-0093) entitled 'Dynamics of Crack-Interface Interaction in Layered Transparencies: An Experimental Investigation using Novel Optical Technique' as well as to undertake research relevant to the U.S. Army in the future years. Specifically, (i) a high energy LED-based incoherent pulsed laser light source, (ii) a pair of high-intensity flash illumination system, (iii) a long focal length macro-zoom lens, are the illumination and recording accessories to be acquired.

Approach

The proposed equipment serve the project as follows: (i) The high energy LED-based incoherent pulsed laser light source is suitable for capturing blur-free digital images of stress and deformation fields in the vicinity of a rapidly evolving damage or a growing crack; (ii) The high-intensity flash illumination system is necessary to record speckles using a digital ultrahigh-speed camera operating at over 1 million frames per second; (iii) The long focal length macro-zoom lens is compatible with the existing ultrahigh-speed camera to perform paraxial imaging from a relatively long distance.

Relevance to Army

Layering of transparent materials is a strategy commonly used to produce failure resistant and lightweight transparent armor structures to replace thick and heavy monolithic sections. Strategic introduction of interfaces, however, requires a thorough mechanics-based understanding of the role interfaces play during high-strain rate loading events. That is, it would require a detailed understanding of how a dynamically propagating crack or a wave front interacts with one or more interfaces of the structure. Such investigations in turn demand development of sophisticated experimental tools capable of full-field visualization and quantification of deformations and/or stresses with a high spatio-temporal resolution during impact loading events. This research instrumentation grant facilitated equipment purchase to supplement facilities in PI's laboratory and carryout ARO sponsored research on 'Dynamics of Crack-Interface Interaction in Layered Transparencies' (Grant No. W911NF-16-1-0093).

Accomplishments

The items to be purchased using this grant were: (i) a high energy LED pulsed laser light source, (ii) a high-intensity flash illumination system, (iii) a long focal length zoom lens and accessories. Each of the above items was purchased after thorough market research and in-house

demonstration of the equipment for suitability and compatibility with the existing equipment. The specific items purchased are as follows:

(I) SI-LUX640-400 Pulsed laser system with accessories (400 Watts peak power with 30 usec total light, pulse width from 10 ns to 30 usec) from Specialized Imaging, Inc.

(II) SI-AD500-SYS-2, with one SI-AD500-CON controller including Fresnel lens assembly and control unit from Specialized Imaging, Inc.

(III-a) Nikon 400mm f/2.8 D II Lens with Nikon TC-20EIII from Cameragraphics, Inc.

(III-b) Lens mount accessories a tripod with translation stage and slider mechanisms Specialized Imaging, Inc.

Collaborations and Technology Transfer

None.

Resulting Publications

S. Dondeti and H.V. Tippur, ‘A comparative study of crack branching in glass using photoelasticity, digital image correlation and digital gradient sensing techniques,’ Proc. SEM Annual Conference, June 2019, submitted.

Graduate Students Involved During Reporting Period

None.

Undergraduate Students Involved During Reporting Period

None

Awards, Honors and Appointments

The PI was elected to the executive committee of ASME-Materials Division in 2018.