Research, scholarship and creative activity at Oklahoma State University 2017

OSU RESEARCH MATTERS

SEARCHING FOR ANSWERS

OSU Pathologists Target Bovine Viral Infections after Long Road to Discovery

Jean d'Offay
Center for Veterinary Health Sciences

OKLAHOMA STATE UNIVERSITY

OSU RESEARCH MATTERS

Burns Hargis President

Kenneth W. Sewell, PhD. Vice President for Research

OSU Research Matters is published annually by Oklahoma State University and is produced by the Office of the Vice President for Research.

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 This publication, issued by Oklahoma State University as authorized by Research Communication, was printed by Royle Printing at a cost of $5,328. 5M / 1/17. #6707

2017

OSU RESEARCH MATTERS

OSU Research Matters

Welcome to Oklahoma State University's annual research magazine, which highlights just a few of the university's many scientific, engineering and scholarly projects and researchers. I think you'll agree that this issue is loaded with fascinating work that illustrates how OSU research impacts our students, Oklahomans, and the world.

You'll notice that the name of the magazine has been changed to *OSU Research Matters*. The change came after discussions with many OSU research leaders who agree with me that OSU's research reputation is one of impact...we do research that MATTERS. In my introductory remarks to last year's magazine, I made the case for why research matters. In our social media posts, we've begun using #OSUResearchMatters as a way to collect topics that highlight this concept. Now we're doubling down by making that statement the title of the university's chief research publication.

Why call it *OSU Research Matters*? As a comprehensive research university and a land-grant institution, research is integral to OSU's mission. This work directly impacts an enormous constituency of individuals and organizations, both public and private. For those directly impacted, our research certainly matters. But even for those who may never realize how they benefit, the results of our research still matter greatly. Research conducted at OSU translates into safer bridges and highways, improved human and animal health, safer and more efficient food production, a cleaner environment, a productive economy, an understanding of how culture enriches our lives, and much, much more.

Research also matters to the tens of thousands of OSU students who, over the years, have participated in research projects while being mentored by professors. For these undergraduate and graduate students, conducting genuine research deeply affects their educational experience and, in many cases, influences careers.

Exciting research is going on in every discipline at OSU and includes an amazing assortment of study areas, a few of which are featured in this inaugural issue of *OSU Research Matters*. Projects in this issue illustrate how research is at the heart of what we do as a land-grant university. I hope you enjoy the projects featured in these pages, and that you will find ways to help us spread the news: *OSU Research Matters*!

Kenneth W. Sewell, Ph.D.
Vice President for Research

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Poetry as the building blocks of engineering

BY CHELSEA ROBINSON

Quite the juxtaposition of words, yet exactly those used as inspiration by James Manimala, assistant professor of mechanical and aerospace engineering.

Manimala discovered a correlation between the two subjects while analyzing the poem "I Wandered Lonely as a Cloud" by William Wordsworth. The fourth line of its second stanza reads "A host, of golden daffodils".

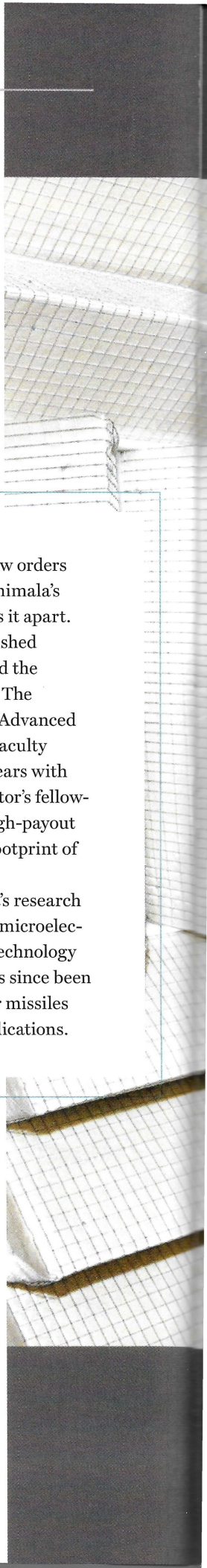
In reflection on that particular phrase, Manimala focused on the long "o" repeated throughout the line and how the subtleness of the sounds impacted the overall effect of the piece. Poets and writers refer to this literary device used as a building block of verse as "assonance." In that moment, he realized the same principle could be applied to his research in mechanical metamaterials. Just as the soft sound of the long "o" created a desired rhythm, he could make repeated alterations within existing materials to achieve the desired effect he sought.

Manimala's research focuses on introducing internal features into materials to get a desired transformation across structures. In practical terms, if a host material can be altered through "clever little dynamics" to change the material, then existing materials can be transformed to realize unprecedented dynamic characteristics.

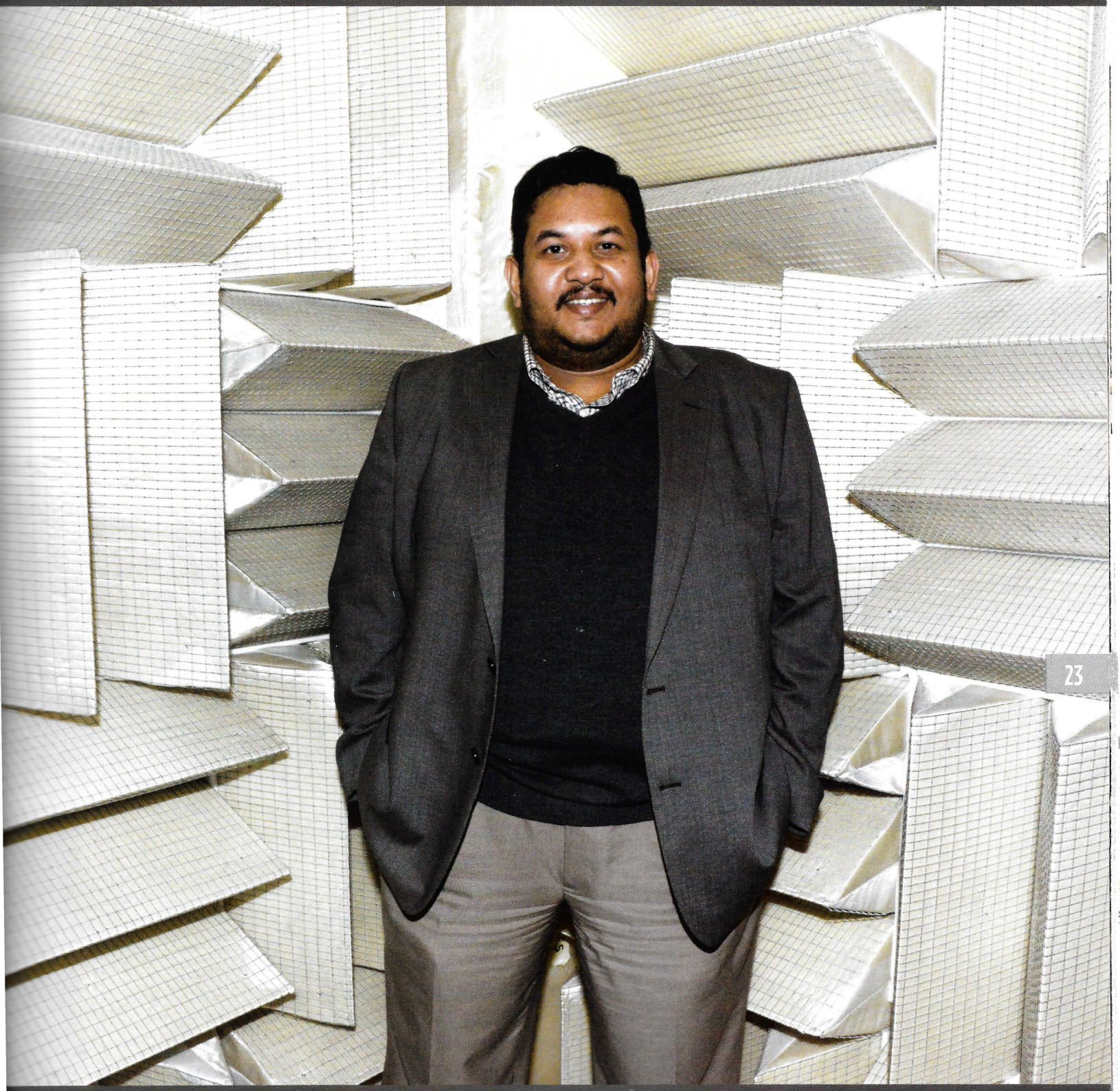
He compares the process to crafting a recipe that has a complicated list of exotic ingredients, but he gets to determine how much of which ingredients to use and in what way to control the flavor of the dish. When applied to metamaterials, this is a groundbreaking approach based on integrating mechanical assonance and inertance. Such metamaterials can steer, focus, disperse or even reject mechanical disturbances and also act as "tuned mass participants", which have a relatively small static mass but a dynamic mass presence a few orders of magnitude greater. The uniqueness of Manimala's research is one of the characteristics that sets it apart.

The foundations of his theory were published recently in the *Journal of Applied Physics* and the *Journal of the Acoustical Society of America*. The publications led to his receiving the Defense Advanced Research Projects Agency (DARPA) Young Faculty Award, which provides $498,000 over two years with the possibility of a $500,000 follow-on director's fellowship. DARPA historically funds high-risk, high-payout projects that have the potential to alter the footprint of modern technology.

Due to the nature of DARPA, Manimala's research will focus on defense applications, including microelectromechanical systems (MEMS). The basic technology of MEMS has existed since the 1980s and has since been utilized for atomic clocks, inertial sensors for missiles and even for micro-robots in biomedical applications.



Manimala's research with metamaterials involves using an anechoic chamber where his group performs transmission loss testing of materials with various acoustic treatments.



"Poets and writers refer to this literary device . . . as 'assonance.' In that moment, he realized the same principle could be applied to his research in mechanical metamaterials."

Manimala will use his mechanical assonance principle to explore mechanical encryption for crucial military devices. In other words, he will encode the device in a way that can only be decoded through his specific type of signal processed through mechanical assonance. This development, if successful, will transform the way MEMS are used for defense purposes.

Through this project, OSU will partner with such universities as Stanford and Purdue. Manimala's experiments require highly specialized types of materials and miniaturized manufacturing that are only available at those academic institutions or at national labs such as Sandia. Manimala's project will also build relationships with a variety of Department of Defense agencies through site visits and communicating with warfighters and defense technologists. He also anticipates working with a handful of national laboratories and defense suppliers due to the specific nature of his research.

Over the course of the two-year project, Manimala and his team will perform experiments on a microscopic level. They will utilize the Solid and Structural Dynamics Lab (SSDL) on OSU's campus to analyze the effects of vibrations on metamaterials up to the microscale — about the width of a human hair. By the end of the project, Manimala expects to have a device prototype for DARPA to review.

Manimala's groundbreaking theory also has practical application outside of defense purposes. He says the principle is scalable and can be applied to macroscale areas such as space and nuclear infrastructure as well as the medical field.

In space, Manimala says mechanical assonance can be applied during launch situations where the event is typically forceful and violent.

"When launching a device into space, you need to isolate sensitive payloads from adverse vibrations," he says. "These payloads have to survive the launch. Assonance-based vibration isolators provide a means to sequester or redirect undesirable mechanical disturbances to protect such valuable assets during their journey into space."

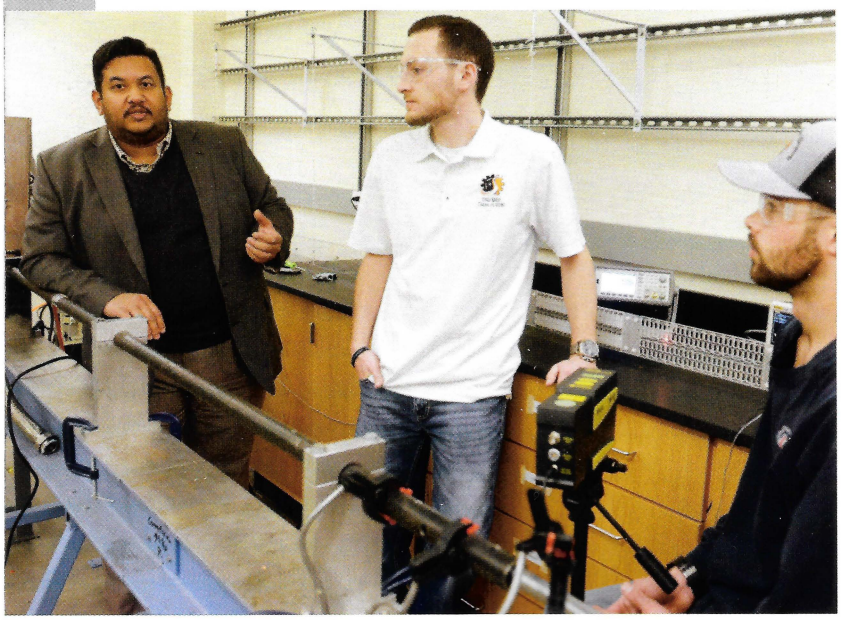
The same idea is used when considering the applications for nuclear infrastructure. For example, the earthquake and ensuing tsunami that hit Japan in 2011 caused serious concern for the nuclear power plant located on the island. Through the utilization of mechanical assonance, the materials used to build a nuclear power plant could be altered to manipulate and reject the energy of the waves caused by a natural disaster, rendering the structure more secure.

Manimala also recognizes the potential for energy harvesting through his principle. He uses the medical field as an example, specifically ongoing research on pacemakers. These devices are implanted in the body through an invasive surgical procedure. The battery life currently only lasts six to 10 years, meaning someone struggling with a severe health issue must go back under the knife.

Mechanical assonance may provide a solution by creating a harvester that can cope better with fluctuations in the heart's vibrations. In other words, the human heart is constantly beating and producing kinetic energy but there is variability depending on the heart rate. Manimala's application of assonant metamaterials within the pacemaker could provide the passive-adaptive stability needed to harvest energy from the person's beating heart to power the device indefinitely. This technology could drastically change the quality of life for millions of people who live with the device.

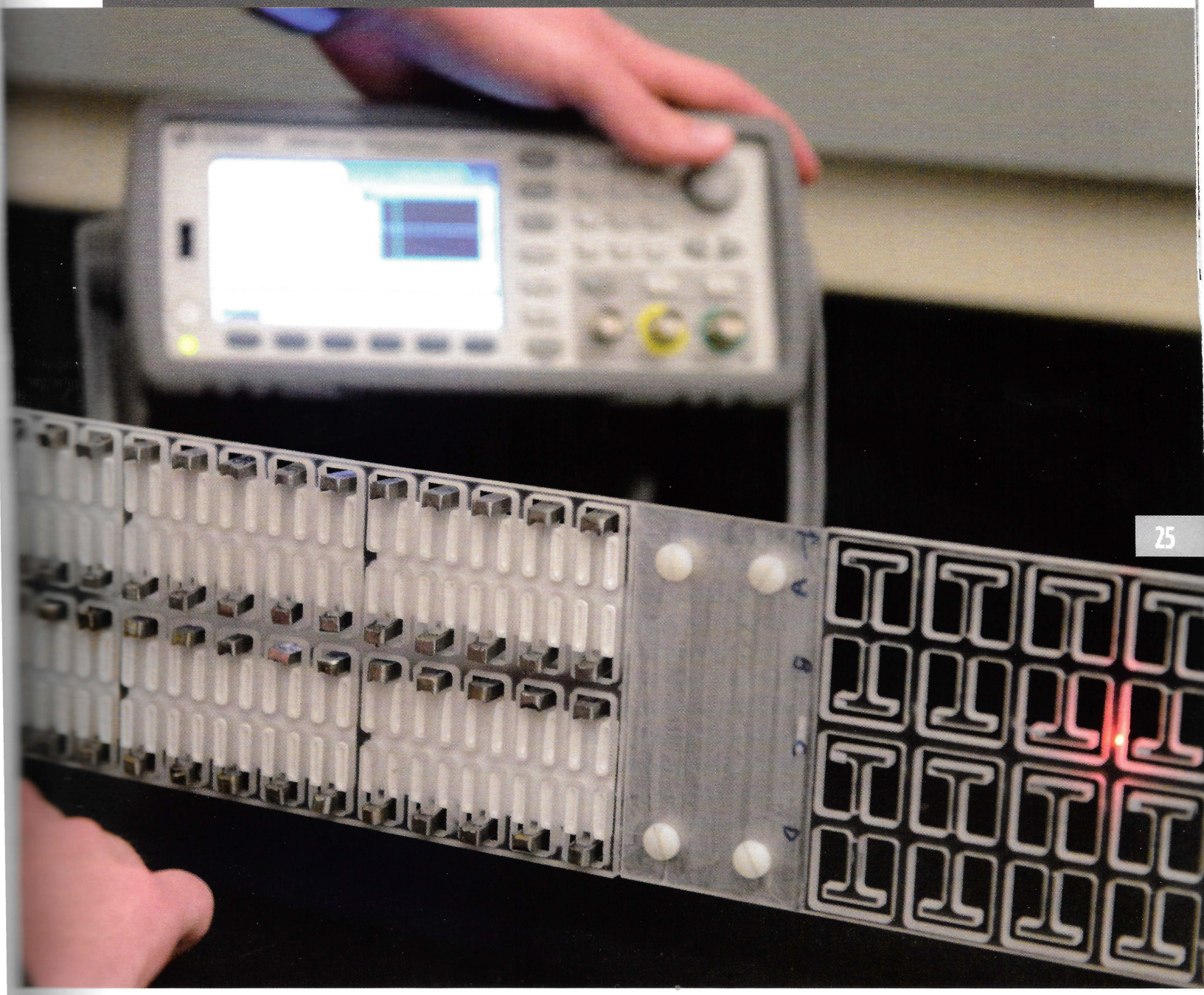
Manimala's theories and his future discoveries promise to bring forth results that will alter the footprint of structural materials. His work at OSU could affect society on a global scale and significantly alter the military, space and energy industries.

Five simple words with three long o's could be the key to a new era of metamaterials engineering. ORM



The mechanical and aerospace engineering professor discusses a project with students Andrew Chambers (center), a master's student, and Alex Svetgoff, a senior.

"This is a groundbreaking approach based on integrating mechanical assonance and inertance. Such metamaterials can steer, focus, disperse or even reject mechanical disturbances."



Testing of a metamaterial waveguide experiment that is part of the research of Prateek Kulkarni, a graduate student in Manimala's lab.