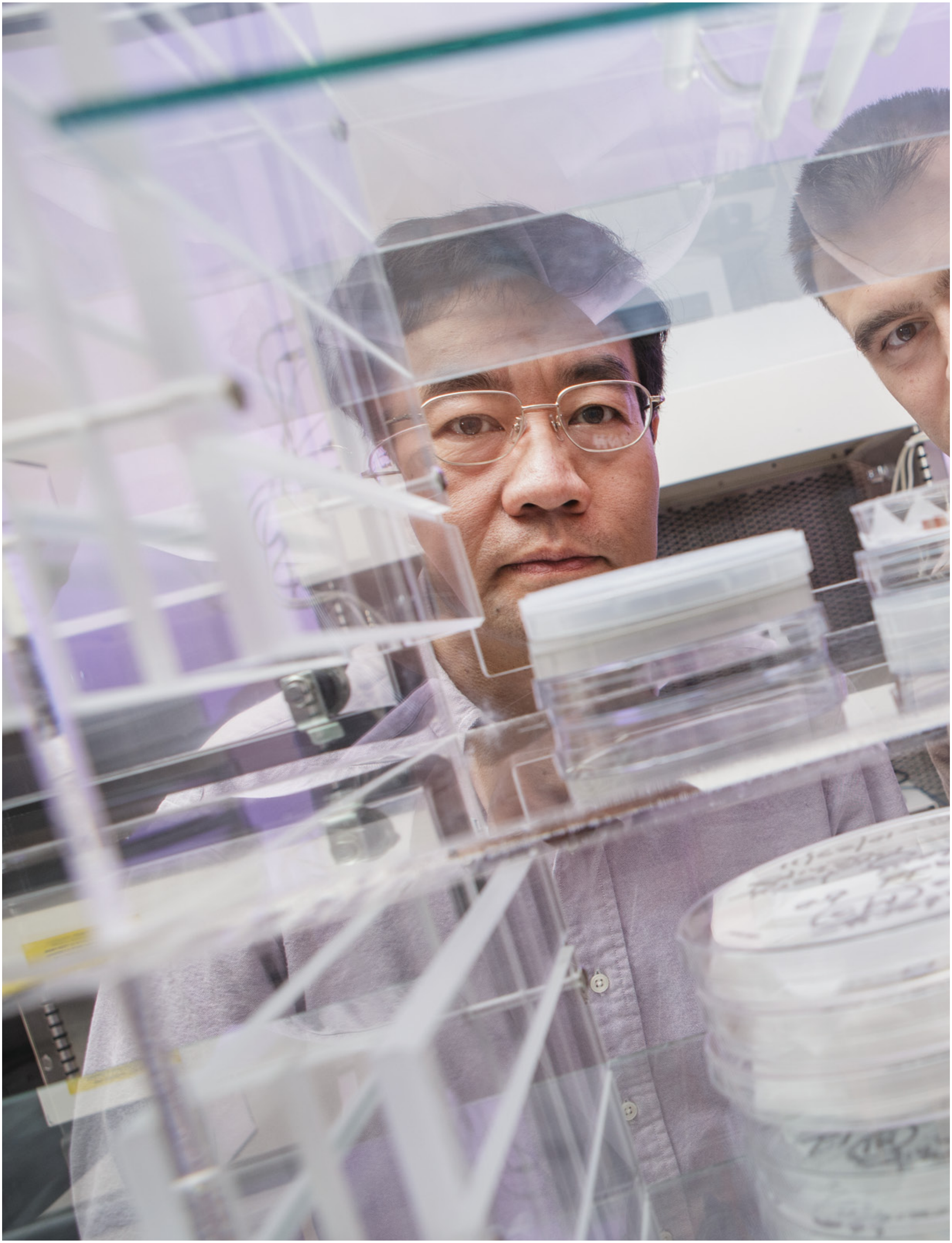

Blazing the Terahertz Trail

PHOTOGRAPHY / **GARY LAWSON** / UNIVERSITY MARKETING

OSU researchers lead the way into megafast components

Since 2003, researchers in electrical and computer engineering at Oklahoma State University have been actively involved in terahertz metamaterials exploration and development. Recently, the efforts of two OSU professors have gained much attention, including four awards and grants totaling more than $1 million from the National Science Foundation and Los Alamos National Laboratory.

"The ultimate goal of this project is to initiate new possibilities for a variety of much- needed terahertz applications with unprecedented functionalities," says WEILI ZHANG, professor of electrical and computer engineering. "The proposed three-dimensional terahertz metamaterials concept and integrated research protocol can be further extended to the broad electromagnetic spectrum for stealth technology, advanced communication systems, medical imaging and remote sensing."

Zhang says OSU is leading this field of research. The OSU labs and professors in this area are well-known and attract some of the best minds on the subject in the world for higher education.

The extensive research aims to help make useful devices that work better and do more at a lower cost of production, Zhang says.

"We are planning to develop integrated terahertz devices and components using metamaterials to bridge the bottleneck due to lack of functioning devices at terahertz frequencies," says Zhang. "By combining the state-of-the-art terahertz spectroscopy and microelectronic fabrication, we have demonstrated, for the first time to our knowledge, actively controllable group delay in metamaterials functioning at terahertz frequencies."

PRACTICAL USAGES

According to JOHN O'HARA, adjunct professor in electrical and computer engineering, a whole new horizon of functionality is ahead.

"Whether or not we pay attention in our everyday lives, we are constantly utilizing a vast amount of the electromagnetic spectrum," says O'Hara. "Each band of this spectrum is important, yet some are still underutilized. The terahertz band is one such gap, and we are developing the technology to fill it. The result could yield myriad applications, from non-destructive testing and imaging to ultra high-speed communications."

Currently, semiconductor devices such as transistors and diodes, which are common in electronics, do not operate at terahertz speeds. O'Hara says electronics made out of silicon transistors work up to about 10 GHz, which is 100 times lower than 1 THz.

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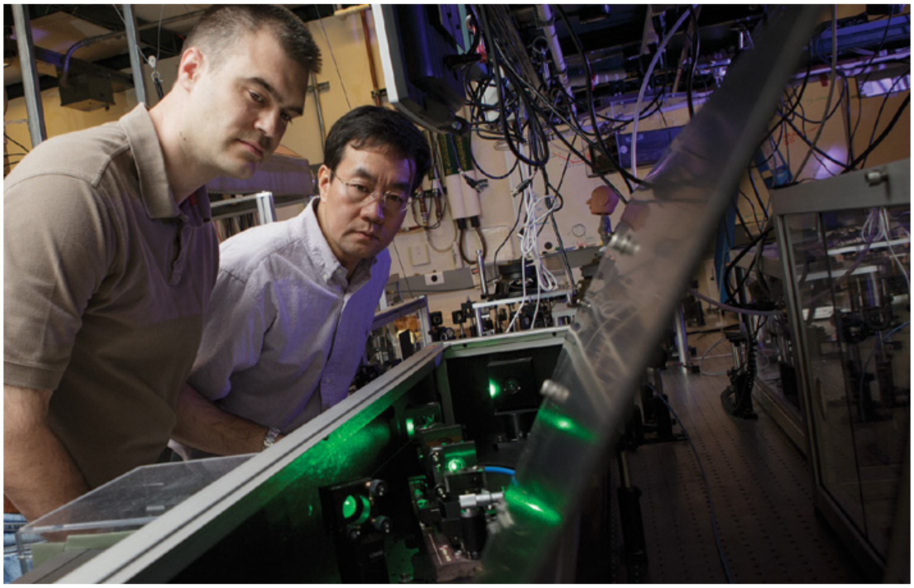

OSU professors John O'Hara (left) and Weili Zhang and are winning acclaim and grants for their work in terahertz metamaterials exploration.

"Our immediate goal is to develop materials that keep pace, while creating and manipulating terahertz waves with a high degree of control and efficiency," says O'Hara. "The specific utility is that these materials would provide a foundation for more practical, larger-scale terahertz systems."

He says it is like any other electromagnetic technology. The basic building blocks that work well, such as antennas, modulators and waveguides are essential. Then complex systems such as radios, cameras or data links can be built.

"This all begins by having appropriate materials to work with," says O'Hara. "The metamaterials concept is about making artificial materials that enable highly functional building blocks, where natural materials do not. Ultimately, we want to create terahertz devices that are ubiquitous in everyday technology."

PIONEERING WORK

As a pioneer, OSU has focused on the use of terahertz time-domain spectroscopy in characterizing the electromagnetic properties of such unique composite structures.

"This all works to explore a range of novel terahertz optical components, including transformation optics-enabled aberration-free terahertz imaging lens and an integrated terahertz spectroscopy platform," says Zhang.

Faculty and students have design and fabrication capabilities available through upscale labs in the Advanced Technology and Research Center at OSU.

"We make real structures," says Zhang. "We work with changes to the terahertz wave."

Students start with a concept. They then work in the classroom with real structures, only seen through microscopes, and then are able to take their created chip to the optics lab.

"OSU is the best place for this research," says Zhang. "Students can develop an idea through simulation, then go straight to production and on to optics. This full process would be hard to accomplish elsewhere."

Zhang and O'Hara have collaborated with other universities such as Northwestern, which helped lead to a recent NSF award.

Recently, Zhang reported the first experimental demonstration of invisibility cloaking in the terahertz regime, and the large-dimension homogeneous terahertz cloaking.

Zhang says metamaterials have found a wide range of promising applications, including perfect lenses, perfect absorbers, invisibility cloaks and anti-reflection structures. These would have significant impacts on communications, medicine, semiconductor fabrication, spectroscopy and imaging.

"Terahertz metamaterials are a timely new field that offers promise in the development of terahertz technology," says Zhang. "In the last two decades, remarkable progress has been made in terahertz generation and detection. I am proud to say OSU, with the leadership of Dr. [Daniel] Grischkowsky in the field, is leading the way in most of these breakthroughs."

"Terahertz technology is eventually going to catch up with the everyday world," says O'Hara. "This research has the promise to bring terahertz into the mainstream, which would be extremely important and valuable."

WRAVENNA BLOOMBERG