The enhanced power of the new measuring technique to characterize materials at scales much smaller than any current technologies will accelerate the discovery and investigation of 2D, micro- and nanoscale materials.

Being able to accurately measure semiconductor properties of materials in small volumes helps engineers determine the range of applications for which these materials may be suitable in the future, particularly as the size of electronic and optical devices continues to shrink.

Daniel Wasserman, an associate professor in the Department of Electrical and Computer Engineering in the Cockrell School of Engineering, led the team that built the physical system, developed the measurement technique capable of achieving this level of sensitivity and successfully demonstrated its improved performance. Their work was reported today in Nature Communications.

The team’s design approach was focused on developing the capability to provide quantitative feedback on material quality, with particular applications for the development and manufacturing of optoelectronic devices. The method demonstrated is capable of measuring many of the materials that engineers believe will one day be ubiquitous to next-generation optoelectronic devices.

Optoelectronics is the study and application of electronic devices that can source, detect and control light. Optoelectronic devices that detect light, known as photodetectors, use materials that generate electrical signals from light. Photodetectors are found in smartphone cameras, solar cells and in the fiber optic communication systems that make up our broadband networks. In an optoelectronic material, the amount of time that the electrons remain photoexcited, or capable of producing an electrical signal, is a reliable indicator of the potential quality of that material for photodetection applications.
The current method used for measuring the carrier dynamics, or lifetimes, of photoexcited electrons is costly and complex. Measuring the decay of the electrical (microwave) signal allows us to measure the materials' carrier lifetime with far greater sensitivity than the current method, Wasserman said. We have discovered it to be a simpler, cheaper and more effective method than current approaches.

Carrier lifetime is a critical material parameter that provides insight into the overall optical quality of a material. High-quality materials will have long carrier lifetimes, meaning that the electron-hole pairs recombine slowly. However, very sensitive materials may not be useful for applications that require high-speed.

Despite the importance of carrier lifetime, there are not many, if any, contact-free options for characterizing infrared pixels or 2D materials, which have gained popularity and technological importance in recent years, Wasserman said. One area certain to benefit from the real-world applications of this technology is infrared detection, a vital component in molecular sensing, thermal imaging and certain defense and security systems.

A better understanding of infrared materials could lead to innovations in night-vision goggles or infrared spectroscopy and sensing systems, Wasserman said. High-speed detectors operating at these frequencies could even enable the development of free-space communication in the infrared, allowing for wireless communication in difficult conditions, in space or between buildings in urban environments.

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