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. The new method uses a microwave resonator to detect the change in size of a microwave signal after a light pulse hits an infrared pixel. The signal indicates the lifetimes of photoexcited charge carriers in small volumes of the material placed in the circuit.

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. A material that has high carrier lifetime 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 materials. Pixels or 2D materials, which have gained popularity and technological importance in recent years, are one area certain to benefit from the real-world applications of this technology. A better understanding of infrared materials could lead to innovations in night-vision goggles or infrared spectroscopy and sensing systems.

High-speed detectors operating at these frequencies could even enable the development of free-space communication in the infrared region, allowing for wireless communication in difficult conditions, in space or between buildings in urban environments.

The research was funded by Air Force Research Laboratories and is part of an ongoing collaboration between Wasserman and researchers from The Ohio State University, University of Wisconsin and Sandia National Laboratories.