Nano-scale 'vibrational wave' research could transform the field of materials physics

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New UK research studying the vibrational properties of matter, or phonons, at the nanoscale, could bring transformational advances in the design and development of a new generation of advanced materials, such as thermoelectrics, among many others.

Thermoelectric materials are used in products that we rely on every day, capturing waste heat and recycling it into electricity, for example recovering heat that is generated when a car brakes to recharge its battery, or using body heat to power wearable health monitoring devices.

However, in the thermoelectric field as in many others, there is a growing requirement for new, higher performing materials to support the constant development of new applications, particularly in the automotive, medical and Internet of Things industries. The design of these new materials takes place quite literally one atom at a time, and thus requires powerful and versatile experimental techniques to probe how heat propagates through solids.

A UK-led team of physicists have published new research that provides a novel, powerful way to study 'phonons' - the collective oscillation of the nuclei of atoms, which can be thought of as waves that control the way that heat or sound carry through materials.

The research was led by Professor Quentin Ramasse, Chair of Advanced Electron Microscopy at the University of Leeds and Director of SuperSTEM, the Engineering and Physical Sciences Research Council's

(EPSRC) National Research Facility. Located at STFC's Daresbury Laboratory, at Sci-Tech Daresbury, SuperSTEM's powerful electron microscopes can pinpoint and identify single atoms a million times smaller than a human hair.

Here, the research team have developed a new technique that enables them to probe the specific properties of phonons, in volumes of material up to 20 orders of magnitude smaller than any other technique in existence. This new approach could provide a way to study how phonons are affected locally, when microscopic amounts of different chemicals are added at the atomic level, which is often the case in the development of new materials.

Professor Ramasse said: "The technique we demonstrate has the potential to provide us with a deeper understanding into how small structural changes at the single atomic level can influence the performance of materials we use in our daily lives. What may appear as very fundamental research on complex properties of matter such as phonon propagation, can have profound implications for industrial and societal benefit."

Professor Susan Smith, Head of STFC's Daresbury Laboratory said: "SuperSTEM is a world leading facility with an outstanding track record in supporting UK industry and academic research right here in the North West. Discoveries made using SuperSTEM will continue to lead to innovations that significantly benefit both society and our economy."

More information: Fredrik S. Hage et al. Nanoscale momentum-resolved vibrational spectroscopy, *Science Advances* (2018). DOI: 10.1126/sciadv.aar7495

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