ICMAB INSTITUT DE CIÈNCIA DE MATERIALS DE BARCELONA EXCELENCIA SEVERO OCHOA

CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

New contactless method

for the measurement of thermal conductivity in materials

THERMAL CONDUCTIVITY

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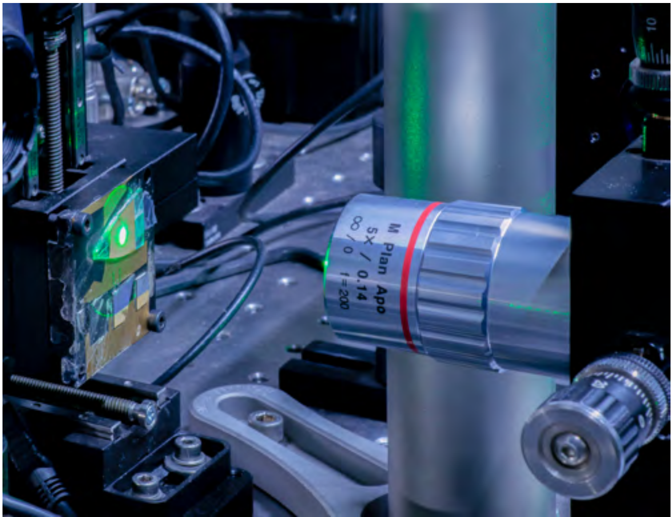
Contactless method to obtain the thermal conductivity tensor of anisotropic and isotropic samples

Why do we need to measure thermal conductivity?



Thermal conductivity is the most essential thermal parameter of a material, which determines how heat propagates through or is dissipated within a material. It constitutes a key characterization of materials for a large range of energy applications, including thermoelectrics, thermosolar, concentration photovoltaics, heat insulation, radiative generators, phase change materials, etc.
It also plays an indirect, but crucial, role in other applications for which performance is strongly linked with temperature, and thus heat management is a must. These include insulating capping in electric wires, heat management in batteries, heat release in electronics, smart windows for efficient thermal management, etc.

Materials in which heat propagates at different rates in different directions are in the forefront of research and development, as these thermal anisotropic properties can be used to enhance performance, and enable new heat management strategies

How does our contactless method work?

Our patented technology is a contactless approach based on frequency-domain thermoreflectance thermometry with a line-shaped (1D) heater geometry, obtained through a focused laser beam, whose intensity distribution is modified using special diffractive optical elements.

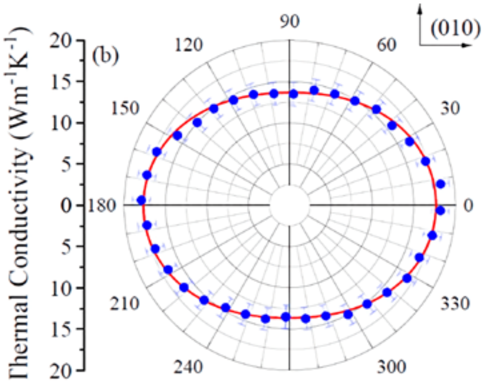
We obtain the thermal conductivity of bulk materials and films in different directions by simply rotating the sample with respect to the line-shaped heater defined by the focused laser.

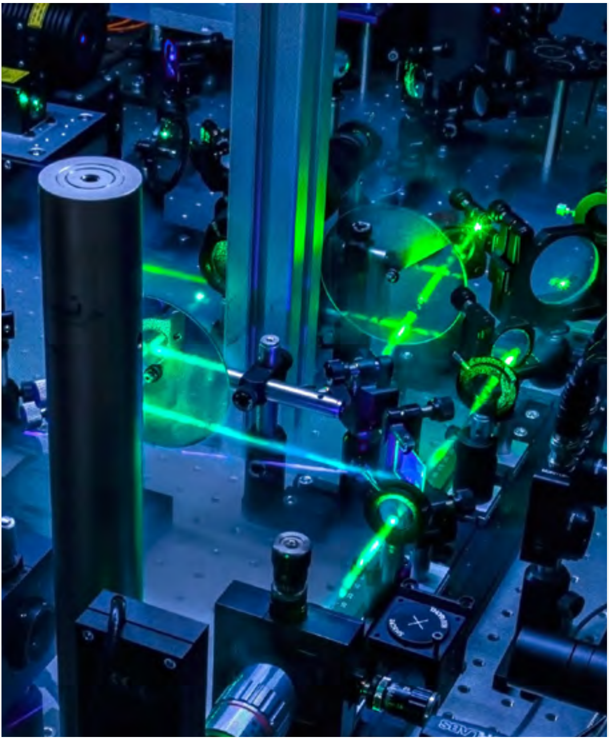
How does it compare with other methods?

Methods to study thermal transport based on linear heat sources offer important advantages to study anisotropic materials, where thermal conductivity is dependent on the direction.

Electrical methodologies typically require the deposition of electrical contacts as well as electrical insulation from the underlying samples, and do not allow the arbitrary rotation of the sample. On the other hand, contactless methods based on focused laser beams, such as Gaussian heater spots, suffer from complicated analysis of data and, in most configurations, anisotropic information is not accessible.

Our approach provides all advantages offered by a line-shaped heater geometry, keeping at the same time the advantages offered by contactless methodologies.





Advantages

» Using a focused laser beam as linear heat source benefits from the geometry of the heat source to determine thermal conductivity, and thermal anisotropy.

» Simple data analysis procedures to obtain the thermal conductivity tensor.

» The method can be applied in isotropic and anisotropic materials. It can also be used to determine the thermal properties of thin films.

» Contactless system.

» Suitable for electrically insulating and conductive samples.

» Possibility to automatize and to operate in transducer-free mode.

» Significant cost reduction in the restricted frequency operational range.

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Reference Article

Anisotropic thermoreflectance thermometry: A contactless frequency-domain thermoreflectance approach to study anisotropic thermal transport
Luis A. Pérez, Kai Xu, Markus R. Wagner, Bernhard Dörling, Aleksandr Perevedentsev, Alejandro R. Goñi, Mariano Campoy-Quiles, M. Isabel Alonso, and Juan Sebastián Reparaz
Review of Scientific Instruments 93, 034902, 2022
doi: 10.1063/5.0066166

Spanish patent application suitable of international extension

"Equipo y método para la obtención de un tensor de conductividad térmica en materiales isótropos y anisótropos"
Sebastián Reparaz and Mariano Campoy
2021

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