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All-optical time-domain nanothermal characterization techniques based on scanning-near field optical microscopy

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To date, there are very few all-optical techniques, if any, that are suitable for the purpose of acquiring, with nanoscale lateral resolution, quantitative maps of the thermal conductivity and thermal expansivity of 2D materials and nanostructured thin films, despite huge demand for nanoscale thermal management, for example in designing integrated circuitry for power electronics. Here, we introduce ω-ω and ω-2ω near-field thermoreflectance imaging as an all-optical and contactless approach to map the thermal conductivity and thermal expansion coefficents at the nanoscale with precision. Testing of our technique is performed on nanogranular films of gold and multilayer graphene (ML-G) platelets. As a case study, our recently invented ω-ω near-field scanning thermoreflectance imaging (NeSTRI) technique is here applied to multilayer graphene thin films on glass substrates. Thermal conductivity of micrometre-size multilayer graphene platelets is determined and is consistent with previous macroscopic predictions. As far as thermal expansion coefficient (TEC) is concerned, our method demonstrates that the TEC of ML-G is (-5.77±3.79) x10-6 K-1 and is assigned to in-plane vibrational bending modes. A vibrational-thermal transition from graphene to graphite is observed, where the TEC becomes positive as the ML thickness increases. Basically, our nanoscale method demonstrates results in excellent agreement with its macroscopic counterparts, as well as superior capabilities to probe 2D materials and interfaces.

Keyword-1

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Keyword-2

Near-field optics

Keyword-3

Thermo-optics

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