Measuring Thermophysical Properties of Magnetic Nanofluid by Lock-in Thermography

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Nanofluids refer to heterogeneous mixtures of nanometer-sized solid particles dispersed in a continuous liquid medium. Nanofluids play a crucial role in thermal science due to their ability to enhance heat transfer, serve as efficient thermal storage materials, act as thermal interface materials, and offer fundamental insights into heat transfer mechanisms. Nevertheless, mapping and observing localized effects on their thermophysical properties are still challenging issues. In this work, we present a new method for measuring and mapping the effective thermal diffusivity D, thermal conductivity κ, volumetric heat capacity ρc_p of nanofluids by means of lock-in thermography (LIT). LIT is an active thermal imaging technique that enables detecting the thermal response in materials to a periodic thermal excitation with high temperature resolution. LIT has shown notable performance in measurements of various properties including D [1], thermoelectric and thermophysical properties of thermoelectric materials [2], and mapping thermophysical properties of composites [3]. Here, we also show that LIT enables simultaneous high-spatial-resolution mapping of D, κ, and ρc_p with a single apparatus for fluids with an application on a ferrofluid, as a type of nanofluid. Since LIT is a non-contact technique, the properties over a wide area of single or multiple samples can be mapped without disturbance of heat leakage through temperature probes. The method is validated by using water as a reference liquid and demonstrating its capability in visualizing the effective D, κ, and ρc_p of a ferrofluid under the influence of external magnetic field. The results show that the LIT-based approach has high reproducibility and sensitivity, which allows for observation of the effect of particle distribution on the properties. The proposed method will be useful for thermal research in nanofluids and colloidal suspensions, and for investigating particle behavior and arrangement effects on the thermophysical properties and heat transfer mechanisms in heat transfer fluids.

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References

1. T. Ishizaki and H. Nagano, Int. J. Thermophys. **36**, 2577 (2015)
2. A. Alasli, et al., Appl. Phys. Lett. **121**, 154104 (2022)
3. A. Alasli, et al., Int. J. Thermophys. **43**, 176 (2022)