磁気熱量効果のハイスループット計測技術の開発

Development of high-throughput measurement techniques for magnetocaloric effects

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The magnetocaloric effect (MCE) refers to the temperature change of a magnetic material as a result of the application of a magnetic field via the change of magnetic entropy [1]. The magnetic refrigeration based on the MCE is one of the promising next-generation cooling technologies because it has a potential to realize high-efficient, safe, quiet, compact, and fluorocarbon-gas-free refrigerators. The MCE is typically characterized by the isothermal magnetic entropy change, estimated from the temperature dependence of the magnetization curve through the thermodynamic Maxwell relation, and the adiabatic temperature change, estimated from the temperature dependence of magnetization and heat-capacity at different magnetic fields or from the direct measurement of the field-induced temperature change. However, to systematically characterize MCE materials by means of conventional methods, lengthy investigations are necessary, which limits the measurement throughput and application of the MCE.

Here we report a novel MCE-measurement method based on the lock-in thermography (LIT) technique [2,3], which enables high-throughput and systematic measurements of the temperature change induced by the MCE. In the MCE measurements based on the LIT, we apply periodic external magnetic fields to magnetic materials and extracts thermal images oscillating with the same frequency as the fields. The obtained thermal images are transformed into the lock-in amplitude and phase images by Fourier analysis. By measuring the magnetic field dependence of the LIT images, we can estimate the temperature change induced by the MCE for wide field and frequency ranges. Importantly, this method allows us to measure the MCE of many materials at the same time, making high-throughput investigations of the MCE possible. We anticipate that the MCE-measurement technique developed here will accelerate materials research towards high-efficient magnetic refrigeration.

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