Development of Near-Field Optics Thermal Nanoscopy for Thermal Analysis at the Nanoscale

Shunta Okitsu [C, S]
School of Integrated Design Engineering, Keio University, Yokohama, Kanagawa, Japan
okitsu@naga.sd.keio.ac.jp

Yoshihiro Taguchi and Yuji Nagasaka
Department of System Design Engineering, Keio University, Yokohama, Kanagawa, Japan

Recently, thermal control using phononic crystals is attracting much attention as a new breakthrough in so called "phonon engineering." A detailed understanding of the phonon transport mechanisms, such as ballistic transport, is important for novel device design, and a nanoscale temperature measurement method is strongly demanded. In the conventional measurement method, contact methods such as the scanning thermal microscope and noncontact methods (e.g. the thermoreflectance method) were widely used for the thermal analysis. However, the thermal transport process in the contact method become complicated because of the heat conduction through the contact point. Furthermore, the spatial resolution of the optical method is restricted to approximately half of the wavelength of the incident light due to the diffraction limit of the light. Here, we have developed a nanoscale temperature measurement method using the near-field light, named polarized near-field optics thermal nanoscopy. The near-field light is a non-propagation light which enables measurement with high spatial resolution beyond the diffraction limit of the light. In this method, near-field polarized light is used to measure the temperature at the nanoscale. When the near-field light irradiates the sample surface, the near-field light is scattered by the sample, and then the polarization plane rotates. This polarization rotation includes information about the temperature change of the sample. Thus, by detecting the polarization state of the near-field light, the local temperature change in the sample can be detected with nanoscale resolution. In this paper, the validity of this measurement technique is confirmed through FDTD simulations and experiments.