Development of Nanoscale Temperature Measurement Technique Using Near-field Fluorescence

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A nanoscale thermal system design, especially precise understanding of temperature distribution and thermophysical properties in microfabricated devices and future generation devices (e.g. designed with new nano materials such as carbon nanotubes and fullerene), has been increasingly important along with the development of nanotechnology. In order to acquire thermal image of microfabricated devices and nanostructures, several scanning probe microscopes based on STM (Scanning Tunnel Microscopy) and AFM (Atomic Force Microscopy) have been developed. However, since the heat transfer mechanism between the probe tip and sample is not verified, the estimation of the contact thermal resistance is obscure.

We have proposed a new approach toward an optical nanoscale temperature measurement method using near-field optics and fluorescence thermometry enabling us an accurate thermal design *in situ*/*in vivo*, namely Fluor-NOTN (Fluorescent Near-field Optics Thermal Nanoscopy). In Fluor-NOTN, a fluorescently modified sample is excited by a near-field light generating fluorescence, and its temperature dependence of signal intensity is monitored. The final goal of this study is to measure biological samples in 10 nm spatial resolution and 0.1 degree temperature resolution. Moreover, Fluor-NOTN has the high potential to expand its applicability to measure not only temperature but also thermophysical properties in nanoscale.

First, the validity of Fluor-NOTN as a temperature measurement system is verified by detecting the temperature dependence in fluorescence spectra of ruby crystal. The experimental result obtained in near-field region was compared with those using a fluorescence microscope. Second, in order to demonstrate proposed technique, a Cy3 monodispersed MEMS sample is designed and fabricated. The MEMS sample consists of a Ni81Fe19 wire, 500 nm in thickness, with electrodes placed on both ends in order to induce Joule heating within the wire. Experimental results using the MEMS sample is discussed in order to illustrate the spatial/temperature resolution of Fluor-NOTN.