Development of High Sensitive Near-Field Thermal Fluorescence Lifetime Thermometry with Nanoscale Spatial Resolution

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We have proposed a new optical nano-scale temperature measurement method based on near-field fluorescence lifetime thermometry, namely Fluor-NOTN (Fluorescence Near-Field Optical Thermal Nanoscopy). Fluor-NOTN enables to measure temperature distribution *in situ*/*in vivo*. In Fluor-NOTN, the excitation laser (Wavelength 473 nm) couples into the Au coating near-field fiber probe (100 nm diameter aperture) and then the near-field light is generated at tip of the probe. Fluorescently modified samples are excited by a near-field light and emit the fluorescence. The fluorescence lifetime, which has temperature dependence, is then monitored, and fluorescence lifetime is measured by phase resolved fluorescence lifetime measurement method. We have measured the temperature dependence of the fluorophore. CdSe/ZnS Quantum dots, namely Qdot®, were used as a fluorophore of Fluor-NOTN. CdSe/ZnS Quantum dots emit the light energy at 655 nm. We measured the fluorescence lifetime shift in the temperature range from 22.0 to 35.4 degrees Celsius, and the measured frequency ranges from 100 kHz to 50 MHz for fluorescence lifetime measurement. The temperature coefficient of Qdot® was evaluated to be -0.20 ns/K. We have detected the auto-fluorescence of near-field fiber probe in this measurement. The intensity of the auto-fluorescence of near-field fiber probe is bigger than that of modified Quantum dots. The fluorescence, emitted from Ge in the fiber probe, is considered to be the most critical noise of Fluor-NOTN. To decrease the noise signal, we fabricated the near-field fiber probe made by pure-silica fiber and Ge doped optical fiber. Since the auto-fluorescence of the new fabricated fiber probe had negligible effects on the measurement any more and signal-to-noise ratio of Fluor-NOTN increased tenfold. In the presentation, the validity of Fluor-NOTN with high spatial resolution of 100 nm and temperature resolution of 1 K is reported.