Local Temperature Measurement Using Cell Investigation Tool for Physiological Measurement of Single Cell

1. Background

Cell measurement is challenging topic in micro-nano robotics

Ex) Mechanism of virus infection

Influenza virus (100 nm) from Science

Nucleus

Cell

Ex) Heat generation during virus multiplication

Current problems

Unstable and short-time measurement by fluorescence intensity (Temperature, pH)

Fluorescence: High sensitivity method

Photo-bleaching

Fluctuation of excitation light

2. Concept

Long-lifetime temperature measurement by spectrum analysis

Hydrogel-sensor

Biocompatible hydrogel-beads containing Q-dot.

Quantum dot

Nano-semiconductor

Temperature sensitive

pH and oxygen non-sensitive

Temperature measurement using color difference of red

Temperature: constant

Intensity decreasing

Color stable

3. Methods

Separation of intensity information from fluorescence color conversion

\[ Y = 0.299R + 0.587G + 0.114B \]

\[ Cr = 0.5000R - 0.419G - 0.081B \]

\[ Cb = -0.169R - 0.331G + 0.500B \]

\[ \text{Y: Brightness, } Cr (Cb): \text{ Color difference of red (blue)} \]

Temperature measurement by spectrum analysis

Conversion from RGB to CyMgYeG

\[ Y = -0.201 \times Mg + 0.294 \times Cy + 0.5 \times Ye \]

\[ Cr = 0.5 \times Mg - 0.41 \times Cy \]

\[ Cb = -0.319 \times Mg - 0.181 \times Cy + 0.15 \times Ye \]

Measurement range

Wavelength: 575 - 800 nm

Temperature increase

\[ \Delta C R < 0, \Delta Mg < 0 \Rightarrow \Delta C R < \Delta Mg \]

Temperature control

ZILCOS (Tokai hit) Accuracy: ±0.3 K

Temperature fluctuation of microchips

4. Experiments

Fluorescence images on each temperature

303 K

10 μm

308 K

313 K

318 K

Materials

Hydrogel: Polyethylene glycol Q-dot: Lumidot 560

Experimental setup

Microscope: IX71

CCD: WAT-250D2

Temperature control

ZILCOS (Tokai hit) Accuracy: ±0.3 K

Fluorescence images on each temperature

5. Conclusions and future work

High accuracy (±0.3 K) and stable (100 x longer) temperature sensor was developed.

6. References