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

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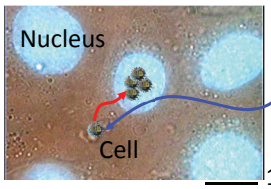
蛍光温度計測の寿命を100倍に延ばす革新的計測手法とは？

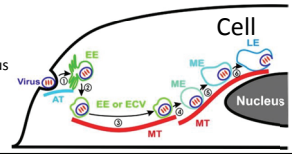
1. Background

Cell measurement is challenging topic in micro-nano robotics



Influenza virus (100 nm) from Science

Ex) Mechanism of virus infection



Heat generation during virus multiplication

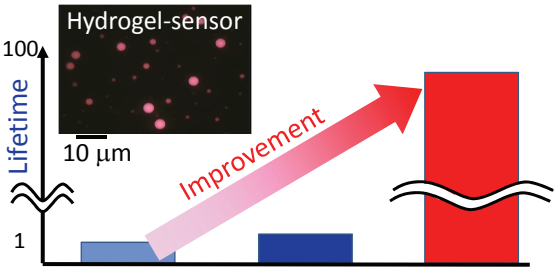
Current problems

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

Fluorescence method: High sensitivity
Photo-bleaching
Fluctuation of excitation light

2. Concept

Long-lifetime temperature measurement by spectrum analysis



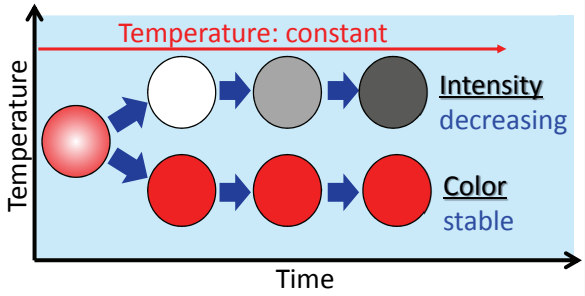
Hydrogel-sensor

Biocompatible hydrogel-beads containing Q-dot.

Quantum dot

Nano-semiconductor
Temperature sensitive
pH and oxygen non-sensitive

Temperature measurement using color difference of red



3. Methods

Separation of intensity information from fluorescence color conversion

$$Y = 0.299R + 0.587G + 0.114B$$

$$Cr = 0.5000R - 0.419G - 0.081B$$

$$Cb = -0.169R - 0.331G + 0.500B$$

Y : Brightness, **Cr (Cb): Color difference of red (blue)**

Temperature measurement by spectrum analysis

Conversion from RGB to CyMgYeG

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

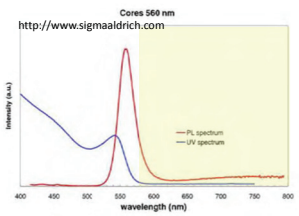
$$Cr = 0.5 \times Mg - 0.41 \times Cy$$

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

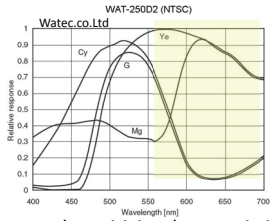
$$(Mg = R + B, Cy = G + B, Ye = R + G, G = G)$$

Measurement range
Wavelength: 575 -800 nm

Temperature increase
ΔCy <0, ΔMg<0 → ΔCy<ΔMg



spectral sensitivity characteristic



spectral sensitivity characteristic

Cr decrease according to temperature increase

4. Experiments

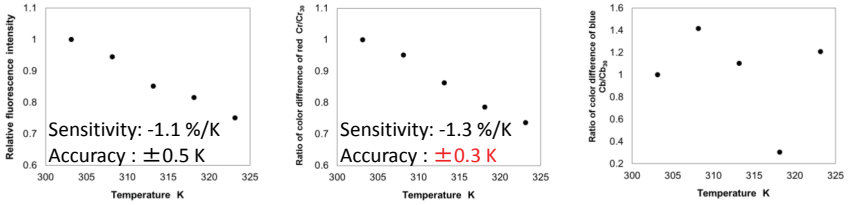
Fluorescence images on each temperature

Materials
Hydrogel: Polyethylene glycol
Q-dot : Lumidot 560

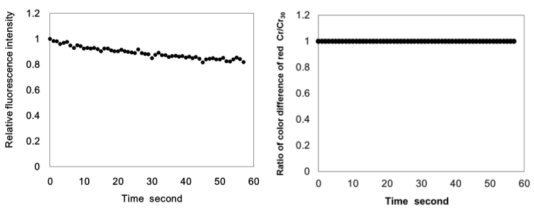
Experimental setup
Microscope: IX71
CCD: WAT-250D2

Temperature control
ZILCOS (Tokai hit)
Accuracy: ±0.3 K

Fluorescence images on each temperature



Comparison of stability of temperature measurement



Measurement stability (303 K)
Y: About 20% decrease,
Cr: About 1% decrease

Cr value is suitable for temperature sensing

5. Conclusions and future work

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

6. References

1. H. Maruyama, T. Fukuda, F. Arai, "Functional gel-microbead manipulated by optical tweezers for local environment measurement in microchip", Microfluidics and Nanofluidics, 6, pp. 383-390, 2009.

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