and a transfer yield approaching 99%.

The team also constructed a finite element theoretical model of the graphene actuator and calculated a coefficient of thermal expansion of $(-6.9 \pm 0.6) \times 10^{-6}$ per °C.

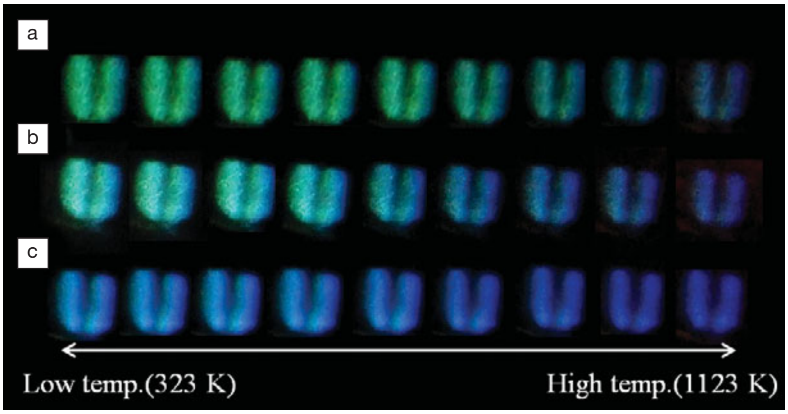
To compare both theoretical and experimental results, the researchers investigated the effect of temperature as a function of input power. The team determined that the temperature of the cantilever changed linearly to 36°C with a supplied power up to 1.26 mW. The deflection of the cantilever increased linearly with temperature or the electrical input power resulting to conversion factors of 0.17 μm/°C and 2.58 μm/mW. These values are in agreement with theoretical values. The oscillation of the beam with a frequency of 0.91 Hz are observed.

Jean L. Njoroge

Y_2O_3:Tb^{3+}/Tm^{3+} phosphors: New materials for thermometry

Phosphor thermometry provides noncontact temperature measurements by analyzing the changes of photoluminescence (lifetime decay or intensity ratios) with temperature. Compared with other noncontact temperature measurements, phosphor thermometry is a low-cost technique and provides simple diagnostics, enabling its use in nonplane geometries and in fluids. N. Ishiwada, S. Fujioka, T. Ueda, and T. Yokomori from the Keio University, Japan have investigated the photoluminescence response to the temperature of Tb^{3+}/Tm^{3+} co-doped Y_2O_3 phosphors, finding that these materials show a clear intensity ratio response even at high temperatures, not suffering from strong thermal quenching. The researchers have shown that these materials present intensities of two emission lines with different responses to temperature, an emission intensity strong enough to avoid optical noise, and emission of blue or green light, where black-body radiation is relatively weak. The results of this study appeared in the March 1st issue of *Optics Letters* (DOI: 10.1364/OL.36.000760; p. 760).

The researchers prepared Y_2O_3:Tb^{3+}, Y_2O_3:Tm^{3+}, and Y_2O_3:Tb^{3+}/Tm^{3+} phosphors by a flame spray synthesis method. They dissolved $Y(NO_3)_6 \times 6H_2O$, $Tb(NO_3)_3 \times 6H_2O$ and $Tm(NO_3)_3 \times 6H_2O$ in distilled water to prepare a 0.3 M precursor solution that was supplied, together with methane and oxygen gases, to the co-axial burner to form a high-temperature diffusion flame where monoclinic Y_2O_3 could be crystallized.



Temperature-sensitive visible photoluminescence images of Yb_2O_3:Tb^{3+}/Tm^{3+} depending on the concentration of the dopants (Tb^{3+} mol% / Tm^{3+} mol%): (a) 2/1, (b) 1/1 and (c) 0.6/1. Reproduced with permission from *Opt. Lett*. **36** (2011) DOI: 10.1364/OL.36.000760; p. 760. © 2011 Optical Society of America.

The researchers investigated the thermal dependence of photoluminescence by placing the phosphors in a 30 mm diameter ceramic vessel, surrounded by a wire heater, and by monitoring and controlling their temperature with a K-type sheath thermocouple connected to a PID temperature control unit within an accuracy of ±2 K. The researchers excited the phosphors with 355 nm UV light and recorded their emissions with a spectroscope in front of which they used a long-pass filter (>430 nm) to remove any remaining excitation light.

The researchers chose the concentrations of Tb^{3+} (1 mol%) and Tm^{3+} (1 mol%) to obtain the optimum intensity difference between the two dopants. The results demonstrate that the peak line at ~456 nm generated by Tm^{3+} was still strong at more than 1000 K whereas the other peak lines at 489, 543, 588, and 624 nm due to Tb^{3+} decreased due to the thermal quenching effect. By monitoring the intensity ratio between the 543 nm and 456 nm emissions with temperature, the researchers observed that this ratio presented a high gradient with temperature change and linearity over a wide temperature range, representing the most appropriate intensity ratio to be used for thermometry, offering the opportunity for measurement of temperature over a wide range and with high sensitivity.

The researchers also investigated the temperature-sensitive visible photoluminescence of Yb_2O_3:Tb^{3+}/Tm^{3+} as a function of dopant concentration. They observed visible photoluminescence color changes from green to blue with increasing temperature for specific dopant concentration (see Figure). The researchers said this property suggests the possibility of measuring the temperature not only by analyzing the intensity ratio but also by observing the color change visually through a visual thermo-sensor (VTS).

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