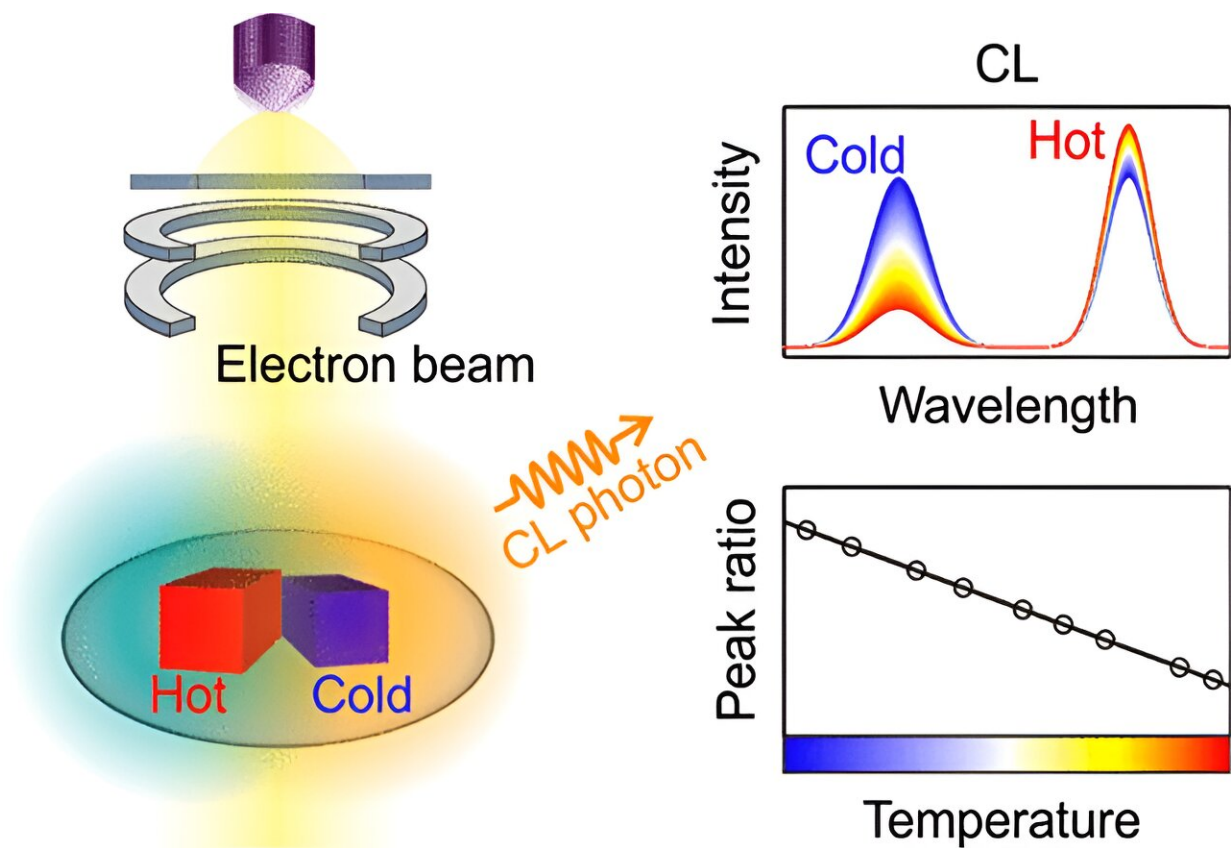


# Newly developed nano-thermometers enable real-time temperature detection in transmission electron microscopy

March 7 2024, by JooHyeon Heo



Schematic illustration of the cathodoluminescence (CL) nanothermometry.  
Credit: UNIST

A method for measuring the temperature of nanometer-sized samples

within a transmission electron microscope (TEM) has been developed by Professor Oh-Hoon Kwon and his research team in the Department of Chemistry at UNIST.

This innovative technology, utilizing nano-thermometers based on cathodoluminescence (CL) spectroscopy, opens up new possibilities for analyzing the thermodynamic properties of fine samples and advancing the development of high-tech materials.

The transmission electron microscope allows researchers to observe samples at a magnification of hundreds of thousands of times by transmitting a short-wavelength [electron beam](#) through the sample. By detecting light emitted from the sample through cathode ray emission spectroscopy, researchers can finely analyze the physical and optical properties of the sample at nanometer scales.

The newly developed nano-thermometers rely on the temperature-dependent intensity variation of a specific cathode ray emission band of europium ions ( $\text{Eu}^{3+}$ ). By synthesizing nanoparticles doped with europium ions within gadolinium oxide ( $\text{Gd}_2\text{O}_3$ ), the research team ensured minimal damage from the electron beam, enabling long-term experiments.

Through dynamic analysis, the team confirmed that the intensity ratio of the light emitting band from europium ions is a reliable indicator of temperature, with an impressive measurement error of about  $4^\circ\text{C}$  using nano thermometer particles measuring approximately 100 nanometers in size. This method offers more than twice the accuracy of conventional TEM temperature measurement techniques and significantly improves spatial resolution.

Furthermore, the team demonstrated the applicability of the nano-thermometers by inducing temperature changes with a laser within the

TEM and simultaneously measuring temperature and structural variations in real time. This capability allows for the analysis of thermodynamic properties at the nanometer level in response to [external stimuli](#) without interfering with standard TEM analysis procedures.

Won-Woo Park, the first author of the study, emphasized the non-invasive nature of the temperature measurement process, highlighting that the interaction between the transmission electron beam and the nanothermometer particles enables real-time temperature detection without disrupting TEM imaging.

He noted, "The big advantage of the developed nanometer is that the temperature measurement process does not interfere with the existing transmission electron microscope analysis. Since temperature is measured using light, a by-product generated by the interaction between the transmission electron beam and the nanometer particle, it is possible to measure the image of the [transmission electron microscope](#) and detect the temperature in real-time."

Professor Kwon underscored the significance of this research, stating that "The developed temperature measurement indicators, when combined with real-time imaging techniques, facilitate the observation of local temperature changes in response to external stimuli. This advancement is poised to significantly contribute to the development of high-tech materials such as secondary batteries and displays."

The work is [published](#) in the journal *ACS Nano*.

**More information:** Won-Woo Park et al, Nanoscale Cathodoluminescence Thermometry with a Lanthanide-Doped Heavy-Metal Oxide in Transmission Electron Microscopy, *ACS Nano* (2024). [DOI: 10.1021/acsnano.3c10020](https://doi.org/10.1021/acsnano.3c10020)

Provided by Ulsan National Institute of Science and Technology

Citation: Newly developed nano-thermometers enable real-time temperature detection in transmission electron microscopy (2024, March 7) retrieved 27 April 2024 from <https://phys.org/news/2024-03-newly-nano-thermometers-enable-real.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.