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TECHNOLOGY UPDATE

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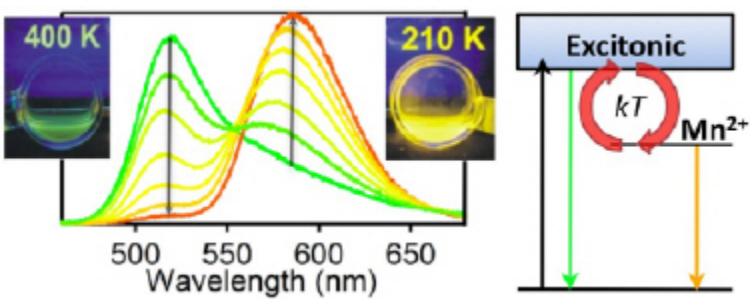
Semiconductor nanocrystals make ideal optical thermometers

Chemists at the University of Washington in Seattle have made a new class of highly sensitive optical thermometer using doped semiconductor nanocrystals. The device works via a fundamentally new photoluminescence mechanism, never before described. The thermometer could be used to measure the temperature of organic LEDs, laser diodes and other nanometre-sized devices during their fabrication.



(http://images.iop.org/objects/ntw/news/9/8/19/DGamelin.jpg)

Luminescence spectrum of Mn-doped semiconductor nanocrystals (http://images.iop.org/objects/ntw/news/9/8/19/DGamelin.jpg)

Daniel Gamelin and colleagues' device is based on colloidal manganese-doped semiconductor nanocrystals. When excited by blue light, the thermometer emits in two bands: 520 and 580 nm – an effect known as "dual emission". The intensity ratio of these peaks can be used to provide an absolute measure of the ambient temperature.

"This result was a serendipitous discovery that spun off from our research in other areas (magneto-optics), and I am particularly proud of it because it appears to be the most beautiful and pronounced example of intrinsic dual emission ever reported," Gamelin told *nanotechweb.org*. "Our work describes a fundamentally new mechanism of photoluminescence in Mn-doped semiconductors never before reported, despite some 10,000 papers in the physics literature on these materials."

Ideal for optical thermometry

Beyond reporting new science, the study shows that these nanocrystals are ideal for optical thermometry because the dual-emission mechanism is extraordinarily sensitive to temperature, adds Gamelin. For instance, the thermometer easily detects 0.2 °C fluctuations in a laboratory water bath in real time.

According to the Washington team, the pronounced dual emission in the nanocrystals comes from the different thermal populations of two emissive excited states of the same nanocrystal. What is more, the emission can also be tuned over a broad range of temperatures. This means that the temperature window in which the optical thermometer works can be tuned too – an unprecedented feature, says Gamelin, that makes it ideal for practical applications, such as thermal imaging of nanodevices during manufacture.

"Our device might also be well suited for biological thermometry measurements because the intensity ratios are completely independent of complications from pH and other extrinsic factors that plague conventional thermal thermometers," he adds.

Researchers have been studying intrinsic dual emission in organic molecules for over half a century, at first for fundamental studies and later for optical thermometry in areas as diverse as biotechnology, aeronautical engineering, microfluidics, microelectronics and thermal therapeutics in medicine. Recently, they have also turned their attention to semiconductor nanocrystals for similar applications because these materials do not photodegrade easily compared with their organic cousins. However, the snag with semiconductor crystals is that they are not very sensitive to small temperature variations and are likely to produce artifacts because you cannot detect intensity ratios with them. "Our dual-emitting nanocrystals solve this problem, allowing ratiometric optical thermometry with photorobust inorganic phosphors – the best of both worlds".

The work will appear in *Nano Letters*.

About the author

Belle Dumé is contributing editor to *nanotechweb.org*