

Spotlight on Luminescence Thermometry: Basics, Challenges, and Cutting-Edge Applications

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FIGURE 1

Typical sizes of conventional thermometers and luminescent nanothermometers. The size of a bacterium and human cells are also presented to illustrate the different scales of the thermal probes.

Luminescence (nano)thermometry is a remote sensing technique that relies on the temperature dependency of a phosphor's luminescence features (e.g., peak energy or intensity) to measure temperature. This technique provides precise thermal readouts with superior spatial resolution in short acquisition times and has experienced significant growth since the turn of the twenty-first century, driven by the increasing technological demands of various fields, such as micro- and nanoelectronics, photonics, energy, catalysis, and nanomedicine.

Examples of thermographic probes include organic dyes, proteins, molecular beacons, chelate complexes, nanodiamonds, quantum dots, gold nanoclusters, and luminescent nanoparticles.

Over the last five years, there has been a notable shift in the focus of (nano)luminescence thermometry. While many studies have sought to identify new phosphors with improved thermographic properties, the scope of research has broadened considerably. Recent efforts

have concentrated on developing comprehensive theoretical frameworks and standardization procedures, including data acquisition, processing, and measurement methodologies. In addition, the reliability, repeatability, and reproducibility of the technique have been scrutinized, leading to the adoption of algorithms to improve data analysis.

This work reviews the latest trends in the field, including the establishment of a comprehensive theoretical background and standardized practices. The reliability, repeatability, and reproducibility of the technique are also discussed, along with the use of multiparametric analysis and artificial intelligence algorithms to enhance thermal readouts. In addition, examples are provided to underscore the challenges that luminescence thermometry faces, alongside the need for a continuous search and design of new materials, experimental techniques, and analysis procedures to improve the competitiveness, accessibility, and popularity of the technology.

