ОПТИКА И ЛАЗЕРНАЯ ФИЗИКА

INVESTIGATION OF OPTICAL CHARACTERISTICS IN Sr_3SiO_5:Ce^{3+} PHOSPHOR FOR HIGH-POWER WHITE LEDs

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A Sr_3SiO_5:Ce^{3+} phosphor was synthesized via a solid-state reaction and systematically characterized for its structural and optical properties. XRD analysis confirmed phase purity and tetragonal crystallinity, with slight peak shifts indicating successful Ce^{3+} substitution at Sr^{2+} sites, which also enhanced crystallinity and reduced defects. Diffuse reflectance spectra revealed an absorption edge at 275–300 nm, corresponding to a host band gap of 3.62 eV, suitable for UV excitation. Photoluminescence studies showed broad excitation (330–416 nm) and strong yellow-green emission centered at 530 nm due to Ce^{3+} $5d \to 4f$ transitions. The phosphor exhibited an average decay lifetime of 46.2 ns, CIE coordinates of (0.42, 0.39), and a color purity of ~67%, highlighting its potential as a warm-white light-emitting material for LED applications.

Keywords: Sr_3SiO_5:Ce^{3+} phosphor, optical properties assessment, solid state reaction, LED.

1. Introduction. In recent years, light-emitting diodes (LEDs) have received considerable attention as both a primary light source and essential components in modern display technologies [1]. This surge in interest has been especially prominent since the successful development of white LEDs, which made LED-based general lighting a practical reality. Among their many advantages, white LEDs stand out due to their remarkably low power consumption, long operational lifetime, and high luminous efficiency. These characteristics make them far more energy-efficient and durable than traditional lighting options such as

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incandescent or fluorescent lamps [2]. White LEDs offer notable environmental benefits. Unlike fluorescent lamps containing hazardous materials like mercury, LEDs are free of toxic elements, making them safer and easier to dispose of [3]. This sustainability aligns with the global shift toward green technologies. In addition to replacing traditional lighting, white LEDs facilitate innovative applications due to their small size, rapid response, and compatibility with digital systems. They are well-suited for architectural lighting, smart homes, automotive systems, and horticulture. As the technology evolves, LEDs are expected to become central to next-generation lighting and display solutions [4]. There are two main methods for generating white light with LEDs. The first combines light from multiple LED chips, typically red, green, and blue (RGB), to create white light. While this allows for precise color control, it requires complex circuitry and calibration [5, 6]. The second more common method is phosphor conversion, where a blue and UV LED excites a phosphor material that re-emits light at longer wavelengths (yellow/green-red). The mix of emitted and re-emitted light appears as white [7]. Among phosphor-converted LEDs, the combination of a blue LED with a yellow-emitting phosphor is the most commercially popular due to its simple design, low cost, and high luminous efficacy [8]. Using a single LED chip simplifies production, as the phosphor layer can be easily applied to the package and encapsulant. However, this method may lead to lower color rendering (CRI) and reduced color stability over time [9]. Ongoing research is focused on improving phosphor materials and device designs to overcome these challenges and expand their range of applications.

Strontium orthosilicate (Sr_3SiO_5) is a key phosphor host in white LEDs due to its favorable structural, thermal, and chemical properties. Doped with Ce^{3+} and Li^+, it efficiently emits blue and yellow light depending on dopant levels and excitation wavelength [10]. Primarily used in phosphor-converted WLEDs excited by blue and near-UV LEDs, Sr_3SiO_5:Ce^{3+} emits a broad blue-to-yellow spectrum, delivering high luminous efficacy and excellent color rendering. Its open lattice structure accommodates a wide range of dopants without causing crystal distortion, supporting strong luminescence. Additionally, it offers excellent thermal stability and resistance to thermal quenching, ensuring consistent performance at elevated temperatures [11]. Chemically stable, non-toxic, and made from abundant, cost-effective elements, Sr_3SiO_5 is environmentally friendly and suitable for scalable LED production [12]...

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