Indonesian Journal of Material Research
e-ISSN: 2987-1654
Vol. 4, No. 2, July 2026

Indonesian Journal of MATERIAL RESEARCH

Research Paper

Non-Proximity as Well as Immediate Tracking for Phosphor Heat Within Phosphor-Transmuted WLED Apparatuses

Nguyen Thi Phuong Loan[1*], Phan Xuan Le[2], Phan Thi Minh Man[3]

[1] *Faculty of Fundamental 2, Posts and Telecommunications Institute of Technology, Ho Chi Minh City, 70000, Vietnam*
[2] *Faculty of Electrical Engineering Technology, Industrial University of Ho Chi Minh City, Ho Chi Minh City, 70000, Vietnam*
[3] *Faculty of Electrical and Electronics Engineering, Ton Duc Thang University, Ho Chi Minh City, 70000, Vietnam*
[*] **Corresponding author**: ntploan@ptithcm.edu.vn

Abstract

Phosphor-transmuted white illuminating diode units (ptWLEDs) prove to be an essential illumination means for universal illumination. For balancing the photometrical attributes for ptWLED apparatuses, significant endeavors are still aiming at regulating the thermic abatement for LED colorants. The thermic issues for phosphor components, being a profound dependability trouble in ptWLED apparatuses, continue to be a significant subject for research. The study herein concerns a reliable method capable of assessing phosphor heat within functioning ptWLED via a non-proximity, immediate tracking technique for distantly tracking the discharge spectrum. Usually, infrared cameras or thermocouples would be employed for assessing heat. IR cameras need decent calibrating for discharge and would be typically obstructed via lenses or disparate modules covering phosphor samples. Furthermore, thermocouples need a period for achieving thermic anology among the tracker as well as samples subject to experiment. Said method would be detrimental if employed in intrinsic tracking. The method herein offers benefits surpassing ordinary techniques for non-intrusiveness, non-proximity, immediate as well as intrinsic tracking. Said technique would not be influenced by apex wavelength for pump illumination, the dosage as well as breadth for phosphors as well as correlated chroma heat (CCT).

Keywords

LED Devices, Phosphors, (Ba,Ca)ScO_2F:Bi^{3+},K^+, Luminescent, Spectrum

Received: 7 January 2026, Accepted: 4 March 2026
https://doi.org/10.26554/ijmr.20264280

1. INTRODUCTION

Solid-state illumination means contribute substantially to contemporary illumination for both exterior and interior uses. Among these technologies, ptWLED apparatuses remain an essential illumination means due to being economical, convenient, proficient, and possessing potent chroma proficiency as well as decent dependability (Loan and Anh, 2020d; Loan and Anh, 2020f). Typically, ptWLED apparatuses comprise one yellow phosphor sheet enveloping blue colorants to generate white illumination across an extensive CCT span while maintaining a decent chroma rendition indicator (CRI). The overall proficiency of ptWLEDs can be evaluated through luminous proficiency, chroma precision, and long-term dependability. Said dependability is strongly associated with thermic flux and heat allocation within apparatuses, as thermal behavior directly governs color stability and luminous degradation (Hanh et al., 2020; Loan and Anh, 2020b).

According to previous work, the location featuring the greatest heat level within an apparatus is often found atop the blue chip or within the phosphor sheet (especially for apparatuses employing remote phosphors). Significant heat levels within ptWLED apparatuses may result in thermic abatement for phosphors, causing chroma divergence and subsequently blue illumination seepage, proficiency sink, and lifetime lessening (Loan and Anh, 2020a). Thus, regulating the thermic influence proves paramount for prolonging the lifetime for ptWLED apparatuses and ensuring stable optical output. Generally, joint heat for LED colorant signals the thermic state from an academic as well as industrial perspective (Loan and Anh, 2020c; Loan and Anh, 2020f). Regardless, said heat in the LED colorant merely shows a weak link to the actual heat level within phosphor sheets, which is the true determinant of photometric stability.

To quantify these thermal conditions, intrusive, quasi intrusive, and non-intrusive approaches have been employed for assessing substances' heat. Intrusive assessments, however, are essentially useless for ptWLED apparatuses due to the difficulty of preserving package wholeness and the extended time required to achieve thermic analogy among thermic proximities. For quasi-intrusive assessments, heat-responsive substances must be incorporated, which alters constituents and disrupts the internal

heat fields as a consequence. Ultimately, non-intrusive assessments offer a non-direct spectroscopy technique, tracking the intenseness variance or wavelength variance of fluorescent bars that prove highly responsive to phosphor heat levels. Evaluating wavelength variance yields superior precision compared to evaluating intenseness variance. Regardless, these non-intrusive techniques require specifically made phosphor samples appliable to heat tracking, which in turn degenerates the balance in ptWLED apparatuses for nearly all practical uses (Loan and Anh, 2020e; Tran et al., 2020a; Tran et al., 2020b).

Although wavelength-shift spectroscopy improves measurement precision compared to intensity-based monitoring, existing spectral-based approaches still depend on specially engineered thermally sensitive phosphors or modified package configurations. Such modifications inevitably alter the optical balance, spectral power distribution, or phosphor concentration, thereby limiting their applicability in standard commercial ptWLED structures. In addition, these techniques often require extensive calibration and are sensitive to optical reabsorption and scattering effects within the phosphor layer. Consequently, a practical, non-modifying method capable of determining the actual internal phosphor temperature in conventional ptWLED packages remains lacking.

Even when employing infrared cameras featuring infrared thermographic assessment, only the heat level at the exterior for sampling units is assessed, rather than the true heat level within said units. Consequently, proficient techniques remain barely available when it comes to assessing phosphor heat levels within ptWLED apparatuses. As of now, the thermic dynamism for phosphor sheets or volumes within ptWLED apparatuses remains poorly understood and insufficiently approved in both academic research and industrial practice.

Therefore, this study proposes a novel non-intrusive thermal characterization approach that determines the internal phosphor temperature in conventional ptWLED packages without requiring specially engineered thermally sensitive phosphors or structural modification. Unlike conventional spectral-based techniques that rely on emission intensity or peak wavelength tracking, the proposed method extracts temperature information from the intrinsic interaction between phosphor conversion efficiency and blue pump excitation under practical operating conditions.

The main objective of this work is to validate the accuracy and stability of the proposed method across different blue pump powers, phosphor concentrations, and correlated color temperatures (CCTs), thereby providing a reliable tool for thermal monitoring and performance optimization in ptWLED systems.

2. METHOD AND MATERIALS

2.1 Chemicals and Instrumentation

For assessing the thermal behavior of the phosphor during testing, an infrared (IR) imaging camera was employed to record temperature-distribution visuals of the conformal-coated phosphor positioned on top of a blue-emitting chip mounted to a test panel. In parallel, the optical emission of the device was monitored using a spectrometer placed either in free space or inside an integrating sphere, depending on the measurement configuration.

2.2 Research Procedures

Because the applied phosphor layer was relatively thin, the temperature extracted from the outermost surface of the phosphor was considered a reliable indicator of the actual internal phosphor temperature. The spectral analysis focused on the characteristic emission band of the phosphor after normalization. To extract meaningful quantitative indicators, a Gaussian function was used to fit this characteristic band, from which the peak wavelength and spectral bandwidth were obtained. Experiments were systematically carried out under a wide range of conditions, including variations in blue-pump wavelength, phosphor dosage, phosphor-layer thickness, and the presence or absence of a lens encapsulant (Tran et al., 2020c; Tran et al., 2020b). The fitted peak wavelength and bandwidth from each measured spectrum were subsequently used to determine the corresponding phosphor temperature in ptWLED systems.

A comprehensive examination of emission spectra under different blue-pump conditions and phosphor concentrations was performed to identify a robust fitting technique capable of modeling the emission profile using a single, simple analytical function. Such a technique needed to minimize spectral crosstalk, particularly in the transition regions between weaker and stronger portions of the phosphor emission that lie farther from the blue excitation peak (Loan and Anh, 2020h). The characteristic emission band showed a consistent and predictable shift with increasing phosphor temperature, confirming that a single Gaussian fitting was adequate for representing temperature-dependent spectral changes. As a result, a Gaussian function was consistently applied to the normalized emission band across multiple temperature levels to extract temperature-sensitive spectral parameters (Loan and Anh, 2020g).

To justify the use of a single Gaussian model, additional fitting analyses were conducted under various operating conditions, including different pump wavelengths, excitation intensities, phosphor concentrations, and encapsulation states. The emission band of Ce^{3+}-activated phosphors originates primarily from a single allowed 5d–4f transition, which is intrinsically broadened by electron–phonon coupling and inhomogeneous crystal-field distribution, resulting in a near-symmetric spectral profile. To evaluate the robustness of the fitting procedure, the normalized emission spectra were fitted using single-Gaussian, double-Gaussian, and Voigt functions. The coefficient of determination (R^2), root-mean-square error (RMSE), and residual distribution were systematically compared. The single-Gaussian model yielded R^2 values above 0.995 across all tested conditions, and the reduction in RMSE obtained by introducing additional fitting components was below 2%, indicating negligible improvement. Moreover, residual analysis showed no systematic asymmetry or temperature-dependent distortion in the spectral tails.

These results confirm that a single Gaussian function provides a physically justified and statistically robust representation

of the phosphor emission band across the full range of experimental parameters investigated. To validate the accuracy and practical applicability of the proposed temperature-estimation method, a phosphor disc was fabricated specifically for verification. The phosphor embedded within the silicone matrix of this disc was identical in composition to the phosphor used in the conformally coated ptWLED devices (Luo et al., 2020a). An intentional spacing layer was introduced between the disc and the blue LED chip to avoid direct thermal conduction and ensure that the disc's temperature change originated primarily from optical excitation. A thermocouple was inserted directly into the phosphor disc to provide an accurate reference temperature measurement (Hanh et al., 2021a; Hanh et al., 2021b; Luo et al., 2020b). The disc was mounted onto a copper heating stage to maintain stable thermal conditions, while a blue laser beam was directed onto the disc to simulate operating excitation. The emission produced by the phosphor was collected using an integrating sphere to ensure uniform and calibrated light collection. This verification confirmed that the proposed spectral-fitting method can be applied reliably across different excitation sources and phosphor geometries, including discs with varying phosphor concentrations.

3. RESULTS AND DISCUSSION

The present study introduces a new methodology designed to accurately evaluate phosphor temperature in phosphor-converted white LED (ptWLED) systems. This tracking concept can be universally applied to a wide range of operating conditions, including different blue-chip emitters, phosphor concentrations, phosphor-layer thicknesses, and target CCT values, and it remains valid in both the presence and absence of an encapsulating lens (Pham et al., 2021; That et al., 2021). The approach begins by examining the emission spectra of the phosphor and subsequently separating the measured spectral profile into two sub-bands. Initially, each sub-band was fitted using a single Gaussian distribution, allowing the extraction of peak wavelength and bandwidth values that reflect the combined influence of the blue emitter and phosphor dosage. However, spectral irregularities emerged when mismatched peak wavelengths of the blue chip or varying phosphor concentrations introduced non-negligible spectral crosstalk between the blue and yellow components (Le et al., 2022; Thi et al., 2021). This crosstalk distorted the extracted parameters and prevented a reliable correlation with phosphor temperature.

To overcome this limitation, a refined fitting spectrum was constructed to isolate a portion of the phosphor-related band where spectral overlap is minimal. The revised Gaussian fitting of this isolated region produced peak wavelengths and bandwidths for the yellow emission that were effectively free of crosstalk contamination. These corrected parameters demonstrated a direct and consistent correlation with true phosphor thermal conditions. Furthermore, the relationship between phosphor temperature and the extracted spectral parameters could be accurately modeled using simple second-order polynomial expressions, enabling straightforward practical implementation. With these polynomial functions, phosphor temperature could be reliably predicted under a variety of operational variations, including changes in blue-chip wavelength, phosphor concentration, phosphor-layer thickness, CCT target, and optical configuration with or without a lens encapsulant (Trang, 2022).

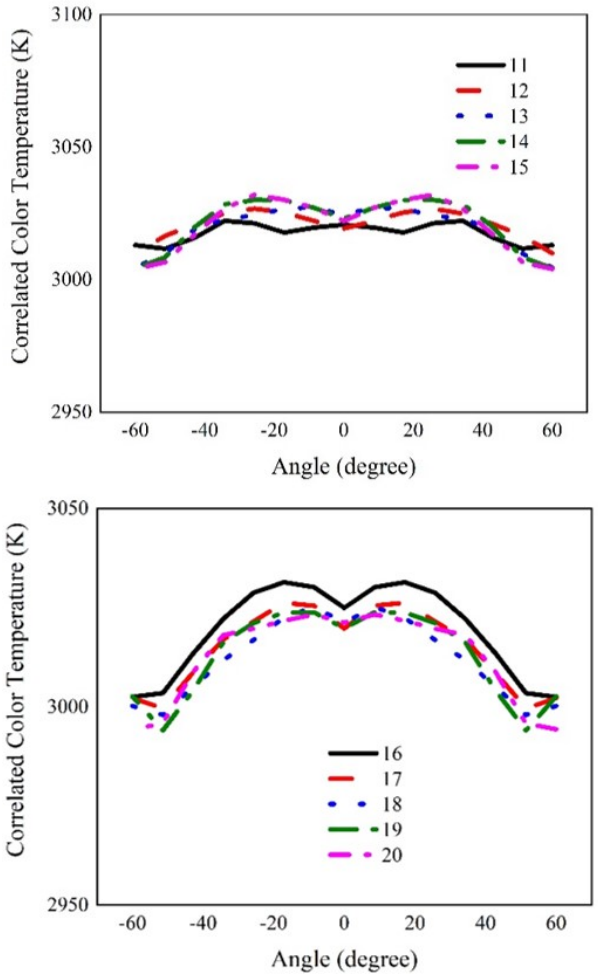

Figure 1. CCT Alteration Based on Particle Size

The primary constraint of the method is the requirement for consistent phosphor material properties between calibration and application. Batch-to-batch variations in phosphor composition, grain size distribution, activator concentration, or internal quantum efficiency can introduce baseline spectral differences that affect the extracted polynomial coefficients. For industrial deployment, this implies that spectral baseline characterization must be performed for each phosphor batch, followed by recalibration of the empirical model if significant deviations are detected. Additionally, long-term phosphor aging caused by thermal stress, oxidation, or photochemical degradation may induce permanent spectral shifts unrelated to instantaneous temperature. Aging can alter emission intensity, bandwidth, or peak position due to defect formation or crystal-field modifications. Under such conditions, the spectral parameters may no longer

represent purely thermal signatures, reducing predictive accuracy. Therefore, while the spectral sieving approach remains robust for fresh or moderately aged phosphor systems, periodic recalibration is necessary for long-term industrial use. Therefore, while the method is robust for fresh or minimally aged phosphor systems, its accuracy diminishes when significant aging processes contribute to spectral evolution.

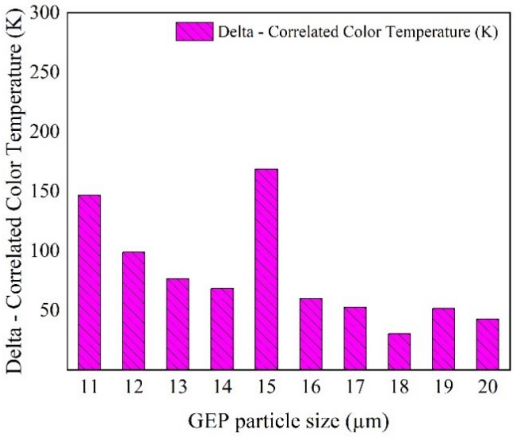

Figure 2. Variation in Hue Aberration Under ZnTe Particle Size

Conventional phosphor temperature evaluation relies on infrared (IR) thermography, which measures surface temperature rather than internal phosphor temperature. IR-based methods are sensitive to emissivity variations, surface roughness, encapsulation lenses, and environmental reflections, often resulting in discrepancies between measured and actual phosphor thermal conditions. In contrast, the proposed spectral sieving approach probes thermally induced changes directly within the phosphor emission band, thereby reflecting intrinsic material temperature instead of surface radiation characteristics.

Moreover, IR systems require emissivity calibration for each packaging configuration and cannot easily resolve internal temperature gradients in multilayer LED structures. The spectral method eliminates these limitations by using in-situ emission analysis without additional thermal sensors. It remains applicable in both lens-encapsulated and non-encapsulated configurations, offering reduced system complexity and improved industrial compatibility.

Variances for the discharge spectra from the phosphor samples signified phosphor heat levels. Regardless, a helpful indicator ought to be extricated from the sounds as well as overlaying activity. Judging the normalized spectrum for YAG:Ce^{3+}, its bar formation show the down transmutation comprising two distinctive Gaussian allocation within the power span caused by the gyrate trajectory linking influence along the excited state as well as foundation state. The whole down transmutation comprised two sub-spectra. It is possible to fit the blue spectrum as described in Equation 1.

$$F_b(\lambda) = \frac{2A_b}{e^{-\left(\frac{\lambda-\lambda_b}{\sigma_l}\right)} + e^{-\left(\frac{\lambda-\lambda_b}{\sigma_r}\right)}} \tag{1}$$

A_b, λ_b, σ_l and σ_r respectively signify the potency, apex wavelength, small bandwidth and extensive bandwidth for the blue illumination. The yellow spectrum generated by the phosphor would be fitted via the combined nonsymmetric spectrum functions from Equation 2.

$$F_p(\lambda) = A_p \frac{\lambda_p^2}{\lambda^2} e^{-\frac{(\lambda-\lambda_p)^2}{(\lambda\sigma_p)^2}} \tag{2}$$

A_p, λ_p and σ_p respectively signify the potency, apex wavelength and matching bandwidth for the nonsymmetric spectrum function. The nonsymmetric spectrum function type, $F_p(\lambda)$, underwent transmutation via a Gaussian form connected with $v(\equiv C/\lambda)$ involving the state for analogous power among the interims for dv as well as $d\lambda$. As such, it is possible manifest the sum spectrum for our ptWLED, $F_T(\lambda)$, in the form of the whole blue LED spectrum ($F_b(\lambda)$), two phosphor spectra for one small wavelength bar ($F_{pS}(\lambda)$) as well as one extensive wavelength bar ($F_{pL}(\lambda)$), expressed by Equation 3.

$$\begin{aligned} F_T(\lambda) &= F_b(\lambda) + F_{pS}(\lambda) + F_{pL}(\lambda) \\ &= \frac{2A_b}{e^{-\left(\frac{\lambda-\lambda_b}{\sigma_l}\right)} + e^{-\left(\frac{\lambda-\lambda_b}{\sigma_r}\right)}} \\ &\quad + A_{pS} \frac{\lambda_{pS}^2}{\lambda^2} e^{-\frac{(\lambda-\lambda_{pS})^2}{(\lambda\sigma_{pS})^2}} \\ &\quad + A_{pL} \frac{\lambda_{pL}^2}{\lambda^2} e^{-\frac{(\lambda-\lambda_{pL})^2}{(\lambda\sigma_{pL})^2}} \end{aligned} \tag{3}$$

For our testing, a blue colorant was linked with a metallic core printed circuit panel (MCPCP) then enveloped said panel using one silicone sheet integrated with YAG:Ce^{3+}. One IR camera was employed for tracking the exterior heat for phosphor sheets. Thermic abatement was not employed for quell the temperature for MCPCP. As such, the heat surges as the administration current surges.

Figure 1 features the relation between particle size and CCT level. The CCT is at its lowest under 4850 K with a particle size of 19 wt.%. With particle sizes of 0 wt.%, the CCT surges to the peaks under around 5200 K. The CCT shows the most dramatic changes with particle sizes ranging between 16 and 20 wt.%. The seen changes lead to dispersion for the illumination generated via the blue chip being propagated then transmuted more into rays under bigger wavelengths. Subsequently, the luminescence will be heightened when the blue-ray dispersion within the fore discharge surge with the blue-ray repeating absorptivity as well as rear-dispersion diminished. The ZnTe particle size has a mostly inverse influence on the hue aberration, as demonstrated by Figure 2. The hue aberration starts declining under 11 wt.%, only showing a sharp surge when the particle size reaches

15 wt.%. However, beyond this point, the aberration continues to decline, showing one more increase at 19 wt.%. For the lumen in LED shown in Figure 3, it starts out at its lowest, showing a sharp rise between 11 and 14 wt.%. Beyond this point, the lumen begins fluctuating a somewhat consistent manner. The observed variations may stem from differences in color allocation and the reduced intensity of blue emission caused by stronger rear-dispersion and repeated absorptivity. It is also notable that when particle size increases, the color shift between blue and yellow or red-orange becomes more pronounced because the phosphor sheet generally broadens at larger particle sizes, leading to a degradation of overall spectral energy. Consequently, at very large particle sizes, the converted light may undergo rear-reflection, which reduces luminous intensity while generating a higher CCT.

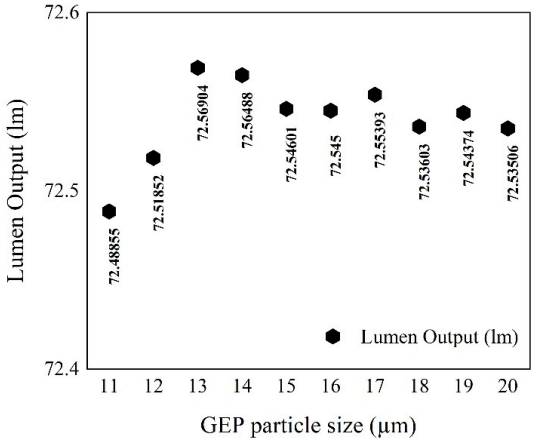

Figure 3. LED Lumen Generated Based on ZnTe Particle Size

The trends observed in Figures 1-3 serve as functional validation of the proposed spectral temperature tracking logic. Variations in particle size alter scattering strength and reabsorption probability, which in turn modify CCT, hue deviation, and luminous flux. These macroscopic photometric variations are directly reflected in the fitted spectral parameters (λp *and* σp) extracted from the isolated phosphor band. Since phosphor temperature produces similar spectral effects, namely peak red-shifting and bandwidth broadening, the consistency between particle-size-induced spectral shifts and thermally induced spectral shifts confirms that the corrected Gaussian fitting parameters reliably encode thermal information. Therefore, the particle-size-dependent photometric data support the robustness and sensitivity of the spectral sieving method for phosphor temperature tracking.

4. CONCLUSIONS

In conclusion, the concept of spectral sieving demonstrates strong potential as a non-contact method for evaluating phosphor behavior within ptWLED systems. The results of this study reveal a clear relationship between the yellow spectral component and the phosphor temperature, even when measured from a single white-light emission with substantial spectral crosstalk. This correlation confirms that temperature-dependent spectral shifts can be reliably extracted despite the inherent overlap of emission bands in phosphor-converted LEDs (Loan et al., 2022; Tung et al., 2022). Our investigation highlights a relatively efficient and practical technique for monitoring phosphor temperature in real time, providing a valuable diagnostic tool for assessing the thermal state of the phosphor layer during operation. Such an approach is highly relevant to the solid-state lighting industry, where maintaining stable chromaticity, ensuring long-term reliability, and maximizing luminous efficiency are essential performance requirements. Overall, the findings demonstrate that spectrum-sieving–based temperature estimation can support the development of more dependable, thermally robust, and chromatically consistent illumination solutions, offering tangible benefits for next-generation ptWLED technologies and other advanced lighting applications.

5. ACKNOWLEDGEMENT

The authors wishes to express their gratitude to the Posts and Telecommunications Institute of Technology, Vietnam, for financial support for this research.

REFERENCES

Hanh, N., N. Loan, and N. D. Quoc Anh (2020). The Application of Green YPO_4:Ce^{3+},Tb^{3+} and Red $LiLaO_2$:Eu^{3+} Layers to Remote Phosphor LED. *TELKOMNIKA (Telecommunication Computing Electronics and Control)*, **18**(6); 3216–3223

Hanh, N., P. That, and N. D. Quoc Anh (2021a). Eu^{2+}-Activated Strontium-Barium Silicate: A Positive Solution for Improving Luminous Efficacy and Color Uniformity of White Light-Emitting Diodes. *Materials Science-Poland*, **38**(4); 681–688

Hanh, N., P. That, N. D. Quoc Anh, and T. Trang (2021b). Triple-Layer Remote Phosphor Structure: A Novel Option for the Enhancement of WLEDs' Color Quality and Luminous Flux. *Materials Science-Poland*, **38**(4); 752–759

Le, P., S. Ho, N. D. Quoc Anh, and H.-Y. Lee (2022). Triple-Layer Remote Phosphor Structure: A Potential Packaging Configuration to Enhance Both Color Quality and Lumen Efficiency of 6,000–8,500 K WLEDs. *Materials Science-Poland*, **39**(4); 526–533

Loan, N., N. D. Quoc Anh, N. Trang, and H.-Y. Lee (2022). Better Color Distribution Uniformity and Higher Luminous Intensity for LED by Using a Three-Layered Remote Phosphor Structure. *Materials Science-Poland*, **40**(1); 60–67

Loan, N. T. P. and N. D. Q. Anh (2020a). The Application of Double-Layer Remote Phosphor Structures in Increasing WLEDs Color Rendering Index and Lumen Output. *International Journal of Electrical and Computer Engineering (IJECE)*, **10**(5); 5183–5190

Loan, N. T. P. and N. D. Q. Anh (2020b). The Effectiveness of $MgCeAl_{11}O_{19}$:Tb^{3+} Phosphor in Enhancing the Luminous

Efficacy and Color Quality of Multi-Chip White LEDs. *International Journal of Electrical and Computer Engineering (IJECE)*, **10**(5); 4631–4638

Loan, N. T. P. and N. D. Q. Anh (2020c). Improving Color Quality and Luminous Flux of White LED Utilizing Triple-Layer Remote Phosphor Structure. *International Journal of Electrical and Computer Engineering (IJECE)*, **10**(5); 5168–5174

Loan, N. T. P. and N. D. Q. Anh (2020d). $Na_3Ce(PO_4)_2$:Tb^{3+} and $Na(Mg_{2-x}Mn_x)LiSi_4O_{10}F_2$:Mn Phosphors: A Suitable Selection for Enhancing Color Quality and Luminous Flux of Remote White Light-Emitting Diodes. *TELKOMNIKA (Telecommunication Computing Electronics and Control)*, **18**(4); 2095–2102

Loan, N. T. P. and N. D. Q. Anh (2020e). The Options in Remote Phosphor Structure for Better White LEDs Color Quality. *TELKOMNIKA (Telecommunication Computing Electronics and Control)*, **18**(5); 2606–2613

Loan, N. T. P. and N. D. Q. Anh (2020f). $SrBaSiO_4$:Eu^{2+} Phosphor: A Novel Application for Improving the Luminous Flux and Color Quality of Multi-Chip White LED Lamps. *International Journal of Electrical and Computer Engineering (IJECE)*, **10**(5); 5147–5154

Loan, N. T. P. and N. D. Q. Anh (2020g). Utilizing $CaCO_3$, CaF_2, SiO_2, and TiO_2 Particles to Enhance Color Homogeneity and Luminous Flux of WLEDs. *International Journal of Electrical and Computer Engineering (IJECE)*, **10**(5); 5175–5182

Loan, N. T. P. and N. D. Q. Anh (2020h). Y_2O_3:Ho^{3+} and ZnO:Bi^{3+}: A Selection for Enhancing Color Quality and Luminous Flux of WLEDs. *International Journal of Electrical and Computer Engineering (IJECE)*, **10**(5); 5162–5167

Luo, G.-J., N. Loan, L. Tho, N. D. Quoc Anh, and H.-Y. Lee (2020a). Enhancement of Color Quality and Luminous Flux for Remote-Phosphor LEDs with Red-Emitting $CaMgSi_2O_6$:Eu^{2+},Mn^{2+}. *Materials Science-Poland*, **38**(3); 405–412

Luo, G.-J., N. Loan, L. Tho, P. That, N. D. Quoc Anh, M.-J. Chen, H.-Y. Liao, and H.-Y. Lee (2020b). Building Superior Lighting Properties for WLEDs Utilizing Two-Layered Remote Phosphor Configurations. *Materials Science-Poland*, **38**(3); 398–404

Pham, T., N. Phan, G.-J. Luo, H.-Y. Lee, and D. Nguyen (2021). The Application of Calcium Carbonate $CaCO_3$ and Titania TiO_2 for Color Homogeneity and Luminous Flux Enhancement in PC-LEDs. *Journal of Advanced Engineering and Computation*, **5**(2); 75–84

That, P., N. Loan, L. Tho, N. D. Quoc Anh, H.-Y. Liao, G.-J. Luo, and H.-Y. Lee (2021). Enhancing Color Quality of WLEDs with Dual-Layer Remote Phosphor Geometry. *Materials Science-Poland*, **38**(4); 689–696

Thi, M. H. N., T. M. Bui, and N. D. Q. Anh (2021). Aiming to the Superior of Phosphor Pattern: Influence of SiO_2 Nanoparticles on Photoluminescence Intensification of YAG:Ce. *International Journal of Electrical and Computer Engineering (IJECE)*, **11**(6); 4833–4839

Tran, A.-M., N. D. Quoc Anh, and N. Loan (2020a). The Influences of Calcium Fluoride and Silica Particles on Improving Color Homogeneity of WLEDs. *TELKOMNIKA (Telecommunication Computing Electronics and Control)*, **18**(5); 2696–2703

Tran, A.-M. D., N. D. Q. Anh, and N. Thi Phuong Loan (2020b). Enhancing Light Sources Color Homogeneity in High-Power Phosphor-Based White LED Using ZnO Particles. *TELKOMNIKA (Telecommunication Computing Electronics and Control)*, **18**(5); 2628–2634

Tran, T., N. D. Quoc Anh, and N. Loan (2020c). Excellent Color Quality of Phosphor Converted White Light Emitting Diodes with Remote Phosphor Geometry. *TELKOMNIKA (Telecommunication Computing Electronics and Control)*, **18**(5); 2757–2763

Trang, T. T. (2022). Comparison Between SEPs of $CaCO_3$ and TiO_2 in Phosphor Layer for Better Color Uniformity and Stable Luminous Flux of WLEDs with 7,000 K. *Materials Science-Poland*, **40**(1); 1–8

Tung, H. T., B. T. Minh, N. L. Thai, H. Y. Lee, and N. D. Q. Anh (2022). ZnO Particles as Scattering Centers to Optimize Color Production and Lumen Efficiencies of Warm White LEDs. *Journal of Science and Technology: Issue on Information and Communications Technology*, **20**(2); 29–34

