

Warm-white light-emitting diodes integrated with colloidal quantum dots for high luminous efficacy and color rendering: reply to comment

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The correlated color temperatures and the corresponding color rendering indices calculated using actual experimental data (and not any prediction) in the original Letter [Opt. Lett. **35**, 3372 (2010)] are correct. In addition, here the color rendering of our white LEDs integrated with nanocrystal quantum dots (NQDs) is provided for all test samples. Also, a new NQD-LED design with both high luminous efficacy of optical radiation and CRI is presented to have a chromaticity point in the quadrangle stated in the comment Letter [Opt. Lett. **36**, 2851 (2011)]. The points made in the original Letter and all the calculation results provided therein are valid. © 2011 Optical Society of America

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We are pleased that our original Letter [1] on nanocrystal quantum dot (NQD)-LEDs has stirred interest. Our work focuses on achieving high luminous efficacy of optical radiation (LER), which is challenging using conventional phosphors with broad emission bands. The comment Letter [2] indeed verifies these high levels of LER reached using NQDs. To analyze LEDs, true color rendering indices (CRIs) can be obtained by using only the correct correlated color temperatures (CCTs). For that, we double-checked our results by using the internationally accepted method of the International Commission on Illumination [3] and crosschecked them using the widely accepted textbook by Schubert [4]. According to these independent calculations, we confirm that our previously reported values are indeed correct (Table 1). We reckon that a possible reason why the comment Letter author finds different results for our CCTs (and thus CRIs) may be that his calculations rely on his predictions, given the significant digit of (x, y) coordinates. (x, y) were provided in three decimal digits in the original Letter, as is reported in the literature, but these are four-digit results. In our analyses, we directly use actual experimental spectra and, as a result, our reported CCTs and CRIs both in the original paper and this response are correct. In our Letter, we reported the general CRIs because they are most widely used in the lighting community and calculated for R1–R8, as also explained in [3,4]. In Table 1, we report R1–R14 for all CIE test color samples. These WLEDs exhibit high CRIs of 89.2, 88.9, and 87.8, while their R(9–14) are 71.4, 76.0, and 82.6. WLED2 and WLED3 also provide high R9s of 92.0 and 87.9, respectively, even though WLED1 has a moderate R9 of 68.7. Although none of WLED1–3 has been previously designed considering the quadrangle chromaticity region specified for product standardization [5,6], Table 1 presents a new design that satisfies high LER and high R1–R14 in the specified quadrangle. In summary, these discussions presented here support the idea of the original Letter. Thanks to the comment paper, our work has now further been extended to cover the specific quadrangle chromaticity region, if desired.

Table 1. White NQD-LEDs (WLED1–3) Reported in [1] along with a New Design

	WLED1	WLED2	WLED3	New WLED
x	0.4257	0.4400	0.4627	0.3728
y	0.3789	0.3840	0.3766	0.3764
CCT (K)	2982	2781	2390	4211
LER _(lm/W_{opt})	357	349	339	340
CRI	89.2	88.9	87.8	89.5
R1	95.3	88.8	79.8	83.0
R2	97.0	97.3	90.6	96.6
R3	66.2	60.1	66.7	86.7
R4	90.6	93.1	89.7	84.3
R5	91.6	97.7	91.1	89.3
R6	85.5	87.1	91.6	92.7
R7	96.2	93.3	96.0	94.3
R8	91.5	94.3	97.1	89.2
R9	68.7	92.0	87.9	83.0
R10	65.9	67.1	85.9	99.0
R11	70.1	80.2	90.8	82.8
R12	52.8	54.9	78.6	86.2
R13	96.2	90.9	79.3	87.2
R14	74.9	70.9	73.5	89.2
R(9–12)	64.3	73.5	85.8	88.2
R(9–14)	71.4	76.0	82.6	88.2
Duv(CIE1976)	0.0128	0.0124	0.0192	0.0029
Duv(CIE1960)	0.0088	0.0078	0.0125	0.0007

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