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Uniform nucleation and growth of $Cs_3Cu_2I_5$ nanocrystals with high luminous efficiency and structured stability and their application in white light-emitting diodes

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Keywords：copper-based ternary halides, uniform nucleation, stable, white light-emitting diodes

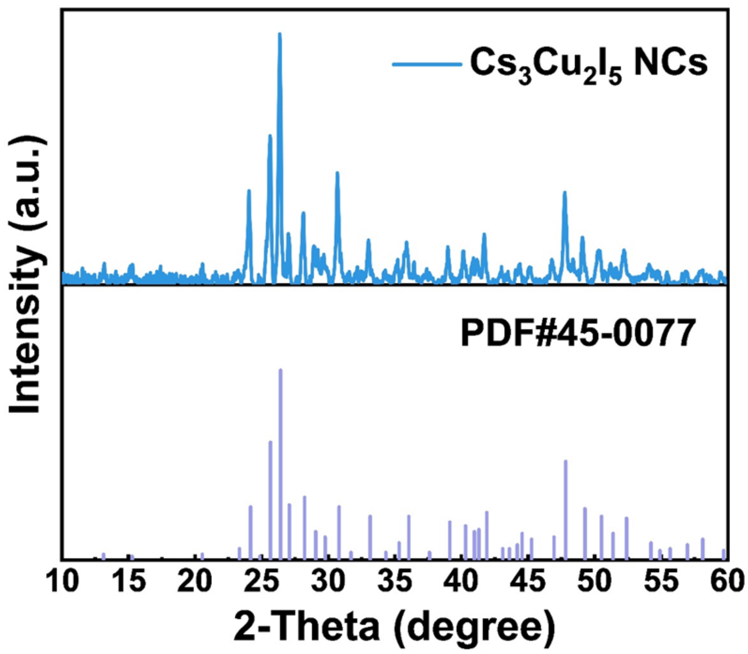

Figure S1. XRD of $Cs_3Cu_2I_5$ NCs and standard PDF card of $Cs_3Cu_2I_5$.

Table S1. Summary of elemental contents of Cs, Cu, and I in $Cs_3Cu_2I_5$ NCs.

Element	Cs	Cu	I
Weight (%)	29.66	24.28	46.06

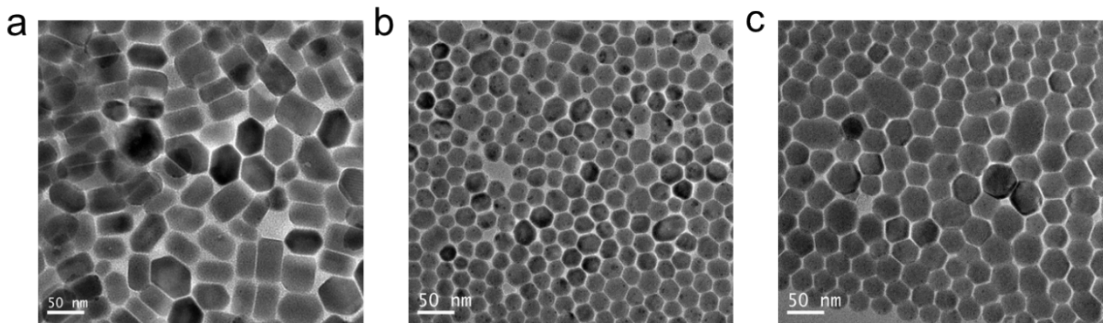

Figure S2. TEM images of $Cs_3Cu_2I_5$ NCs prepared by high-energy ultrasound method for (a) 1 min, (b) 2 min and (c) 5 min.

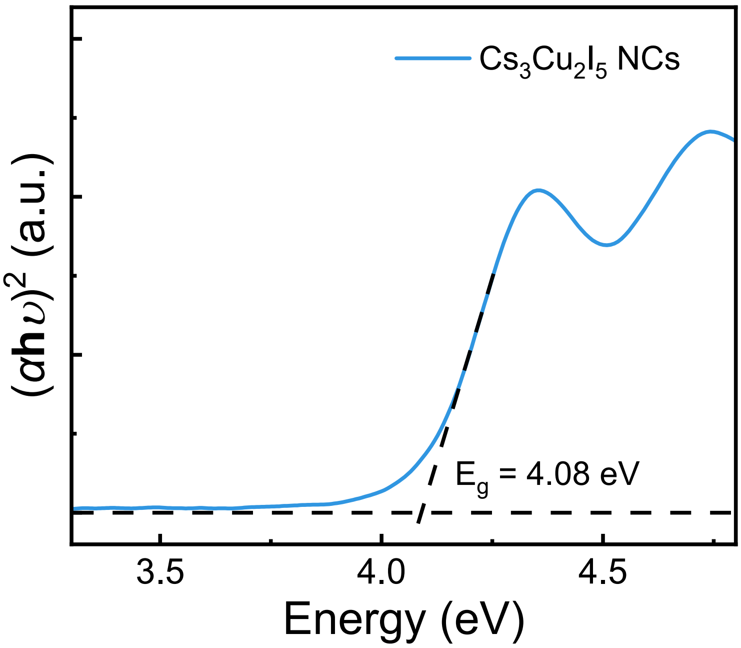

Figure S3. Tauc plot of the $Cs_3Cu_2I_5$ NCs.

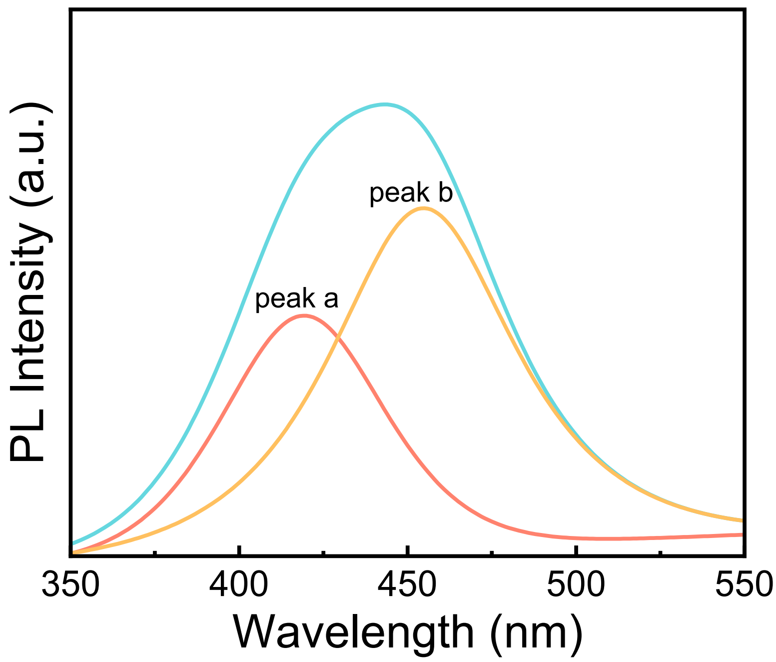

Figure S4. The PL spectra and the fitting results of $Cs_3Cu_2I_5$ NCs.

Table S2. Summary of fitting data of PL decay curve.

Samples	τ_1(ns)	A_1(%)	τ_2(ns)	A_2(%)	τ_{avq}(ns)
$Cs_3Cu_2I_5$-NCs	124	0.16	1072	0.84	1051

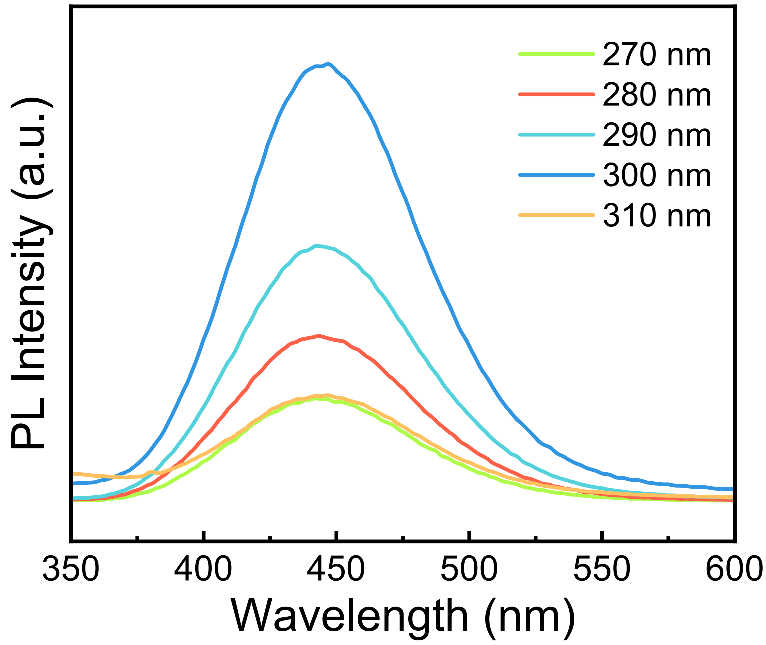

Figure S5. PL spectra of $Cs_3Cu_2I_5$ NCs under different excitation wavelengths from 270 to 310 nm.

Table S3. Summary of the properties $Cs_3Cu_2I_5$ NCs in literatures.

NCs	PL peak (nm)	PLQY (%)	Ref
$Cs_3Cu_2I_5$	445	73.7	1
$Cs_3Cu_2I_5$	445	72.6	2
$Cs_3Cu_2I_5$	445	78.42	3
$Cs_3Cu_2I_5$	447	72.4	4
$Cs_3Cu_2I_5$	445	59	5
$Cs_3Cu_2I_5$	445	39.8	6

$Cs_3Cu_2I_5$	395	10	7
$Cs_3Cu_2I_5$	441	85	Our work

References

1. L. Lian, M. Zheng, W. Zhang, L. Yin, *Adv. Sci*., 2020, **7**, 2000195.
2. X. Hu, Y. Li, Y. Wu, W. Chen, H. Zeng, and X. Li, *Mater. Chem. Front*., 2021, **5**, 6152-6159
3. X. Hu, P. Yan, P. Ran, L. Lu, *J. Phys. Chem. Lett*., 2022, **13**, 2862–2870.
4. C. Li, S. Cho, D. Kim, and I. Park, *Chem. Mater*., 2022, 34, **15**, 6921–6932.
5. J. Zhou, K. An, P. He, J. Yang, et al, *Adv. Optical Mater*., 2021, **9**, 2002144.
6. F. Zhang, W. Liang, L. Wang, Z. Ma, et al, *Adv. Funct. Mater*., 2021, **31**, 2105771.
7. A. L. M. Freitas, A. Tofanello, F. P. Sabino, et al, *ACS Appl. Nano Mater*., 2023, **6**, 7196–7205.

Table S4. Summary of the lead-free device performances of the prepared WLEDs.

Emitter	CRI	CCT (K)	LE (lm/W)	Ref
$(CH_6N_3)_2MnCl_4$	93.7	3984	90.41	1
$(NH_4)_2Sn_{1-x}Te_xCl_6$	83	3855	—	2
$Cs_2AgIn_{0.9}Bi_{0.1}Cl_6$	94.5	6432	—	3
$(C_{13}H_{30}N)_2SnCl_6$	96.7	—	—	4
Cs_2SnCl_6: Bi^{3+}/Te^{4+}	94	6386-3668	—	5
$Cs_2TeCl_6:Cr^{3+}$	81.3	5826	—	6
$Cs_2Zr_{1-x}Te_xCl_6$	74.8	4959	91.16	7
$OTA_{2+x}SnI_{4+x}$	92	2654		8
$CsCu_2I_3$	83	6718		9

$Cs_2NaInCl_6:Sb^{3+}/Sm^{3+}/Eu^{3+}/Tb^{3+}/Dy^{3+}$	80	8035	37.5	10
$(OCTAm)_2SnBr_4$	89	6530	—	11
$(Cs_4N_2H_{14}Br)_4SnBr_xI_{6-x}$	84	5632	32.2	12
$(C_4N_2H_{14}Br)_4SnBr_6$	70	4946	—	13
$Cs_3Cu_2I_5/CsCu_2I_3$	89.5	5877	54.6	14
$Cs_3Cu_2I_5$	95.3	5489	41.5	This work

References

1. S. Wang, X. Han, T. Kou, et al, *J. Mater. Chem. C.*, 2021, **9**, 4895-4902.
2. Z. Li, C. Zhang, B. Li, C. Lin, Y. Li, L. Wang, R. Xie, *Chemical Engineering Journal.*, 2021, **420**, 129740.
3. Y. Zhang, Z. Zhang, W. Yu, et al, *Adv. Sci.*, 2022, **9**, 2102895.
4. W. Lin, Q. Wei, T. Huang, et al, *J. Mater. Chem. C*, 2023, Advance Article.
5. Z. Liu, X. Ji, Z. Ma, *Laser Photonics Rev.*, 2023, 2300094.
6. L. Zi, W. Xu, Z. Song, R. Sun, *J. Mater. Chem. C.*, 2023, **11**, 2695-2702.
7. Z. Li, Z. Rao, Q. Li, L. Zhou, X. Zhao, X. Gong, *Adv. Optical Mater.*, 2021, **9**, 2100804.
8. Z. Li, Z. Deng, A. Johnston, *Adv. Funct. Mater.*, 2022, **32**, 2111346.
9. W. Liu, K. W. Ng, H. Lin, Z. Dai, *J. Phys. Chem. C.*, 2021, **125**, 13076–13083.
10. X, Li, D, Wang, Y. Zhong, F. Jiang, *Adv. Sci.*, 2023, 2207571.
11. J. Sun, J. Yang, J. I. Lee, J. H. Cho, and M. S. Kang, *J. Phys. Chem. Lett.*, 2018, **9**, 1573–1583.
12. C. Zhou, Y. Tian, Z. Yuan, et al, *ACS Appl. Mater. Interfaces.*, 2017, **9**, 44579–44583.
13. C. Zhou, H. Lin, Y. Tian, Z. Yuan, *Chem. Sci.*, 2018, **9**, 586-593.
14. L. Wang, Z. Ma, F. Zhang, et al, *J. Mater. Chem. C.*, 2021, **9**, 6151-6159.