

Impact of Bismuth-Doping on the Enhanced Radiative Recombination in Lead-free Double Perovskite Nanocrystals

Author name: Xiaoyu Huang^{1,2}, Yoshitaka Matsushita³, Hong-Tao Sun,¹ Naoto Shirahata^{1,2,4*}

Author address:

¹International Center for Materials Nanoarchitectonics (MANA), National Institute for Materials Science (NIMS), Ibaraki 305-0044, Japan

²Graduate School of Chemical Sciences and Engineering, Hokkaido University, Sapporo 060-0814, Japan; Department of Physics, Chuo University, Tokyo 112-8551, Japan

³Research Network and Facility Services Division, National Institute for Materials Science (NIMS), Ibaraki 305-0047, Japan

⁴Department of Physics, Chuo University, Tokyo 112-8551, Japan

Email: SHIRAHATA.Naoto@nims.go.jp

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Supporting Figure

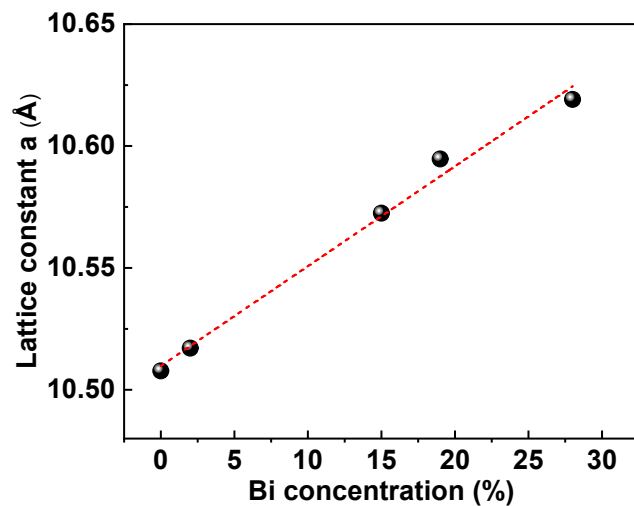


Figure S1. The lattice constant as function of Bi concentration in $\text{Cs}_2\text{Ag}_{0.65}\text{Na}_{0.35}\text{InCl}_6$ NCs. (PLQY: 11.5% for 19% Bi-doped NCs, and 9.3% for 28% Bi-doped NCs.)

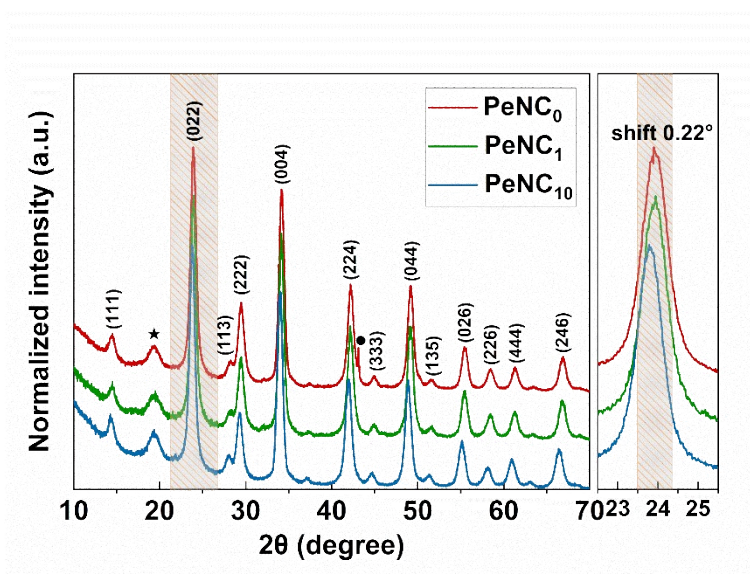


Figure S2. XRD patterns of PeNC_0 , PeNC_1 and PeNC_{10} measured at 5 K. The peaks indicating as ★ and ● are from the X-ray window materials of the cryostat and from Cu sample holder, respectively.

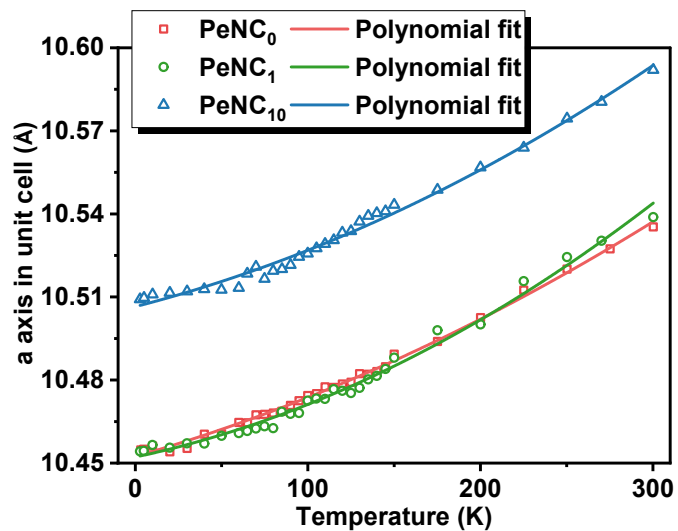


Figure S3. Thermal expansion coefficient fitting of PeNC₀, PeNC₁ and PeNC₁₀.

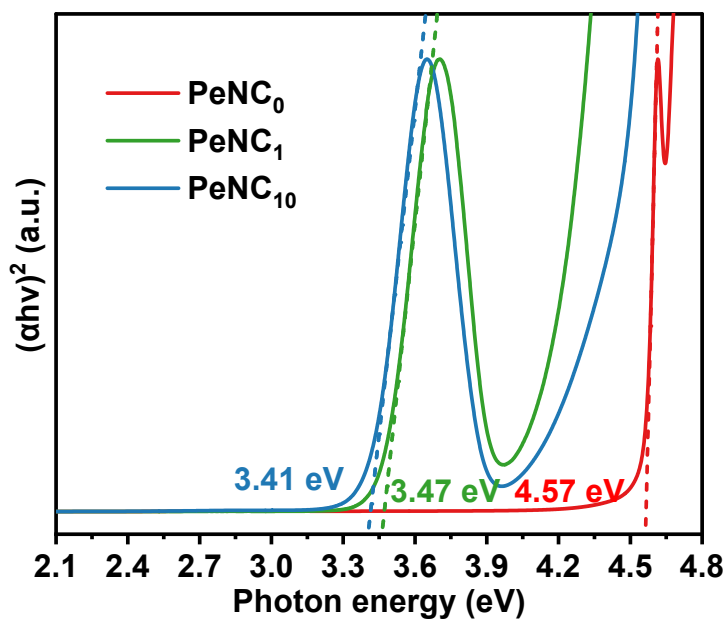


Figure S4. $(\alpha h\nu)^2$ - $h\nu$ plots of PeNC₀ (red), PeNC₁ (green) and PeNC₁₀ (blue). The values of E_g extracted from extrapolations to $\alpha = 0$.

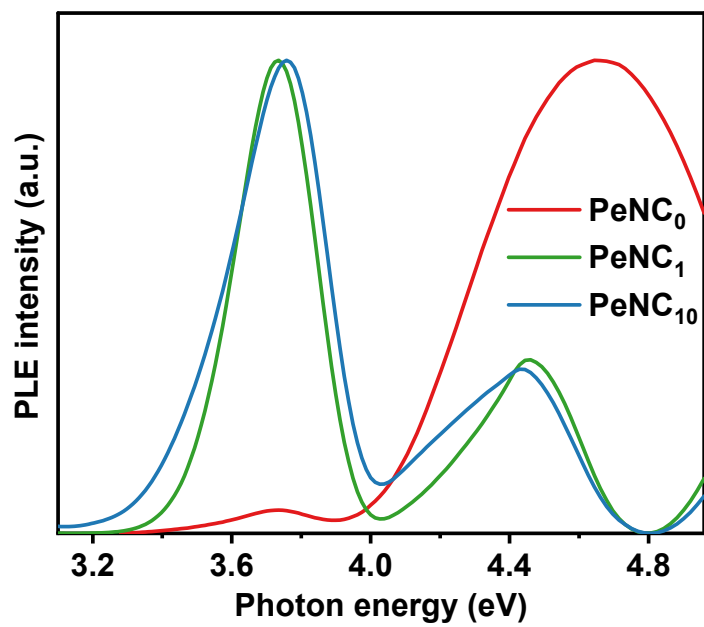


Figure S5. Excitation spectra of photoluminescence measured for PeNC₀ (634 nm-emission peak), PeNC₁ (592 nm-emission peak) and PeNC₁₀ (630 nm-emission peak).

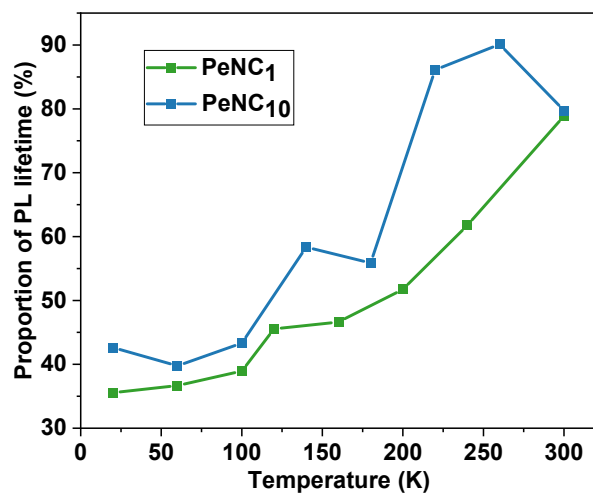


Figure S6. The proportion of less-long lived PL lifetime for PeNC₁ (green) and PeNC₁₀ (blue) dependent on temperature.

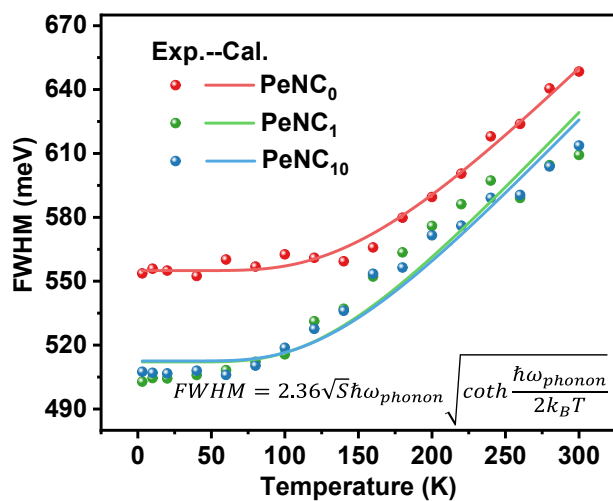


Figure S7. Temperature-dependent PL FWHM of PeNC₀, PeNC₁ and PeNC₁₀.

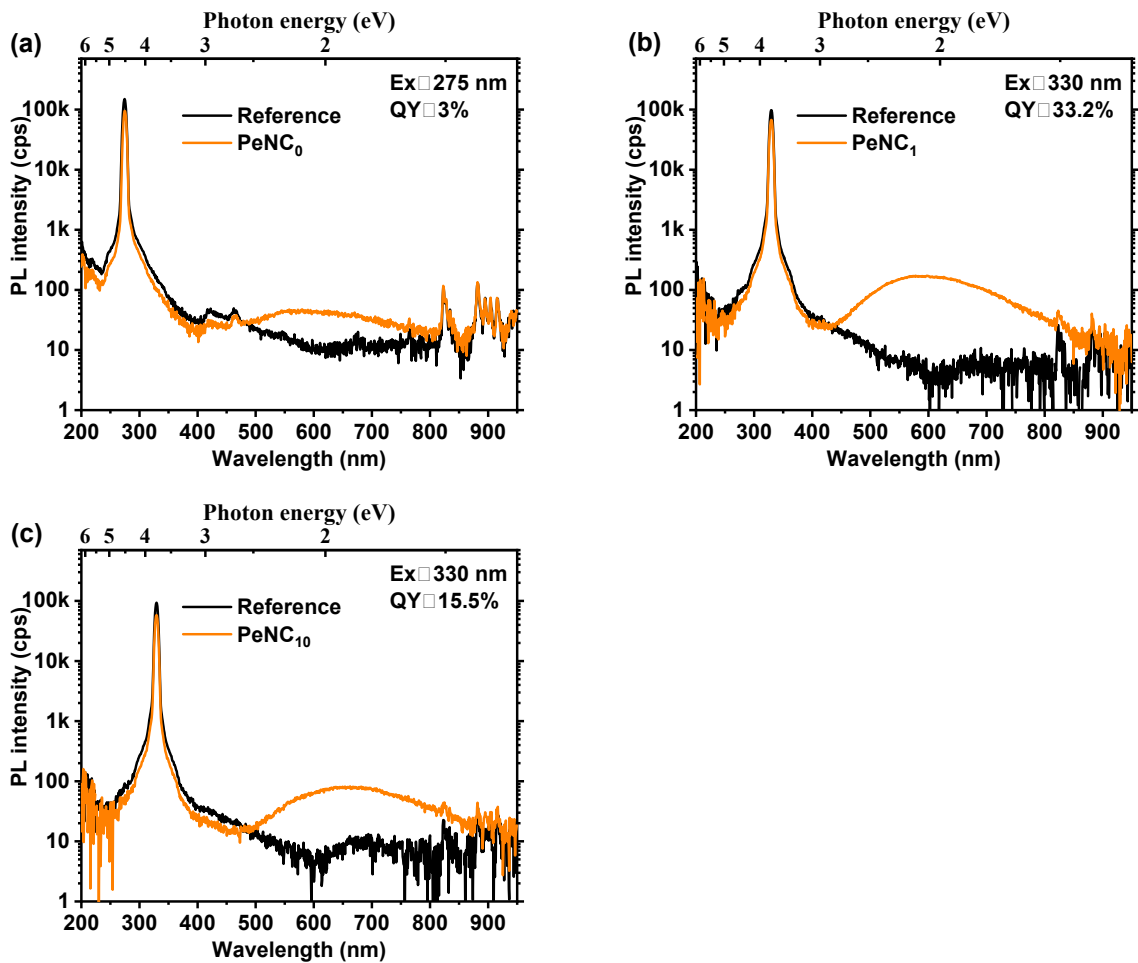


Figure S8. PLQY for PeNC₀ (a), PeNC₁ (b) and PeNC₁₀ (c).

Supporting Table

Table S1. STEM-EDS elemental analysis on Bi-doped and undoped NCs.

EDS/atom ratio	Cs/In	Ag/(Ag+Na)	Na/(Ag+Na)	In/(In+Bi)	Bi/(In+Bi)	Cl/In
PeNC ₀	2.32	0.66	0.35	1	0	5.61
PeNC ₁	2.39	0.65	0.35	0.98	0.02	5.50
PeNC ₁₀	2.48	0.63	0.37	0.85	0.15	4.86

Table S2. Fitted decay parameters of PeNCs at different temperature.

Temperature (K)		20	60	100	140	180	220	260	300
PeNC ₁	τ_1 (μ s) (A ₁ %)	3.13 (36%)	0.97 (37%)	1.06 (39%)	1.65 (46%) @ 120 K	0.95 (47%) @ 160 K	1.00 (52%) @ 200 K	1.08 (62%) @ 240 K	1.10 (79%)
	τ_2 (μ s) (A ₂ %)	50.56 (64%)	17.82 (63%)	16.48 (61%)	17.20 (54%) @ 120 K	14.99 (53%) @ 160 K	12.14 (48%) @ 200 K	9.65 (38%) @ 240 K	7.26 (21%)
	R-square	0.998	0.996	0.996	0.991	0.994	0.992	0.985	0.971
PeNC ₁₀	τ_1 (μ s) (A ₁ %)	2.99 (43%)	2.19 (40%)	2.24 (43%)	3.87 (58%)	1.92 (56%)	3.45 (86%)	1.82 (90%)	0.81 (80%)
	τ_2 (μ s) (A ₂ %)	43.52 (57%)	19.27 (60%)	18.16 (57%)	19.52 (42%)	13.51 (44%)	19.70 (14%)	12.50 (10%)	3.53 (20%)
	R-square	0.999	0.998	0.997	0.993	0.994	0.975	0.978	0.999