

## Supporting Information

### Seed-Mediated Growth Synthesis and Tunable Narrow-band Luminescence of Quaternary Ag-In-Ga-S Alloyed Nanocrystals

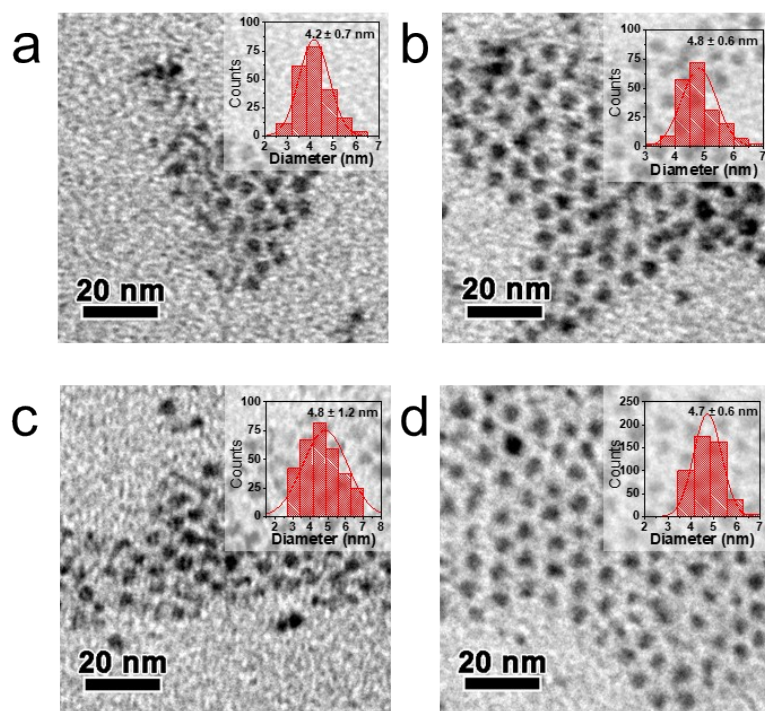
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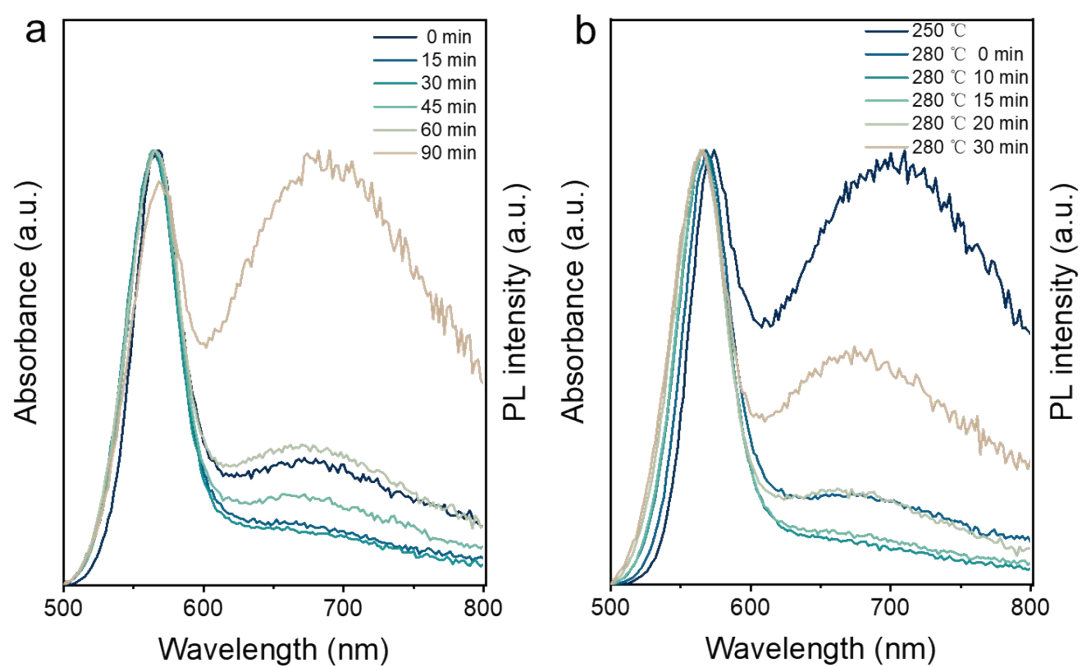
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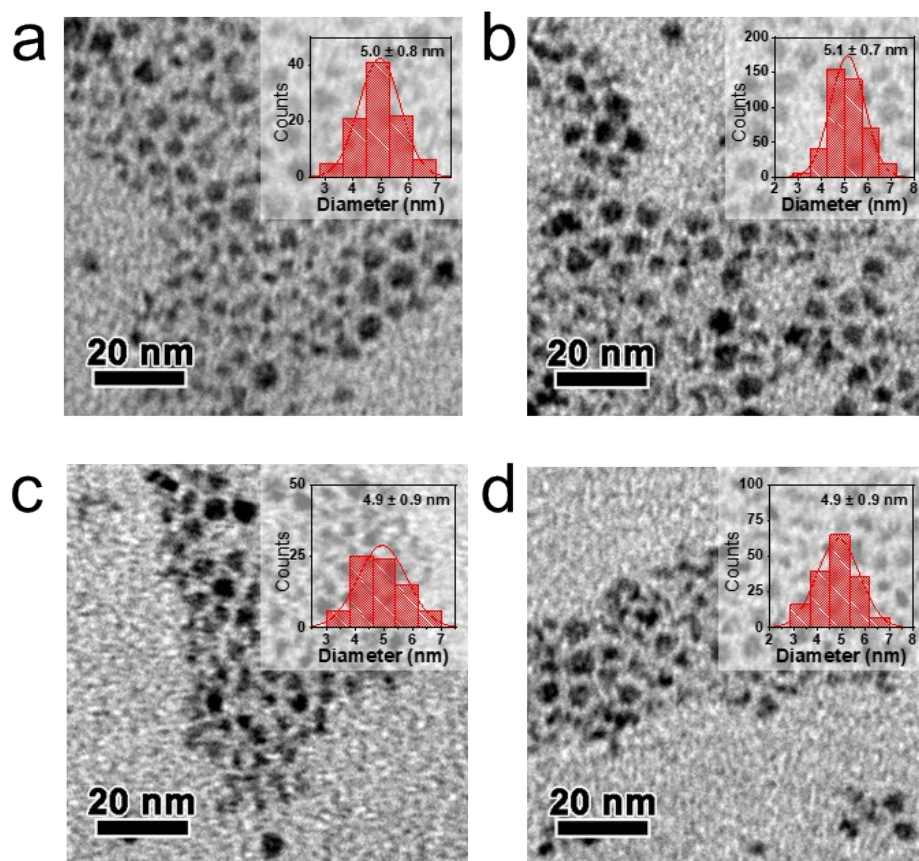
E-mail: [awtang@bjtu.edu.cn](mailto:awtang@bjtu.edu.cn); [zhyu@bjtu.edu.cn](mailto:zhyu@bjtu.edu.cn)



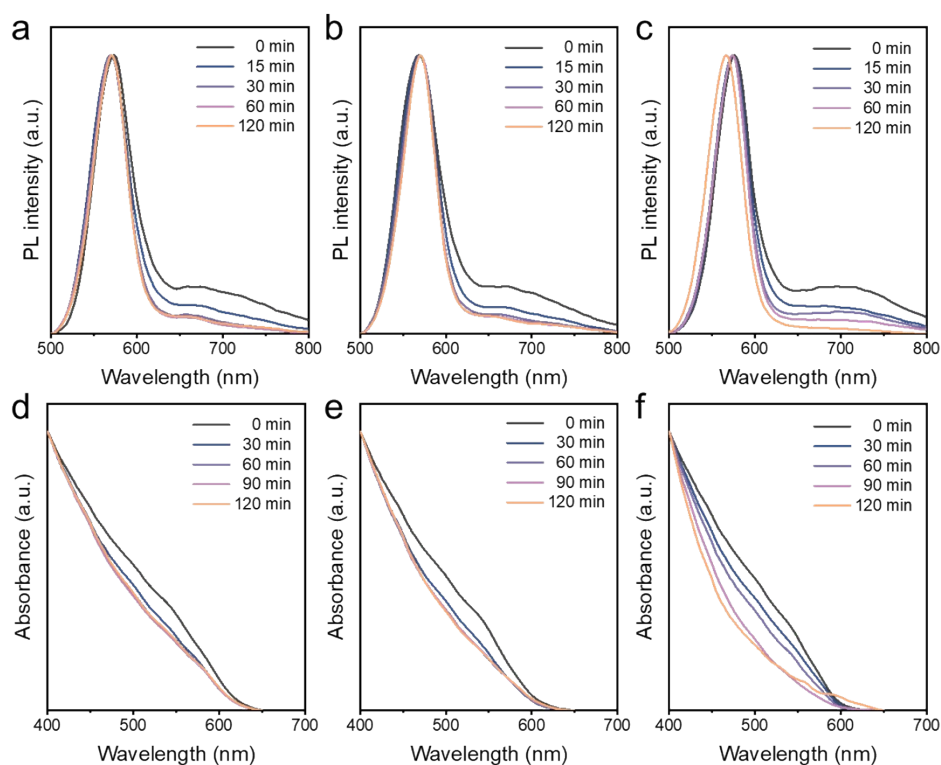
**Fig. S1** TEM images of AIGS nanocrystals without DDT (a) 250°C, (b) 280°C 0 min, (c) 280°C 15 min, (d) 280°C 30 min.



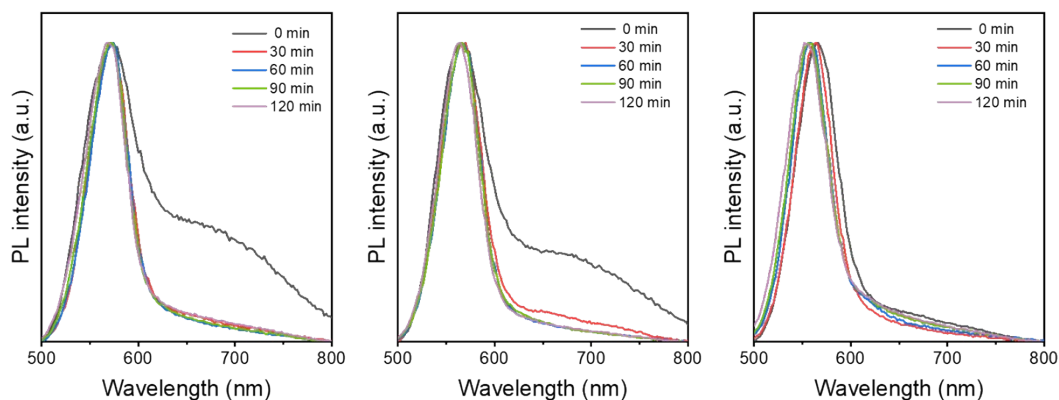
**Fig. S2** Evolution of the PL spectra of AIGS nanocrystals with different Ga precursor (a) 0.3 mmol and (b) 0.5 mmol.



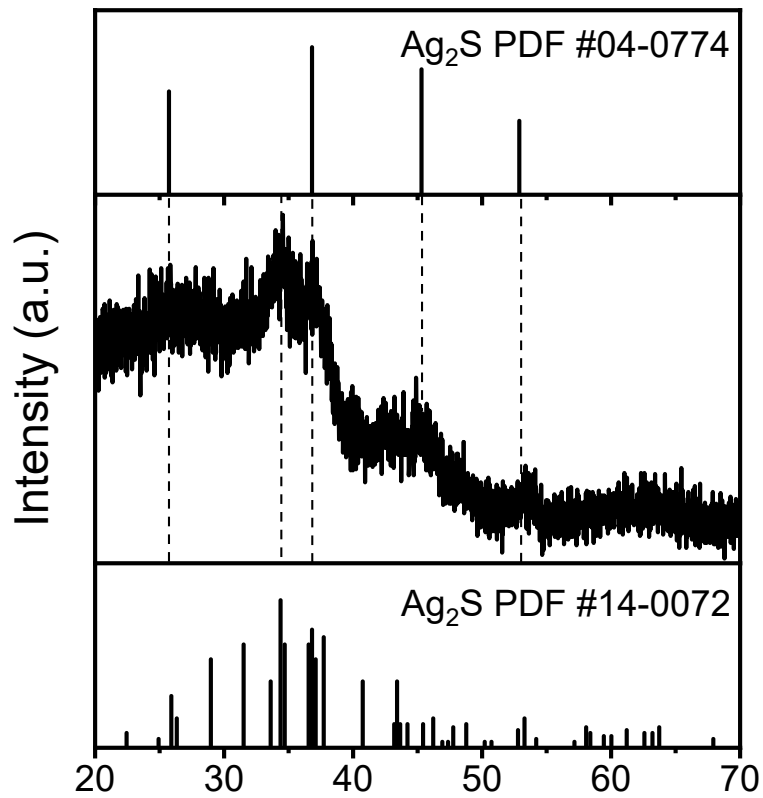
**Fig. S3** TEM images of AIGS nanocrystals with DDT (a) 0 min, (b) 30 min, (c) 60 min, (d) 120 min.



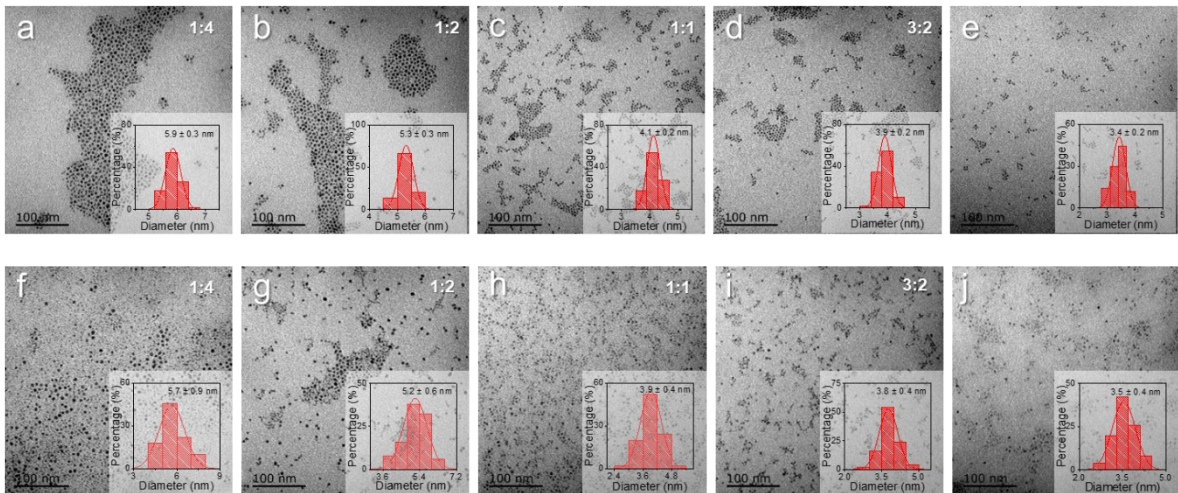
**Fig. S4** Evolution of the PL spectra of AIGS nanocrystals with different addition of DDT (a) 0.1 mL, (b) 0.2 mL and (c) 0.5 mL.



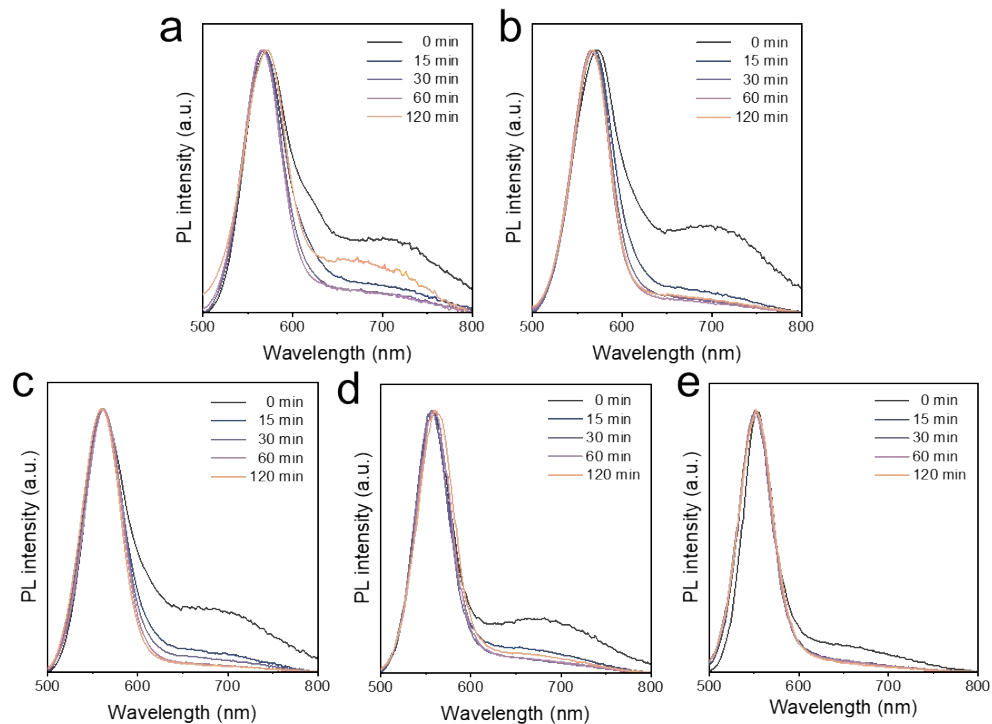
**Fig. S5.** Evolution of the PL spectra of AIGS nanocrystals with different addition of DMTU (a) 0.3 mmol, (b) 0.45 mmol and (c) 0.6 mmol.



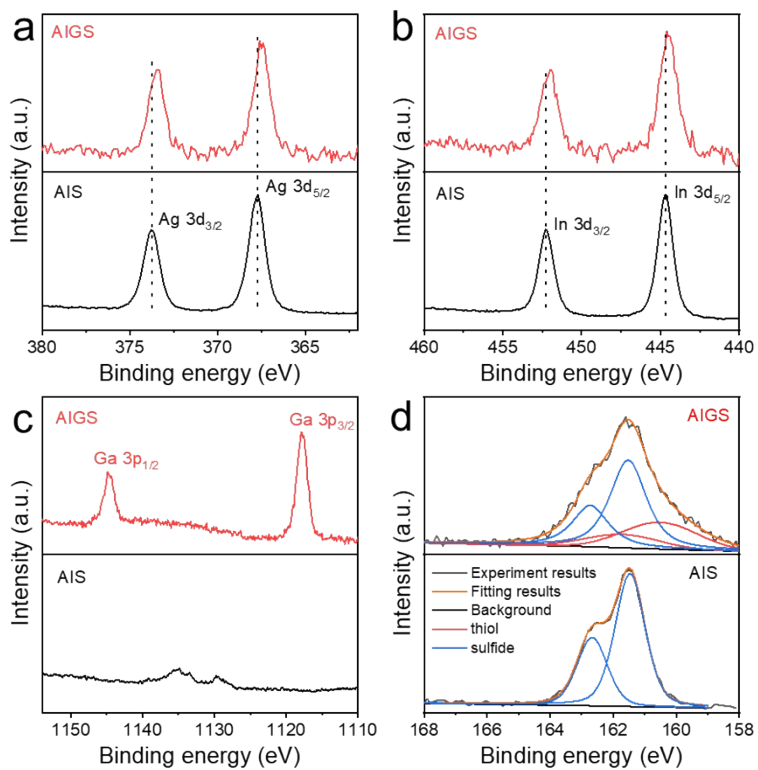
**Fig. S6** XRD patterns of precipitate produced during the synthesis in AIS seeds.



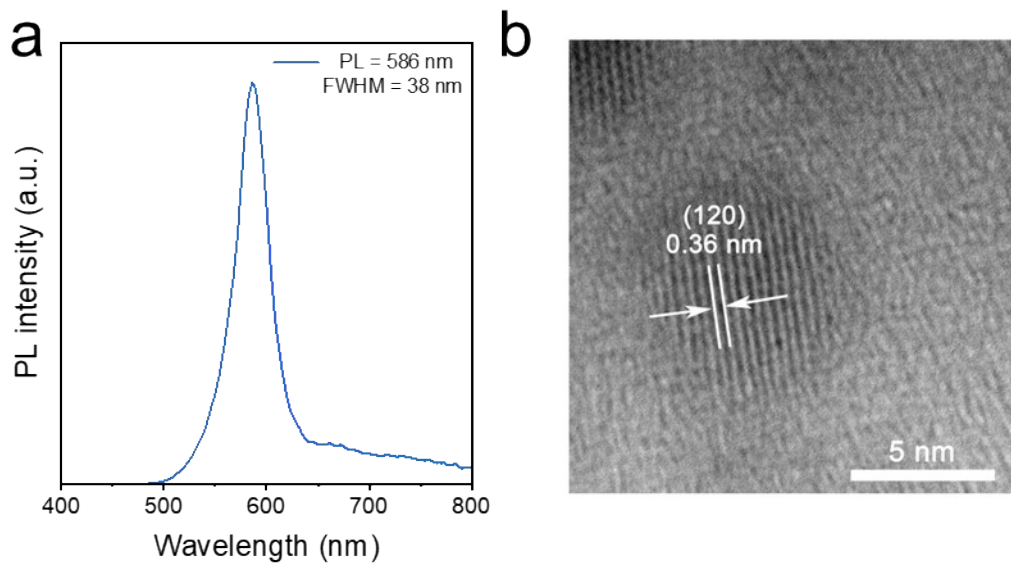
**Fig. S7** TEM images of AIS seeds synthesized with different Ag/In (a) 1:4, (b) 1:2, (c) 1:1, (d) 3:2, (e) 2:1 and corresponding AIGS nanocrystals (f) 1:4, (g) 1:2, (h) 1:1, (i) 3:2, and (j) 2:1. The insets show the size distribution.



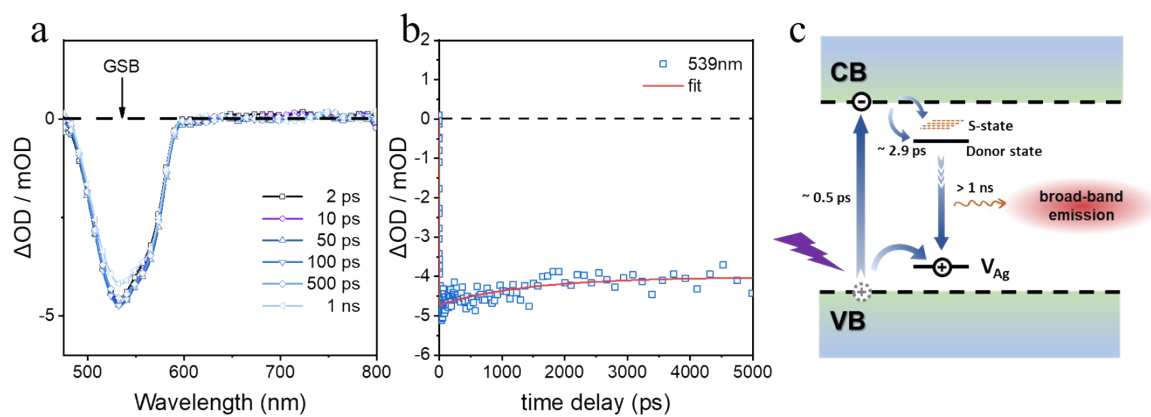
**Fig. S8** PL spectra of AIGS nanocrystals with different Ag/In when AIS seeds synthesis (a) 1:4, (b) 1:2, (c) 1:1, (d) 3:2 and (e) 2:1.



**Fig. S9** XPS results of AIS seeds (Ag:In = 1:1) and corresponding AIGS nanocrystals (a) Ag 3d, (b) In 3d, (c) Ga 3p and (d) S.



**Fig. S10** (a) PL spectra and (b)HRTEM of large size ( $\sim 8$  nm) AIGS NCs were synthesized by using an equal amount of sulfur powder as a sulfur source.



**Fig. S11.** (a) TA spectra of AIGS NCs excited by 365 nm pulses (b) TA kinetics of AIS NCs probed at the GSB ( $\sim 539$  nm) (c) Schematic illustration of the electron dynamics in AIS nanocrystals following bandgap excitation.

**Table S1.** PL decay components for AIGS NCs without 1-dodecanethiol

Sample	Reaction stage	$\tau_1/\text{ns}$	$\alpha_1$	$\tau_2/\text{ns}$	$\alpha_2$	$\tau_3/\text{ns}$	$\alpha_3$	$\tau_{ave}/\text{ns}$
Seeds (740 nm)	-	131.7	2.4%	690.7	42.5%	1548.0	55.1%	1149.8
Narrow-band luminescence peak (564 nm)	250°C	5.6	14.8%	31.9	22.0%	175.9	63.2%	119.0
	0 min	6.8	6.9%	34.0	29.8%	151.0	63.4%	106.3
	15 min	10.9	4.1%	46.4	39.7%	147.5	56.2%	101.7
	30 min	8.5	4.3%	38.0	33.8%	151.8	61.9%	107.1
Broad-band luminescence peak (670 nm)	250 °C	5.5	2.2%	37.1	7.0%	315.6	90.8%	289.3
	0 min	5.6	3.0%	36.9	9.3%	281.4	87.6%	250.1
	15 min	5.6	2.2%	37.6	10.9%	251.5	86.9%	222.6

**Table S2.** Element atomic ratio (ICP analysis) of AIGS NCs (without DDT during the AIGS NCs growth.)

Sample	Element	Seed	250°C	0min	15min	30min
AIGS NCs	Ag	38.7%	3.5%	4.4%	3.4%	4.5%
	Ga	-	91.0%	87.8%	88.5%	89.5%
	In	61.3%	5.5%	7.8%	8.1%	6.0%



**Table S3.** PL decay components for AIGS NCs with 1-dodecanethiol

Sample	Reaction stage	$\tau_1/\text{ns}$	$\alpha_1$	$\tau_2/\text{ns}$	$\alpha_2$	$\tau_3/\text{ns}$	$\alpha_3$	$\tau_{ave}/\text{ns}$
Seeds (740 nm)	-	131.7	2.4%	690.7	42.5%	1548.0	55.1%	1149.8
Narrow-band emission peak (560 nm)	0 min	12.1	9.2%	46.1	32.2%	176.0	58.6%	119.0
	30 min	11.7	6.1%	47.7	39.8%	160.3	54.1%	106.5
	60 min	13.8	6.1%	48.7	41.0%	161.0	52.9%	105.9
	120 min	13.0	8.3%	48.8	42.1%	163.4	49.6%	102.7
Broad-band emission peak (670 nm)	0 min	5.3	2.7%	34.8	11.7%	249.1	85.6%	217.5
	30 min	5.2	3.2%	33.5	13.2%	234.8	83.5%	200.7
	60 min	5.1	3.9%	31.8	14.8%	226.9	81.3%	189.3
	120 min	5.1	3.2%	31.1	16.4%	209.4	80.4%	173.6

**Table S4.** Element atomic ratio (ICP analysis) of AIGS NCs (with DDT during the AIGS NCs growth.)

Sample	Element	Seed	0 min	30 min	60 min	120 min
AIGS NCs	Ag	38.7%	20.7%	16.8%	16.5%	15.1%
	Ga	-	55.3%	61.2%	63.8%	66.1%
	In	61.3%	24.0%	22.0%	19.6%	18.8%

**Table S5.** Element atomic ratio of AIS seeds synthesized with different Ag/In and corresponding AIGS NCs

Sample	Element	1:4	1:2	1:1	3:2	2:1
AIS seeds	Ag	46.7%	43.2%	38.7%	34.6%	29.6%
	In	53.3%	56.8%	61.3%	65.4%	70.4%
	Ag/In	0.88	0.76	0.63	0.52	0.42
AIGS NCs	Ag	9.5%	7.7%	5.5%	4.8%	3.4%
	Ga	78.9%	80.2%	83.5%	84.2%	88.5%
	In	11.6%	12.1%	11.0%	11.0%	8.1%
	Ag/In	0.82	0.64	0.5	0.43	0.42

**Table S6.** Stripping XPS element atomic ratio of AIGS NCs

Sample	Element	Step 0	Step 1	Step 2	Step 3
AIGS NCs	Ag	11.4%	13.7%	14.3%	14.8%
	In	10.8%	13.9%	14.7%	16.4%
	Ga	77.8%	72.4%	71.0%	68.7%

**Table S7.** Element atomic ratio (ICP analysis) of large-size AIGS NCs (size ~ 8 nm)

Sample	Element	Seed	AIGS
Large size AIGS NCs (size ~ 8 nm)	Ag	13.1%	11.9%
	Ga	-	46.2%
	In	86.9%	41.9%

**Table S8.** Kinetics fitting parameters for Fig. 5.

	$\tau_1/\text{ns}$	$\tau_2/\text{ns}$	$\tau_3/\text{ns}$
GSB (524 nm)	0.9±0.4	53.2±3.7	-
SE (565 nm)	1.4±0.4	35.9±5.2	270±77

**Table S9.** Kinetics fitting parameters for Fig. S11.

	$\tau_1/\text{ps}$	$\tau_2/\text{ps}$	$\tau_3/\text{ps}$
GSB (539 nm)	0.5 ± 0.2	2.9 ± 26	1412 ± 921