***Supporting Information***

# Mass Production of $Mn^{2+}$-Doped $CsPbCl_3$ Perovskite Nanocrystals with High Quality and Enhanced Optical Performance

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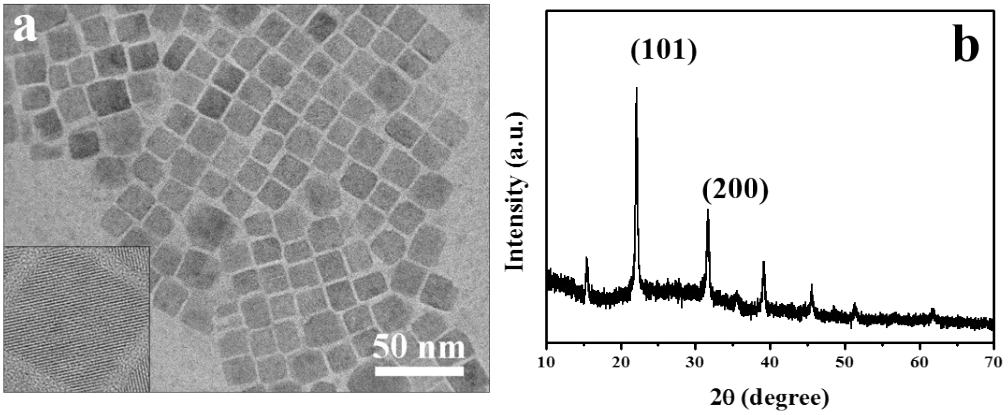


**Figure S1.** (a) TEM image and (b) XRD pattern of $Mn^{2+}$:$CsPbCl_3$ NCs prepared by scaling the reactant amounts up to 20 times. The inset in (a) is the corresponding HRTEM image.

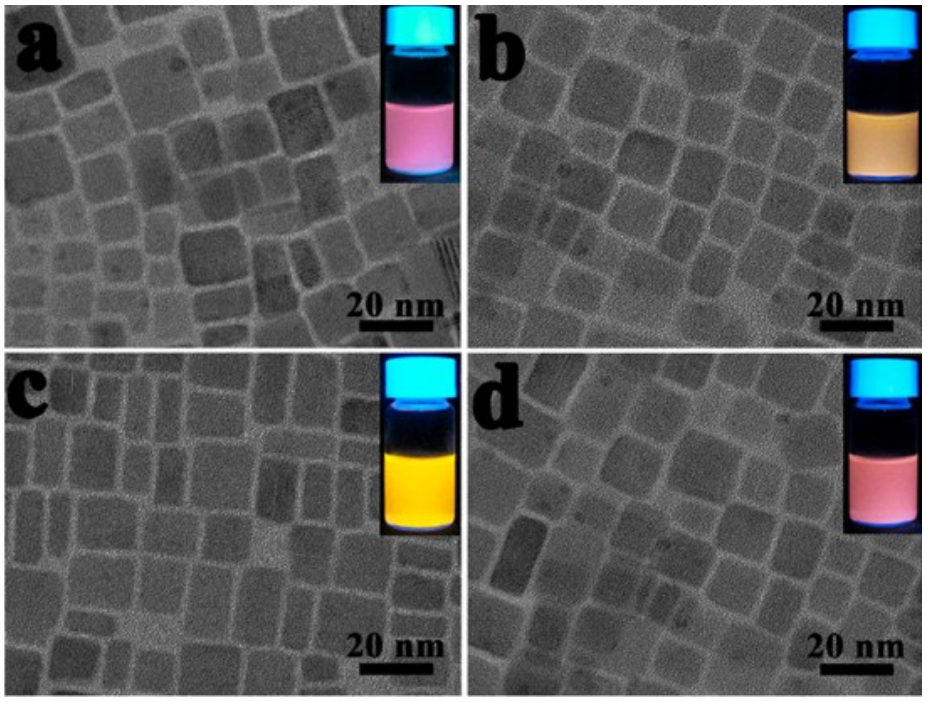


**Figure S2.** TEM images of the $Mn^{2+}$:$CsPbCl_3$ NCs prepared by one step microwave irradiation method with Pb-to-Mn molar feed ratio of 1:2.5 (a), 1:5 (b), 1:10 (c), and 1:15 (d). The insets are the corresponding PL images excited by 365 nm UV light. Copyright from Reference [1] (https://www.ncbi.nlm.nih.gov/pubmed/29200265).

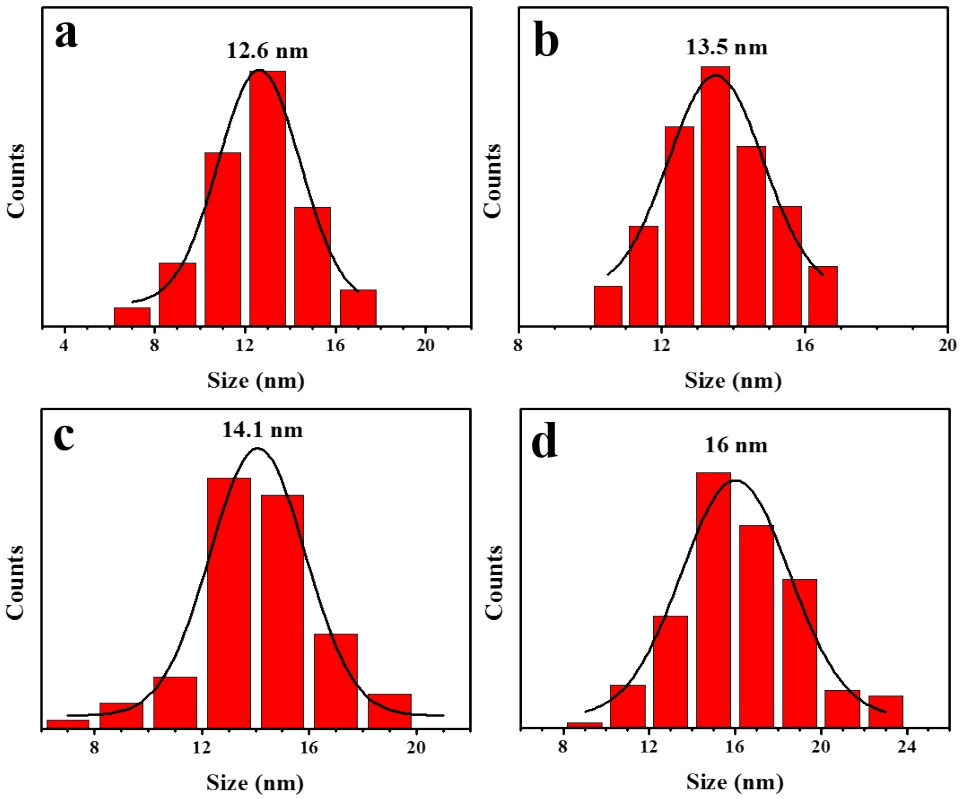


**Figure S3.** Typical size distributions of samples synthesized at different temperature (a) 150, (b) 170, (c) 190 and (d) 210 °C.

**Table S1.** The Mn PL decay parameters of the samples synthesized at different reaction temperatures.

| Sample | $T_1$ (ms) | $A_1$ (%) | $T_2$ (ms) | $A_2$ (%) | $T_{ave}$ (ms) |
|---|---|---|---|---|---|
| 150 °C | 1.76 | 100 | / | / | 1.76 |
| 170 °C | 1.74 | 100 | / | / | 1.74 |
| 190 °C | 1.64 | 100 | / | / | 1.64 |
| 210 °C | 1.63 | 90.75 | 0.52 | 9.25 | 1.52 |

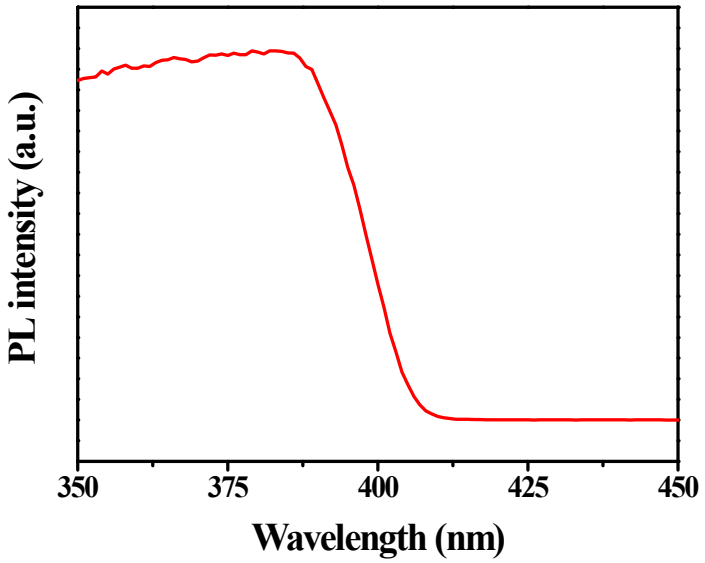


**Figure S4.** PL excitation spectrum of the $Mn^{2+}$:$CsPbCl_3$ NCs with Mn/Pb feed ratio of 1/1 synthesized at 190 °C.

**Table S2:** The typically reported PLQY of $Mn^{2+}$:$CsPbCl_3$ prepared by different method at various temperatures.

| Synthetic method | Reaction temperature (℃) | PLQY (%) | References |
|---|---|---|---|
| Microwave Irradiation | / | 26 | 1 |
| Hot Injection | 170 | 60 | 2 |
| Hot Injection | 185 | 27 | 3 |
| Hot Injection | 200 | 60 | 4 |
| Hot Injection | 170 | 54 | 5 |
| Hot Injection | 180 | 27 | 6 |
| Hot Injection | 190 | 60 | 7 |
| Supersaturated Recrystallization | RT | 20 | 8 |
| Microwave-Assisted Hot Injection | 190 | 65 | This work |

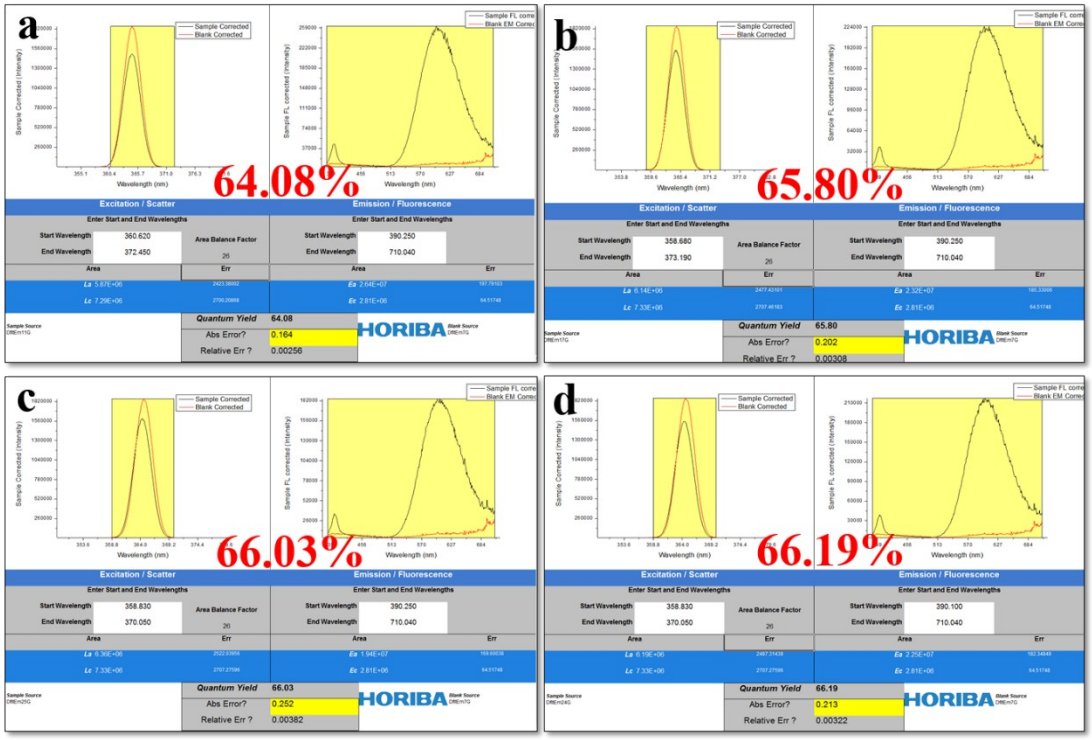


**Figure S5.** Repeated measurments of the PL QY for the sample syntheized at 190 °C with the feed ratio of Mn/Pb at 1/1.

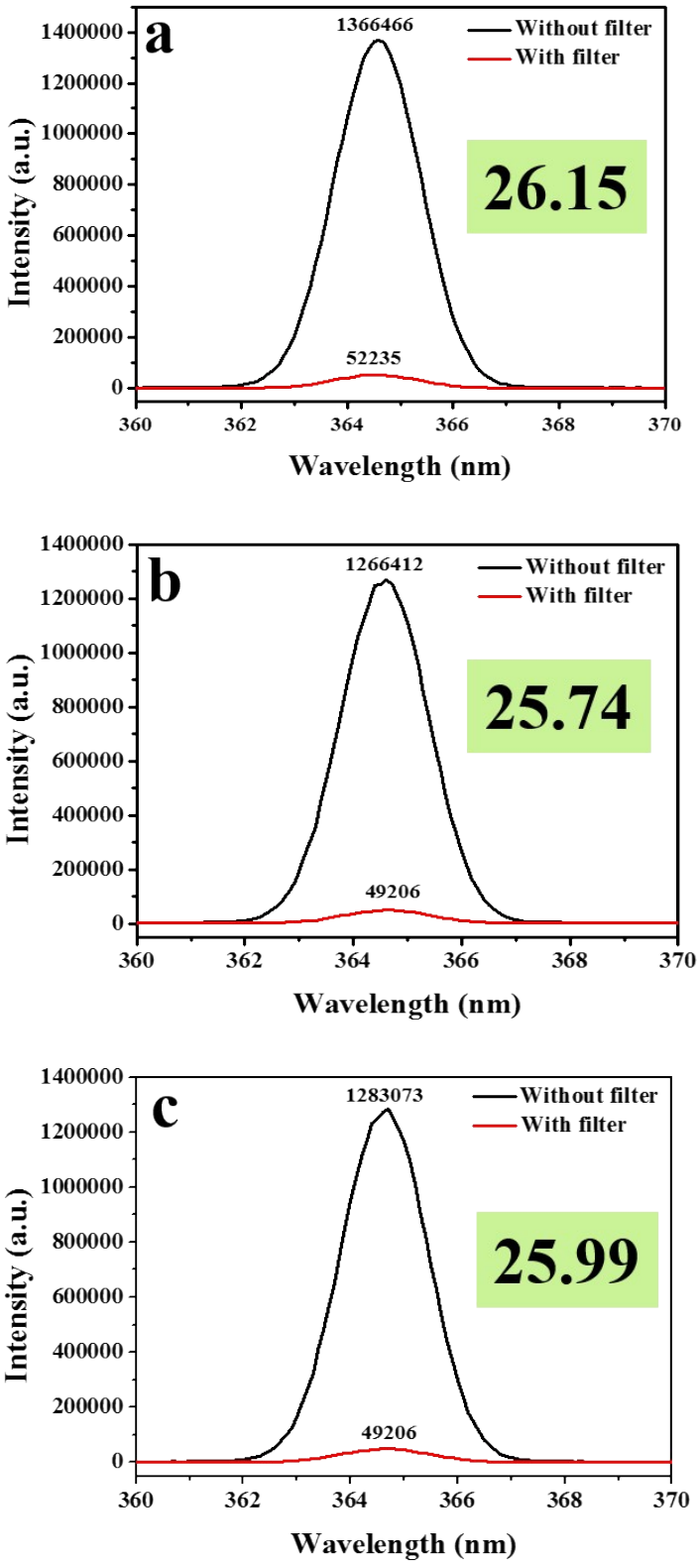


**Figure S6.** The decay factors of the filter applied for measuring the PL QY.

**Table S3.** The $Mn^{2+}$ concentrations (relative to $Pb^{2+}$) in various $Mn^{2+}$:$CsPbCl_3$ NCs synthesized at 190 °C with different feed amounts of $MnCl_2$.

| **Feed ratio of Mn/Pb** | 0.2/1 | 0.5/1 | 1/1 | 1.5/1 | 2/1 | 3/1 |
|---|---|---|---|---|---|---|
| **$Mn^{2+}$ concentrations** | 0.9% | 2.6% | 6.6% | 12.8% | 20.5% | 32.5% |

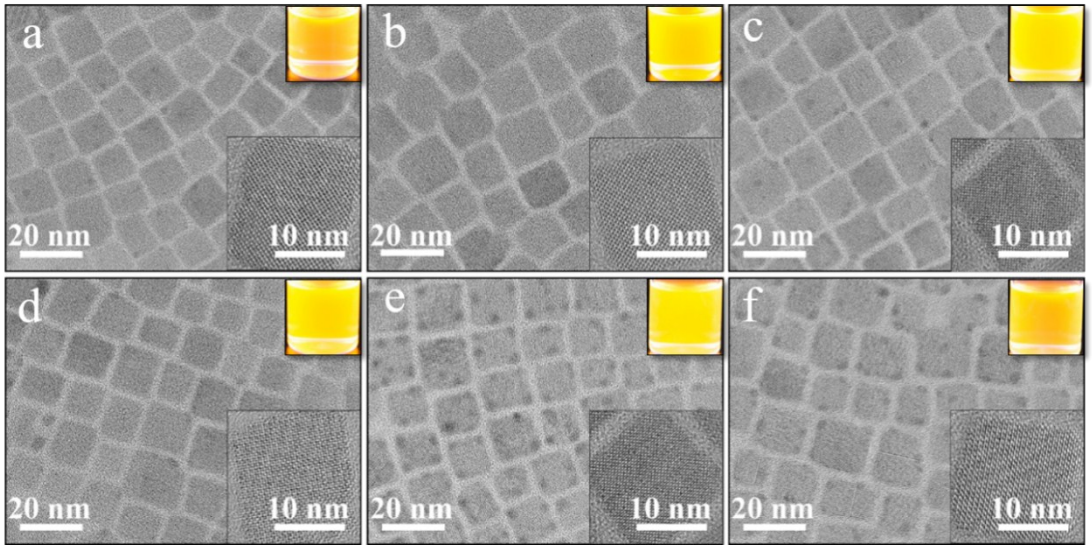


**Figure S7.** Typical TEM images of $Mn^{2+}$:$CsPbCl_3$ NCs with different feed ratios of Mn/Pb: (a) 0.2/1, (b) 0.5/1, (c) 1/1 (d) 1.5/1, (e) 2/1, (f) 3/1. The down-right insets are the corresponding HRTEM images, and the up-right insets are the corresponding digital photographs of the samples excited under UV light.

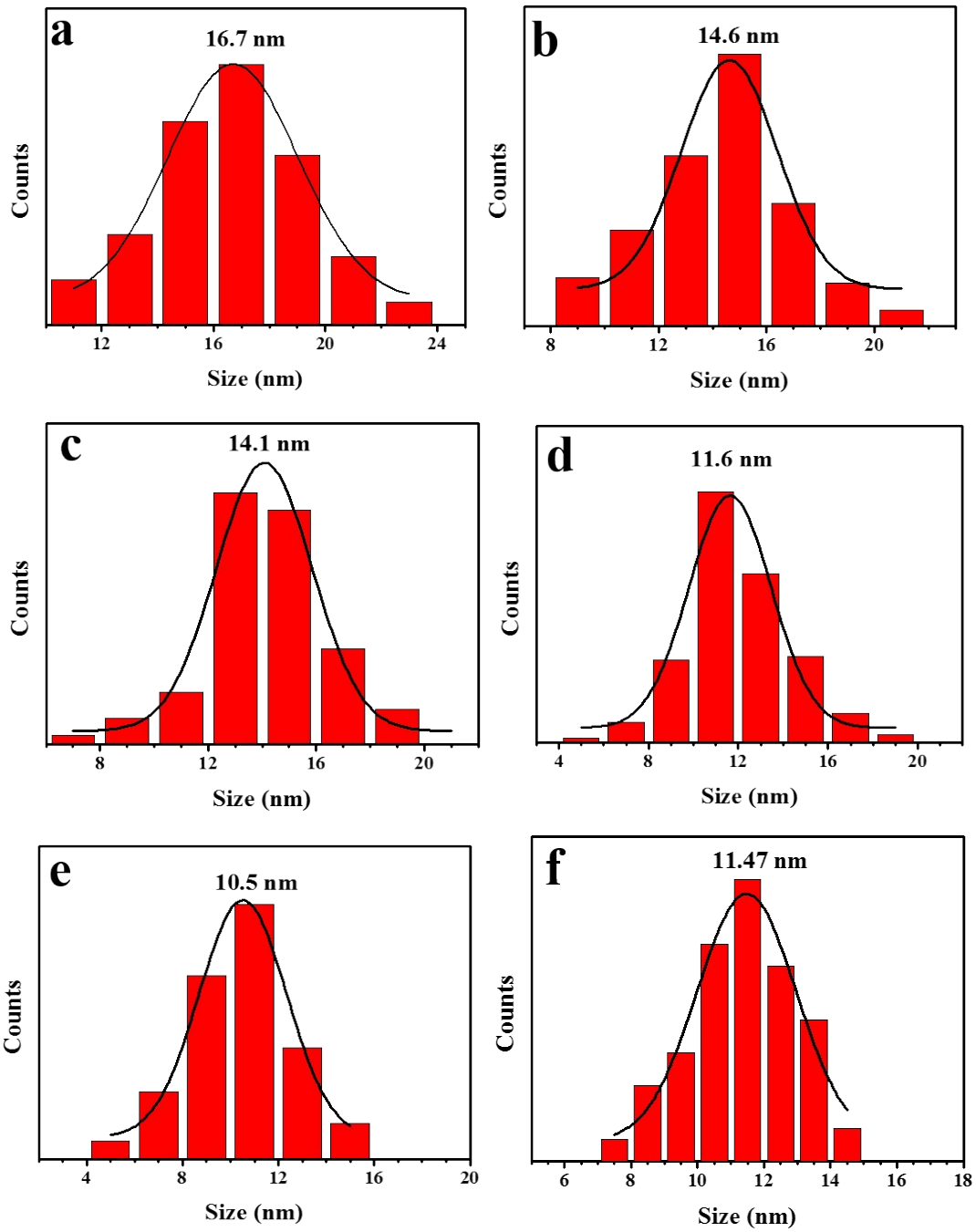


**Figure S8.** Size distributions of $Mn^{2+}$:$CsPbCl_3$ NCs with different feed ratios of Mn/Pb: (a) 0.2/1, (b) 0.5/1, (c) 1/1 (d) 1.5/1, (e) 2/1, (f) 3/1.

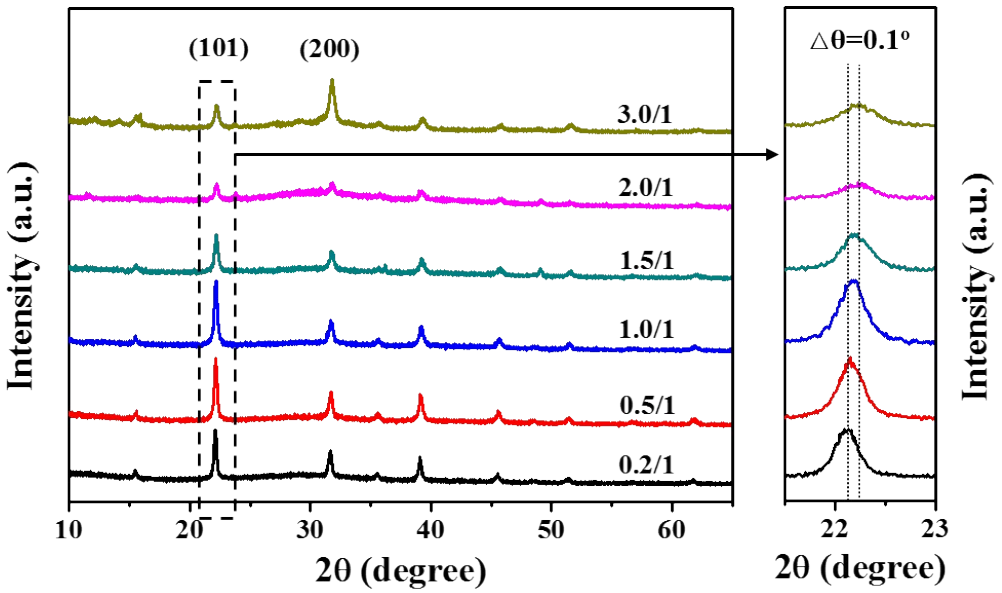


**Figure S9.** The XRD patterns of $Mn^{2+}$:$CsPbCl_3$ NCs synthesized with different amounts of $MnCl_2$.

**Table S4.** $Mn^{2+}$ PL decay parameters of $Mn^{2+}$:$CsPbCl_3$ NCs with different feed ratios of Mn/Pb.

| Sample | $T_1$ (ms) | $A_1$ (%) | $T_2$ (ms) | $A_2$ (%) | $T_{ave}$ (ms) |
|---|---|---|---|---|---|
| 0.2/1 | 1.86 | 100 | / | / | 1.86 |
| 0.5/1 | 1.85 | 100 | / | / | 1.85 |
| 1/1 | 1.64 | 100 | / | / | 1.64 |
| 1.5/1 | 1.58 | 100 | / | / | 1.58 |
| 2/1 | 1.53 | 100 | / | / | 1.53 |
| 3/1 | 1.46 | 71.49 | 0.66 | 28.51 | 1.34 |

**Table S5.** The statistics of the peak position and intensity of the exciton and $Mn^{2+}$ emission with the varying of the temperature, and the corresponding lifetime of the $Mn^{2+}$ emission.

| T (K) | Exciton emission peak (nm) | Exciton emission intensity (a.u.)[a] | $Mn^{2+}$ emission peak (nm) | $Mn^{2+}$ emission intensity (a.u.)[b] | $\tau_{ave}$ (ms) |
|---|---|---|---|---|---|
| 80 | 412 | 1 | 617 | 0.11203 | 1.98 |
| 100 | 411 | 0.89383 | 616 | 0.12432 | 1.99 |
| 120 | 410 | 0.80888 | 613 | 0.13015 | 1.88 |
| 140 | 410 | 0.78503 | 612 | 0.16132 | 1.75 |
| 160 | 408 | 0.49635 | 610 | 0.27867 | 1.66 |
| 180 | 408 | 0.48445 | 609 | 0.33165 | 1.59 |
| 200 | 409 | 0.30968 | 608 | 0.45555 | 1.51 |
| 220 | 409 | 0.28223 | 605 | 0.54725 | 1.44 |
| 240 | 409 | 0.19771 | 603 | 0.56862 | 1.33 |
| 260 | 410 | 0.14919 | 602 | 0.54657 | 1.28 |
| 280 | 410 | 0.05526 | 601 | 0.46841 | 1.22 |
| 300 | 410 | 0.05416 | 598 | 0.56476 | 1.25 |
| 320 | 411 | 0.01678 | 595 | 0.69769 | 1.20 |
| 340 | 411 | 0.01229 | 593 | 0.79873 | 1.18 |
| 360 | 411 | 0.00624 | 591 | 0.89723 | 1.14 |
| 380 | 411 | 0.00605 | 590 | 1 | 1.09 |
| 400 | 411 | 0.00001 | 589 | 0.86415 | 0.96 |

[a]After normalization on the basis of the intensity at 80K.

[b]After normalization on the basis of the intensity at 380K.

## *References:*


1. H. Liu, Z. Wu, H. Gao, J. Shao, H. Zou, D. Yao, Y. Liu, H. Zhang and B. Yang, *ACS Appl. Mater. Interfaces*, 2017, **9**, 42919-42927.
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