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Supporting Information

Sn-Doped ZnO for Efficient and Stable Quantum Dot Light-Emitting Diodes via Microchannel Synthesis Strategy

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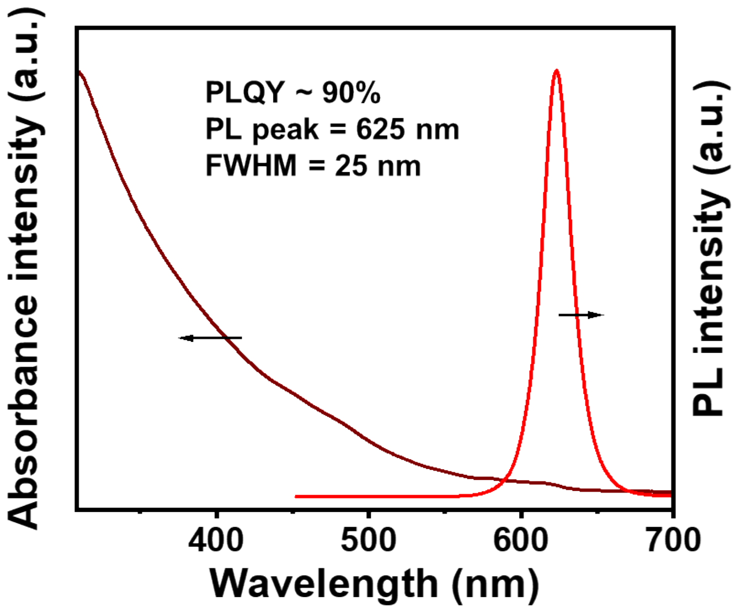

Fig. S1 The absorption and PL spectra of red QDs in octane.

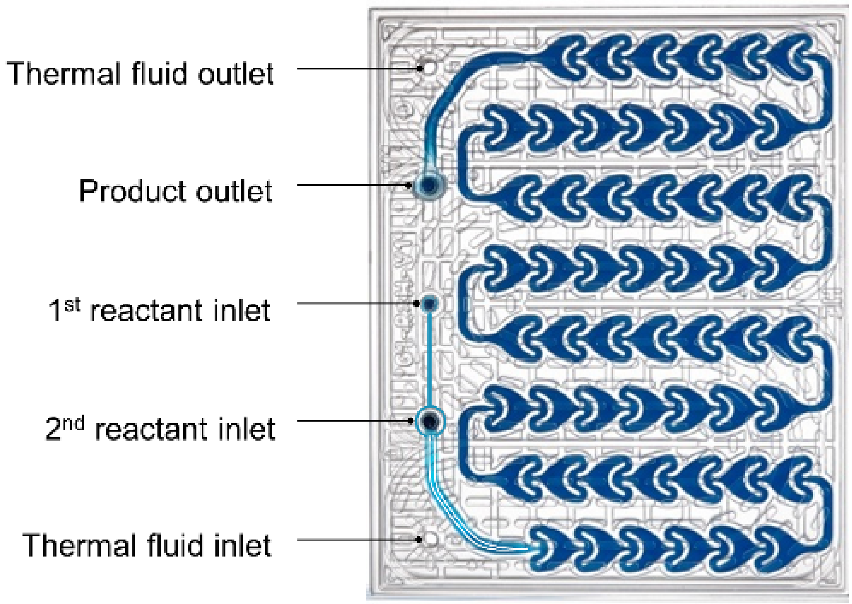

Fig. S2 The schematic representation of the experimental setup based on the spiral glass tube microchannel. To better observe the microchannel structure, a blue liquid is passed through the channel.

The main reaction chamber of the microchannel is a boron-glass pipe that has a 2.7 mL volume and 800 μm inner diameter. The boron glass tube was arranged spirally in 8 loops with a 200 mm diameter for each loop.

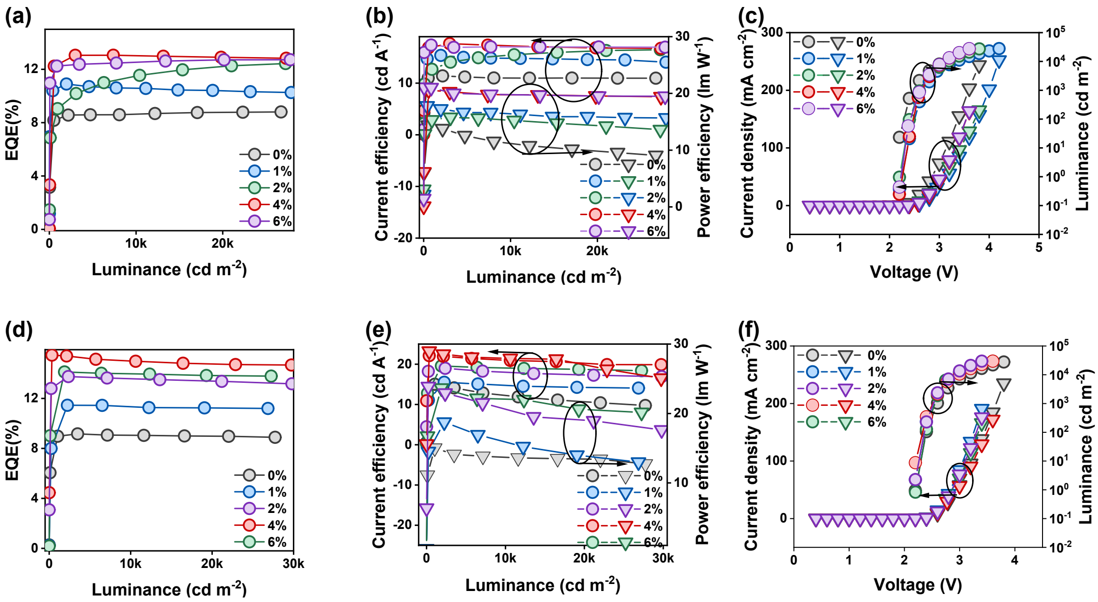

Fig. S3 (a) $EQE-L$, (b) $CE-L-PE$, (c) $J-V-L$ are the properties of the devices synthesized by OP with different doping concentrations; (d) $EQE-L$, (e) $CE-L-PE$, (f) $J-V-L$ are the properties of devices synthesized by MC with different doping concentrations.

Table S1 summarizes the device performance of $Zn_{1-x}Sn_xO$ NPs synthesized in different proportions by two different synthesis methods, By OP and MC.

By OP	V_{on}	EQE_{max}(%)	CE_{max}(cd A^{-1})	PE_{max}(lm W^{-1})	CIE(x,y)
0%	2.24	8.8	11.4	14.4	(0.68,0.31)
1%	2.23	10.9	15.4	15.8	(0.68,0.31)
2%	2.21	12.4	16.5	17.8	(0.68,0.31)
4%	2.22	13.1	17.6	20.6	(0.68,0.31)
6%	2.23	12.7	17.0	21.1	(0.68,0.31)
By MC	V_{on}	EQE_{max}(%)	CE_{max}(cd A^{-1})	PE_{max}(lm W^{-1})	CIE(x,y)
0%	2.22	9.2	12.5	15.0	(0.68,0.31)
1%	2.17	11.5	15.5	18.7	(0.68,0.31)
2%	2.17	13.8	18.9	23.8	(0.68,0.31)
4%	2.12	15.5	22.1	28.9	(0.68,0.31)
6%	2.22	14.1	19.6	23.6	(0.68,0.31)

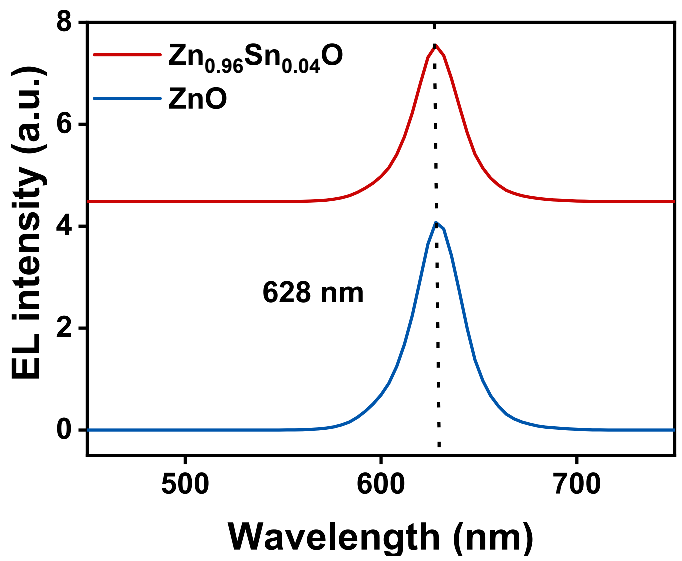

Fig. S4 EL spectrum at an applied voltage of 3 V. Inset: red emitting photographs.

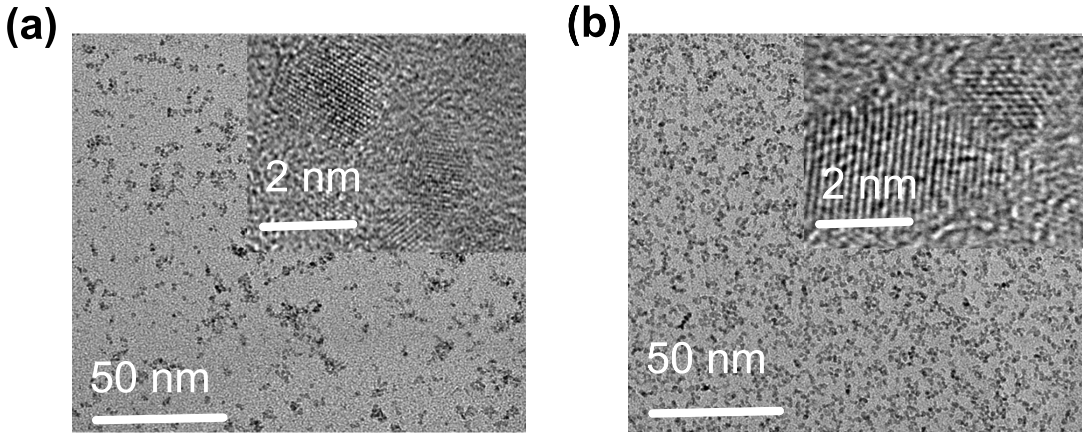

Fig. S5 HR TEM image of $Zn_{0.96}Sn_{0.04}O$ NPs synthesized (a) by MC method, (b) by OP method, illustration is a close-up view of a single $Zn_{0.96}Sn_{0.04}O$ NPs.

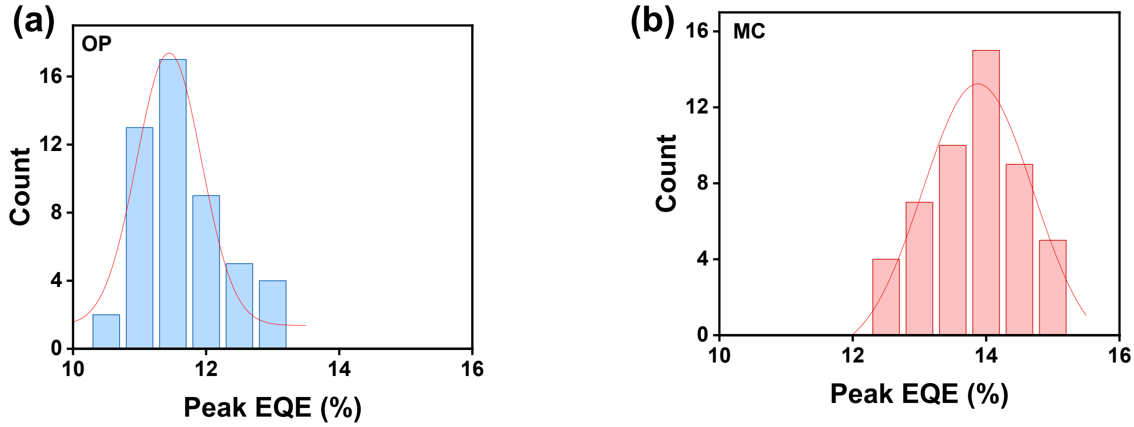

Fig. S6 Reproducibility of the EQE of QLED performances fabricated with $Zn_{0.96}Sn_{0.04}O$ NPs as ETL layer. (a) By OP and (b) By MC.

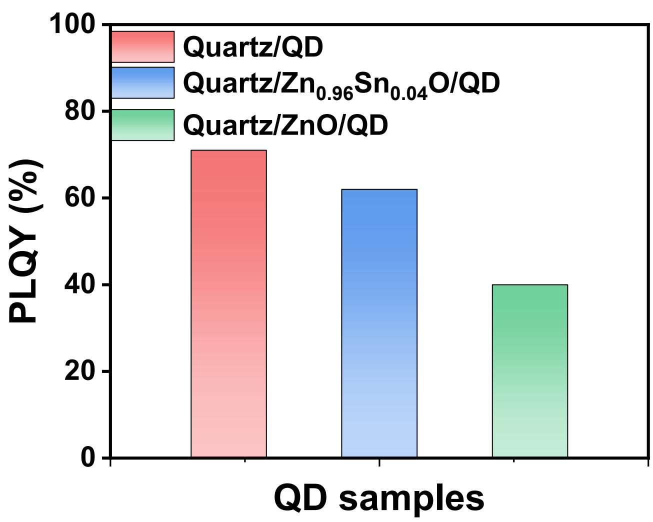

Fig. S7 PLQYs for QDs contacting different layers.

Table S2 UPS and UV-visible spectrum detailed data summary.

	ZnO	$Zn_{0.96}Sn_{0.04}O$
Eg/eV	3.3	3.4
Ecut-off/eV	18.4	18.32
Eonset/eV	4.0	4.1
VBM/eV	6.8	7.0
CBM/eV	3.5	3.6

Table S3 TRPL data summary.

ETL/QDs	A1	τ1	A2	τ2	τave
QD	1610.31	7.41	793.69	14.08	10.63
ZnO	1508.30	4.41	1448.70	10.08	8.30
$Zn_{0.96}Sn_{0.04}O$	1819.47	5.88	1088.51	12.83	9.82

Table S4 The fitting parameters of the Nyquist plot with red QLED at 3 V.

Device	Rs(Ω/cm^2)	Rtr(Ω/cm^2)	Rrec(Ω/cm^2)	CPE_1 (S·Secn/cm^2)	CPE_2 (S·Secn/cm^2)
ZnO	95.5	212	125	559E-010	4.51E-010
$Zn_{0.96}Sn_{0.04}O$	94.5	172	363	509E-010	21.3E-009

The series resistance (RS) represents the total external resistance, including the electrodes, the external wires and the contact resistance between the electrodes and the functional layer. Rtr reflects the charge transfer related resistance of the light emitting phase and CPE1 reflects the capacitance of the charge transfer layer. Rrec is related to the compounding rate and CPE2 reflects the chemical capacitance of the compounding region. The fitted parameters for the corresponding devices for the different ETLs are shown in the table. Considering that the same HTL is used for both devices, Rtr can be considered as reflecting the electron transport capacity of the HTL.

Equation1:

$$I = I_0 + A_1 \bullet e^{-\frac{\tau_1 - t_0}{t}} + A_2 \bullet e^{-\frac{\tau_2 - t_0}{t}}$$

$$\tau_{ave} = \frac{A_1 \bullet \tau_1^2 + A_2 \bullet \tau_2^2}{A_1 \bullet \tau_1 + A_2 \bullet \tau_2}$$