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High-performance UV-Vis-NIR photomultiplier detectors assisted by interfacial trapped-electrons

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To determine the optimal mixing ratio of the nanocomposites, we conducted parallel experiments using different proportions (i.e. 1.5:1,1.25:1, 1:1, 1:1.25 and 1:1.5) as shown in the ESI†, Fig. S1-S4, Table S1-S4. The *R* spectra of YZ-PD with different Y-TiOPc: ZnS weight were investigated. As depicted in Fig. S1 and Table S1, the data demonstrates that *R* shows the maximum value at wavelengths of 365 nm, 400 nm, 500 nm and 850 nm when Y-TiOPc:ZnS weight ratio is 1:1. The other ratios only have the best performance at 1 or 2 wavelengths, which is relatively less than that of 1:1. Fig. S2 and Table S2 show the *EQE* spectra of YZ-PD with different Y-TiOPc: ZnS weight ratios under -18 V bias. The *EQE* of Y-TiOPc:ZnS (1:1) show the best performance at four wavelengths (365 nm, 420 nm and 500 nm). It is worth noting that the *EQE* values at both 600 nm and 700 nm are very close to the best performance of Y-TiOPc: ZnS (1.5:1). Fig. S3 depicts the noise currents of YZ-PDs with different Y-TiOPc: ZnS weight ratios. As shown in Table S3, the lowest noise current is observed at a 1:1 ratio. Fig. S4 and Table S4 show the YZ-PD with the Y-TiOPc:ZnS weight ratio of 1:1 having the highest D^* values at all wavelengths. In summary, the YZ-PD with Y-TiOPc: ZnS ratio of 1:1 has the best overall performance from the perspective of *EQE*, *R* and D^*. This specific ratio has thus been identified as the optimal blending proportion of the photoactive layer.

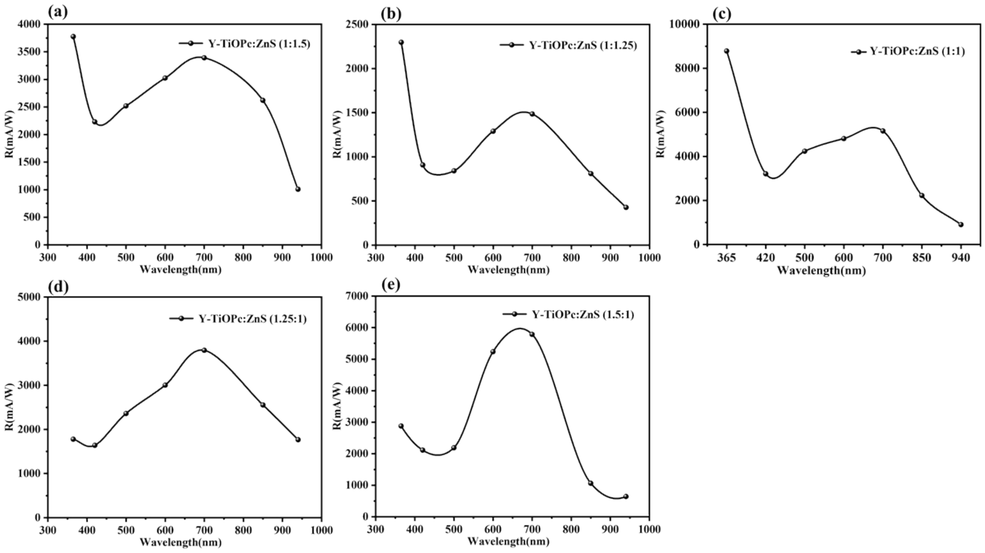

Fig. S1 *R* spectra of YZ-PD with different Y-TiOPc: ZnS weight ratios under 0.01 mW/cm^2 at -18 V bias, (a) 1:1.5, (b) 1:1.25, (c) 1:1, (d) 1.25:1, (e) 1.5:1

Table S1 *R* values (mA/W) of YZ-PD with different Y-TiOPc: ZnS weight ratios at -18 V and 0.01 mW/cm^2 (Bold numbers represent the maximum value).

No.	**365 nm**	**420 nm**	**500 nm**	**600 nm**	**700 nm**	**850 nm**	**940 nm**
Y-TiOPc:ZnS(1:1.5)	3776	2230	2518	3022	3390	2619	1007
Y-TiOPc:ZnS(1:1.25)	2296	907	841	1290	1485	809	427
Y-TiOPc:ZnS(1:1)	**8782**	**3210.67**	**4236**	4808	5156	**2225.33**	906.67
Y-TiOPc:ZnS(1.25:1)	1779	1639	2362	3003	3793	2553	**1777**
Y-TiOPc:ZnS(1.25:1)	2878	2114	2189	**5237**	**5786**	1061	641

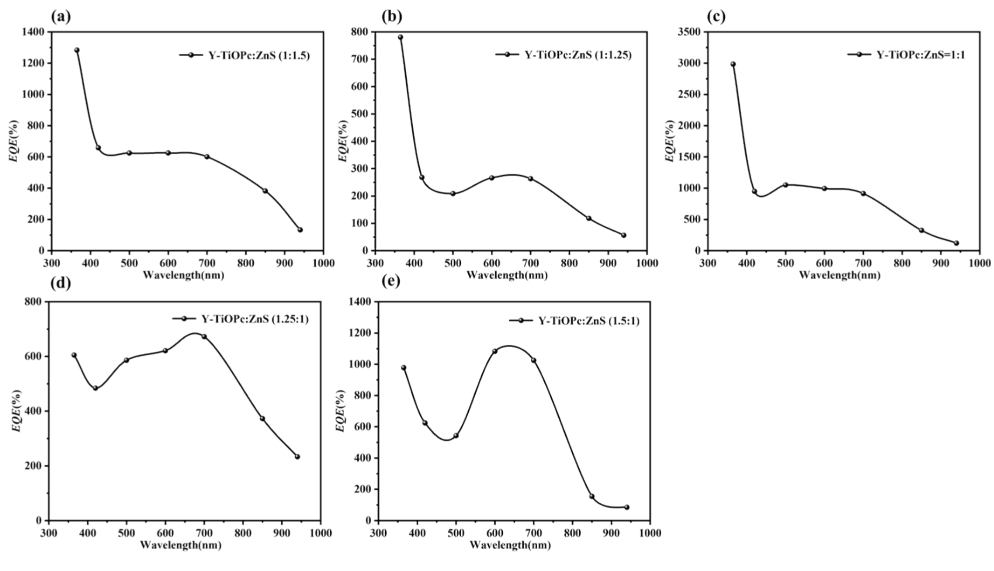

Fig. S2 *EQE* spectra of YZ-PD with different Y-TiOPc: ZnS weight ratios under 0.01 mW/cm^2 at -18 V bias, (a) 1:1.5, (b) 1:1.25, (c) 1:1, (d) 1.25:1, (e) 1.5:1

Table S2 *EQE* values (%) of YZ-PD with different Y-TiOPc: ZnS weight ratios at -18 V and 0.01 mW/cm^2 (Bold numbers represent the maximum value).

No.	**365 nm**	**420 nm**	**500 nm**	**600 nm**	**700 nm**	**850 nm**	**940 nm**
Y-TiOPc:ZnS(1:1.5)	1284	659	625	625	601	**382**	133
Y-TiOPc:ZnS(1:1.25)	781	268	209	266	263	118	56
Y-TiOPc:ZnS(1:1)	**2985.46**	**948.54**	**1051.23**	994.31	913.95	324.85	119.68
Y-TiOPc:ZnS(1.25:1)	604	484	586	621	672	373	**233**
Y-TiOPc:ZnS(1.5:1)	978	624	543	**1083**	**1025**	155	85

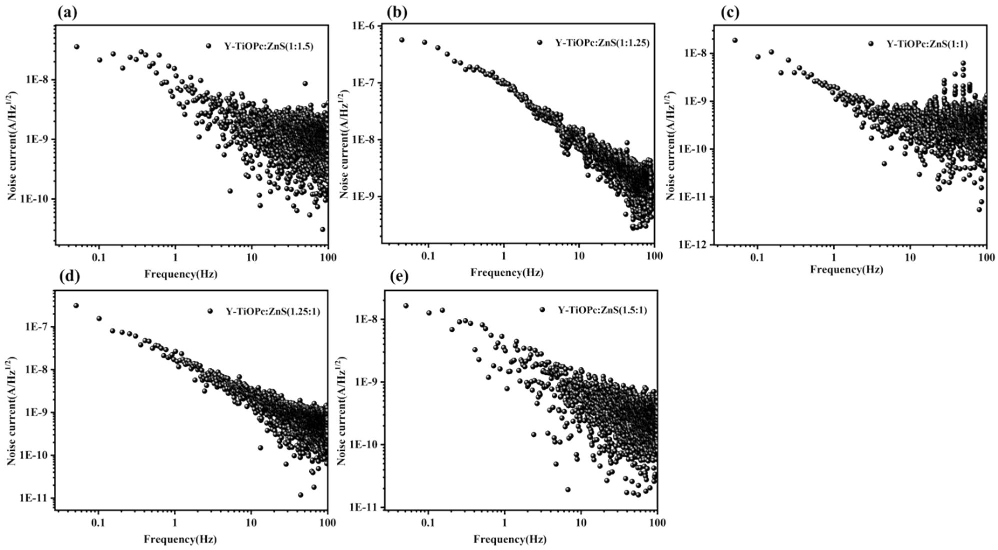

Fig. S3 Noise currents of YZ-PD with different Y-TiOPc: ZnS weight ratios under -18 V bias, (a) 1:1.5, (b) 1:1.25, (c) 1:1, (d) 1.25:1, (e) 1.5:1

Table S3 $\sqrt{\overline{i_n^2}}$ values (A/Hz$^{1/2}$) of YZ-PD with different Y-TiOPc: ZnS weight ratios at -18 V (Bold numbers represent the maximum value).

No.	$\sqrt{\overline{i_n^2}}$
Y-TiOPc:ZnS(1:1.5)	6.4×10^{-7}
Y-TiOPc:ZnS(1:1.25)	1.18×10^{-6}
Y-TiOPc:ZnS(1:1)	$\mathbf{2.19\times10^{-7}}$
Y-TiOPc:ZnS(1.25:1)	5.78×10^{-6}
Y-TiOPc:ZnS(1.5:1)	6.38×10^{-7}

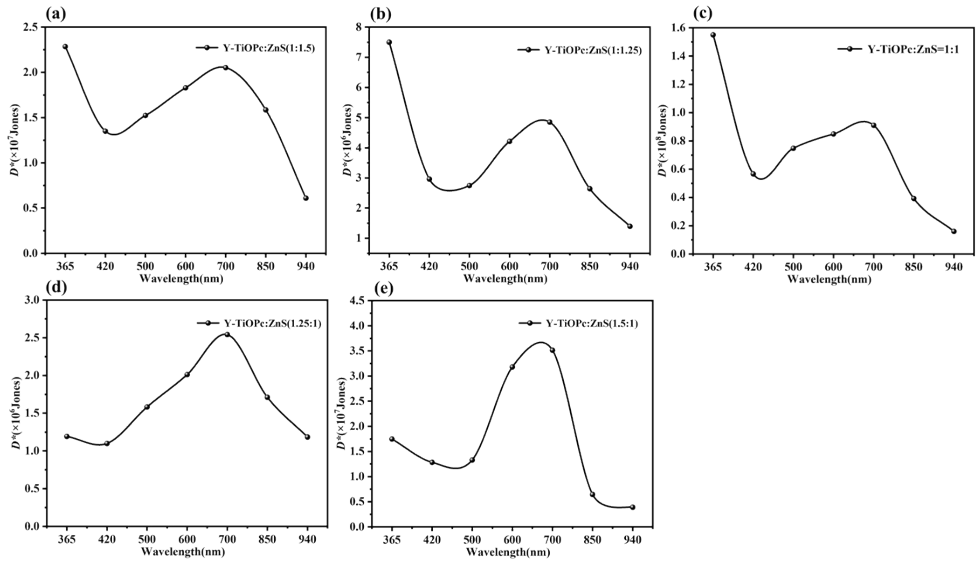

Fig. S4 D^* spectra of YZ-PD with different Y-TiOPc: ZnS weight ratios under 0.01 mW/cm^2 at -18 V bias, (a) 1:1.5, (b) 1:1.25, (c) 1:1, (d) 1.25:1, (e) 1.5:1

Table S4 D^* values (Jones) of YZ-PD with different Y-TiOPc: ZnS weight ratios at -18 V and 0.01 mW/cm^2 (Bold numbers represent the maximum value).

No.	365 nm	420 nm	500 nm	600 nm	700 nm	850 nm	940 nm
Y-TiOPc:ZnS(1:1.5)	2.29×10^7	1.35×10^7	1.52×10^7	1.83×10^7	2.05×10^7	1.59×10^7	6.10×10^6
Y-TiOPc:ZnS(1:1.25)	7.50×10^6	2.96×10^6	2.75×10^6	4.21×10^6	4.85×10^6	2.64×10^6	1.40×10^6
Y-TiOPc:ZnS(1:1)	**1.55×10^8**	**5.67×10^7**	**7.48×10^7**	**8.48×10^7**	**9.10×10^7**	**3.93×10^7**	**1.60×10^7**
Y-TiOPc:ZnS(1.25:1)	1.19×10^6	1.10×10^6	1.58×10^6	2.01×10^6	2.54×10^6	1.71×10^6	1.18×10^6
Y-TiOPc:ZnS(1.5:1)	1.75×10^7	1.28×10^7	1.33×10^7	3.18×10^7	3.51×10^7	6.45×10^6	3.89×10^6

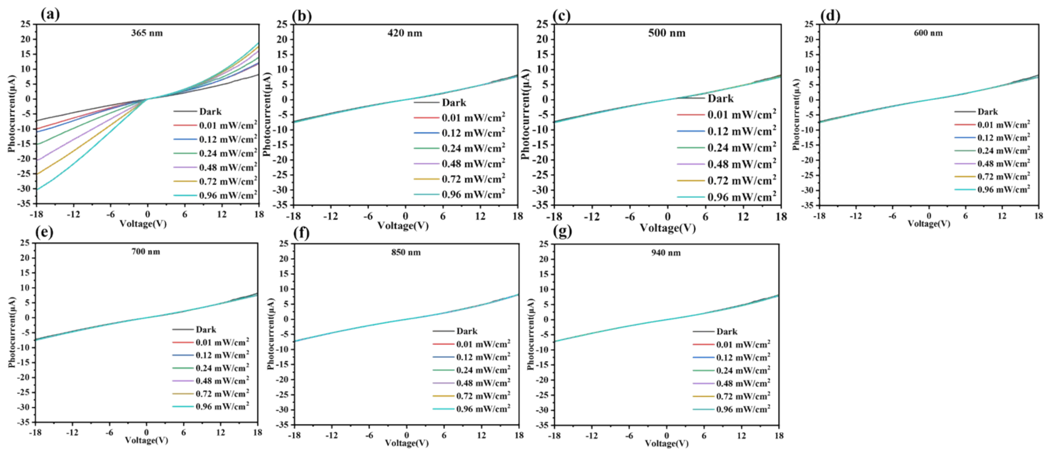

Fig. S5 The *I-V* curves of Z-PD measured in the dark and under different exposure wavelengths: (a) 365 nm, (b) 420 nm, (c) 500 nm, (d) 600 nm, (e) 700 nm, (f) 850 nm, (g)940 nm. The effective exposure area of the device was 0.15 cm^2

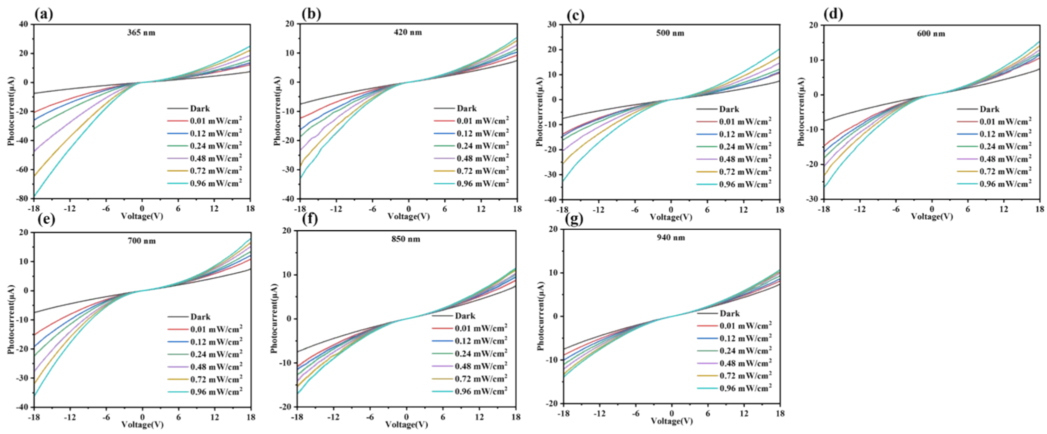

Fig. S6 The *I-V* curves of YZ-PD measured in the dark and under different exposure wavelengths: (a) 365 nm, (b) 420 nm, (c) 500 nm, (d) 600 nm, (e) 700 nm, (f) 850 nm, (g)940 nm. The effective exposure area of the device was 0.15 cm^2

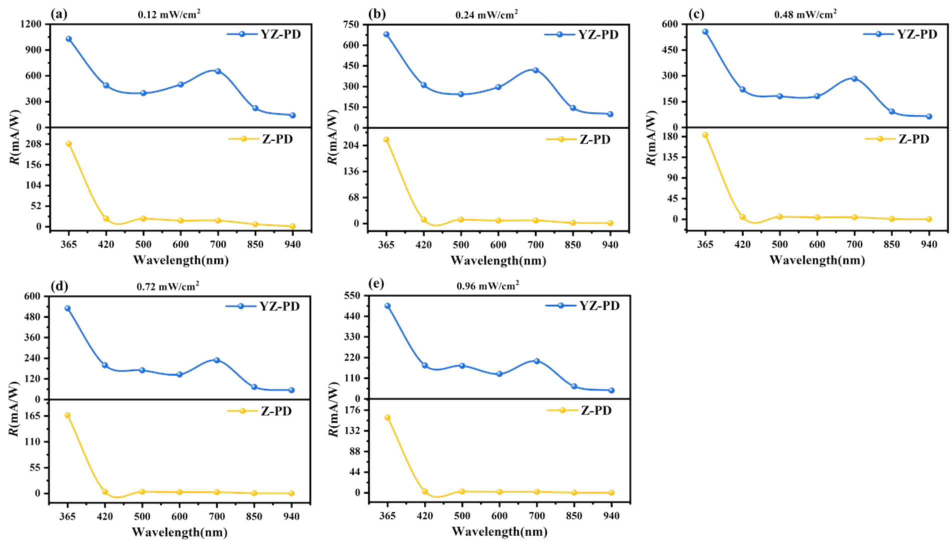

Fig. S7 *R* of Z-PD and YZ-PD as a function of different wavelengths at -18 V bias, (a) 0.12mW/cm^2, (b) 0.24 mW/cm^2, (c) 0.48 mW/cm^2, (d) 0.72 mW/cm^2, (e) 0.96 mW/cm^2.

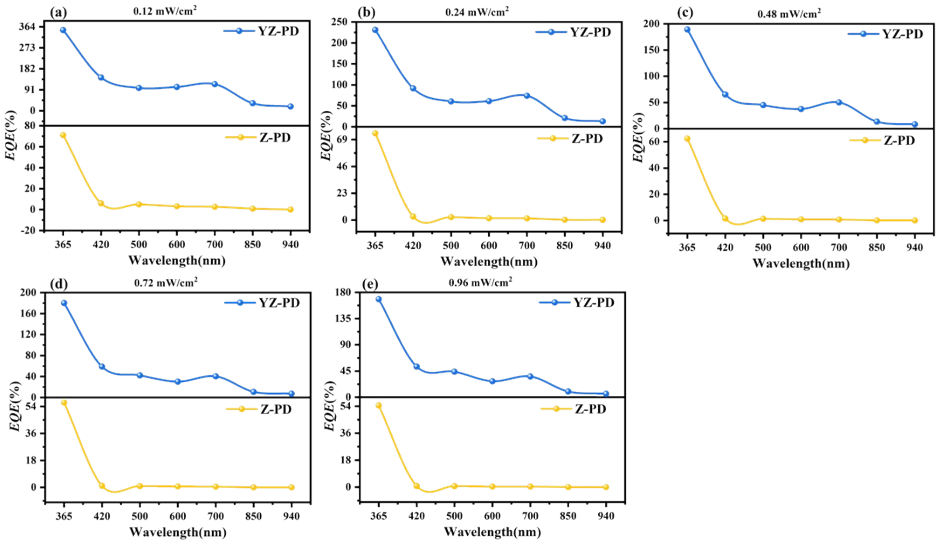

Fig. S8 *EQE* of Z-PD and YZ-PD as a function of different wavelengths at -18 V bias, (a) 0.12mW/cm^2, (b) 0.24 mW/cm^2, (c) 0.48 mW/cm^2, (d) 0.72 mW/cm^2, (e) 0.96 mW/cm^2.

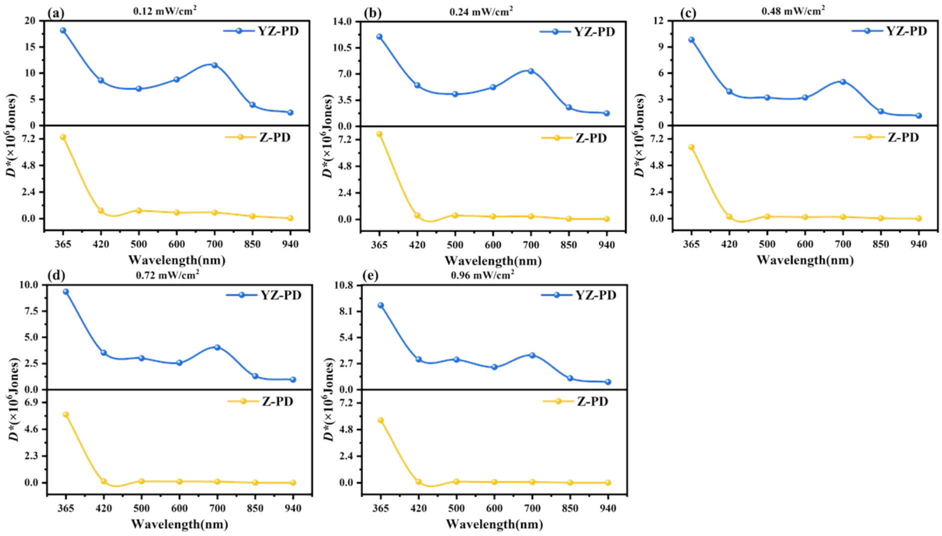

Fig. S9 *D** of Z-PD and YZ-PD as a function of different wavelengths at -18 V bias, (a) 0.12mW/cm^2, (b) 0.24 mW/cm^2, (c) 0.48 mW/cm^2, (d) 0.72 mW/cm^2, (e) 0.96 mW/cm^2.

Table S5 *R* values (mW/cm^2) of Z-PD and YZ-PD at -18 V and 0.01 mW/cm^2.

No.	**365 nm**	**420 nm**	**500 nm**	**600 nm**	**700 nm**	**850 nm**	**940 nm**
Z-PD	1805.33	244	252	196	190.67	74.67	11.33
YZ-PD	8782	3210.67	4236	4808	5156	2225.33	906.67
Magnification	5	13	17	25	27	30	80

Table S6 *EQE* values (%) of Z-PD and YZ-PD at -18 V and 0.01 mW/cm^2.

No.	**365 nm**	**420 nm**	**500 nm**	**600 nm**	**700 nm**	**850 nm**	**940 nm**
Z-PD	613.73	72.09	62.54	40.53	33.80	10.90	1.50

YZ-PD	2985.46	948.54	1051.23	994.31	913.95	324.85	119.68
Magnification	5	13	17	25	27	30	80

Table S7 D^* values (Jones) of Z-PD and YZ-PD at -18 V.

No.	**365 nm**	**420 nm**	**500 nm**	**600 nm**	**700 nm**	**850 nm**	**940 nm**
Z-PD	6.35×10^{7}	8.58×10^{6}	8.86×10^{6}	6.89×10^{6}	6.70×10^{6}	2.63×10^{6}	3.99×10^{5}
YZ-PD	1.55×10^{8}	5.67×10^{7}	7.48×10^{7}	8.48×10^{7}	9.10×10^{7}	3.93×10^{7}	1.60×10^{7}
Magnification	2	7	8	12	14	15	40

The decay curves of ZnS NRs and Y-TiOPc NPs@ ZnS NRs were studied (Fig. 3b), and the decay traces for the samples could be fitted with a double exponential function by equation S1. The average lifetime (τ_{ave}) of the samples can be obtained by the following equation S2, where A_1, A_2 are fractional contributions of time-resolved emission decay lifetimes τ_1, τ_2.

$$y = y_0 + A_1 \exp(-x/\tau_1) + A_2 \exp(-x/\tau_2) \quad (1)$$

$$\tau_{ave} = (A_1\tau_1^2 + A_2\tau_2^2)/(A_1\tau_1 + A_2\tau_2) \quad (2)$$

Where τ_1=0.63 ns, τ_2=1.92 ns, A_1=0.216, A_2=0.005 (ZnS NRs). τ_1=0.58 ns, τ_2=9.76 ns, A_1=0.241, A_2=0 (Y-TiOPc:ZnS).