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Supplementary information

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Paving continuous heat dissipation pathways for quantum dots in polymer with orange-inspired radially aligned UHMWPE fibers

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Morphology of UHMWPEF fibers (UPEF)

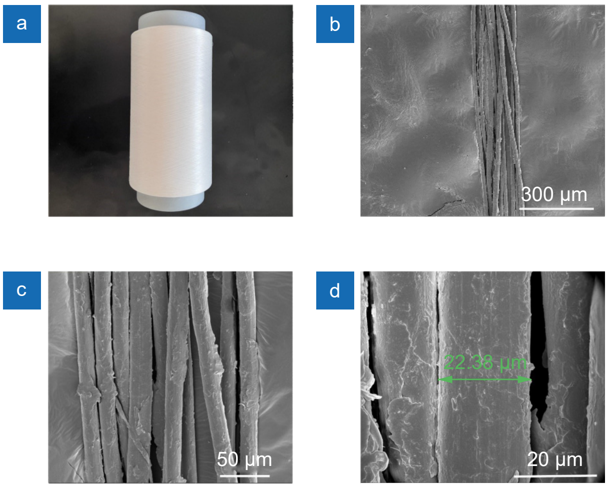

Fig. S1 | (**a**) Photograph of UPEF. (**b–d**) SEM images of UPEF under different magnifications.

Thermal simulation of QDs-LC and QDs-RAPE

Figure S2 gives models of QDs-LC and QDs-RAPE for thermal simulation by finite element method (FEM). The radius of the sample is 12.5 mm. A circle heat source is located in the center of the samples with a constant temperature of 120 °C, and the temperature on the outer boundary of the samples were set as 20 °C. The thermal conductivity of UPEF κ_{UPEF} and silicone $\kappa_{silicone}$ are 50 W m^{-1} K^{-1} and 0.15 W m^{-1} K^{-1}. The UPEF are rectangles with a length of 25 mm and a width of 0.02 mm. In this simulation, the number of the UPEF is 60.

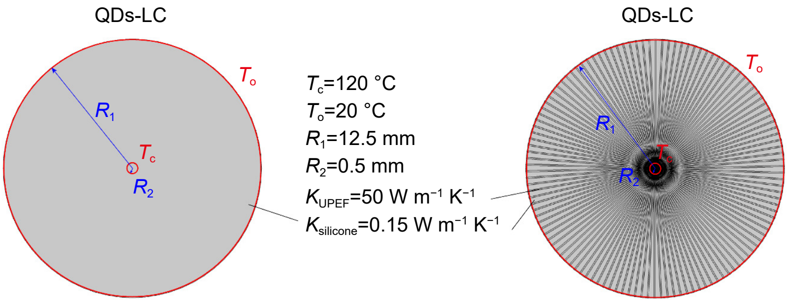

Fig. S2 | Thermal boundary conditions of QDs-LC and QDs-RAPE.

Comparison of thermal conductivities of RA-PE and QDs-RAPE by calculation

Due to QDs and phosphor are small particles, the thermal conductivity of QDs-LC is calculated by Maxwell-Eucken model[S1]:

$$\kappa_c = \kappa_m \frac{\kappa_f + 2\kappa_m + 2V_f(\kappa_f - \kappa_m)}{\kappa_f + 2\kappa_m - V_f(\kappa_f - \kappa_m)} , \tag{S1}$$

where κ_c, κ_m and κ_f are the thermal conductivities of composite (QDs-LC), matrix (silicone), and fillers (QDs and phosphor), respectively. V_f is the volume fraction of fillers. The data for calculation and the results are listed in Table S1.

Table S1 | Calculation data and results for QDs-LC.

Components	Thermal conductivity (W m^{-1} K^{-1})	Mass(g)	Density(g cm^{-1})	Volume fraction (%)
Silicone	0.15	2	1.03	95.87
Phosphor	15	0.4	4.8	4.11
QDs	15	0.0026	5.81	0.02
QDs-LC	**0.17**			

Due to UPEF are fibers throughout the polymer, thermal conductivities of QDs-RAPE and RA-PE can be calculated by the parallel model[S2]:

$$\kappa_c = (1 - V_f) \cdot \kappa_m + V_f \cdot \kappa_f \ , \tag{S2}$$

where QDs-RAPE is regarded as a composite composed of QDs-LC matrix and UPEF fillers. The thermal conductivity of UPEF for calculation is 50 W m^{-1} K^{-1}. Table S2 listed the calculated results of RA-PE and QDs-RAPE.

Table S2 | Calculation data and result for QDs-RAPE and RA-PE.

Volume fraction (%)	Thermal conductivity of RA-PE (W m^{-1} K^{-1})	Thermal conductivity of QDs-RAPE (W m^{-1} K^{-1})
8.22	4.25	4.27
12.46	6.36	6.37
18.11	9.18	9.19
22.57	11.40	11.42
24.46	12.34	12.36

The results in Table S2 shows that the calculated thermal conductivities of QDs-RAPE are consistent with RA-PE under different UPEF volume fraction, which indicates that thermal conductivity of RA-PE could be served as that of QDs-RAPE.

Temperature gradients calculation

Temperature gradients were calculated by following equation:

$$Temperaturegradient = (T_{\max} - T_{\min})/\Delta x \ , \tag{S3}$$

where $T_{\max}$ and $T_{\min}$ are the maximum and minimum surface temperature of the samples, respectively. Δx is the distance between the area where maximum and minimum surface temperature of the samples are located.

Table S3 | Temperature gradients of QDs-LC, 8.15 and 26.70 vol% QDs-RAPE under driving currents of 700 and 1000 mA, respectively.

Driving current (mA)	Temperature gradient (K m^{-1})		
	QDs-LC	QDs-RAPE	
		8.15 vol%	26.70 vol%
700	19568.00	2976.00	2024.00
1000	32146.40	4856.00	3224.00

Heat power of QDs-LC and QDs-RAPE

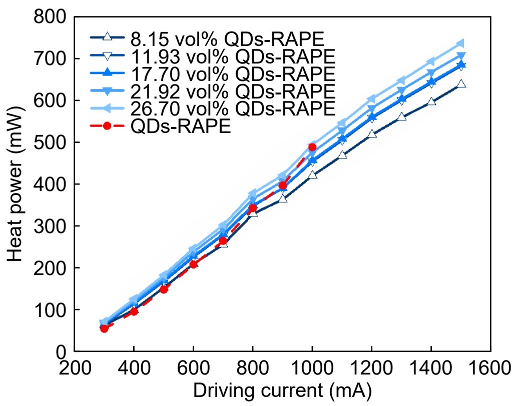

Fig. S3 | Heat power of the samples under different driving currents.

Enhancement ratio of yellow- and red- light intensity

The enhancement ratio of yellow- and red-light intensity of QDs-RAPE to QDs-LC under different driving currents were calculated by following equation:

$$\text{Enhancement ratio} = (\text{light intensity of QDs-RAPE}) / (\text{light intensity of QDs-LC}) \ . \quad \text{(S4)}$$

Table S4 | Calculation results of enhancement ratio of yellow- and red-light intensity of QDs-RAPE to QDs-LC under different driving currents.

Driving current (mA)	Enhancement ratio									
	8.15 vol%		11.93 vol%		17.70 vol%		21.92 vol%		26.70 vol%	
	Yellow light	Red light	Yellow light	Red light	Yellow light	Red light	Yellow light	Red light	Yellow light	Red light
300	−3.11	−8.55	−4.17	−13.46	−9.85	−8.73	−19.17	−11.65	−28.79	−20.60
400	5.66	4.32	−5.17	−9.84	−11.81	−5.78	−20.88	−8.95	−30.63	−18.68
500	5.54	11.66	−1.00	0.56	−7.10	5.66	−16.61	2.60	−26.46	−8.12
600	7.98	25.06	2.55	14.67	−3.79	20.90	−13.58	17.31	−24.17	4.45
700	13.01	39.45	5.99	26.84	−0.29	34.51	−10.43	30.71	−21.05	16.67
800	16.56	52.50	12.85	43.29	6.12	52.16	−4.78	47.70	−16.27	31.43
900	26.68	71.72	20.46	58.06	14.12	69.50	2.53	65.08	−9.71	46.54
1000	50.66	106.60	41.97	90.19	33.14	102.34	19.50	97.14	4.94	74.75

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S1. Levy FL. A modified maxwell-eucken equation for calculating the thermal conductivity of two-component solutions or mixtures. *Int J Refrig* **4**, 223–225(1981).

S2. Yang J, Shen X, Yang W et al. Templating strategies for 3D-structured thermally conductive composites: recent advances and thermal energy applications. *Prog Mater Sci* **133**, 101054(2023).