Supporting Information

Copper sulfide nanodisks doped solid-solid phase change materials for full spectrum solar-thermal energy harvesting and storage

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Table S1. Thermal properties of PEG based PU from different formulations

Ratios of n (TDI) : n (PEG)	PEG4000		PEG6000		PEG8000	
	T_m (°C)	ΔH_m (J /g)	T_m (°C)	ΔH_m (J /g)	T_m (°C)	ΔH_m (J /g)
0 : 1	60.1	160.9	60.4	173	62	180.1
1 : 1	53.3	136.8	56.7	140.3	57	150
3 : 2	53.2	129.9	58.2	130.1	56.5	143.9
2 : 1	53.2	124.1	58.1	122.8	56.9	134

Table S2. Thermal properties of composite PCMs during heating-cooling cycles

Cycling times	0 cycle	50 cycles	100 cycles
Melting point (°C)	58.8	58.7	58.7
Latent heat (J /g)	120	119.5	119.3
Energy loss percentage	0%	0.40%	0.60%

Table S3. Evaluated charge and discharge rates of CuS@PU solar-thermal energy storage systems

CuS content (wt.%)	Thermal charge rate C_{on} (mW/cm^2)	Thermal discharge rate C_{off} (mW/cm^2)
1%	85.6	47.2
2%	87.8	45.5
3%	90.1	47.2
4%	91.6	48.2
5%	92.6	45.7
6%	92.9	45.3

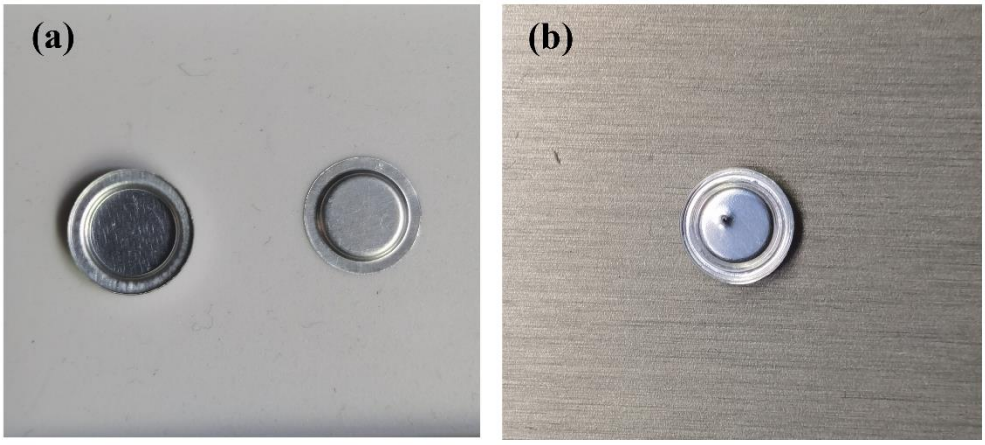

Figure S1. Photograph of the Aluminum crucible (a) with a hole on the top (b) used in the heating-cooling test of composite PCMs.

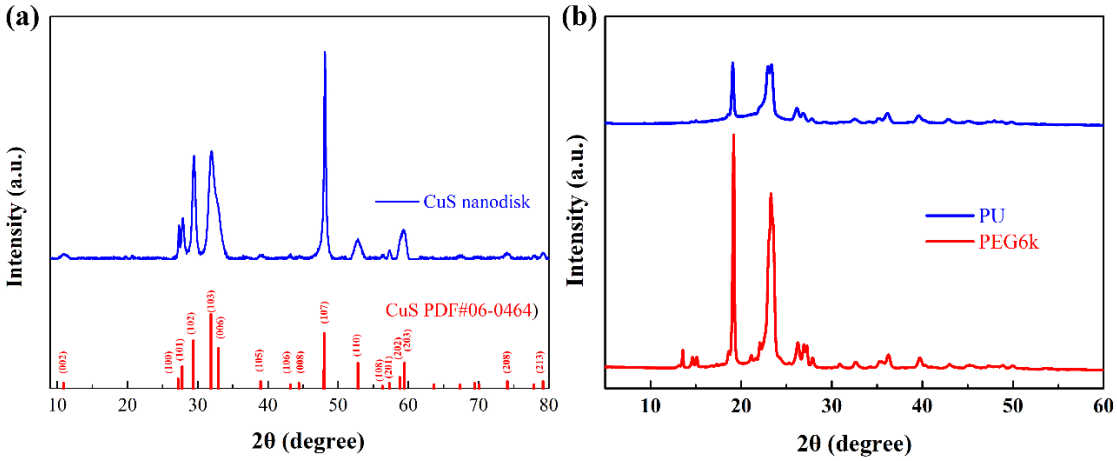

Figure S2. (a) PDF#06-0464 data from Jada 6.5 and XRD pattern of prepared CuS nanodisks. (b) XRD patterns of PEG and PU.

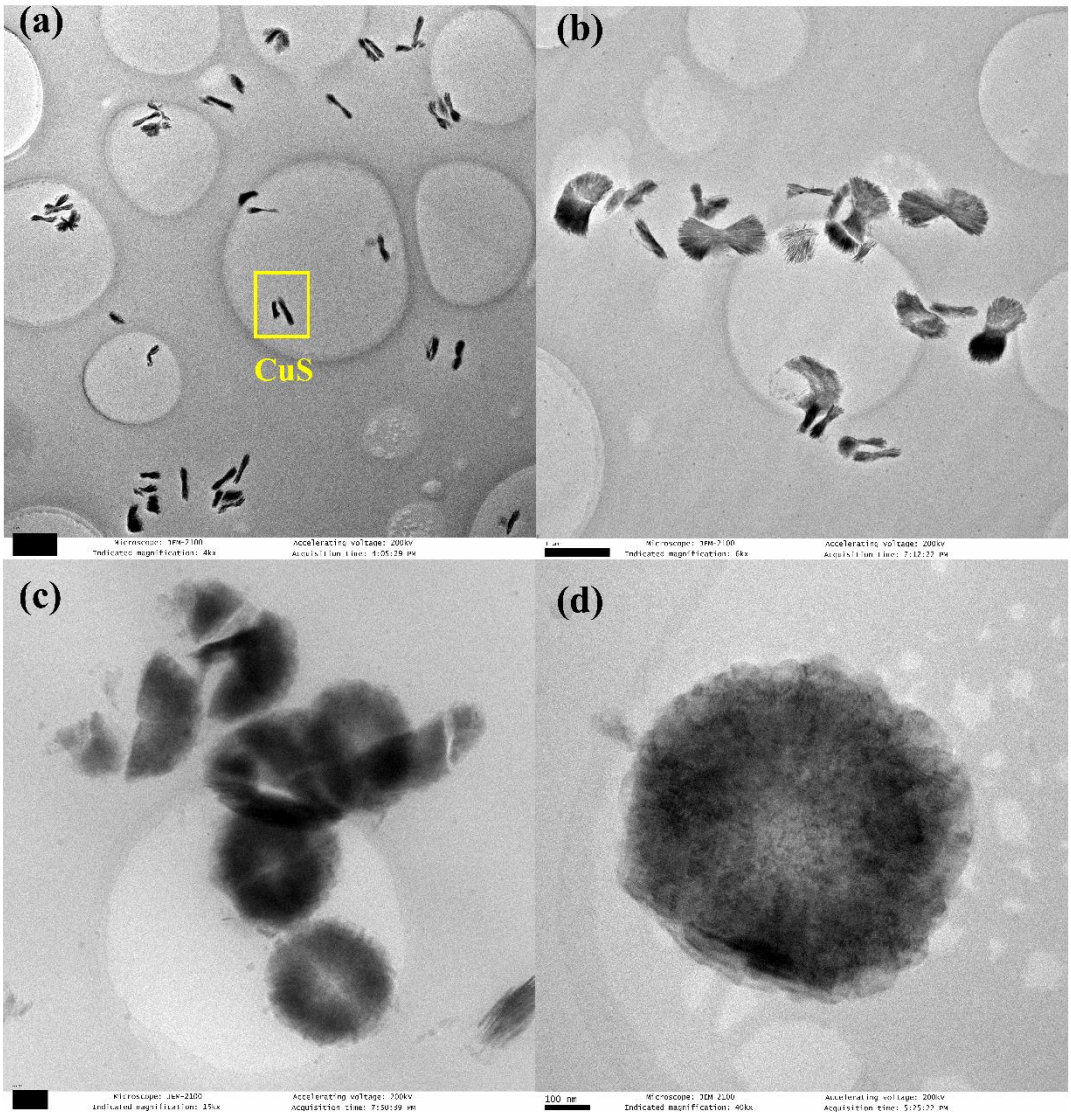

Figure S3. TEM images of CuS@PU composite PCMs at different magnifications.

(a)(b) Scale bar of 1 μm (c)(d) Scale bar of 100 nm

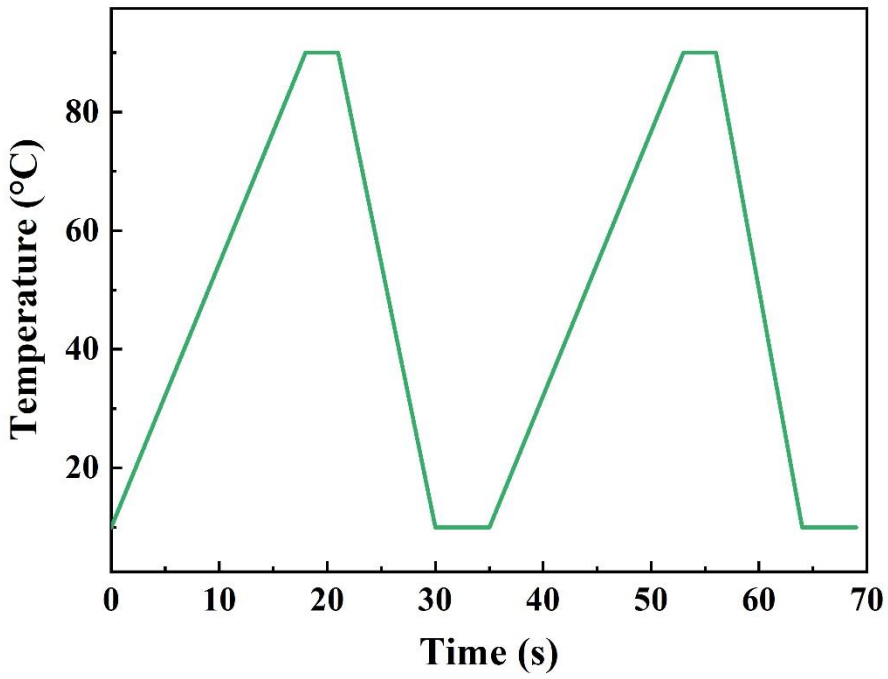

Figure S4. Illustration of temperature program for repeated heating and cooling cycles

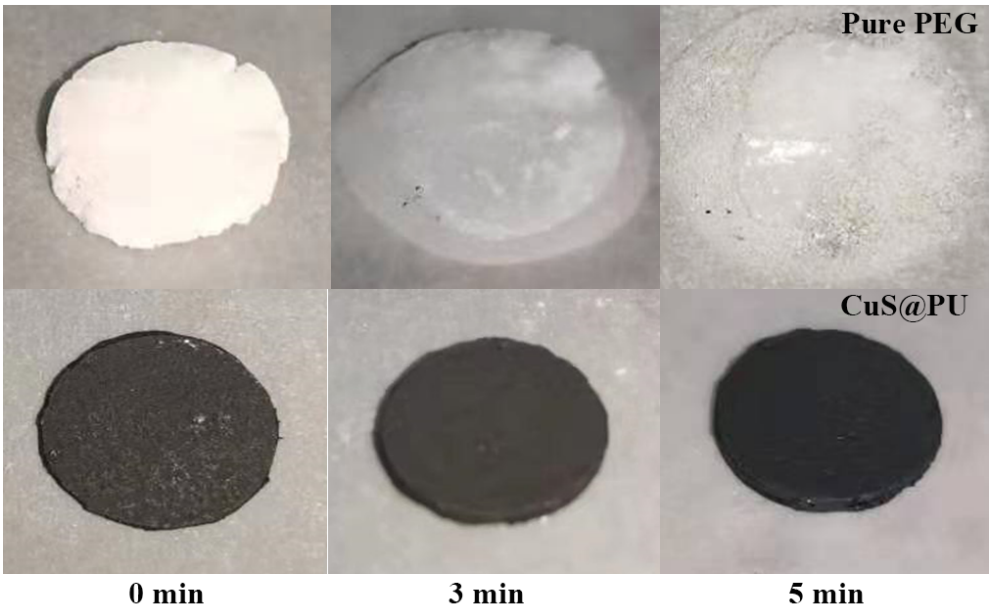

Figure S5. Digital photographic images of pure PEG and CuS@PU PCMs were heated at 90 °C for a certain time.

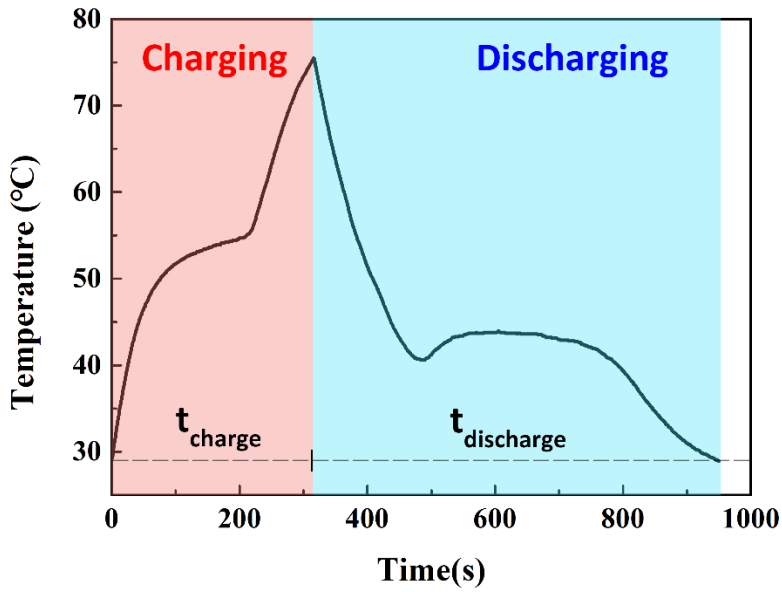

Figure S6. Temperature changing during thermal charging and discharging period of this system occurring with the simulation sunlight on and off.

The solar-thermal charging/discharging system are showed in Figure 6b, the thermal charging process of a series of CuS@PU samples (25mm*25mm*2mm) happened with the protection of a thermal insulator box and the discharging part was held exposed to air temperature at 30 ℃. A peak temperature of 75 ℃ was kept the same. The charge rates per unit area are evaluated through equation (2)

$$C_{on} = \frac{Q_{charge}}{S * t_{charge}} \qquad (2)$$

Where S is the area of tested sample, Q_{charge} and t_{charge} are the absorbed heat and absorbing time of the same period. Considering heat loss during charging process, the interval between the phase changing beginning and end are chosen to do the calculation.

The discharge rates per unit area are evaluated through equation (3)

$$C_{off} = \frac{Q_{discharge}}{S * t_{discharge}} \quad (3)$$

Where $Q_{discharge}$ and $t_{discharge}$ are the released heat and the releasing time of the discharging period.

The evaluated charge and discharge rates are listed in Table S2, which shows that under sunlight the charging rates are proportionate to the solar-thermal conversion property of the composite PCMs and the discharging ones are of small differences due to their similar thermal conductivities.

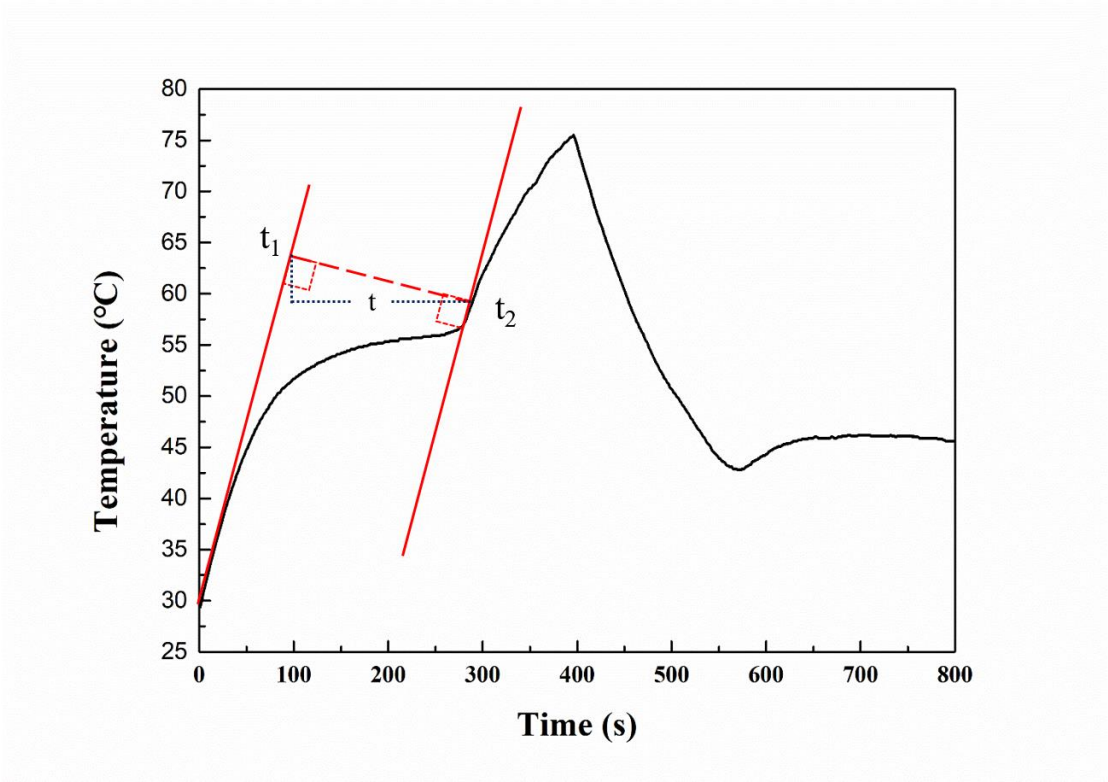

Figure S7. The tangential method for determining the starting and terminating time of the phase transition: $t = t_2 - t_1$

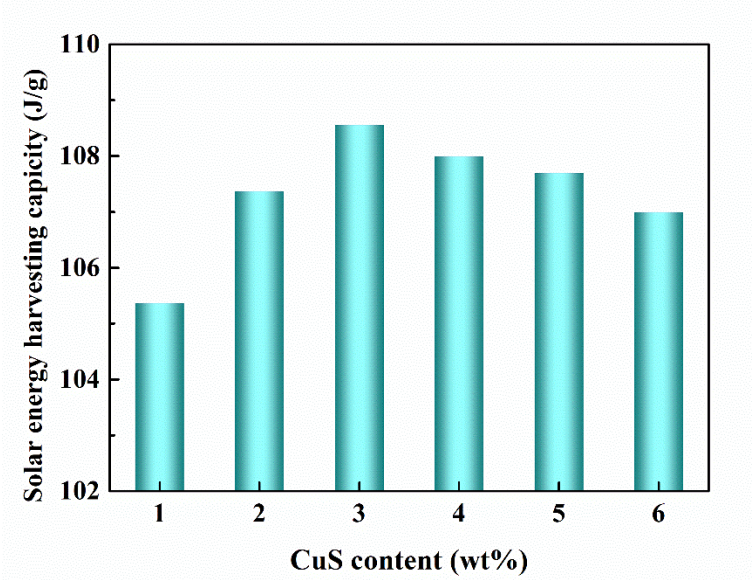

Figure S8. Bar graph showing solar harvesting parameter θ of CuS@PU composites with increasing content of CuS dopants.

With the increasing mass fraction of dopant CuS nanodisks, the solar-thermal conversion efficiency (η) rises but the energy storage capacity (△H) of composite PCMs is decreased which means the dopant volume is not the more the better. Therefore, the product of solar-thermal conversion efficiency (η) and enthalpy (ΔH) is temporarily chosen as the parameter θ to do the judgment which can be calculated using equation (4)

$$\theta = \eta \times \Delta H \qquad (4)$$

Figure S8 shows the judging parameter related to different doped composites. Different θ can be chosen to meet different research or application requirements and more characters like density, cost, phase change point may be taken into consideration. According to this evaluating method, 3 wt.% doped CuS@PU composite PCMs deserves to be the best choice in this work.