Supporting information

Ultrahigh Thermal Conductive Polymer Composites by 3D Printing Induced Vertical Alignment of Carbon Fiber

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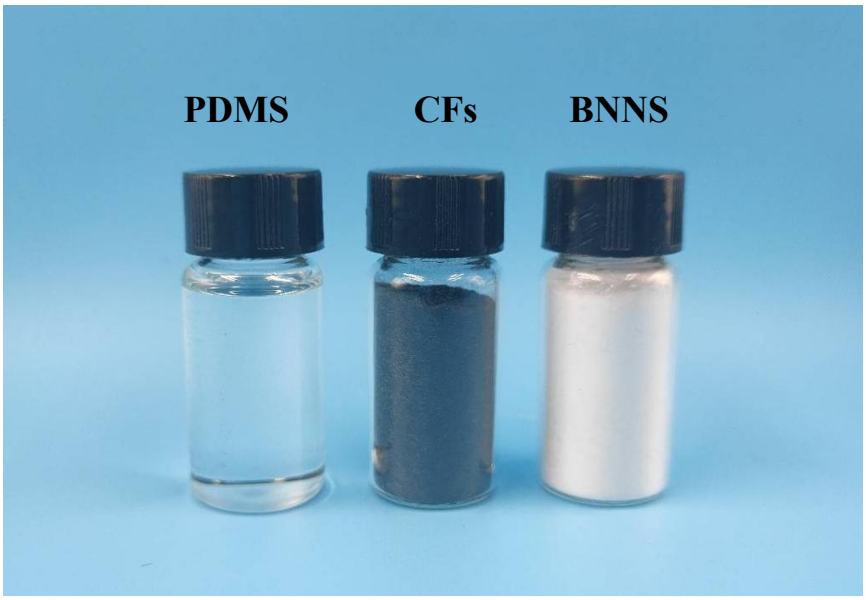

Figure S1. Optically photo of PDMS, CF and BNNS.

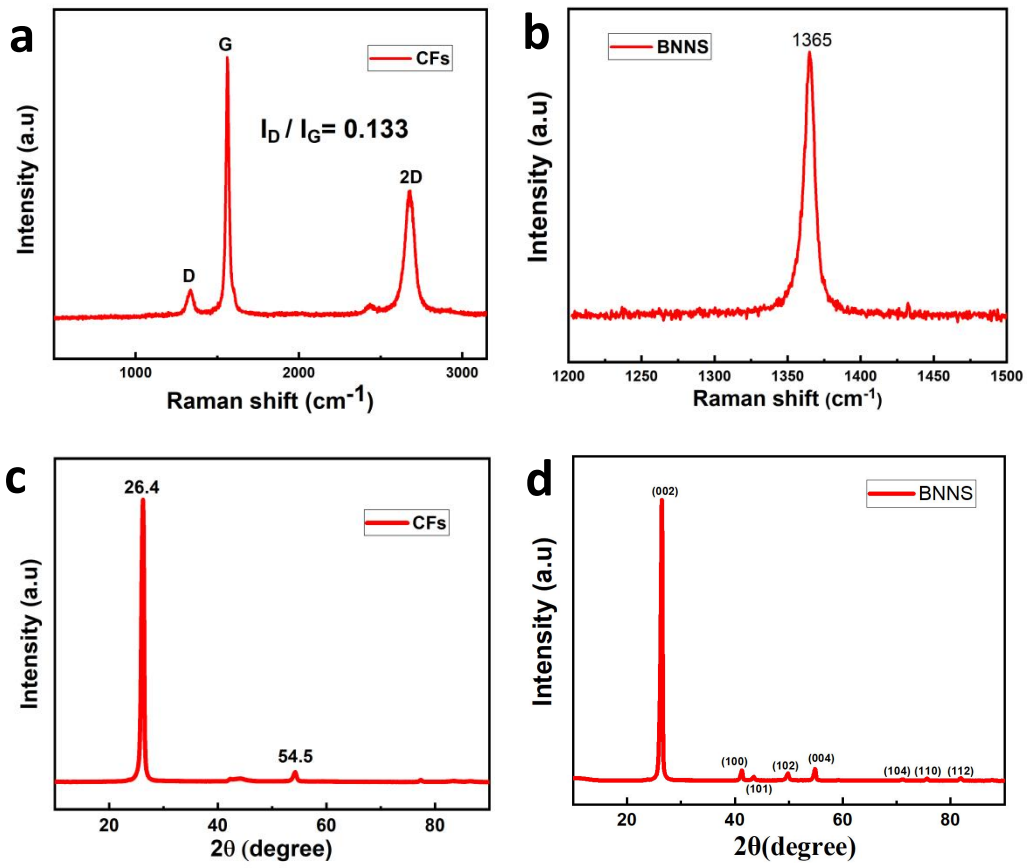

Figure S2. Raman spectroscopy and XRD test. Raman spectrum of CF (a) and BNNS (b). XRD pattern of CF (c) and BNNS (d).

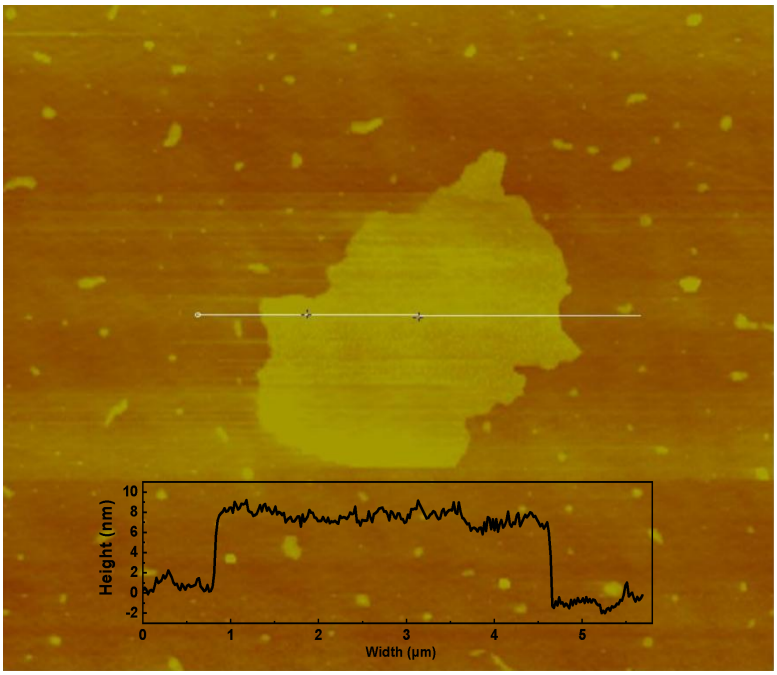

Figure S3. AFM image of BNNS and corresponding height.

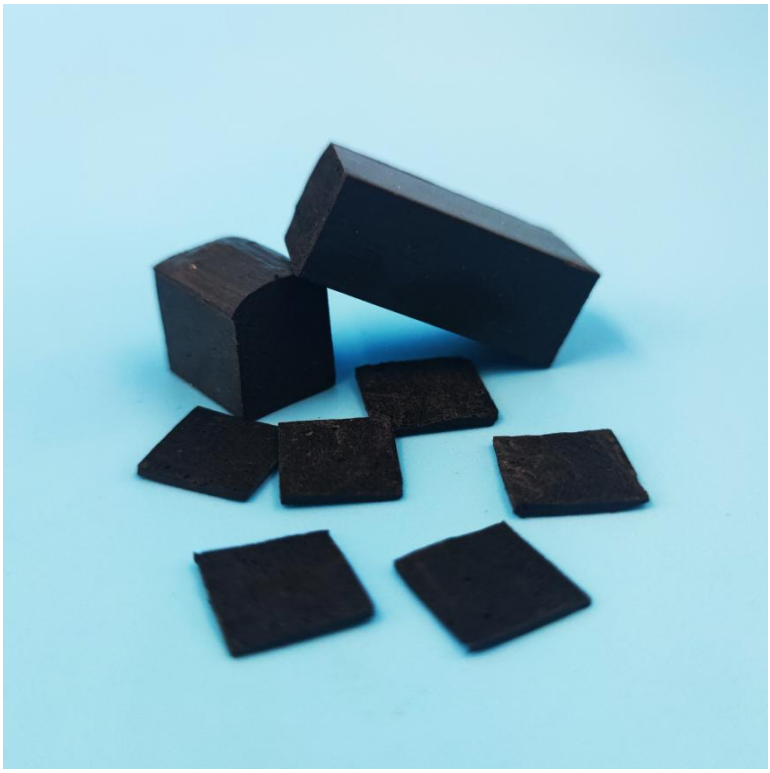

Figure S4. Photo of bulk PCB-60wt%-Aligned composites and sliced TIM.

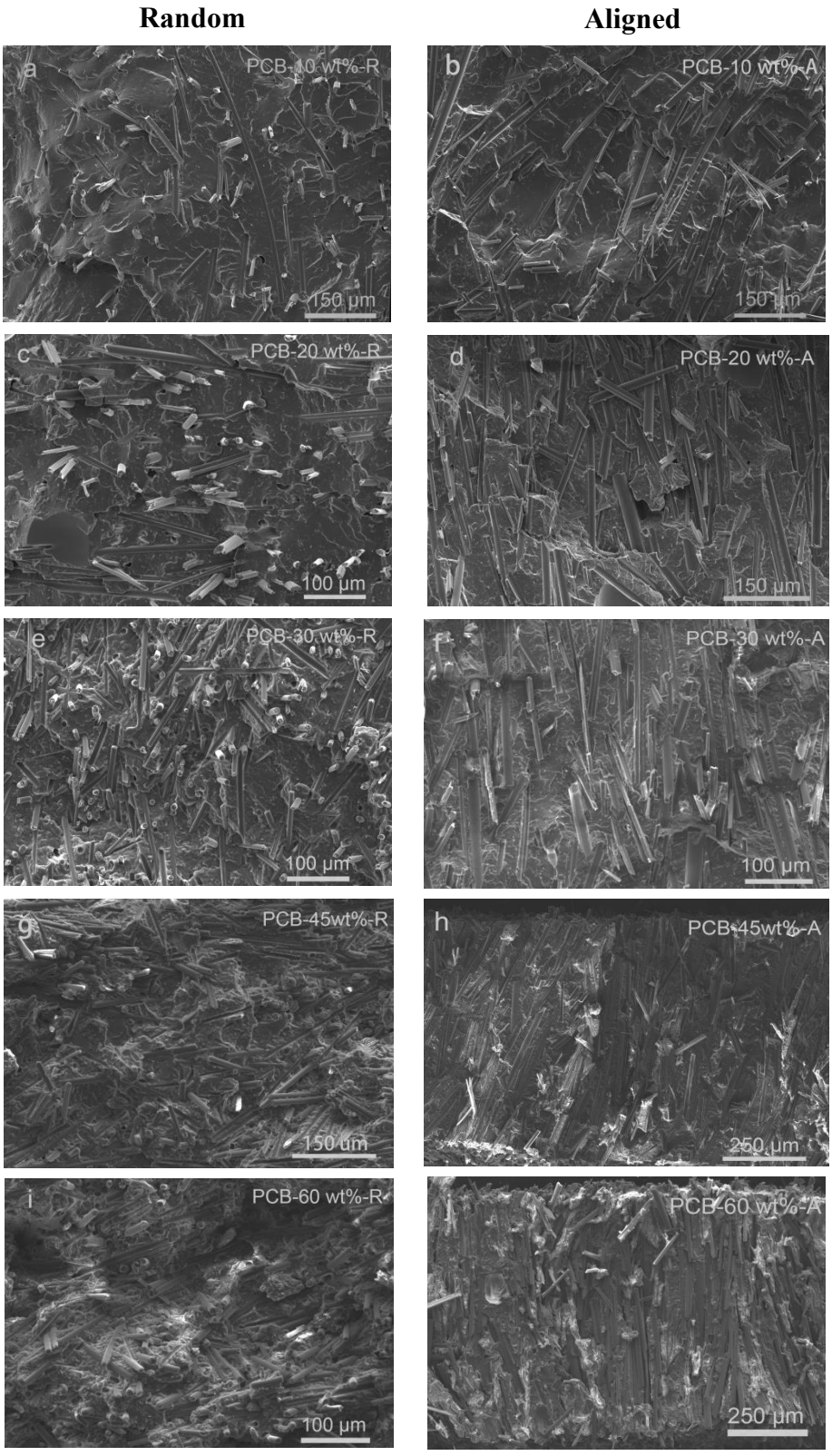

Figure S5. Cross-sectional SEM image of PCB composites under different filler loading.

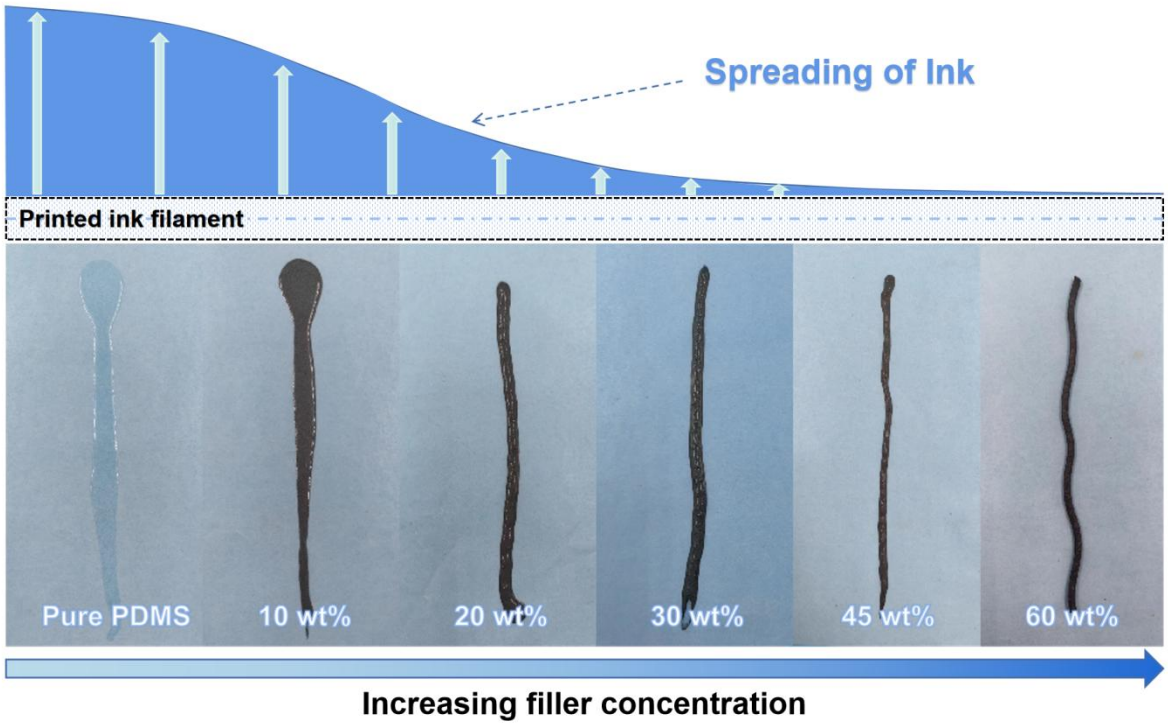

Figure S6. The rheological properties of ink and shape fidelity of filament under various filler contents.

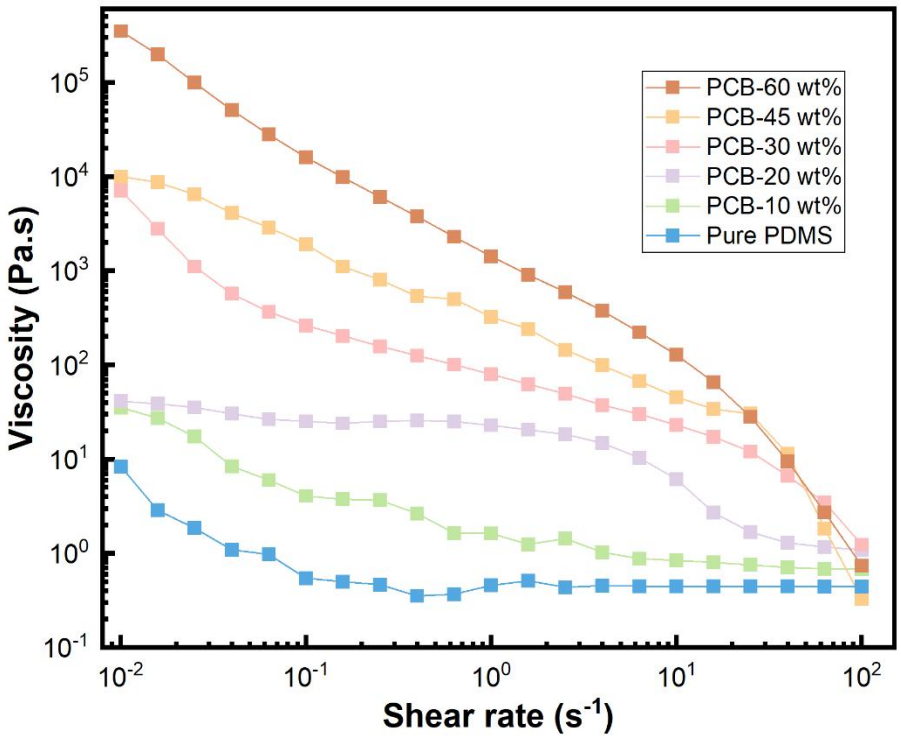

Figure S7. Viscosity as a function of shear rate for polymer inks of varying filler concentration.

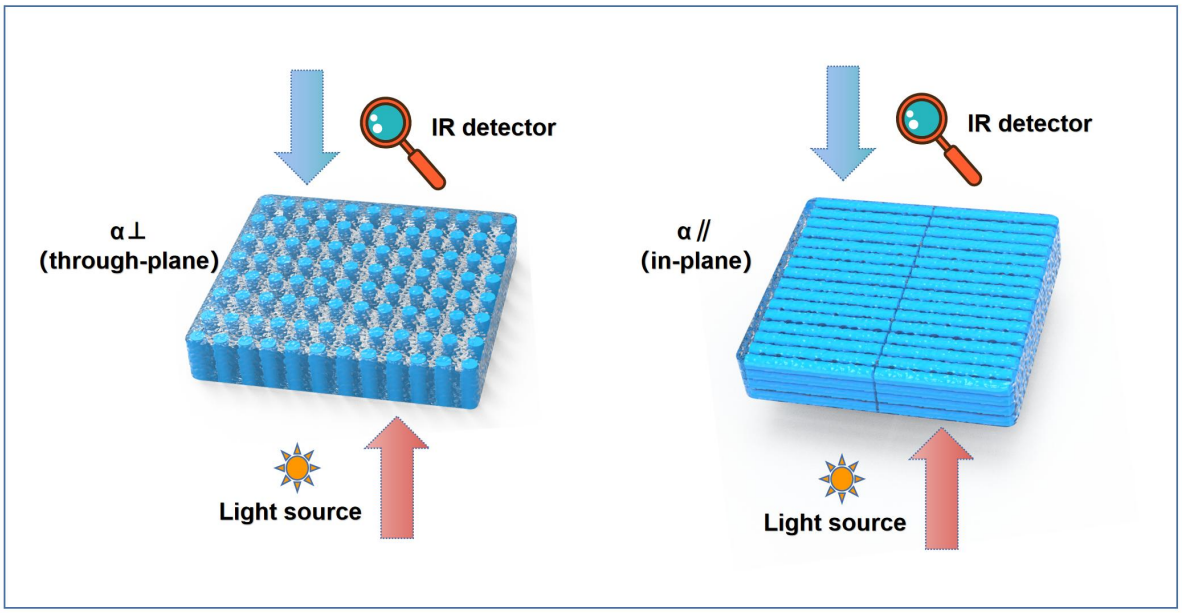

Figure S8. The schematic diagrams of the structures and LFA testing principles for the through plane (⊥) samples and in-plane (//) samples.

Sample	ρ (g/cm^3)	Cp (J/g.K)	α// (mm^2/s)	κ// (W·m^{-1}·K^{-1})	α⊥ (mm^2/s)	κ⊥ (W·m^{-1}·K^{-1})
Pure PDMS	1.025	1.523	0.105	0.164	0.105	0.164
PCB-10 wt%	1.012	1.490	0.505	0.761	1.698	2.559
PCB-20 wt%	1.054	1.446	0.809	1.233	3.859	5.879
PCB-30 wt%	1.098	1.403	1.592	2.451	7.430	11.440
PCB-45 wt%	1.223	1.190	1.988	2.892	14.359	20.893
PCB-60 wt%	1.302	1.067	2.273	3.157	25.353	35.218

Table S1. Details of calculation for in plane and through-plane thermal conductivity (K) of PCB composites and Pure PDMS at room temperature (25 ℃).

No.	Type	Matrix	Filler	Loading	K ($W \cdot m^{-1} \cdot K^{-1}$)	Ref
1	Random	PDMS	CFs	20 wt%	2.73	[1]
2	Random	Epoxy	CFs/Al_2O_3	80.4 wt%	3.84	[2]
3	Random	PDMS	CFs/Al_2O_3	30 vol%	7.91	[3]
4	Ice-template	Epoxy	CFs	13.0 vol%	2.84	[4]
5	Ice-template	PDMS	CFs	12.8 vol%	6.04	[5]
6	Ice-template	Epoxy	CFs/Mxenes	30.2 wt%	9.68	[6]
7	Magnetic	Silicone rubber	CFs	9 vol%	4.72	[7]
8	Magnetic	PDMS	NICFs	51.54 wt%	10.5	[8]
9	Magnetic	Silicone rubber	CFs	20 vol%	11.76	[9]
10	Electrostatic flocking	Epoxy	CFs	10 wt%	1.2	[10]
11	Electrostatic flocking	Silicone rubber	CFs/CNT	2.31 wt%	7.51	[11]
12	Electrostatic flocking	FKM	CFs	13.2 wt%	23.3	[12]
13	Stress induced	PE	CFs	40wt%	3.11	[13]
14	Stress induced	Silicone rubber	CFs	-	19.1	[14]
15	Stress induced	Epoxy	CFs	46 wt%	32.6	[15]
16	3D Printing	Silicone rubber	CFs /Al_2O_3	30 vol%	7.36	[16]
17	3D Printing	PDMS	CFs/BN	60 wt%	35.22	This work

Table S2. Comparison of thermal conductivity of our PCB composite with others reported CF/polymer composites.

Applied TIMs	BLT (μm)	k_{TIM} ($W \cdot m^{-1} \cdot K^{-1}$)	k_{eff} ($W \cdot m^{-1} \cdot K^{-1}$)	R_{total} ($K \cdot mm^2 \cdot W^{-1}$)	R_c ($K \cdot mm^2 \cdot W^{-1}$)
PCB-60 wt%-Aligned	800	35.22	15.68	51.02	28.29
Commercial CFs TIM	800	25	7.37	108.52	76.52

Table S3. Details of calculation for thermal resistance (R_{total}) and contact thermal resistance (R_c) of the two applied TIMs.

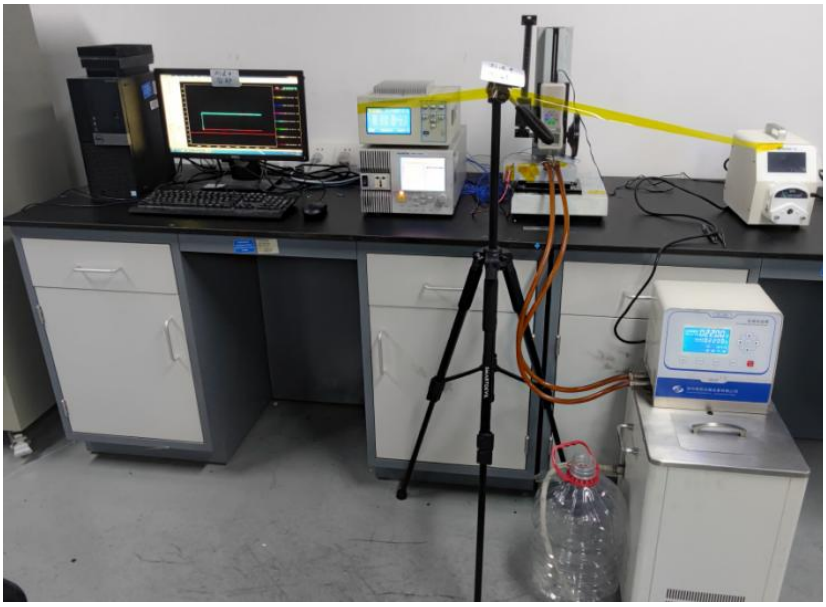

Figure S9. Photography of TIM performance test system.

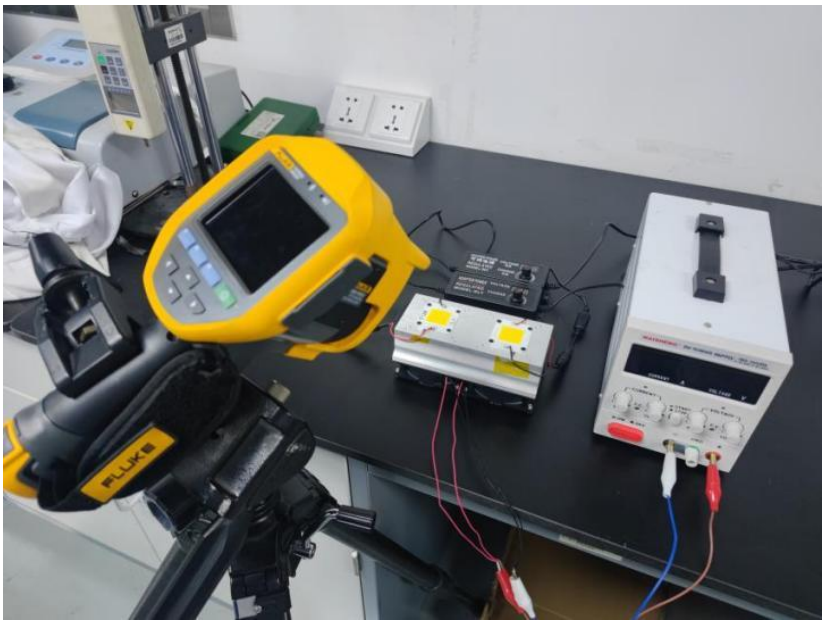

Fig. S10. Photography of temperature monitoring system for LED lamp.

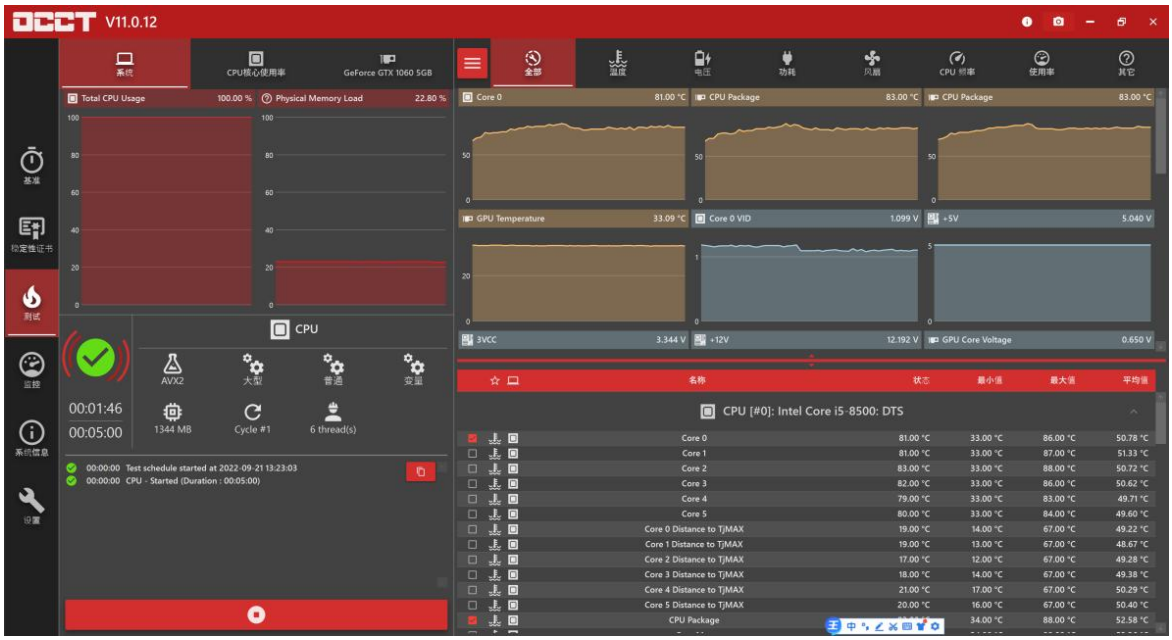

Figure S11. Screenshot of real-time monitoring software for recording relevant parameters in CPU stress test.

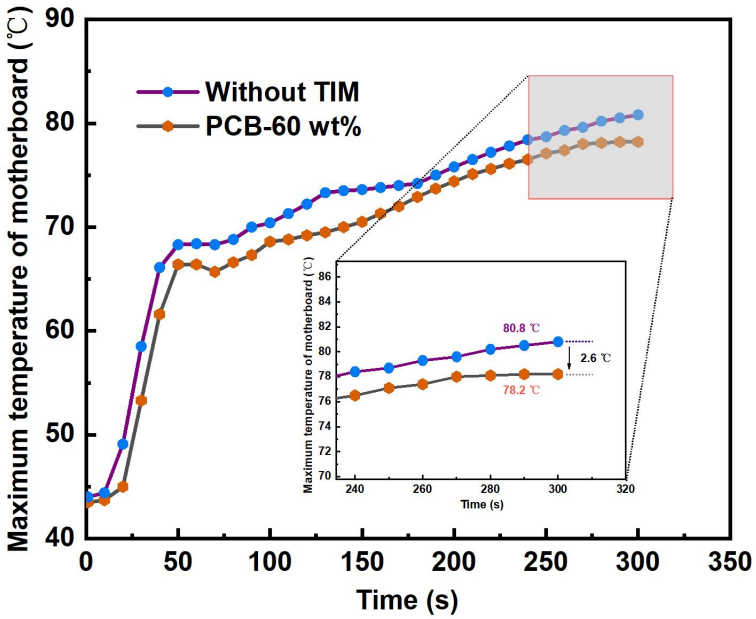

Figure S12. Temperature evolution curve of computer motherboard in CPU stress test stage.

Supplementary Reference

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