# 3D-Printed $Bi_2Te_3$-based Thermoelectric Devices with Phase Change Heat Sinks: Toward Efficient Energy Harvesting and Ultra-Fast Temperature Sensing

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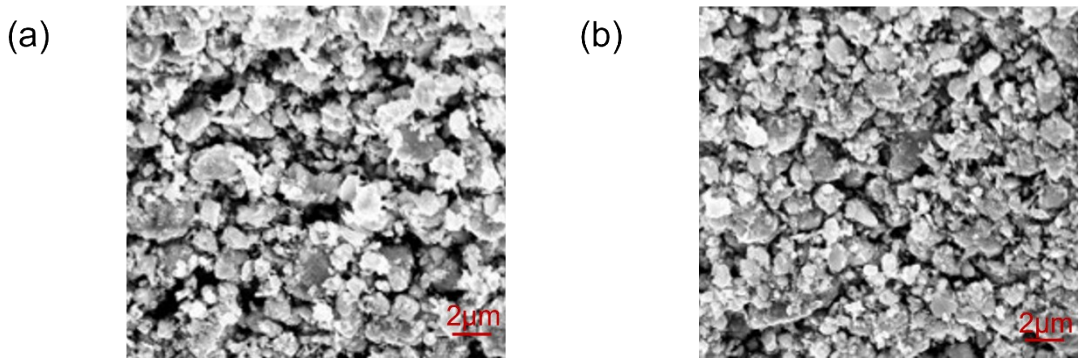


**Fig. S1** Scanning electron microscopy(SEM). (a) P-type sample; (b) N-type sample.

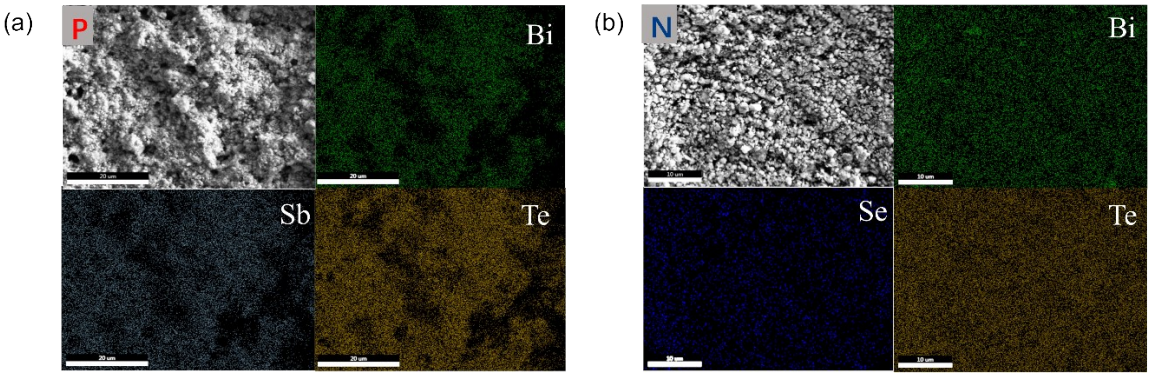


**Fig. S2** EDS energy spectrum analysis of 3D printed thermoelectric inks. (a) P-type sample; (b) N-type sample.

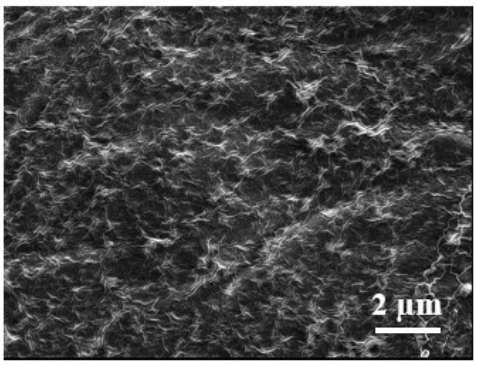


**Fig. S3** Cross-sectional scanning electron microscope images of composite phase change materials.

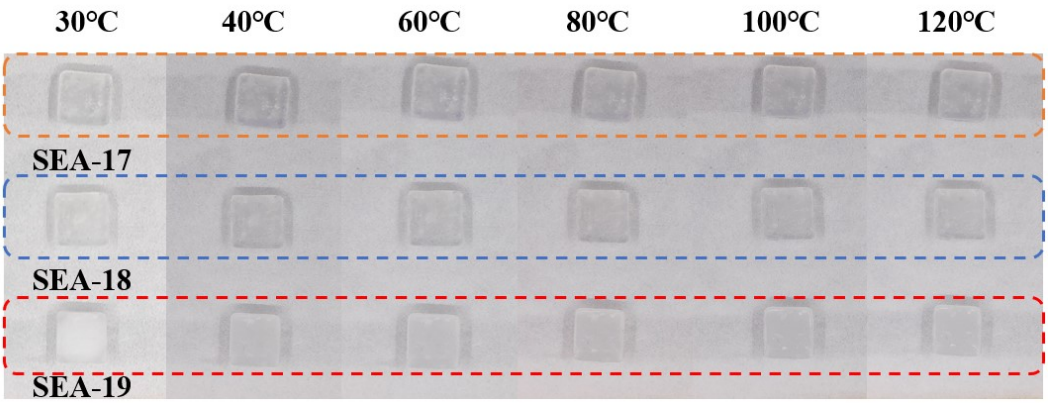


**Fig. S4** Thermal Stability Testing of SEA-17, SEA-18 and SEA-19 Composite Phase Change Materials

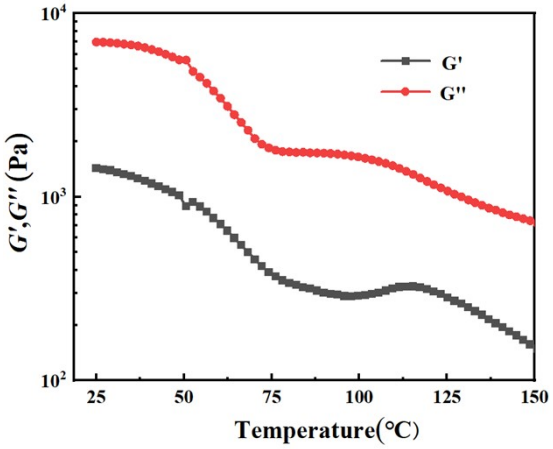


**Fig. S5** Rheological properties of composite phase change materials.

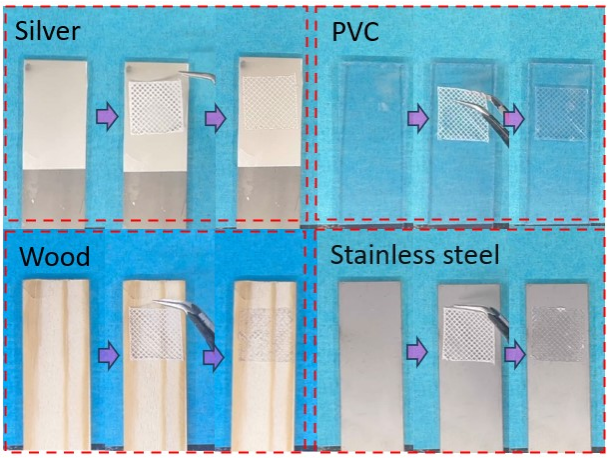


**Fig. S6** Adhesion test of printed composite phase change materials on different substrates

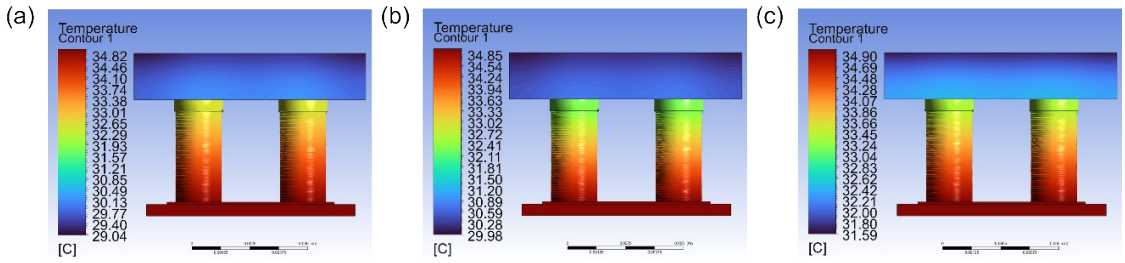


**Fig. S7** The phase transition-thermoelectric coupling simulations (a-c) are in orderSEA-17, SEA-18, and SEA-19 composite PCMs

**Table S1** TE propertties and power performance of TE materials

| Material | Methods | TE legs | $\sigma$ (S m$^{-1}$) | $\Delta T$ (K) | $V_{out}$ (mV) | $P$ (μW) | Citation |
|---|---|---|---|---|---|---|---|
| p- $Bi_{0.5}Sb_{1.5}Te_3$<br>n- $Bi_2Te_{2.7}Se_{0.3}$ | DIW | 6 pairs | 42400<br>125000 | 50 | 42.2 | 32.78 | [1] |
| p- $Bi_{0.4}Sb_{1.6}Te_3$<br>n- $Bi_2Te_3$ | Screen-printing | 1 pairs | ~65000<br>50000 | 20 | 13.8 | 2.9 | [2] |
| p- $Bi_{0.5}Sb_{1.5}Te_3$<br>n- $Ag_2Se$ | DIW | 32 pairs | 14800<br>58600 | 20 | ~308.9<br>2 | ~8480 | [3] |
| p- $Bi_{0.4}Sb_{1.6}Te_3$<br>n- $Bi_2Te_{2.6}Se_{0.4}$ | DIW | N/A | 27900<br>36100 | 20 | ~7.5 | ~520.9 | [4] |
| p- $Bi_{0.5}Sb_{1.5}Te_3$<br>n- $Bi_2Te_{2.7}Se_{0.3}$ | DIW | 1 pairs | 4000<br>1000 | 80 | 38 | 29 | [5] |
| p- $Bi_{0.55}Sb_{1.45}Te_3$<br>n- $Bi_2Te_{2.7}Se_{0.3}$ | DIW | 2 pairs | 1173.5<br>879.3 | 13 | 9.07 | 0.3775 | This work |

**Reference:**


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