CLAIMS

1. A thermal sensor comprising:

two electrodes;

a metal phosphorus chalcogenide configured between and in contact with the two electrodes, wherein the metal phosphorus chalcogenide is represented by a formula of:

$$AMP_2X_6$$

wherein:

A is a metal comprising vanadium, tin, silver, or copper,

M is a metal comprising (i) chromium, vanadium, tin, iron, cobalt, nickel, or manganese, or (ii) indium when A is not copper,

P is phosphorus, and

X is a chalcogen comprising sulfur, selenium, or tellurium.

2. The thermal sensor of claim 1, wherein A and M comprise the same metal.

3. The thermal sensor of claim 2, wherein A and M comprise vanadium or tin.

4. The thermal sensor of claim 1, wherein A and M comprise different metals.

5. The thermal sensor of claim 4, wherein A comprises silver or copper.

6. The thermal sensor of claim 1, the metal phosphorus chalcogenide is represented by a formula of:

$$A^{I}M^{III}P_2X_6$$

wherein:

A^{I} is a metal, and the metal has a valency of one,

M^{III} is a metal, and the metal has a valency of three,

P is phosphorus, and

X is the chalcogen.

7. The thermal sensor of claim 1, wherein the metal phosphorus chalcogenide comprises $CuVP_2S_6$, $AgVP_2S_6$, $V_2P_2S_6$, or $Sn_2P_2S_6$.

8. The thermal sensor of any one of claims 1 to 7, wherein the thermal sensor is a negative temperature coefficient resistance thermistor.

9. The thermal sensor of any one of claims 1 to 8, further comprises a carbon nanotube configured below the metal phosphorus chalcogenide, wherein the carbon nanotube is electrically coupled to two bottom electrodes.

10. The thermal sensor of claim 9, wherein the carbon nanotube is a single-walled carbon nanotube.

11. The thermal sensor of claim 9 or 10, further comprises an insulating layer configured between the metal phosphorus chalcogenide and the carbon nanotube.

12. The thermal sensor of claim 11, wherein the insulating layer comprises hexagonal boron nitride, silicon dioxide, hafnium dioxide, aluminum oxide, or gallium oxide.

13. A method of forming the thermal sensor of any one of claims 1 to 12, the method comprising:

providing the two electrodes;

forming the metal phosphorus chalcogenide; and

configuring the metal phosphorus chalcogenide between and in contact with the two electrodes.

14. The method of claim 13, wherein forming the metal phosphorus chalcogenide is carried out via chemical vapor transport, which comprises:

loading a powder mixture into one end of a sealable enclosure, wherein the powder mixture comprises one or more metals, phosphorus, and the chalcogen;

arranging the sealable enclosure, which is sealed, in a furnace with the one end of the sealable enclosure containing the powder mixture positioned (i) proximal to a reaction zone of the furnace and (ii) distal from a growth zone of the furnace; and

heating the furnace to render the reaction zone to have a lower temperature than the growth zone for a period, then heating the furnace to render the reaction zone to have a higher temperature than the growth zone so as to obtain a crystal form of the metal phosphorus chalcogenide.

15. The method of claim 14, further comprising maintaining the reaction zone at the higher temperature for a duration shorter than the period.

16. The method of claim 14 or 15, further comprising:

providing two bottom electrodes;

forming a carbon nanotube which is electrically coupled to the two bottom electrodes; and

configuring the carbon nanotube between and in contact with the two bottom electrodes.

17. The method of claim 16, further comprising configuring an insulating layer on the carbon nanotube.

18. The method of claim 17, wherein the insulating layer comprises hexagonal boron nitride, silicon dioxide, hafnium dioxide, aluminum oxide, or gallium oxide.

19. The method of claim 17 or 18, wherein the metal phosphorus chalcogenide is configured on the insulating layer.