CLAIMS

1. A heat spreader comprising:

a thermally conductive body configured to contact a heat source and a heat sink, in which at least a portion of the thermally conductive body comprises a copper composite that comprises copper nanoparticles and a coefficient of thermal expansion (CTE) modifier.

2. The heat spreader of claim 1, wherein the copper composite further comprises micron-sized copper particles and is formed through consolidation of the copper nanoparticles with micron-size copper particles and the CTE modifier.

3. The heat spreader of claim 1, wherein the copper composite has a uniform nanoporosity of 2% to 30%.

4. The heat spreader of claim 1, wherein the CTE modifier comprises particles or fibers selected from the group consisting of carbon, W, Mo, diamond, boron nitride, aluminum nitride, silicon nitride, carbon nanotubes, graphene, graphite, copper oxide nanoparticles, and any combination thereof.

5. The heat spreader of claim 1, further comprising:

a plurality of thermally conductive fibers extending from at least a portion of the thermally conductive body.

6. The heat spreader of claim 1, wherein the thermally conductive body is wholly formed from the copper composite.

7. The heat spreader of claim 6, wherein the CTE modifier is distributed throughout the thermally conductive body.

8. The heat spreader of claim 1, wherein the thermally conductive body is tapered.

9. The heat spreader of claim 1, wherein the CTE modifier is present in the copper composite in a stepwise or gradient concentration distribution.

10. The heat spreader of claim 1, wherein the copper composite has a CTE of 3 ppm/°C to 7 ppm/°C.

11. A printed circuit board (PCB) comprising:

a heat-producing component located upon or recessed within an electrically insulating substrate; and

at least one heat spreader in thermal communication with the heat-producing component, the at least one heat spreader comprising:

a thermally conductive body, in which at least a portion of the thermally conductive body comprises a copper composite that comprises copper nanoparticles and a coefficient of thermal expansion (CTE) modifier

wherein the copper composite is formed through consolidation of the copper nanoparticles and the CTE modifier.

12. The PCB of claim 11, wherein the copper composite further comprises micron-size copper particles and is formed through consolidation of the copper nanoparticles with micron-size copper particles and the CTE modifier.

13. The PCB of claim 11, wherein the copper composite has a uniform nanoporosity of 2% to 30%.

14. The PCB of claim 11, wherein the at least one heat spreader is bonded to the heat-producing component via a bonding layer comprising a second copper composite that is CTE-matched to the heat-producing component.

15. The PCB of claim 14, wherein the second copper composite of the bonding layer has a uniform nanoporosity of 2% to 30%.

16. The PCB of claim 11, wherein the CTE modifier comprises particles or fibers selected from the group consisting of carbon, W, Mo, diamond, boron nitride, aluminum nitride, silicon nitride, carbon nanotubes, graphene, graphite, copper oxide nanoparticles, and any combination

thereof.

17. The PCB of claim 11, wherein the thermally conductive body is wholly formed from the copper composite.

18. The PCB of claim 17, wherein the CTE modifier is distributed throughout the thermally conductive body.

19. The PCB of claim 11, wherein the thermally conductive body is tapered.

20. The PCB of claim 11, wherein the heat-producing component is located upon or recessed within a surface of the electrically insulating substrate, and:

the at least one heat spreader is bonded to a top surface of the heat-producing component,

the at least one heat spreader is bonded to a side surface of the heat-producing component,

the at least one heat spreader is bonded to a bottom surface of the heat-producing component and the at least one heat spreader extends through the electrically insulating substrate,

or any combination thereof.

21. The PCB of claim 11, wherein the CTE modifier is present in the copper composite in a stepwise or gradient concentration distribution.

22. The PCB of claim 11, wherein the copper composite has a CTE of 3 ppm/°C to 7 ppm/°C.

23. A heat dissipation system comprising:

a heat spreader having a thermally conductive body, in which at least a portion of the thermally conductive body comprises a copper composite that comprises a coefficient of thermal expansion (CTE) modifier, such that the thermally conductive body has a CTE of 3 ppm/°C to 7 ppm/°C;

a heat-producing component in contact with a first surface of the

thermally conductive body, the heat-producing component having a CTE of 3 ppm/°C to 7 ppm/°C; and

a heat sink or a heat pipe in contact with a second surface of the thermally conductive body;

wherein the heat sink or the heat pipe is also formed from the copper composite comprising the coefficient of thermal expansion modifier and has a CTE of 3/°C to 7 ppm/°C;

wherein the copper composite is formed through consolidation of the copper nanoparticles and the CTE modifier.

24. The heat dissipation system of claim 23, wherein the thermally conductive body is metallurgically bonded to the heat sink or the heat pipe via a bonding layer.

25. The heat dissipation system of claim 23, wherein the thermally conductive body has a CTE within ±20% of the heat-producing component.

26. The heat spreader of claim 9, wherein the heat spreader comprises a multi-layered interface and the CTE modifier in the copper composite is adjusted between each layer to provide a stepwise or gradient concentration distribution.

27. The heat spreader of claim 26, wherein the CTE change between each layer is between 1 ppm/°C to 2.5 ppm/°C.

28. The heat spreader of claim 1, wherein the copper composite further comprises diamond particles, wherein the diamond particles have a size between 0.5 to 1000 microns.

29. The PCB of claim 21, wherein the heat spreader comprises a multi-layered interface and the CTE modifier in the copper composite is adjusted between each layer to provide a stepwise or gradient concentration distribution.

30. The PCB of claim 29, wherein the CTE change between each layer is

between 1 ppm/°C to 2.5 ppm/°C.

31. The PCB of claim 11, wherein the copper composite further comprises diamond particles, wherein the diamond particles have a size between 0.5 to 1000 microns.

32. The heat dissipation device of claim 23, wherein the copper composite further comprises diamond particles, wherein the diamond particles have a size between 0.5 to 1000 microns.

33. The heat spreader of claim 2, wherein the consolidated copper composite has a pore size between 50 and 500 nm.