CLAIMS

1. A heat pipe comprising:

a structure having a sealed outer shell comprising a copper composite that comprises a coefficient of thermal expansion (CTE) modifier; and

a working fluid movable within an internal space defined within the sealed outer shell, the internal space comprising a wicking structure interposed between the sealed outer shell and a hollow core, or a flow channel defined upon a surface of the sealed outer shell.

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

3. The heat pipe of claim 1, wherein the wicking structure comprises a foam, a wire mesh, a plurality of grooves, or any combination thereof.

4. The heat pipe of claim 1, wherein the sealed outer shell penetrates into at least a portion of the wicking structure.

5. The heat pipe of claim 1, wherein a complementary part contacts the sealed outer shell and seals an upper surface of the flow channel.

6. The heat pipe of claim 1, wherein the copper composite has a uniform nanoporosity of about 2% to about 30%.

7. The heat pipe of claim 1, wherein the CTE modifier comprises carbon fibers, W particles, Mo particles, diamond particles, boron nitride, aluminum nitride, carbon nanotubes, graphene, or any combination thereof.

8. The heat pipe of claim 1, further comprising:

a plurality of thermally conductive fibers extending from an end portion of the structure, optionally wherein at least a portion of the thermally conductive fibers extend into the internal space and contact the working fluid.

9. A printed circuit board (PCB) comprising:

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

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

a structure having a sealed outer shell comprising a copper composite that comprises a coefficient of thermal expansion (CTE) modifier; and

a working fluid movable within an internal space defined within the sealed outer shell, the internal space comprising wicking structure interposed between the sealed outer shell and a hollow core, or a flow channel defined upon a surface of the sealed outer shell.

10. The PCB of claim 9, wherein the copper composite is formed through consolidation of copper nanoparticles with micron-size copper particles and the CTE modifier.

11. The PCB of claim 9, wherein the wicking structure comprises a foam, a wire mesh, a plurality of grooves, or any combination thereof.

12. The PCB of claim 9, wherein the sealed outer shell penetrates into at least a portion of the wicking structure.

13. The PCB of claim 9, wherein a complementary part contacts the sealed outer shell and seals an upper surface of the flow channel.

14. The PCB of claim 9, wherein the copper composite has a uniform nanoporosity of about 2% to about 30%.

15. The PCB of claim 9, wherein the at least one heat pipe is bonded to the heat-producing component via a bonding layer comprising a copper composite that is CTE-matched to the copper composite comprising the sealed outer shell.

16. The PCB of claim 9, wherein: the at least one heat pipe is bonded to a top surface of the heat- producing component, one or more heat pipes are bonded to a side surface of the

heat- producing component, the at least one heat pipe is bonded to a bottom surface of the heat-producing component and the at least one heat pipe extends through the electrically insulating substrate, or any combination thereof.

17. The PCB of claim 9, wherein the CTE modifier comprises carbon fibers, W particles, Mo particles, diamond particles, boron nitride, aluminum nitride, carbon nanotubes, graphene, or any combination thereof.

18. The PCB of claim 9, further comprising: a plurality of thermally conductive fibers extending from an end portion of the structure, optionally wherein at least a portion of the thermally conductive fibers extend into the internal space and contact the working fluid.

19. A method comprising:

providing an elongate wicking structure having an outer surface and an inner surface defining a hollow core;

applying a copper nanoparticle paste composition to the outer surface, the copper nanoparticle paste composition comprising a plurality of copper nanoparticles, a plurality of micron-size copper particles, and a coefficient of thermal expansion (CTE) modifier;

consolidating the copper nanoparticles to form a sealed outer shell upon the outer surface of the elongate wicking structure; partially loading the hollow core with a working fluid; and

closing off at least one end portion of the sealed outer shell to confine the working fluid in the hollow core.

20. The method of claim 19, wherein the at least one end portion is closed off by applying a second portion of the copper nanoparticle paste composition to the at least one end portion, and consolidating the copper nanoparticles therein.

21. The method of claim 20, further comprising: placing a plurality of thermally conductive fibers in the second portion of the copper nanoparticle paste composition and extending from the at least one end portion, optionally wherein at least a portion of the thermally conductive fibers extend into the hollow core and contact the working fluid.

22. The method of claim 19, wherein the wicking structure comprises a foam, a wire mesh, a plurality of grooves, or any combination thereof.

23. The method of claim 19, wherein the copper composite has a uniform nanoporosity of about 2% to about 30%.

24. The method of claim 19, wherein the CTE modifier comprises carbon fibers, W particles, Mo particles, diamond particles, boron nitride, aluminum nitride, carbon nanotubes, graphene, or any combination thereof.

25. The method of claim 19, wherein the sealed outer shell penetrates into at least a portion of the wicking structure.

26. The heat pipe of claim 2, wherein the copper nanoparticles have a surfactant coating containing one or more surfactants on their surface.

27. The heat pipe of claim 2, wherein the copper composite comprises about 30 % to about 98% copper nanoparticles by weight and about 0.1 to about 15% micron-scale particles by weight.

28. The heat pipe of claim 2, wherein at least a portion of the copper nanoparticles are in a range of from about 1 to about 10 nm in size and the remaining copper nanoparticles are in a range of 25 to about 50 nm in size.