CLAIMS

What is claimed is the following:

1. An article comprising:

a matrix material selected from the group consisting of polymer matrix, a rubber matrix, a ceramic matrix, a metal matrix and a glass matrix; and

a plurality of copper nanoparticles in the matrix material that have been at least partially fused together;

wherein the plurality of copper nanoparticles are less than ~~about~~ 20 nm in size.

2. The article of claim 1, wherein the plurality of copper nanoparticles further comprise a surfactant system.

3. The article of claim 2, wherein the surfactant system comprises a bidentate diamine and one or more C6 – C18 alkylamines.

4. The article of claim 1, wherein the plurality of copper nanoparticles range between ~~about~~ 1 nm and ~~about~~ 10 nm in size.

5. The article of claim 1, wherein the plurality of copper nanoparticles range between ~~about~~ 1 nm and ~~about~~ 5 nm in size.

~~6. The article of claim 1, wherein the plurality of copper nanoparticles become at least partially fused together in the matrix material by applying at least one of heat or pressure to the article.~~

~~7. The article of claim 6, wherein the article is heated at a temperature of at most about 200°C to at least partially fuse the plurality of copper nanoparticles together.~~

~~8. The article of claim 6, wherein the article is heated at a temperature of at most about 100°C to at least partially fuse the plurality of copper nanoparticles together.~~

~~6~~9. An ~~The~~ article comprising~~of claim 1, further comprising~~:

a ~~filler~~ matrix material.~~,~~;

a plurality of copper nanoparticles in the matrix material that have been at least partially fused together;

wherein the plurality of copper nanoparticles are less than 20 nm in size; and a filler material.

7~~10~~. The article of claim ~~9~~6, wherein the filler material is selected from the group consisting of flame retardants, UV protective agents, antioxidants, graphite, graphite oxide, graphene, carbon nanotubes, fiber materials, ceramic materials, and combinations thereof.

8~~11~~. The article of claim 1, wherein the article comprises ~~about~~ 10% to ~~about~~ 99.9% copper nanoparticles.

9~~12~~. The article of claim 1, wherein the plurality of copper nanoparticles comprise a thermally conductive percolation pathway in the matrix material.

10~~13~~. The article of claim 1, wherein the article has a thermal conductivity ranging between ~~about~~ 50 watts/m·K and ~~about~~ 400 watts/m·K.

~~14. The article of claim 1, wherein the matrix material is selected from the group consisting of a polymer matrix, a rubber matrix, a glass matrix, a ceramic matrix and a metal matrix.~~

11~~15~~. A method comprising:

providing a plurality of copper nanoparticles;

wherein the plurality of copper nanoparticles are less than ~~about~~ 20 nm in size;

mixing the plurality of copper nanoparticles with a matrix material selected from the group consisting of polymer matrix, a rubber matrix, a ceramic matrix, a metal matrix and a glass matrix; and

applying ~~at least one of heat or~~ pressure to at least partially fuse the plurality of copper nanoparticles together.

12~~16~~. The method of claim 11~~15~~, wherein the plurality of copper nanoparticles further comprise a surfactant system.

13~~17~~. The method of claim 12~~16~~, wherein the surfactant system comprises a bidentate diamine and one or more C6 – C18 alkylamines.

14~~18~~. The method of claim 11~~15~~, wherein the plurality of copper nanoparticles range between ~~about~~ 1 nm and ~~about~~ 10 nm in size.

1519. The method of claim 1115, wherein the plurality of copper nanoparticles range between ~~about~~ 1 nm and ~~about~~ 5 nm in size.

1620. The method of claim 1115, further comprising:

curing the matrix material.

1721. The method of claim 1115, wherein the plurality of copper nanoparticles are at least partially fused together by heating at a temperature of at most ~~about~~ 200°C.

1822. The method of claim ~~15~~12, wherein the plurality of copper nanoparticles are at least partially fused together by heating at a temperature of at most ~~about~~ 100°C.

~~23. The method of claim 15, further comprising:~~

~~removing the matrix material to leave behind a network of at least partially fused copper nanoparticles.~~

1924. The method of claim 1115, wherein applying pressure comprises extruding the mixture of copper nanoparticles and the matrix material.

~~2025. The method of claim 1115, wherein the matrix material is selected from the group consisting of a polymer matrix, a rubber matrix, a glass matrix, a ceramic matrix and a metal matrix.~~

2026. A method comprising:

providing an article comprising:

a matrix material selected from the group consisting of polymer matrix, a rubber matrix, a ceramic matrix, a metal matrix and a glass matrix; ~~and~~

a plurality of copper nanoparticles that have been at least partially fused together in the matrix material;

wherein the plurality of copper nanoparticles are less than ~~about~~ 20 nm in size; and

a filler material; and

placing the article in thermal contact with a heat source.

2127. The method of claim 2026, further comprising:

placing the article in thermal contact with a heat sink.

2228. The method of claim 2026, wherein the plurality of copper nanoparticles further comprise a surfactant system comprising a bidentate diamine and one or more C6 – C18 alkylamines.

2329. The method of claim 2026, wherein the plurality of copper nanoparticles comprise a thermally conductive percolation pathway in the matrix material.

2430. The method of claim 2026, wherein the article has a thermal conductivity ranging between ~~about~~ 50 watts/m·K and ~~about~~ 400 watts/m·K.

2531. A composition comprising:

a plurality of copper nanoparticles that are less than ~~about~~ 20 nm in size that further comprise a surfactant system comprising a bidentate diamine and one or more C6 – C18 alkylamines; and

a matrix material selected from the group consisting of a polymer matrix, a rubber matrix, a ceramic matrix, a metal matrix, and a glass matrix.

2632. A method comprising:

providing a plurality of copper nanoparticles that are mixed with a matrix material to form a paste;

wherein the matrix material is selected from the group consisting of a polymer matrix, a rubber matrix, a ceramic matrix, a metal matrix and a glass matrix; and

wherein the plurality of copper nanoparticles are less than ~~about~~ 20 nm in size and further comprise a surfactant system comprising a bidentate diamine and one or more C6 – C18 alkylamines;

placing the paste in a joint between a first member and a second member; and

joining the first member to the second member by at least partially fusing the plurality of copper nanoparticles together.

~~33. The method of claim 32, wherein the plurality of copper nanoparticles are sufficiently porous to allow for rework of the joint after being at least partially fused together.~~

2734. The method of claim 2633, wherein the plurality of copper nanoparticles are up to ~~about~~ 25% porous after being at least partially fused together.

2835. The method of claim 2632, wherein a strength to failure joining the first member and the second member is at least ~~about~~ 4400 psi.

29. The method of claim 25 or 26, wherein the bidentate diamine is a N,N'-dialkylethylenediamine.