CLAIMS

1. An amalgamation preform, comprising:

a base metal, and

a plurality of types of solid particles dispersed in the base metal, the base metal including one of a liquid base metal and a solid base metal,

wherein the plurality of types of solid particles at least includes:

non-reactive magnetic particles, responsive to a magnetic field for controllably dispersing the plurality of types of solid particles in the base metal, and

reactive particles, capable of being reactive with the base metal under the magnetic field for amalgamation; and

wherein the plurality of types of solid particles are together solely located in one or more regions that are proximal to an outermost surface of the amalgamation preform.

2. The preform according to claim 1, wherein:

the base metal includes Ga, In, Sn, Bi, Pb, Cd, Hg, Rb, Zn, Bi, or a combination thereof; and/or

the reactive particle at least includes a reactive metal material, the reactive metal material including Fe, Ni, Cu, Ag, Au, In, Cu, Sn, Bi, Zn, Ti, V, Cr, Mo, Nb, Zr, Hf, Pt, Ir, or a combination thereof.

3. The preform according to claim 1, wherein:

a particle of the reactive particles includes a core-shell structure, wherein:

the core-shell structure includes a core material, and a shell material different than the core material and at least partially surrounding the core material, and

the core material has a reaction rate with the base metal different than the shell material.

4. The preform according to claim 3, wherein:

the shell material has a thickness ranging from a thickness of an atomic layer to a thickness of about 100 nm,

the core material includes a reactive metal material, and

the shell material includes an oxide layer of the reactive metal material.

5. The preform according to claim 3, wherein:

the core-shell structure includes one or more of:

a core-shell structure having the shell material including an oxide of one or more of Fe and Ni, and the core material including the one or more of Fe and Ni;

a core-shell structure having the shell material including Cu, and the core material including Au;

a core-shell structure having the shell material including steel, and the core material including Cu;

a core-shell structure having the shell material including ZnO or TiO_2, and the core material including Cu, Ag, Ni, or a combination thereof; and

a core-shell structure having the shell material including Cu and copper oxide at least partially covering Cu, and the core material including Co, BeO, Si_3N_4, B_4C, WC, diamond, AlN, SiC, SiO_2, TiO_2, ZrO_2, Al_2O_3, or a combination thereof.

6. The preform according to claim 1, wherein:

the reactive particle includes a reactive magnetic particle, a reactive non-magnetic particle, or a combination thereof.

7. The preform according to claim 6, wherein:

the reactive magnetic particle includes one or more of Fe and Ni,

the reactive magnetic particles have an average size of more than about 50 microns, and/or

the reactive non-magnetic particle includes Cu, Ag, Au, In, Cu, Sn, Bi, Zn, Ti, V, Cr, Mo, Nb, Zr, Hf, Pt, Ir, or a combination thereof.

8. The preform according to claim 1, wherein:

a ratio of the base metal over the plurality of types of solid particles ranges from 4:1 to 1:4 by weight.

9. The preform according to claim 1, wherein:

the plurality of types of solid particles have an average size ranging from about 100 nm to about 100 μm,

the reactive particles have an average size ranging from about 100 nm to about 50 μm, and/or

the non-reactive magnetic particles have an average size ranging from about 5 microns to about 100 microns.

10. The preform according to claim 1, wherein:

the non-reactive magnetic particles include Co-containing particles, Nd- containing particles, Cr-containing particles, or a combination thereof.

11. The preform according to claim 1, wherein:

the non-reactive magnetic particles include large-size magnetic particles having at least one dimension greater than 5 μm, and

the large-size magnetic particles include microwires, microfibers, or combination thereof, and a length direction of the microwires and the microfibers is aligned, in parallel with a direction along the outermost surface of the amalgamation preform.

12. The preform according to claim 1, wherein:

the plurality of types of solid particles further includes additives, including semiconductor particles, metal doped semiconductor particles, or combination thereof, and

the semiconductor particles include SiC particles, AlN particles, SiO_2 particles, or a combination thereof.

13. A amalgamation preform, comprising:

a liquid base metal, and

a plurality of types of solid particles magnetically dispersed in the liquid base metal without solidifying the liquid base metal,

wherein

the plurality of types of solid particles at least includes:

non-reactive magnetic particles, responsive to a magnetic field for controllably dispersing the plurality of types of solid particles in the liquid base metal, and

reactive particles, wherein

the plurality of types of solid particles are together solely located in one or more regions that are proximal to an outermost surface of the amalgamation preform,

the reactive particles are capable of being reactive with the liquid base metal under the magnetic field for amalgamation, and

no reactions occur between the reactive particles and the liquid base metal at a temperature of about 25 °C or less.

14. A method of making the amalgamation preform according to claim 1 or claim 13, comprising:

providing a particle-liquid mixture containing the plurality of types of solid particles and the liquid base metal, wherein the plurality of types of solid particles at least includes the reactive particles and the non-reactive magnetic particles;

applying a magnetic field to the particle-liquid mixture to magnetically disperse the plurality of types of solid particles in the liquid base metal to form a particle-liquid dispersion without substantially inducing a reaction between the reactive particles and the liquid base metal, and

preparing the amalgamation preform including the plurality of types of solid particles and the base metal.

15. A method of using the amalgamation preform the amalgamation preform according to claim 1 or claim 13, comprising:

providing mating bonding surfaces;

placing a particle-liquid mixture corresponding to the amalgamation preform between the mating bonding surfaces; and

applying a magnetic field to the particle-liquid mixture.