A composition includes an alloy that has, by weight, 25-65% zirconium, 25-65% tungsten, and 6-25% of a combined amount of nickel in at least one of iron and cobalt. The alloy may be formed into a geometric body that has a density of 7.8 grams per cubic centimeter to 11.4 grams per cubic centimeter.
COMPOSITION FOR REACTIVE MATERIAL

BACKGROUND

[0001] The present disclosure relates to a reactive material and, more specifically, to a reactive metallic alloy.

[0002] Reactive or energetic materials are known and used in pyrotechnics, munitions, and the like. Some reactive materials are composed of reactive metal and oxidizer that are held in a metallic or organic matrix. A high energy charge can be used to input an activation energy into the reactive material to trigger a reactive thermal release. Example reactive compositions can include iron, titanium, aluminum, or magnesium.

SUMMARY

[0003] A composition of matter according to an example of the present disclosure includes an alloy including, by weight, 25-65% zirconium, 25-65% tungsten, and 6-25% of a combined amount of nickel and at least one of iron and cobalt.

[0004] In a further embodiment of any of the foregoing embodiments, the alloy includes 5-20% nickel.

[0005] In a further embodiment of any of the foregoing embodiments, the alloy includes 1-5% of at least one of iron and cobalt.

[0006] In a further embodiment of any of the foregoing embodiments, the alloy includes iron and excludes cobalt.

[0007] In a further embodiment of any of the foregoing embodiments, the alloy includes cobalt and excludes iron.

[0008] In a further embodiment of any of the foregoing embodiments, the zirconium, tungsten, nickel, and at least one of iron and cobalt are uniformly distributed throughout the alloy.

[0009] In a further embodiment of any of the foregoing embodiments, the alloy consists of 25-65% zirconium, 25-65% tungsten, and 6-25% of a combined amount of nickel and at least one of iron and cobalt.

[0010] In a further embodiment of any of the foregoing embodiments, the alloy consists essentially of 25-65% zirconium, 5-65% tungsten, and 6-25% of a combined amount of nickel and at least one of iron and cobalt.

[0011] An article according to an example of the present disclosure includes a geometric body formed of an alloy having a density of 7.8 grams per cubic centimeter to 11.4 grams per cubic centimeter. The density is selected with respect to a kinetic energy parameter of the geometric body. The alloy includes zirconium, tungsten, nickel, and at least one of iron and cobalt.

[0012] In a further embodiment of any of the foregoing embodiments, the alloy, by weight, includes 25-65% zirconium, 25-65% tungsten, and 6-25% of a combined amount of nickel and at least one of iron and cobalt.

[0013] In a further embodiment of any of the foregoing embodiments, the alloy includes 5-20% nickel.

[0014] In a further embodiment of any of the foregoing embodiments, the alloy includes 1-5% of at least one of iron and cobalt.

[0015] In a further embodiment of any of the foregoing embodiments, the alloy includes iron and excludes cobalt.

[0016] In a further embodiment of any of the foregoing embodiments, the alloy includes cobalt and excludes iron.

[0017] In a further embodiment of any of the foregoing embodiments, the zirconium, tungsten, nickel, and at least one of iron and cobalt are distributed throughout the alloy.

[0018] In a further embodiment of any of the foregoing embodiments, the alloy, by weight, consists of 25-65% zirconium, 25-65% tungsten, and 6-25% of a combined amount of nickel and at least one of iron and cobalt.

[0019] In a further embodiment of any of the foregoing embodiments, the geometric body is spherical, cylindrical, or polygonal.

[0020] An article according to an example of the present disclosure includes a reactive fragment formed of an alloy including, by weight 25-65% zirconium, 25-65% tungsten, and 6-25% of a combined amount of nickel and at least one of iron and cobalt.

[0021] In a further embodiment of any of the foregoing embodiments, the alloy consists essentially of 25-65% zirconium, 25-65% tungsten, and 6-25% of a combined amount of nickel and at least one of iron and cobalt.

[0022] In a further embodiment of any of the foregoing embodiments, the reactive fragment is spherical, cylindrical, or polygonal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The various features and advantages of the present disclosure will become apparent to those skilled in the art from the following detailed description. The drawings that accompany the detailed description can be briefly described as follows.

[0024] FIG. 1 illustrates an example article having a cylindrical body formed of a reactive alloy.

[0025] FIG. 2 illustrates an example article having a polygonal body formed of a reactive material.

[0026] FIG. 3 illustrates an example article having a spherical body formed of the reactive material.

[0027] FIG. 4 illustrates an example article that has a plurality of geometric bodies that are formed of a reactive material.

DETAILED DESCRIPTION

[0028] FIG. 1 illustrates an example article 20 that is formed of the reactive alloy 22. The reactive alloy 22 is reactive in that an input of an initial transitory activation energy triggers a sustained reaction of the reactive alloy 22 to provide a release of thermal energy beyond the input of the initial transitory activation energy. In this regard, the reactive alloy 22 can be used in pyrotechnics, munitions, and the like.

[0029] In this example, the article 20 is a geometric body 24 that is formed of the reactive alloy 22. The geometric body 24 is cylindrical as shown in FIG. 1; however, as will be appreciated given this disclosure, the geometric body 24 can alternatively have other shapes, such as but not limited to, a polygonal body 124 as shown in FIG. 2 or a spherical body 224 as shown in FIG. 3.

[0030] The geometric body 24 can be formed from the reactive alloy 22. In this regard, the geometric body 24 can exclude organics such that the geometric body 24 is substantially or entirely metallic. The reactive alloy 22 includes, by weight, 25-65% zirconium, 25-65% tungsten, and 6-25% of a combined amount of nickel and at least one of iron and cobalt, amounting to 100%. In a further example, the reactive alloy 22 includes 5-20% of the nickel and 1-5% of at least one of iron and cobalt. In further examples, the reactive alloy 22 includes iron and excludes the cobalt, or vice versa. In additional examples, the zirconium, tungsten, nickel, and at least one of iron and cobalt are uniformly distributed through the reactive alloy 22 (as shown by the uniform pattern of the
reactive alloy 22 in FIG. 1). In yet a further example, the reactive alloy 22 can include only the above-listed elements and impurities.

[0031] The reactive alloy 22 has a density of 7.8 grams per cubic centimeter to 11.4 grams per cubic centimeter. In pyrotechnic, munition, or other similar applications, the density of the reactive alloy 22 can be selected with respect to a kinetic energy parameter. For example, the composition of the reactive alloy 22 is selected with respect to a target density that corresponds to a target kinetic energy given a defined input energy into the geometric body 24. The tungsten of the reactive alloy 22 has a relatively high density in comparison to the other elements of the composition such that varying the amount tungsten can be used to tailor the density of the reactive alloy 22 according to achieve a target density that corresponds to a target kinetic energy given a defined input energy into the geometric body 24. The composition of the reactive alloy 22 can be further tailored to control the timing and rate at which thermal energy is released upon input of the initial activation energy.

[0032] FIG. 4 schematically illustrates an example implementation of a plurality of the geometric bodies 24 in an article 330. In this example, the article 330 includes a structure 332 having one or more panel side walls 334. One or more of the geometric bodies 24 are attached to at least one of the panels 334. For instance, the geometric bodies 24 can be attached to the panel 334 using an adhesive, one or more fasteners, an interference fit, or combinations thereof, but is not limited to these attachment mechanisms. The geometric bodies 24 serve as reactive fragments in the article 330. In this regard, the article 330 can include an energetic reaction initiator (not shown) that inputs activation energy and kinetic energy into the geometric bodies 24 to propel the geometric bodies 24 outwards and to trigger the reactive thermal energy release from the reactive alloy 22.

[0033] The geometric body or bodies 24 can be formed using powder metallurgy. In one example, elemental or composite powders of the zirconium, tungsten, nickel, and at least one of iron and cobalt are blended to a uniform mixture in amounts that correspond to the weight percentage composition of the reactive alloy 22. The blended powder can then be compacted under pressure into the shape of the geometric body 24 and sintered to consolidate the powder into a solid, unified form. For example, sintering of the compositions disclosed herein can be conducted at a temperature of approximately 1250°C to 1550°C in an evacuated environment that is substantially free of oxygen. Alternatively, the reactive alloy 22 can be melted and cast into the shape of the geometric body 24. As can be appreciated, the processing of the reactive alloy 22 to form the geometric body 24 is not limited to the techniques disclosed herein, and other metal-forming techniques can additionally or alternatively be used, subject to avoidance of processing conditions that initiate the reactive thermal release of the reactive alloy 22.

[0034] Although a combination of features is shown in the illustrated examples, not all of them need to be combined to realize the benefits of various embodiments of this disclosure. In other words, a system designed according to an embodiment of this disclosure will not necessarily include all of the features shown in any one of the Figures or all of the portions schematically shown in the Figures. Moreover, selected features of one example embodiment may be combined with selected features of other example embodiments.

[0035] The preceding description is exemplary rather than limiting in nature. Variations and modifications to the disclosed examples may become apparent to those skilled in the art that do not necessarily depart from the essence of this disclosure. The scope of legal protection given to this disclosure can only be determined by studying the following claims.

What is claimed is:
1. A composition of matter comprising:
an alloy including, by weight:
25-65% zirconium;
25-65% tungsten; and
6-25% of a combined amount of nickel and at least one of iron and cobalt.
2. The composition as recited in claim 1, wherein the alloy includes 5-20% nickel.
3. The composition as recited in claim 1, wherein the alloy includes 1-5% of at least one of iron and cobalt.
4. The composition as recited in claim 1, wherein the alloy includes iron and excludes cobalt.
5. The composition as recited in claim 1, wherein the alloy includes cobalt and excludes iron.
6. The composition as recited in claim 1, wherein the zirconium, tungsten, nickel, and at least one of iron and cobalt are distributed throughout the alloy.
7. The composition as recited in claim 1, wherein the alloy consists of:
25-65% zirconium;
25-65% tungsten; and
6-25% of a combined amount of nickel and at least one of iron and cobalt.
8. The composition as recited in claim 1, wherein the alloy consists essentially of:
25-65% zirconium;
25-65% tungsten; and
6-25% of a combined amount of nickel and at least one of iron and cobalt.
9. An article comprising:
a geometric body formed of an alloy having a density of 7.8 grams per cubic centimeter to 11.4 grams per cubic centimeter, the density being selected with respect to a kinetic energy parameter of the geometric body, the alloy including zirconium, tungsten, nickel, and at least one of iron and cobalt.
10. The article as recited in claim 9, wherein the alloy, by weight, includes:
25-65% zirconium;
25-65% tungsten; and
6-25% of a combined amount of nickel and at least one of iron and cobalt.
11. The article as recited in claim 9, wherein the alloy includes 5-20% nickel.
12. The article as recited in claim 9, wherein the alloy includes 1-5% of at least one of iron and cobalt.
13. The article as recited in claim 9, wherein the alloy includes iron and excludes cobalt.
14. The article as recited in claim 9, wherein the alloy includes cobalt and excludes iron.
15. The article as recited in claim 9, wherein the zirconium, tungsten, nickel, and at least one of iron and cobalt are distributed throughout the alloy.
16. The article as recited in claim 9, wherein the alloy, by weight, consists of:
25-65% zirconium;
25-65% tungsten; and
6-25% of a combined amount of nickel and at least one of iron and cobalt.

17. The article as recited in claim 9, wherein the geometric body is spherical, cylindrical, or polygonal.

18. An article comprising:
   a reactive fragment formed of an alloy including, by weight:
   25-65% zirconium;
   25-65% tungsten; and
   6-25% of a combined amount of nickel and at least one of iron and cobalt.

19. The article as recited in claim 18, wherein the alloy consists essentially of:
   25-65% zirconium;
   25-65% tungsten; and
   6-25% of a combined amount of nickel and at least one of iron and cobalt.

20. The article as recited in claim 18, wherein the reactive fragment is spherical, cylindrical, or polygonal.