CLAIMS

What is claimed is:

1. A cutting element, comprising:

a cutting element substrate; and

a polycrystalline compact bonded to the cutting element substrate, the polycrystalline compact comprising:

a polycrystalline material comprising a plurality of inter-bonded grains of hard material; and

a metallic material disposed in interstitial spaces between the inter-bonded grains of hard material, at least a portion of the metallic material comprising a metal alloy having a melting temperature of about seven hundred fifty degrees Celsius (750°C) or less, the metal alloy comprising two or more elements, a first element of the two or more elements comprising at least one of cobalt, iron, and nickel, a second element of the two or more elements comprising at least one of dysprosium, yttrium, terbium, gadolinium, germanium, samarium, neodymium, and praseodymium.

2. The cutting element of claim 1, wherein the at least one of dysprosium, yttrium, terbium, gadolinium, germanium, samarium, neodymium, and praseodymium comprises at least about five weight percent (5 wt%) or more of the metal alloy.

3. The cutting element of claim 1 or claim 2, wherein the metal alloy is a eutectic composition.

4. The cutting element of claim 1 or claim 2, wherein the metal alloy comprises a near-eutectic composition.

5. The cutting element of claim 4, wherein the near-eutectic composition comprises at least one of a near-eutectic composition of cobalt and dysprosium, a near-eutectic composition of cobalt and yttrium, a near-eutectic composition of cobalt and terbium, a near-eutectic composition of cobalt and gadolinium, a near-eutectic composition of cobalt and germanium, a near-eutectic composition of cobalt and samarium, a near-eutectic composition of cobalt and neodymium, and a near-eutectic composition of cobalt and praseodymium.

6. The cutting element of claim 4, wherein the near-eutectic composition comprises at least one of a near-eutectic composition of iron and dysprosium, a near-eutectic composition of iron and yttrium, a near-eutectic composition of iron and terbium, a near-eutectic composition of iron and gadolinium, a near-eutectic composition of iron and germanium, a near-eutectic composition of iron and samarium, a near-eutectic composition of iron and neodymium, and a near-eutectic composition of iron and praseodymium.

7. The cutting element of claim 4, wherein the near-eutectic composition comprises at least one of a near-eutectic composition of nickel and dysprosium, a near-eutectic composition of nickel and yttrium, a near-eutectic composition of nickel and terbium, a near-eutectic composition of nickel and gadolinium, a near-eutectic composition of nickel and germanium, a near-eutectic composition of nickel and samarium, a near-eutectic composition of nickel and neodymium, and a near-eutectic composition of nickel and praseodymium.

8. The cutting element of claim 1 or claim 2, wherein the metal alloy has a melting temperature of about three hundred degrees Celsius (300°C) or more.

9. The cutting element of claim 8, wherein the metal alloy has a melting temperature of between about five hundred fifty degrees Celsius (550°C) and about six hundred fifty degrees Celsius (650°C).

10. The cutting element of claim 1 or claim 2, wherein the metallic material comprises between about one percent by volume (1 vol%) and about twenty percent by volume (20 vol%) of the polycrystalline compact.

11. The cutting element of claim 1, wherein the metallic material is not disposed in a portion of the interstitial spaces between the inter-bonded grains of hard material, the portion of the interstitial spaces between the inter-bonded grains of hard material comprising voids between the inter-bonded grains of hard material.

12. The cutting element of any one of claims 1, 2, and 11, wherein the hard material comprises diamond.

13. An earth-boring tool, comprising:

a tool body; and

at least one cutting element of any one of claims 1, 2, and 11 attached to the tool body.

14. A method of forming a polycrystalline compact, comprising:

forming an unsintered compact preform comprising a plurality of grains of hard material;

sintering the compact preform in the presence of a catalyst material for catalyzing the formation of inter-granular bonds between the grains of hard material of the plurality of grains of hard material, sintering the compact preform comprising forming a polycrystalline material comprising interbonded grains of hard material formed by bonding together the plurality of grains of hard material; and

providing a metal alloy in at least some interstitial spaces between the inter-bonded grains of hard material; and

formulating the metal alloy to comprise at least two elements;

selecting a first element of the at least two elements from the group consisting of cobalt, iron, and nickel; and

selecting a second element of the at least two elements from the group consisting of dysprosium, yttrium, terbium, gadolinium, germanium, samarium, neodymium, and praseodymium.

15. The method of claim 14, further comprising formulating the metal alloy to comprise a near-eutectic composition.

16. The method of claim 14, further comprising formulating the metal alloy to comprise a eutectic composition.

17. The method of any one of claims 14 or 16, further comprising formulating the metal alloy to have a melting temperature of about seven hundred fifty degrees Celsius (750°C) or less.

18. The method of claim 17, further comprising formulating the metal alloy to have a melting temperature of between about five hundred fifty degrees Celsius (550°C) and about six hundred fifty degrees Celsius (650°C).

19. The method of one of claims 14 or 16, further comprising causing the metal alloy to comprise between about one percent by volume (1 vol%) and about twenty percent by volume (20 vol%) of the polycrystalline compact.

20. The method of one of claims 14 or 16, further comprising:

providing the metal alloy in a first region of the polycrystalline material; and

forming a second region of the polycrystalline material to be at least substantially free of the metal alloy.

CLAIMS

What is claimed is:

1. A polycrystalline compact, comprising:

a polycrystalline material comprising a plurality of inter-bonded grains of hard material; and

a metallic material disposed in interstitial spaces between the inter-bonded grains of hard material, at least a portion of the metallic material comprising a metal alloy having a melting temperature of about seven hundred fifty degrees Celsius (750° C) or less, the metal alloy comprising two or more elements, a first element of the two or more elements selected from the group consisting of cobalt, iron, and nickel, a second element of the two or more elements selected from the group consisting of dysprosium, yttrium, terbium, gadolinium, germanium, samarium, neodymium, and praseodymium.

2. The polycrystalline compact of claim 1, wherein the second element comprises at least about five weight percent (5 wt%) or more of the metal alloy.

3. The polycrystalline compact of claim 1, wherein the metal alloy comprises a near-eutectic composition.

4. The polycrystalline compact of claim 3, wherein the metal alloy is a eutectic composition.

5. The polycrystalline compact of claim 4, wherein the metal alloy is selected from the group consisting of a binary eutectic composition, a ternary eutectic composition, and a quaternary eutectic composition.

6. The polycrystalline compact of claim 3, wherein the near-eutectic composition is selected from the group consisting of a near-eutectic composition of cobalt and dysprosium, a near-eutectic composition of cobalt and yttrium, a near-eutectic composition of cobalt and terbium, a near-eutectic composition of cobalt and gadolinium, a near-eutectic composition of cobalt and germanium, a near-eutectic composition of cobalt and samarium, a near-eutectic composition of cobalt and neodymium, and a near-eutectic composition of cobalt and praseodymium.

7. The polycrystalline compact of claim 3, wherein the near-eutectic composition is selected from the group consisting of a near-eutectic composition of iron and dysprosium, a near-eutectic composition of iron and yttrium, a near-eutectic composition of iron and terbium, a near-eutectic composition of iron and gadolinium, a near-eutectic composition of iron and germanium, a near-eutectic composition of iron and samarium, a near-eutectic composition of iron and neodymium, and a near-eutectic composition of iron and praseodymium.

8. The polycrystalline compact of claim 3, wherein the near-eutectic composition is selected from the group consisting of a near-eutectic composition of nickel and dysprosium, a near-eutectic composition of nickel and yttrium, a near-eutectic composition of nickel and terbium, a near-eutectic composition of nickel and gadolinium, a near-eutectic composition of nickel and germanium, a near-eutectic composition of nickel and samarium, a near-eutectic composition of nickel and neodymium, and a near-eutectic composition of nickel and praseodymium.

9. The polycrystalline compact of claim 1, wherein the metal alloy has a melting temperature of about three hundred degrees Celsius (300° C) or more.

10. The polycrystalline compact of claim 9, wherein the metal alloy has a melting temperature of about six hundred fifty degrees Celsius (650° C) or less.

11. The polycrystalline compact of claim 10, wherein the metal alloy has a melting temperature of between about five hundred fifty degrees Celsius (550° C) and about six hundred fifty degrees Celsius (650° C).

12. The polycrystalline compact of claim 1, wherein the polycrystalline material comprises between about eighty percent by volume (80 vol%) and about ninety nine percent by volume (99 vol%) of the polycrystalline compact.

13. The polycrystalline compact of claim 10, wherein the metallic material comprises between about one percent by volume (1 vol%) and about twenty percent by volume (20 vol%) of the polycrystalline compact.

14. The polycrystalline compact of claim 1, wherein the polycrystalline material comprises:

a first region, the metal alloy having a melting temperature of about seven hundred fifty degrees Celsius (750° C) or less disposed in the first region of the polycrystalline material; and

a second region, the metal alloy having a melting temperature of about seven hundred fifty degrees Celsius (750° C) or less not disposed in the second region of the polycrystalline material.

15. The polycrystalline compact of claim 1, wherein the metallic material is not disposed in a portion of the interstitial spaces between the inter-bonded grains of hard material, the portion of the interstitial spaces between the inter-bonded grains of hard material comprising voids between the inter-bonded grains of hard material.

16. The polycrystalline compact of claim 1, wherein the hard material comprises diamond.

17. A polycrystalline compact, comprising:

a polycrystalline material comprising a plurality of inter-bonded grains of hard material; and

a metallic material disposed in interstitial spaces between the inter-bonded grains of hard material, at least a portion of the metallic material comprising a metal alloy having a melting temperature of about seven hundred fifty degrees Celsius (750° C) or less, the metal alloy comprising a near-eutectic composition of at least two elements, a first element of the at least two elements selected from the group consisting of cobalt, iron, and nickel, a second element of the at least two elements selected from the group consisting of dysprosium, yttrium, terbium, gadolinium, germanium, samarium, neodymium, and praseodymium.

18. The polycrystalline compact of claim 17, wherein the metal alloy is a eutectic composition.

19. A cutting element, comprising:

a cutting element substrate; and

a polycrystalline compact bonded to the cutting element substrate, the polycrystalline compact comprising:

a polycrystalline material comprising a plurality of inter-bonded grains of hard material; and

a metallic material disposed in interstitial spaces between the inter-bonded grains of hard material, at least a portion of the metallic material comprising a metal alloy having a melting temperature of about seven hundred fifty degrees Celsius (750° C) or less, the metal alloy comprising two or more elements, a first element of the two or more elements selected from the group consisting of cobalt, iron, and nickel, a second element of the two or more elements selected from the group consisting of dysprosium, yttrium, terbium, gadolinium, germanium, samarium, neodymium, and praseodymium.

20. The cutting element of claim 19, wherein the metal alloy comprises a near-eutectic composition.

21. The cutting element of claim 20, wherein the hard material comprises diamond.

22. The cutting element of claim 21, wherein the metal alloy has a melting temperature of between about five hundred fifty degrees Celsius (550° C) and about six hundred fifty degrees Celsius (650° C).

23. A cutting element, comprising:

a cutting element substrate; and

a polycrystalline compact bonded to the cutting element substrate, the polycrystalline compact comprising:

a polycrystalline material comprising a plurality of inter-bonded grains of hard material; and

a metallic material disposed in interstitial spaces between the inter-bonded grains of hard material, at least a portion of the metallic material comprising a metal alloy having a melting temperature of about seven hundred fifty degrees Celsius (750° C) or less, the metal alloy comprising a near-eutectic composition of at least two elements, a first element of the at least two elements selected from the group consisting of cobalt, iron, and nickel, a second element of the at least two elements selected from the group consisting of dysprosium, yttrium, terbium, gadolinium, germanium, samarium, neodymium, and praseodymium.

24. The polycrystalline compact of claim 23, wherein the metal alloy is a eutectic composition.

25. An earth-boring tool, comprising:

a tool body; and

at least one cutting element attached to the tool body, the at least one cutting element comprising

a polycrystalline compact comprising:

a polycrystalline material comprising a plurality of inter-bonded grains of hard material; and

a metallic material disposed in interstitial spaces between the inter-bonded grains of hard material, at least a portion of the metallic material comprising a metal alloy having a melting temperature of about seven hundred fifty degrees Celsius (750° C) or less, the metal alloy comprising two or more elements, a first element of the two or more elements selected from the group consisting of cobalt, iron, and nickel, a second element of the two or more elements selected from the group consisting of dysprosium, yttrium, terbium, gadolinium, germanium, samarium, neodymium, and praseodymium.

26. The earth-boring tool of claim 25, wherein the metal alloy comprises a near-eutectic composition.

27. A method of forming a polycrystalline compact, comprising:

forming an unsintered compact preform comprising a plurality of grains of hard material;

sintering the compact preform in the presence of a catalyst material for catalyzing the formation of inter-granular bonds between the grains of hard material of the plurality of grains of hard material, sintering the compact preform comprising forming a polycrystalline material comprising interbonded grains of hard material formed by bonding together the plurality of grains of hard material; and

providing a metal alloy having a melting temperature of about seven hundred fifty degrees Celsius (750° C) or less in at least some interstitial spaces between the inter-bonded grains of hard material; and

formulating the metal alloy to comprise at least two elements;

selecting a first element of the at least two elements from the group consisting of cobalt, iron, and nickel; and

selecting a second element of the at least two elements from the group consisting of dysprosium, yttrium, terbium, gadolinium, germanium, samarium, neodymium, and praseodymium.

28. The method of claim 27, further comprising sintering the compact preform at a pressure greater than about five gigapascals (5.0 GPa) and a temperature greater than about one thousand three hundred degrees Celsius (1,300° C).

29. The method of claim 28, further comprising selecting the plurality of grains of hard material to comprise a plurality of diamond grains.

30. The method of claim 27, further comprising formulating the metal alloy to comprise a near-eutectic composition.

31. The method of claim 30, further comprising formulating the metal alloy to comprise a eutectic composition.

32. The method of claim 31, further comprising formulating the eutectic composition to comprise one of a binary eutectic composition, a ternary eutectic composition, and a quaternary eutectic composition.

33. The method of claim 30, further comprising formulating the near-eutectic composition to comprise at least one of a near-eutectic composition of cobalt and dysprosium, a near-eutectic composition of cobalt and yttrium, a near-eutectic composition of cobalt and terbium, a near-eutectic composition of cobalt and gadolinium, a near-eutectic composition of cobalt and germanium, a near-eutectic composition of cobalt and samarium, a near-eutectic composition of cobalt and neodymium, and a near-eutectic composition of cobalt and praseodymium.

34. The method of claim 30, further comprising formulating the near-eutectic composition to comprise at least one of a near-eutectic composition of iron and dysprosium, a near-eutectic composition of iron and yttrium, a near-eutectic composition of iron and terbium, a near-eutectic composition of iron and gadolinium, a near-eutectic composition of iron and germanium, a near-eutectic composition of iron and samarium, a near-eutectic composition of iron and neodymium, and a near-eutectic composition of iron and praseodymium.

35. The method of claim 30, further comprising formulating the near-eutectic composition to comprise at least one of a near-eutectic composition of nickel and dysprosium, a near-eutectic composition of nickel and yttrium, a near-eutectic composition of nickel and terbium, a near-eutectic composition of nickel and gadolinium, a near-eutectic composition of nickel and germanium, a near-eutectic composition of nickel and samarium, a near-eutectic composition of nickel and neodymium, and a near-eutectic composition of nickel and praseodymium.

36. The method of claim 27, further comprising formulating the metal alloy to have a melting temperature of about six hundred fifty degrees Celsius (650° C) or less.

37. The method of claim 36, further comprising formulating the metal alloy to have a melting temperature of between about five hundred fifty degrees Celsius (550° C) and about six hundred fifty degrees Celsius (650° C).

38. The method of claim 27, further comprising causing the polycrystalline material to comprise between about eighty percent by volume (80 vol%) and about ninety nine percent by volume (99 vol%) of the polycrystalline compact.

39. The method of claim 38, further comprising causing the metal alloy to comprise between about one percent by volume (1 vol%) and about twenty percent by volume (20 vol%) of the polycrystalline compact.

40. The method of claim 27, further comprising:
providing the metal alloy in a first region of the polycrystalline material; and
forming a second region of the polycrystalline material to be at least substantially free of the metal alloy.

41. The method of claim 27, wherein selecting the first element further comprises selecting the first element to comprise at least a portion of the catalyst material.

42. The method of claim 27, wherein providing the metal alloy in at least some interstitial spaces between the inter-bonded grains of hard material comprises alloying at least a portion of the catalyst material with at least the second element of the at least two elements.

43. The method of claim 27, further comprising removing the metal alloy from at least a portion of the interstitial spaces between the inter-bonded grains of hard material.

44. The method of claim 43, wherein removing the metal alloy comprises heating the metal alloy to a temperature of about seven hundred fifty degrees Celsius (750° C) or less to melt the metal alloy, and removing the molten metal alloy from the polycrystalline compact prior to using the polycrystalline compact in an earth-boring process.

45. The method of claim 44, wherein removing the metal alloy comprises removing the metal alloy from the polycrystalline compact during use of the polycrystalline compact in an earth-boring process.