transformation is accelerated in the presence of cobalt through a combination of mechanical and chemical effects. For example, the shear resistance of the cobalt drops rapidly, and the grains are not strongly held, leading to additional damage to the surface. It is also known that the real area of contact depends on the velocity with which plastic strains are propagated in the metal binder. The shearing occurs so rapidly that full plastic yielding under the normal load is not possible.

[0014] In addition, there is a significant difference between the thermal expansion coefficients of cobalt and diamond. During heating, cobalt expands at a higher rate than diamond. The amount of thermal stress in the diamond table increases, and the structure breaks down. The cobalt between the diamond crystals expands and breaks the diamond-to-diamond bonds, allowing for chipping and cracking of the diamond grains from the PD table.

[0015] PDC cutters can be categorized by their abrasion resistance, impact resistance and thermal stability, and it is difficult to achieve all three properties maximized in one cutter variant. In general, a cutter that is highly abrasion resistant is characterized by fine diamond particle/grain size, and a cutter that is highly impact resistant is characterized by a coarse particle/grain size.

[0016] Accordingly, there remains a need in the art for a fixed cutter bit with a cutting structure capable of enhancing bit ROP, and bit durability. Such cutting structures would be particularly well-received if they included PD material with enhanced bonding between diamond grains to provide improved resistance to mechanical failure and thermal properties. As such, embodiments disclosed herein address the requirement for improved thermal stability in PDC cutting elements, and further embodiments provide PDC cutting elements with characteristics to impart high abrasive resistance and high impact strength as compared to certain conventional cutters known in the art.

BRIEF SUMMARY OF THE DISCLOSURE

[0017] In an ~~aspect~~embodiment, there is provided a method for making a cutter element for a drill bit, the method comprising: forming a suspension comprising nanocrystalline diamond particles and a solvent; forming a blend comprising a first plurality of polycrystalline diamond particles and a second plurality of polycrystalline diamond particles, wherein each of the first plurality of polycrystalline diamond particles has a size that is greater than a size of each of the second plurality of polycrystalline diamond particles and mixing the blend and the suspension to form a mixture, wherein the mixture comprises less than 5 wt. % of the nanocrystalline diamond particles, further comprising: spray drying the mixture to form a dry mixture,

wherein the dry mixture comprises a plurality of nanocrystalline diamond coated polycrystalline diamond particles (NDCPD), wherein the plurality of nanocrystalline diamond particles are homogenously distributed around each of the plurality of polycrystalline diamond particles; and sintering the dry mixture to form the cutter element.

[0018] In an alternate ~~aspect~~embodiment, there is provided a method of making a cutter element for a drill bit, the method comprising: forming a suspension comprising a plurality of nanocrystalline diamond particles and a solvent, wherein the solvent is a polar liquid, and wherein each of the plurality of nanocrystalline diamond particles has a size of 1 nm – 10 nm and disposing a plurality of polycrystalline diamond particles in the suspension to form a mixture, wherein a plurality of the plurality of nanocrystalline diamond particles are homogenously distributed about each of the plurality of polycrystalline diamond particles in the mixture, and wherein the plurality of polycrystalline diamond particles are distributed homogenously throughout the mixture, and wherein each of the plurality of polycrystalline diamond particles has a size of 15 μm - 50 μm; wherein the zeta potential of at least one of the suspension and the mixture is from ±30 to ±100mV,the method further comprising drying the mixture using a solgel process; forming a dried mixture after drying the mixture, wherein the dried mixture comprises the plurality of nanocrystalline diamond particles homogenously distributed about each of the plurality of polycrystalline diamond particles, and wherein the plurality of polycrystalline diamond particles are distributed homogenously throughout the dried mixture; and sintering the dry mixture to form the cutter element.

[0019] In ~~an alternate~~one aspect, there is provided a method of making a cutter element for a drill bit, the method comprising: forming a suspension comprising a plurality of nanocrystalline diamond particles and a solvent, wherein the solvent is a polar liquid; disposing a plurality of polycrystalline diamond particles in the suspension to form a mixture, wherein a plurality of the plurality of nanocrystalline diamond particles are homogenously distributed about each of the plurality of polycrystalline diamond particles in the mixture, and wherein the plurality of polycrystalline diamond particles are distributed homogenously throughout the mixture; and wherein the zeta potential of at least one of the suspension and the mixture is from ±30 to ±100mV, the method further comprising: drying the mixture using one of a spray-drying or a solgel process, wherein the dry mixture comprises a plurality of nanocrystalline diamond coated polycrystalline diamond particles (NDCPD), wherein the plurality of nanocrystalline diamond particles are homogenously distributed around each of the plurality of polycrystalline diamond particles; forming a dried mixture after drying the mixture, wherein the dried mixture comprises the plurality of plurality of nanocrystalline diamond particles homogenously

CLAIMS

What is claimed is:

1. A method for making a cutter element for a drill bit, the method comprising:

forming a suspension comprising nanocrystalline diamond particles and a solvent;

forming a blend comprising a first plurality of polycrystalline diamond particles and a second plurality of polycrystalline diamond particles, wherein each of the first plurality of polycrystalline diamond particles has a size that is greater than a size of each of the second plurality of polycrystalline diamond particles;

mixing the blend and the suspension to form a mixture, wherein the mixture comprises less than 5 wt. % of the nanocrystalline diamond particles;

spray drying the mixture to form a dry mixture, wherein the dry mixture comprises a plurality of nanocrystalline diamond coated polycrystalline diamond particles (NDCPD), wherein the plurality of nanocrystalline diamond particles are homogenously distributed around each of the plurality of polycrystalline diamond particles; and

sintering the dry mixture to form the cutter element.

2. The method of claim 1, wherein the blend further comprises a third plurality of polycrystalline diamond particles, wherein each of the third plurality of polycrystalline diamond particles is between 1 μm and 10μm.

3. The method of claim 2, wherein the blend further comprises a fourth plurality of polycrystalline diamond particles, wherein each of the fourth plurality of polycrystalline diamond particles is between 0.01 μm and 5 μm.

4. The method of claim 3, wherein the mixture comprises;

about 5% to about 10 % by weight of the first plurality of polycrystalline diamond particles;

about 70% to about 80% by weight of the second plurality of polycrystalline diamond particles;

about 1% to about 5 % by weight of the third plurality of polycrystalline diamond particles;

about 1% to 5 % by weight of the fourth plurality of polycrystalline diamond particles; and

about 0.01% to about 1% by weight of the plurality of nanocrystalline diamond particles.

5. The method of claim 4, wherein the mixture further comprises;

about 1% by weight of tantalum; and

about 1% by weight of tungsten.

6. The method of claim 1, wherein the size of each of the first plurality of polycrystalline diamond particles is between 15 μm and 50 μm.

7. The method of claim 1, wherein the size of each of the first plurality of polycrystalline diamond particles is between 20 μm and 40μm.

8. The method of claim 1, wherein the size of each of the first plurality of polycrystalline diamond particles is between 22 μm and 36 μm.

9. The method of claim 1, wherein the size of each of the second plurality of polycrystalline diamond particles is between 5 μm and 15μm.

10. The method of claim 1, wherein the size of each of the second plurality of polycrystalline diamond particles is between 8 μm and 12μm.

11. The method of claim 2, wherein the size of each of the third plurality of polycrystalline diamond particles is between 4 μm and 6 μm.

12. The method of claim 3, wherein the size of each of the fourth plurality of polycrystalline diamond particles is between 1 μm and 3 μm.

13. The method of claim 1, wherein each of the plurality of nanocrystalline diamond particles has a size between 1nm and 10 nm.

14. The method of claim 1, wherein each of the plurality of nanocrystalline diamond particles has a size between 4nm and 6 nm.

15. The method of claim 1, wherein each of the plurality of nanocrystalline diamond particles has a size of about 5nm.

16. The method of claim 1, wherein the solvent is selected from the group consisting of water, alcohols, polar liquids, non-polar liquids, water miscible organic solvent, hydrophilic solvents, and hydrophobic solvents.

17. The method of claim 1, wherein the solvent is water.

18. The method of claim 1, wherein the mixing further comprises coating the first and second plurality of polycrystalline diamond particles with the plurality of nanocrystalline diamond particles by van der Waals adhesion forces to form the plurality of nanocrystalline diamond coated polycrystalline diamond particles.

19. The method of claim 1, wherein the plurality of nanocrystalline diamond particles comprise elongated geometry, spherical geometry, irregular geometry or combinations thereof

20. A method of making a cutter element for a drill bit, the method comprising:

forming a suspension comprising a plurality of nanocrystalline diamond particles and a solvent, wherein the solvent is a polar liquid, and wherein each of the plurality of nanocrystalline diamond particles has a size of 1 nm – 10 nm;

disposing a plurality of polycrystalline diamond particles in the suspension to form a mixture, wherein a plurality of the plurality of nanocrystalline diamond particles are homogenously distributed about each of the plurality of polycrystalline diamond particles in the mixture, and wherein the plurality of polycrystalline diamond particles are distributed homogenously throughout the mixture, and wherein each of the plurality of polycrystalline diamond particles has a size of 15 μm - 50 μm;

wherein the zeta potential of at least one of the suspension and the mixture is from ±30 to ±100mV;

drying the mixture using a solgel process;

forming a dried mixture after drying the mixture, wherein the dried mixture comprises the plurality of nanocrystalline diamond particles homogenously distributed about each of the plurality of polycrystalline diamond particles, and wherein the plurality of polycrystalline diamond particles are distributed homogenously throughout the dried mixture;

sintering the dry mixture to form the cutter element.

21. The method of claim 20, wherein the polar liquid is water, alcohol, glycol, or combinations thereof.

22. The method of claim 20, wherein the nanocrystalline diamond particles are doped diamond particles, undoped diamond particles, or combinations of doped and undoped diamond particles.

23. The method of claim 22, wherein the suspension comprises doped diamond particles, undoped diamond particles, or a mix of doped and undoped diamond particles.

24. The method of claim 22, wherein the mixture is doped with a dopant selected from the group consisting of Al, B, N, Ti, P, V, Ti, Cr, Ta, and Zr.

25. The method of claim 22, wherein the nanocrystalline diamond particles comprise substantially SP3 carbon.

26. The method of claim 22, wherein the nanocrystalline diamond particles are derivitized with a chemical moiety.

27. The method of claim 26, wherein the moiety comprises alkenyl, alkynyl, carboxyl, hydroxyl, amino, amido, epoxy, keto, alkoxy, ether, ester, lactones, metallic groups, organometallic groups, polymeric groups, ionic groups, or combinations thereof.

28. The method of claim 20, wherein the mixture further comprises a metal catalyst selected from cobalt, iron, nickel, or alloys thereof.

29. The method of claim 20, wherein the mixture further comprises a cobalt catalyst.

30. A method of making a cutter element for a drill bit, the method comprising:

forming a suspension comprising a plurality of nanocrystalline diamond particles and a solvent, wherein the solvent is a polar liquid;

disposing a plurality of polycrystalline diamond particles in the suspension to form a mixture, wherein a plurality of the plurality of nanocrystalline diamond particles are homogenously distributed about each of the plurality of polycrystalline diamond particles in the mixture, and wherein the plurality of polycrystalline diamond particles are distributed homogenously throughout the mixture;

wherein the zeta potential of at least one of the suspension and the mixture is from ±30 to ±100mV;

drying the mixture using one of a spray-drying or a solgel process, wherein the dry mixture comprises a plurality of nanocrystalline diamond coated polycrystalline diamond particles (NDCPD), wherein the plurality of nanocrystalline diamond particles are homogenously distributed around each of the plurality of polycrystalline diamond particles;

forming a dried mixture after drying the mixture, wherein the dried mixture comprises the plurality of plurality of nanocrystalline diamond particles homogenously distributed about each of the plurality of polycrystalline diamond particles, and wherein the plurality of polycrystalline diamond particles are distributed homogenously throughout the dried mixture;

sintering the dry mixture to form the cutter element.

31. The method of claim 30, wherein each of the plurality of nanocrystaline diamond particles has a size of 1 nm – 10 nm.

32. The method of claim 30, wherein each of the plurality of polycrystalline diamond particles

has a size of 15 μm - 50 μm.

33. The method of claim 30, wherein the polar liquid is water, alcohol, glycol, or combinations thereof.

34. The method of claim 30, wherein the nanocrystalline diamond particles are doped diamond particles, undoped diamond particles, or combinations of doped and undoped diamond particles.

35. The method of claim 30, wherein the zeta potential is ±30 mV to ±40 mV.

36. The method of claim 30, wherein the zeta potential is ±41 mV to ±50 mV.

37. The method of claim 30, wherein the zeta potential is ±51 mV to ±60 mV.

38. The method of claim 30, wherein the zeta potential is ±61 mV to ±100 mV.

What is claimed is:

1. A method of making a cutter element for a drill bit, the method comprising:
forming a suspension comprising a plurality of nanocrystalline diamond particles and a solvent, wherein the solvent is a polar liquid;
disposing a plurality of polycrystalline diamond particles in the suspension to form a mixture, wherein a plurality of the plurality of nanocrystalline diamond particles are homogenously distributed about each of the plurality of polycrystalline diamond particles in the mixture, and wherein the plurality of polycrystalline diamond particles are distributed homogenously throughout the mixture;
wherein the zeta potential of at least one of the suspension and the mixture is from ±30 to ±100 mV;
drying the mixture using one of a spray-drying or a solgel process, wherein the dry mixture comprises a plurality of nanocrystalline diamond coated polycrystalline diamond particles (NDCPD), wherein the plurality of nanocrystalline diamond particles are homogenously distributed around each of the plurality of polycrystalline diamond particles;
forming a dried mixture after drying the mixture, wherein the dried mixture comprises the plurality of the plurality of nanocrystalline diamond particles homogenously distributed about each of the plurality of polycrystalline diamond particles, and wherein the plurality of polycrystalline diamond particles are distributed homogenously throughout the dried mixture;
sintering the dry mixture to form the cutter element.

2. The method of claim 1, wherein each of the plurality of nanocrystalline diamond particles has a size of 1 nm-10 nm.

3. The method of claim 1, wherein each of the plurality of polycrystalline diamond particles has a size of 15 μm-50 μm.

4. The method of claim 1, wherein the polar liquid is water, alcohol, glycol, or combinations thereof.

5. The method of claim 1, wherein the nanocrystalline diamond particles are doped diamond particles, undoped diamond particles, or combinations of doped and undoped diamond particles.

6. The method of claim 1, wherein the zeta potential is ±30 mV to ±40 mV.

7. The method of claim 1, wherein the zeta potential is ±41 mV to ±50 mV.

8. The method of claim 1, wherein the zeta potential is ±51 mV to ±60 mV.

9. The method of claim 1, wherein the zeta potential is ±61 mV to ±100 mV.