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(54) Title: FLEXIBLE ABRASIVE GRINDING APPARATUS AND RELATED METHODS

(57) Abstract: Flexible abrasive articles and related methods are presented.

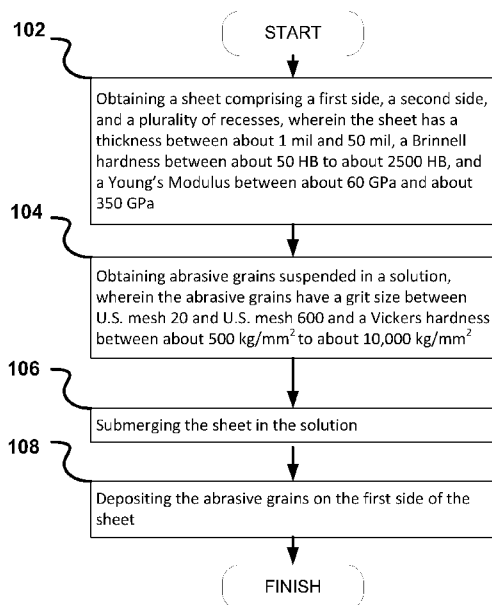


FIG. 1



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FLEXIBLE ABRASIVE GRINDING APPARATUS AND RELATED METHODS

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority to U.S. Patent Application no. 13/192,953, filed July 28, 2011 and also claims benefit under 35 U.S.C. § 119(e) to U.S. Provisional Patent Application Serial No. 61/369,381, filed July 30, 2010, the contents of which are incorporated herein by reference in their entirety.

FIELD OF THE INVENTION

The present disclosure relates generally to flexible abrasive articles and methods for making them.

BACKGROUND OF THE INVENTION

Abrasive articles, such as coated abrasives and bonded abrasives, are used in various industries to machine workpieces, such as by lapping, grinding, or polishing. Machining processes that use abrasive articles span a wide industrial scope from automotive paint repair industries, to metal fabrication industries, to jet engine fabrication industries. In each of these examples, manufacturing facilities use abrasives to remove bulk material or affect surface characteristics of products.

For example, jet engine vanes are thermally deposited with refractory alloys to increase wear resistance of the vanes. The refractory alloy is deposited in a non-uniform fashion on the vanes. To bring the coating to a uniform thickness, manufacturers often use flexible abrasive articles to remove the high spots of refractory alloy. Flexible abrasive articles are better able to accommodate the complex geometrical profile of the vanes than traditional rigid abrasive articles.

Abrasive articles may be made flexible by varying the thickness of the article, by using flexible backing materials, or by adding recesses to the article. The degree of flexibility is a function of the elastic modulus of the material. Higher flexibility is achieved with lower modulus. The material is usually a low stiffness material such as polymer resin composites. In such cases, the retention of the abrasives is also done using a compatible resin system. Such a mechanical retention is not very strong, resulting in very short life of the disk. Loss of grains degrades the performance of these abrasive articles, leading to frequent replacement. Often, an

article that is too thin from a high stiffness material or made thicker from an inherently low stiffness material will wear out more quickly than desired. A known solution to this problem has been to use a perforated disk as the backing material. Perforating a naturally rigid material will increase its flexibility without sacrificing its resilience. Perforating will also improve the cooling properties of the material during operation, and increases the amount of machine waste removed from the workpiece.

In known solutions, abrasive grains are mechanically affixed to the disk. For example, in known flexible disks, abrasive grains may be held in place using resin. These flexible disks wear out quickly, however. The disks flex with each rotation, placing cyclic loads on the resin and the abrasive grain. The bond between the resin and the disk is insufficiently strong to withstand the cyclic loading for long, so the abrasive grains fall off the disk. Loss of grains degrades the performance of these abrasive articles, leading to frequent replacement.

Another sort of abrasive article known in the art uses electroplating methods to significantly increase grit retention on the disk. However, abrasive articles of this sort are not flexible and are ill-suited for use in applications where the workpiece has a complex geometry. Consequently, a need exists therefore that overcomes one or more of the disadvantages of the known processes and products.

DEFINITIONS AND NOTES

A “disk” refers to any shape in which the length and width are very large in comparison to the thickness. A disk may be, but is not necessarily, a circle. In many instances, a disk may be cut (e.g., using a water jet) from a sheet, such as a roll of sheet metal.

The term “recesses” includes both indentations extending partially through the thickness of a sheet or a disk, and perforations extending entirely through the thickness of a sheet or disk.

The “major dimension” of a disk or recess refers to the diameter of the smallest circle that circumscribes the disk or recess. For example, the major dimension of a square recess is its diagonal.

A mil is 1/1000 of an inch.

The size of abrasive grains is given in U.S. mesh. The smaller the grain size, the coarser the grain.

SUMMARY OF THE INVENTION

Embodiments of the invention comprise a process comprising obtaining a sheet comprising a first side, a second, side, and a plurality of recesses, wherein the sheet has a thickness between about 1 mil and about 50 mil, a Brinnell hardness between about 50 HB and about 2500 HB, and a Young's Modulus between about 60 GPa and about 350 GPa; and abrasive grains suspended in a solution, wherein the abrasive grains have a grit size between about U.S. mesh 20 and about U.S. mesh 600 and a Vickers hardness between about 500 kg/mm² and about 10,000 kg/mm²; submerging the sheet in the solution; and depositing the abrasive grains on the first side of the sheet. The grains may be deposited on the sheet in a random fashion or in a regular array. The depositing step may comprise the steps of tacking and plating.

Another embodiment of the invention is a process comprising: obtaining a disk comprising a first face, a second face, and plurality of recesses, wherein the disk has a major dimension between about 0.5 in. and about 8 in., a thickness between about 1 mil and about 50 mil, a Brinnell hardness between about 50 HB and about 2500 HB, and a Young's Modulus between about 60 GPa and about 350 GPa; and abrasive grains suspended in a solution, wherein the abrasive grains have a grit size between about U.S. mesh 20 and about U.S. mesh 600, and a Vickers hardness between about 500 kg/mm² and about 10,000 kg/mm²; submerging the disk in the solution; and depositing the abrasive grains on one face of the disk. The grains may be deposited in a random pattern or in a regular array. The depositing step may comprise the steps of tacking and plating.

Other embodiments of the invention comprise an apparatus comprising a sheet comprising a first side, a second side, and plurality of recesses, wherein the sheet has a thickness between about 1 mil and about 50 mil, a Brinnell hardness between about 50 HB and about 2500 HB, and a Young's Modulus between about 60 GPa and about 350 GPa; and abrasive grains deposited on the first side of the sheet in a random pattern, wherein the abrasive grains have a grit size between about U.S. mesh 20 and about U.S. mesh 600, and a Vickers hardness between about 500 kg/mm² and about 10,000 kg/mm².

Still other embodiments of the invention comprise an apparatus comprising a disk comprising a first face, a second face, and a plurality of recesses, wherein the disk has a major dimension between about 0.5 in. and about 8 in., a thickness between about 1 mil and about 50 mil, a Brinnell hardness between about 50 HB and about 2500 HB, and a Young's Modulus

between about 60 GPa and about 350 GPa; and abrasive grains deposited on the first face in a random pattern, wherein the abrasive grains have a grit size between about U.S. mesh 20 and about U.S. mesh 600, and a Vickers hardness between about 500 kg/mm² and about 10,000 kg/mm².

5 In one aspect, the disclosed processes may further comprise applying an electric current to the solution. In other aspects, depositing may comprise plating with one or more of nickel, chromium, iron, silver, copper, tin, zinc, aluminum, tungsten, cadmium, and bismuth plating.

 In other aspects, the recesses may be circles, ellipses, triangles, squares, pentagons, regular polygons, or irregular polygons. In other aspects, the disk may comprise a circle, and
10 ellipse, or multiple lobes. The recesses may be of regular size and shape, or may be of different sizes and shapes. Further, the recesses may be spaced regularly, or may be spaced randomly.

BRIEF DESCRIPTION OF THE DRAWINGS

 The following drawings illustrate by way of example and not limitation. Every feature of each embodiment is not always labeled in every figure in which that embodiment appears, in
15 order to keep the figures clear.

 FIG. 1 illustrates one embodiment of a process for depositing abrasive grains on a sheet.

 FIG. 2 illustrates one embodiment of a process for depositing abrasive grains on a disk.

 FIG. 3 illustrates a top view of one embodiment of a disk comprising recesses and
abrasive grains.

20 FIG. 4A illustrates a side view of one embodiment of a disk comprising recesses and abrasive grains.

 FIG. 4B illustrates a side view of one embodiment of a disk comprising recesses and abrasive grains.

 FIG. 5 illustrates shapes of various recesses.

25 FIG. 6A–6D illustrate various embodiments of disks having different shapes.

DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

 The term “coupled” is defined as connected, although not necessarily directly, and not necessarily mechanically; two items that are “coupled” may be integral with each other. The
30 terms “a” and “an” are defined as one or more unless this disclosure explicitly requires

otherwise. The terms “substantially,” “approximately,” and “about” are defined as largely but not necessarily wholly what is specified, as understood by a person of ordinary skill in the art.

The terms “comprise” (and any form of comprise, such as “comprises” and “comprising”), “have” (and any form of have, such as “has” and “having”), “include” (and any
5 form of include, such as “includes” and “including”) and “contain” (and any form of contain, such as “contains” and “containing”) are open-ended linking verbs. As a result, an apparatus that “comprises,” “has,” “includes” or “contains” one or more elements possesses those one or more elements, but is not limited to possessing only those one or more elements. Further, a device or structure that is configured in a certain way is configured in at least that way, but it can also be
10 configured in other ways than those specifically described.

The schematic flow chart diagrams that follow are generally set forth as logical flow chart diagrams. As such, the depicted order and labeled steps are indicative of one embodiment of the presented method. Other steps and methods may be conceived that are equivalent in function, logic, or effect to one or more steps, or portions thereof, of the illustrated method.
15 Additionally, the format and symbols employed are provided to explain the logical steps of the method and are understood not to limit the scope of the method. Although various arrow types and line types may be employed in the flow chart diagrams, they are understood not to limit the scope of the corresponding method. Additionally, the order in which a particular method occurs may or may not strictly adhere to the order of the corresponding steps shown. Finally, certain
20 embodiments of the invention may comprise fewer than all illustrated steps. For example, some embodiments of the invention will comprise obtaining, submerging, and depositing steps, but will not comprise cutting, applying, or coupling steps.

Flexible abrasive articles may be used in a variety of applications. In one application, flexible abrasive articles are used to abrade the refractory alloys on the vanes of a jet engine to
25 achieve a uniform thickness. Flexibility is an important feature of the flexible abrasive article because of the complex geometry of many jet engine vanes. A flexible abrasive article is better able to reach all surfaces of a jet engine vane than a rigid abrasive article.

In certain instances, it may be desirable to manufacture and sell finished abrasive articles (e.g., an abrasive disk) to an end user. In other instances, it may be desirable to sell a sheet from
30 which an end user may fabricate its own abrasive articles. The end user may use its own

fabrication equipment (e.g., a CNC cutting machine) to manufacture its own abrasive disks in custom dimensions from the sheet.

Turning now to the figures, FIGS. 1 and 2 illustrate embodiments of processes for depositing abrasive grains on a sheet and a disk. Turning to FIG. 1, a sheet comprising a plurality of recesses is obtained. The sheet is submerged in a solution that contains ionic metal molecules (“plating medium”) in solution and abrasive grains in suspension. For example, a Nickel Watts Bath may be used. The sheet is oriented such that a first side of the sheet will be plated.

In certain embodiments, the sheet is submerged in the solution such that the sheet is oriented substantially horizontally (i.e., the force of gravity acts substantially perpendicularly to the surface of the sheet). The first side of the sheet faces upwards, and the second side of the sheet faces downwards. Gravity pulls the abrasive grains down through the solution to the first side of the sheet.

In some embodiments, using processes known as electroplating, electrodeposition, or electrophoretic deposition, an electric current is applied to the sheet and the solution, with the sheet acting as an anode.

In certain embodiments, the depositing step comprises a tacking step and a plating step. In the tacking step, a solution comprising the plating medium and the abrasive grains is used. When the current is applied, the metal ions and abrasive grains in suspension are deposited on the first side of the sheet. In certain embodiments, the abrasive grains are deposited in a random fashion. In other embodiments, the abrasive grains are deposited in a regular array. Any suitable electroplating method and plating medium may be used to deposit the abrasive grains on the first face of the sheet. For example, nickel, chromium, iron, silver, copper, tin, zinc, aluminum, tungsten, cadmium, and bismuth may be used as the plating medium.

In the plating step, the sheet is placed in a solution comprising the plating medium and any other necessary chemicals used in that step; however, abrasive grains are not present in the solution used for the plating step. As in the tacking step, an electric current is applied to the solution and the sheet. The metal ions from the plating medium are deposited on the first face of the sheet to further anchor the abrasive grains. In certain embodiments, a generally greater amount of plating medium is deposited on the sheet during the plating step than is deposited during the tacking step.

In certain embodiments, the tacking step and the plating step are performed in the same tank. In other embodiments, the tacking step is performed in a different tank than the plating step.

In certain embodiments, electroless (or chemical or auto-catalytic) plating may be used to deposit the abrasive grains on the first side of the sheet. In these embodiments, depositing occurs entirely as a result of chemical reactions between the solution and the sheet; an external electrical current is not required. For example, known methods of electroless nickel plating would be suitable for use in these embodiments.

In certain embodiments, the second side of the sheet may be masked during the depositing step. In certain embodiments, the second side of the sheet is masked during the tacking step, the plating step, or both. The masking may then be removed upon completion of the depositing step, the tacking step, or the plating step. In other embodiments, masking the second side of the sheet may be unnecessary, as only an insignificant amount of abrasive grains may be deposited on the second side.

The sheet may have a thickness of between about 1 and about 50 mil. The sheet may be made of any material or group of materials with a Brinnell hardness between about 50 HB and about 2500 HB and a Young's Modulus between about 60 GPa and about 350 GPa. Examples include metals and alloys of steel, stainless steel, bronze, brass, tungsten carbide, titanium, tantalum, vanadium, copper, nickel, iron, aluminum, cobalt, chromium, tungsten, molybdenum, tin, zinc, and silver.

The abrasive grains may comprise any material having a grit size between about U.S. mesh 20 and about U.S. mesh 600 (between about 900 microns and about 20 microns) and a Vickers hardness between about 500 kg/mm² and about 10,000 kg/mm². In some embodiments, the solution may maintain a homogenous blend of abrasive grains in suspension. In other embodiments, the solution may maintain a heterogeneous blend of abrasive grains in suspension. Examples of suitable abrasive grains include diamond, garnet, zirconium oxide, cubic boron nitride, alumina, tungsten carbide, tungsten boride, tungsten nitride, tungsten oxide, tungsten silicide, titanium, boron, silicon, tantalum, or aluminum.

In other embodiments, as shown in FIGS. 2 and 3, the process may include additional steps directed to cutting a disk 200 from the sheet. As shown in FIGS. 3, 4A and 4B, such a disk 200 may comprise a first face 204 and a second face 206. Abrasive grains will be deposited

primarily on first face 204 of disk 200. In some embodiments, disk 200 is cut from the sheet after the abrasive grains have been plated on the sheet. In other embodiments, disk 200 is cut from the sheet, then the abrasive grains are plated on the sheet. Any suitable mechanical, electrical, or chemical machining process may be used to cut the disk from the sheet. For example, disk 200
5 may be cut using a water jet, a stamping machine, a punching machine, or a laser, or may be chemically cut.

As shown in FIG. 4B, in certain embodiments, the process may comprise an additional step of bending disk 200 to form a shape such that first face 204 is a convex face 214, and second face 206 is a concave face 216. Disk 200 may be bent using any suitable machining
10 process, including die bending, drawing, extruding, or stamping. In some embodiments, disk 200 is bent such that the abrasive grains are deposited on convex side 214. In other embodiments, disk 200 is bent such that the abrasive grains are deposited is concave side 216.

Depending on the desired flexibility of the sheet or disk 200, recesses 202 may be perforations that extend through the entire thickness of the sheet or disk 200 or indentations that
15 extend partially through the thickness of the sheet or disk 200. A more rigid sheet or disk will comprise fewer recesses or will comprise relatively more recesses that are indentations. A more flexible sheet or disk will comprise more recesses or will comprise relatively more recesses that are perforations. Some embodiments may comprise both perforations and indentations. In certain
20 embodiments, the recesses may extend to the outer edge of the article. In other embodiments, the recesses may be concentrated in a central portion of the article such that a portion of the article exists that is substantially free of recesses.

As shown in FIG. 5, recesses 202 may be circles, ellipses, triangles, squares, pentagons, regular polygons, or irregular polygons. The major dimension of each recess 202 may range
25 between about 3 mil and about 500 mil. All recesses on a sheet or disk 200 may be of a uniform size and shape, as is shown in FIG. 3. Or, each sheet or disk 200 may comprise a number of recesses 202 having different sizes or shapes. Recesses 202 may have a spacing between about 3 mil and about 500 mil. Any number of mechanical, chemical, or electrical processes may be used to form recesses 202. For example, recesses 202 may be punched, stamped, chemically
30 machined, cut with a water jet, or cut with a laser. In some embodiments, recesses 202 may extend to the periphery of the sheet or disk 200. In other embodiments, recesses 202 may be concentrated in a first portion of the sheet or disk 200, while a second portion of the sheet or disk

200 does not comprise recesses 202. In still other embodiments, recesses may be regularly-spaced 202. In certain embodiments, recesses

As shown in FIGS 3, 5A, and 5B, other embodiments of the process comprise an additional step of coupling a fastener 212 to disk 200. Fastener 212 may be removably coupled
5 to disk 200, such as with a screw or threaded bolt 210 configured to be received by a corresponding hole 203 in the center of disk 200. Or fastener 212 may be permanently affixed to disk 200, such as through welding, brazing, soldering, or gluing.

Fastener 212 may be any fastener that allows the disk to be coupled to an angle grinder or similar tool. In certain embodiments, fastener 212 comprises a quick-lock spindle. In other
10 embodiments, fastener 212 is a quarter-turn fastener. In still other embodiments, fastener 212 is a spindle that is configured to be coupled to a chuck on an angle grinder, hand drill, or rotary grinder.

Other embodiments of the invention comprise the additional step of coupling a backsheet (not pictured) to second face 206 of disk 200. The backsheet may comprise one or more of a
15 polymer resin, a metal sheet, a metal wire mesh, or woven fibers. The backsheet may be coupled to second face of the disk to increase the stability or durability of the disk. In embodiments where disk 200 comprises perforations, the backsheet may be added to protect against anything (e.g. work gloves, fingers) becoming caught in the perforations. Other embodiments comprise an additional step of applying a coating to second face 206 of disk 200. The coating may comprise a
20 polymer coating, a metal coating, or a metal alloy coating.

As shown in FIGS. 6A–6D, disk 200 may comprise any shape. For example, in some embodiments, disk 200 comprises a circle. In other embodiments, disk 200 may comprise an ellipse. In still other embodiments, disk 200 comprises a plurality of two, three, four, five, six,
25 seven, eight, or more lobes. The major dimension of disk 200 may range from about 0.5 inch to about 8 inches.

The following paragraphs enumerated consecutively from 1 through 175 provide for various aspects of the present invention. In one embodiment, in a first paragraph (1), the present invention provides a process comprising:

obtaining:

30 a sheet comprising a first side, a second, side, and a plurality of recesses, wherein the sheet has a thickness between about 1 mil and about 50 mil, a Brinnell

hardness between about 50 HB and about 2500 HB, and a Young's Modulus between about 60 GPa and about 350 GPa; and abrasive grains suspended in a solution, wherein the abrasive grains have a grit size between about U.S. mesh 20 and about U.S. mesh 600 and a Vickers hardness between about 500 kg/mm² and about 10,000 kg/mm²;

submerging the sheet in the solution; and depositing the abrasive grains on the first side of the sheet.

2. The process of paragraph 1, where depositing further comprises depositing the abrasive grains in a random fashion.

3. The process of paragraph 1, where depositing further comprises depositing the abrasive grains in a regular array.

4. The process of paragraph 1, where depositing further comprises tacking the abrasive grains on the first side of the sheet.

5. The process of paragraph 4, where depositing further comprises plating the sheet with a plating medium.

6. The process of paragraph 1, where depositing further comprises applying an electric current to the solution.

7. The process of paragraph 6, where depositing comprises nickel plating.

8. The process of paragraph 6, where depositing comprises chromium plating.

9. The process of paragraph 6, where depositing comprises iron plating.

10. The process of paragraph 6, where depositing comprises silver plating.

11. The process of paragraph 6, where depositing comprises copper plating.

12. The process of paragraph 6, where depositing comprises tin plating.

13. The process of paragraph 6, where depositing comprises zinc plating.

14. The process of paragraph 6, where depositing comprises aluminum plating.

15. The process of paragraph 6, where depositing comprises tungsten plating.

16. The process of paragraph 6, where depositing comprises cadmium plating.

17. The process of paragraph 6, where depositing comprises bismuth plating.

18. The process of paragraph 1, where depositing comprises electrophoretic deposition.

19. The process of paragraph 1, where depositing comprises electroless nickel plating.

20. The process of paragraph 1, wherein the recesses have a major dimension between
5 about 3 mil and about 500 mil.

21. The process of paragraph 20, wherein the spacing of the recesses is between about 3
mil and about 500 mil.

22. The process of paragraph 20, where the recesses are circular.

23. The process of paragraph 20, where the recesses are elliptical.

10 24. The process of paragraph 20, where the recesses are polygonal.

25. The process of paragraph 24, where the polygon is a three-sided polygon.

26. The process of paragraph 24, where the polygon is a four-sided polygon.

27. The process of paragraph 24, where the polygon is a five-sided polygon.

28. The process of paragraph 24, where the polygon is an irregular polygon.

15 29. The process of paragraph 1, where the sheet comprises steel.

30. The process of paragraph 1, where the sheet comprises copper.

31. The process of paragraph 1, where the sheet comprises aluminum.

32. The process of paragraph 1, where the abrasive grains comprise diamond.

33. The process of paragraph 1, where the abrasive grains comprise aluminum oxide.

20 34. The process of paragraph 1, where the abrasive grains comprise silicon carbide.

35. The process of paragraph 1, where the abrasive grains comprise tungsten carbide.

36. The process of paragraph 1, where the abrasive grains comprise zirconium oxide.

37. The process of paragraph 1, where the abrasive grains comprise comprises garnet.

38. The process of paragraph 1, further comprising cutting a disk from the sheet, wherein
25 the disk comprises a first face and a second face.

39. The process of paragraph 38, wherein the first face of the disk further comprises abrasive grains.

40. The process of paragraph 38, wherein cutting is performed using a water jet.

41. The process of paragraph 38, wherein cutting is performed using a stamping machine.

5 42. The process of paragraph 38, wherein cutting is performed using a punching machine.

43. The process of paragraph 38, wherein cutting is performed using a laser.

44. The process of paragraph 38, further comprising bending the disk.

45. The process of paragraph 38, further comprising coupling a fastener to the disk.

46. The process of paragraph 45, where the fastener is a quick-lock spindle.

10 47. The process of paragraph 45, where the fastener is a quarter-turn fastener.

48. The process of paragraph 38, where the disk is a circle.

49. The process of paragraph 38, where the disk is an ellipse.

50. The process of paragraph 38, where the disk comprises a plurality of lobes.

15 51. The process of paragraph 38, where the major dimension of the disk is between about 0.5 inches and about 8 inches.

52. The process of paragraph 38, wherein the disk has a surface area less than about 52 in.².

53. The process of paragraph 38, further comprising coupling a backsheet to the second face of the disk.

20 54. The process of paragraph 53, where the backsheet comprises a polymer resin.

55. The process of paragraph 54, where the backsheet further comprises woven fibers.

56. The process of paragraph 53, where the backsheet comprises a metal wire mesh.

57. The process of paragraph 38, further comprising applying a coating to the second face of the disk.

25 58. The process of paragraph 57, where the coating comprises a polymer coating.

59. The process of paragraph 57, where the coating comprises a metal coating.

60. The process of paragraph 57, where the coating comprises a metal alloy.

61. A process comprising:

obtaining:

5 a disk comprising a first face, a second face, and plurality of recesses, wherein the disk has a major dimension between about 0.5 in. and about 8 in., a thickness between about 1 mil and about 50 mil, a Brinnell hardness between about 50 HB and about 2500 HB, and a Young's Modulus between about 60 GPa and about 350 GPa; and

10 abrasive grains suspended in a solution, wherein the abrasive grains have a grit size between about U.S. mesh 20 and about U.S. mesh 600, and a Vickers hardness between about 500 kg/mm² and about 10,000 kg/mm²;

submerging the disk in the solution; and

depositing the abrasive grains on the first face of the disk.

15 62. The process of paragraph 61, where depositing further comprises depositing the abrasive grains in a random fashion.

63. The process of paragraph 61, further comprising tacking the abrasive grains on the first face of the disk.

64. The process of paragraph 63, where depositing further comprises plating the sheet with a plating medium.

20 65. The process of paragraph 61, where depositing further comprises depositing the abrasive grains in a regular array.

66. The process of paragraph 61, where depositing further comprises applying an electric current to the solution.

67. The process of paragraph 66, where depositing comprises nickel plating.

25 68. The process of paragraph 66, where depositing comprises chromium plating.

69. The process of paragraph 66, where depositing comprises iron plating.

70. The process of paragraph 66, where depositing comprises silver plating.

71. The process of paragraph 66, where depositing comprises copper plating.

72. The process of paragraph 66, where depositing comprises tin plating.

73. The process of paragraph 66, where depositing comprises zinc plating.

74. The process of paragraph 66, where depositing comprises aluminum plating.

5 75. The process of paragraph 66, where depositing comprises tungsten plating.

76. The process of paragraph 66, where depositing comprises cadmium plating.

77. The process of paragraph 66, where depositing comprises bismuth plating.

78. The process of paragraph 61, where depositing comprises electrophoretic deposition.

79. The process of paragraph 61, where depositing comprises electroless nickel plating.

10 80. The process of paragraph 61, where depositing comprises soldering.

81. The process of paragraph 62, where depositing comprises brazing.

82. The process of paragraph 61, wherein the recesses have a major dimension between about 3 mil and about 500 mil.

15 83. The process of paragraph 82, wherein the spacing of the recesses is between about 3 mil and about 500 mil.

84. The process of paragraph 82, where the recesses are elliptical.

85. The process of paragraph 82, where the recesses are polygonal.

86. The process of paragraph 85, where the polygon is a three-sided polygon.

87. The process of paragraph 85, where the polygon is a four-sided polygon.

20 88. The process of paragraph 85, where the polygon is a five-sided polygon.

89. The process of paragraph 85, where the polygon is an irregular polygon.

90. The process of paragraph 61, where the disk comprises steel.

91. The process of paragraph 61, where the disk comprises copper.

92. The process of paragraph 61, where the disk comprises aluminum.

25 93. The process of paragraph 61, where the abrasive grains comprise diamond.

94. The process of paragraph 61, where the abrasive grains comprise aluminum oxide.

95. The process of paragraph 61, where the abrasive grains comprise silicon carbide.

96. The process of paragraph 61, where the abrasive grains comprise tungsten carbide.

97. The process of paragraph 61, where the abrasive grains comprise zirconium oxide.

5 98. The process of paragraph 61, where the abrasive grains comprise comprises garnet.

99. The process of paragraph 61, further comprising bending the disk.

100. The process of paragraph 61, further comprising coupling a fastener to the disk.

101. The process of paragraph 100, where the fastener is a quick-lock spindle.

102. The process of paragraph 100, where the fastener is a quarter-turn fastener.

10 103. The process of paragraph 61, where the major dimension of the disk is between about 0.5 inches and about 8 inches.

104. The process of paragraph 61, wherein the first face of the disk has a surface area less than about 52 in.².

15 105. The process of paragraph 61, further comprising applying a coating to one side of the disk.

106. The process of paragraph 105, where the coating comprises a polymer coating.

107. The process of paragraph 105, where the coating comprises a metal coating.

108. The process of paragraph 105, where the coating comprises a metal alloy.

109. An apparatus comprising:

20 a sheet comprising a first side, a second side, and plurality of recesses, wherein the sheet has a thickness between about 1 mil and about 50 mil, a Brinnell hardness between about 50 HB and about 2500 HB, and a Young's Modulus between about 60 GPa and about 350 GPa; and

25 abrasive grains deposited on the first side of the sheet, wherein the abrasive grains have a grit size between about U.S. mesh 20 and about U.S. mesh 600, and a Vickers hardness between about 500 kg/mm² and about 10,000

kg/mm².

110. The apparatus of paragraph 109, wherein the abrasive grains are further deposited on the first side of the sheet in a random fashion.

111. The apparatus of paragraph 109, wherein the abrasive grains are further deposited on
5 the first side of the sheet in a regular array.

112. The apparatus of paragraph 109, where the grains are deposited on the sheet with nickel plating.

113. The apparatus of paragraph 109, where the grains are deposited on the sheet with chromium plating.

10 114. The apparatus of paragraph 109, where the grains are deposited on the sheet with iron plating.

115. The apparatus of paragraph 109, where the grains are deposited on the sheet with silver plating.

15 116. The apparatus of paragraph 109, where the grains are deposited on the sheet with copper plating.

117. The apparatus of paragraph 109, where the grains are deposited on the sheet with tin plating.

118. The apparatus of paragraph 109, where the grains are deposited on the sheet with zinc plating.

20 119. The apparatus of paragraph 109, where the grains are deposited on the sheet with aluminum plating.

120. The apparatus of paragraph 109, where the grains are deposited on the sheet with tungsten plating.

25 121. The apparatus of paragraph 109, where the grains are deposited on the sheet with cadmium plating.

122. The apparatus of paragraph 109, where the grains are deposited on the sheet with bismuth plating.

123. The process of paragraph 109, wherein the recesses have a major dimension between about 3 mil and about 500 mil.

124. The process of paragraph 123, wherein the spacing of the recesses is between about 3 mil and about 500 mil.

5 125. The apparatus of paragraph 123, where the recesses are circular.

126. The apparatus of paragraph 123, where the recesses are elliptical.

127. The apparatus of paragraph 123, where the recesses are polygonal.

128. The apparatus of paragraph 127, where the polygon is a three-sided polygon.

129. The apparatus of paragraph 127, where the polygon is a four-sided polygon.

10 130. The apparatus of paragraph 127, where the polygon is a five-sided polygon.

131. The apparatus of paragraph 127, where the polygon is an irregular polygon.

132. The apparatus of paragraph 109, where the sheet comprises steel.

133. The apparatus of paragraph 109, where the sheet comprises copper.

134. The apparatus of paragraph 109, where the sheet comprises aluminum.

15 135. The apparatus of paragraph 109, where the abrasive grains comprise diamond.

136. The apparatus of paragraph 109, where the abrasive grains comprise aluminum oxide.

137. The apparatus of paragraph 109, where the abrasive grains comprise silicon carbide.

20 138. The apparatus of paragraph 109, where the abrasive grains comprise tungsten carbide.

139. The apparatus of paragraph 109, where the abrasive grains comprise zirconium oxide.

140. The apparatus of paragraph 109, where the abrasive grains comprise garnet.

25 141. An apparatus comprising:

a disk comprising a first face, a second face, and a plurality of recesses, wherein

the disk has a major dimension between about 0.5 in. and about 8 in., a thickness between about 1 mil and about 50 mil, a Brinnell hardness between about 50 HB and about 2500 HB, and a Young's Modulus between about 60 GPa and about 350 GPa; and

5 abrasive grains deposited on the first face, wherein the abrasive grains have a grit size between about U.S. mesh 20 and about U.S. mesh 600, and a Vickers hardness between about 500 kg/mm² and about 10,000 kg/mm².

142. The apparatus of paragraph 141, where the abrasive grains are further deposited in a random fashion.

10 143. The apparatus of paragraph 141, where the abrasive grains are further deposited in a regular array.

144. The apparatus of paragraph 141, further comprising a spindle coupled to the second face.

15 145. The apparatus of paragraph 141, where the first face of the disk has a surface area less than about 52 in.².

146. The apparatus of paragraph 141, where the spindle is a quick-lock spindle.

147. The apparatus of paragraph 141, further comprising a backsheet coupled to the spindle and the second face.

148. The apparatus of paragraph 147, where the backsheet comprises a polymer resin.

20 149. The apparatus of paragraph 148, where the backsheet further comprises woven fibers.

150. The apparatus of paragraph 147, where the backsheet comprises a metal wire mesh.

151. The apparatus of paragraph 141, further comprising a coating applied to the second face.

25 152. The apparatus of paragraph 151, where the coating comprises a polymer.

153. The apparatus of paragraph 151, where the coating comprises a metal.

154. The apparatus of paragraph 151, where the coating comprises a metal alloy.

155. The process of paragraph 109, wherein the recesses have a major dimension between about 3 mil and about 500 mil.

156. The process of paragraph 123, wherein the spacing of the recesses is between about 3 mil and about 500 mil.

5 157. The apparatus of paragraph 155, where the recesses are circular.

158. The apparatus of paragraph 155, where the recesses are elliptical.

159. The apparatus of paragraph 155, where the recesses are polygonal.

160. The apparatus of paragraph 159, where the polygon is a three-sided polygon.

161. The apparatus of paragraph 159, where the polygon is a four-sided polygon.

10 162. The apparatus of paragraph 159, where the polygon is a five-sided polygon.

163. The apparatus of paragraph 159, where the polygon is an irregular polygon.

164. The apparatus of paragraph 141, where the sheet comprises steel.

165. The apparatus of paragraph 141, where the sheet comprises copper.

166. The apparatus of paragraph 141, where the sheet comprises aluminum.

15 167. The apparatus of paragraph 141, where the abrasive grains comprise diamond.

168. The apparatus of paragraph 141, where the abrasive grains comprise aluminum oxide.

169. The apparatus of paragraph 141, where the abrasive grains comprise silicon carbide.

20 170. The apparatus of paragraph 141, where the abrasive grains comprise tungsten carbide.

171. The apparatus of paragraph 141, where the abrasive grains comprise zirconium oxide.

172. The apparatus of paragraph 141, where the abrasive grains comprise garnet.

25 173. The process of paragraph 141, where the disk is a circle.

174. The process of paragraph 146, where the disk is an ellipse.

175. The process of paragraph 146, where the disk comprises two, three, four, five, six, seven, eight, nine or more lobes.

The following paragraphs enumerated consecutively from 1 through 15 also provide for additional embodiments of the present invention. In one embodiment, in a first paragraph (1), the present invention provides a process comprising:

obtaining:

a sheet comprising a first side, a second, side, and a plurality of recesses, wherein the sheet has a thickness between about 1 mil and about 50 mil, a Brinnell hardness between about 50 HB and about 2500 HB, and a Young's Modulus between about 60 GPa and about 350 GPa; and

abrasive grains suspended in a solution, wherein the abrasive grains have a grit size between about U.S. mesh 20 and about U.S. mesh 600 and a Vickers hardness between about 500 kg/mm² and about 10,000 kg/mm²;

submerging the sheet in the solution; and

depositing the abrasive grains on the first side of the sheet.

2. The process of paragraph 1, wherein the depositing further comprises applying an electric current to the solution to provide nickel plating, chromium plating, iron plating, silver plating, copper plating, tin plating, zinc plating, aluminum plating, tungsten plating, cadmium plating, or bismuth plating.

3. The process of either paragraph 1 or 2, wherein the recesses are circular, elliptical, or polygonal.

4. The process of any of paragraphs 1 through 3, wherein the sheet comprises steel, copper or aluminum.

5. The process of any of paragraphs 1 through 4, wherein the abrasive grains comprise diamond, aluminum oxide, silicon carbide, tungsten carbide, zirconium oxide, or garnet.

6. The process of any of paragraphs 1 through 5, further comprising cutting a disk from the sheet, wherein the disk comprises a first face and a second face.

7. The process of paragraph 6, further comprising coupling a backsheet to the second face of the disk, wherein the backsheet comprises a polymer resin or a metal wire mesh.

8. An apparatus comprising:

5 a sheet comprising a first side, a second side, and plurality of recesses, wherein the sheet has a thickness between about 1 mil and about 50 mil, a Brinnell hardness between about 50 HB and about 2500 HB, and a Young's Modulus between about 60 GPa and about 350 GPa; and
abrasive grains deposited on the first side of the sheet, wherein the abrasive grains have a
grit size between about U.S. mesh 20 and about U.S. mesh 600, and a Vickers hardness between
10 about 500 kg/mm² and about 10,000 kg/mm².

9. The apparatus of paragraph 8, wherein the recesses are circular, elliptical, or polygonal.

15 10. The apparatus of paragraph 8 or 9, wherein the sheet comprises steel, copper or aluminum.

11. The apparatus of any of paragraphs 8 through 10, wherein the abrasive grains
comprise diamond, aluminum oxide, silicon carbide, tungsten carbide, zirconium oxide, or
20 garnet.

12. The apparatus of any of paragraphs 8 through 11, wherein the sheet is electrolytically
plated with nickel plating, chromium plating, iron plating, silver plating, copper plating, tin
plating, zinc plating, aluminum plating, tungsten plating, cadmium plating, or bismuth plating.
25

13. The apparatus of any of paragraphs 8 through 12, further comprising coupling a
backsheet to the second side of the disk, wherein the backsheet comprises a polymer resin or a
metal wire mesh.

30 14. The apparatus of any of paragraphs 8 through 13, further comprising a spindle coupled to the second face.

15. The apparatus of paragraph 14, further comprising a backsheet coupled to the spindle and the second face.

The appended claims are not to be interpreted as including means-plus-function limitations, unless such a limitation is explicitly recited in a given claim using the phrase(s) “means for” and/or “step.

CLAIMS

I claim:

1. A process comprising:
obtaining:
a sheet comprising a first side, a second, side, and a plurality of recesses, wherein the sheet has a thickness between about 1 mil and about 50 mil, a Brinnell hardness between about 50 HB and about 2500 HB, and a Young's Modulus between about 60 GPa and about 350 GPa;
and
abrasive grains suspended in a solution, wherein the abrasive grains have a grit size between about U.S. mesh 20 and about U.S. mesh 600 and a Vickers hardness between about 500 kg/mm² and about 10,000 kg/mm²;
submerging the sheet in the solution; and
depositing the abrasive grains on the first side of the sheet.
2. The process of claim 1, where depositing further comprises depositing the abrasive grains in a random fashion.
3. The process of claim 1, where depositing further comprises depositing the abrasive grains in a regular array.
4. The process of claim 1, where depositing further comprises tacking the abrasive grains on the first side of the sheet.
5. The process of claim 4, where depositing further comprises plating the sheet with a plating medium.
6. The process of claim 1, where depositing further comprises applying an electric current to the solution.
7. The process of claim 6, where depositing comprises nickel plating.
8. The process of claim 6, where depositing comprises chromium plating.
9. The process of claim 6, where depositing comprises iron plating.

10. The process of claim 6, where depositing comprises silver plating.
11. The process of claim 6, where depositing comprises copper plating.
12. The process of claim 6, where depositing comprises tin plating.
13. The process of claim 6, where depositing comprises zinc plating.
14. The process of claim 6, where depositing comprises aluminum plating.
15. The process of claim 6, where depositing comprises tungsten plating.
16. The process of claim 6, where depositing comprises cadmium plating.
17. The process of claim 6, where depositing comprises bismuth plating.
18. The process of claim 1, where depositing comprises electrophoretic deposition.
19. The process of claim 1, where depositing comprises electroless nickel plating.
20. The process of claim 1, wherein the recesses have a major dimension between about 3 mil and about 500 mil.
21. The process of claim 20, wherein the spacing of the recesses is between about 3 mil and about 500 mil.
22. The process of claim 20, where the recesses are circular.
23. The process of claim 20, where the recesses are elliptical.
24. The process of claim 20, where the recesses are polygonal.
25. The process of claim 24, where the polygon is a three-sided polygon.
26. The process of claim 24, where the polygon is a four-sided polygon.
27. The process of claim 24, where the polygon is a five-sided polygon.
28. The process of claim 24, where the polygon is an irregular polygon.

- 29. The process of claim 1, where the sheet comprises steel.
- 30. The process of claim 1, where the sheet comprises copper.
- 31. The process of claim 1, where the sheet comprises aluminum.
- 32. The process of claim 1, where the abrasive grains comprise diamond.
- 33. The process of claim 1, where the abrasive grains comprise aluminum oxide.
- 34. The process of claim 1, where the abrasive grains comprise silicon carbide.
- 35. The process of claim 1, where the abrasive grains comprise tungsten carbide.
- 36. The process of claim 1, where the abrasive grains comprise zirconium oxide.
- 37. The process of claim 1, where the abrasive grains comprise garnet.
- 38. The process of claim 1, further comprising cutting a disk from the sheet, wherein the disk comprises a first face and a second face.
- 39. The process of claim 38, wherein the first face of the disk further comprises abrasive grains.
- 40. The process of claim 38, wherein cutting is performed using a water jet.
- 41. The process of claim 38, wherein cutting is performed using a stamping machine.
- 42. The process of claim 38, wherein cutting is performed using a punching machine.
- 43. The process of claim 38, wherein cutting is performed using a laser.
- 44. The process of claim 38, further comprising bending the disk.
- 45. The process of claim 38, further comprising coupling a fastener to the disk.
- 46. The process of claim 45, where the fastener is a quick-lock spindle.
- 47. The process of claim 45, where the fastener is a quarter-turn fastener.

48. The process of claim 38, where the disk is a circle.
49. The process of claim 38, where the disk is an ellipse.
50. The process of claim 38, where the disk comprises a plurality of lobes.
51. The process of claim 38, where the major dimension of the disk is between about 0.5 inches and about 8 inches.
52. The process of claim 38, wherein the disk has a surface area less than about 52 in.².
53. The process of claim 38, further comprising coupling a backsheet to the second face of the disk.
54. The process of claim 53, where the backsheet comprises a polymer resin.
55. The process of claim 54, where the backsheet further comprises woven fibers.
56. The process of claim 53, where the backsheet comprises a metal wire mesh.
57. The process of claim 38, further comprising applying a coating to the second face of the disk.
58. The process of claim 57, where the coating comprises a polymer coating.
59. The process of claim 57, where the coating comprises a metal coating.
60. The process of claim 57, where the coating comprises a metal alloy.
61. A process comprising:
obtaining:
a disk comprising a first face, a second face, and plurality of recesses, wherein the disk has a major dimension between about 0.5 in. and about 8 in., a thickness between about 1 mil and about 50 mil, a Brinnell hardness between about 50 HB and about 2500 HB, and a Young's Modulus between about 60 GPa and about 350 GPa; and

abrasive grains suspended in a solution, wherein the abrasive grains have a grit size between about U.S. mesh 20 and about U.S. mesh 600, and a Vickers hardness between about 500 kg/mm² and about 10,000 kg/mm²;

submerging the disk in the solution; and

depositing the abrasive grains on the first face of the disk.

62. The process of claim 61, where depositing further comprises depositing the abrasive grains in a random fashion.

63. The process of claim 61, further comprising tacking the abrasive grains on the first face of the disk.

64. The process of claim 63, where depositing further comprises plating the sheet with a plating medium.

65. The process of claim 61, where depositing further comprises depositing the abrasive grains in a regular array.

66. The process of claim 61, where depositing further comprises applying an electric current to the solution.

67. The process of claim 66, where depositing comprises nickel plating.

68. The process of claim 66, where depositing comprises chromium plating.

69. The process of claim 66, where depositing comprises iron plating.

70. The process of claim 66, where depositing comprises silver plating.

71. The process of claim 66, where depositing comprises copper plating.

72. The process of claim 66, where depositing comprises tin plating.

73. The process of claim 66, where depositing comprises zinc plating.

74. The process of claim 66, where depositing comprises aluminum plating.

75. The process of claim 66, where depositing comprises tungsten plating.
76. The process of claim 66, where depositing comprises cadmium plating.
77. The process of claim 66, where depositing comprises bismuth plating.
78. The process of claim 61, where depositing comprises electrophoretic deposition.
79. The process of claim 61, where depositing comprises electroless nickel plating.
80. The process of claim 61, where depositing comprises soldering.
81. The process of claim 62, where depositing comprises brazing.
82. The process of claim 61, wherein the recesses have a major dimension between about 3 mil and about 500 mil.
83. The process of claim 82, wherein the spacing of the recesses is between about 3 mil and about 500 mil.
84. The process of claim 82, where the recesses are elliptical.
85. The process of claim 82, where the recesses are polygonal.
86. The process of claim 85, where the polygon is a three-sided polygon.
87. The process of claim 85, where the polygon is a four-sided polygon.
88. The process of claim 85, where the polygon is a five-sided polygon.
89. The process of claim 85, where the polygon is an irregular polygon.
90. The process of claim 61, where the disk comprises steel.
91. The process of claim 61, where the disk comprises copper.
92. The process of claim 61, where the disk comprises aluminum.
93. The process of claim 61, where the abrasive grains comprise diamond.

94. The process of claim 61, where the abrasive grains comprise aluminum oxide.
95. The process of claim 61, where the abrasive grains comprise silicon carbide.
96. The process of claim 61, where the abrasive grains comprise tungsten carbide.
97. The process of claim 61, where the abrasive grains comprise zirconium oxide.
98. The process of claim 61, where the abrasive grains comprise comprises garnet.
99. The process of claim 61, further comprising bending the disk.
100. The process of claim 61, further comprising coupling a fastener to the disk.
101. The process of claim 100, where the fastener is a quick-lock spindle.
102. The process of claim 100, where the fastener is a quarter-turn fastener.
103. The process of claim 61, where the major dimension of the disk is between about 0.5 inches and about 8 inches.
104. The process of claim 61, wherein the first face of the disk has a surface area less than about 52 in.².
105. The process of claim 61, further comprising applying a coating to one side of the disk.
106. The process of claim 105, where the coating comprises a polymer coating.
107. The process of claim 105, where the coating comprises a metal coating.
108. The process of claim 105, where the coating comprises a metal alloy.
109. An apparatus comprising:
a sheet comprising a first side, a second side, and plurality of recesses, wherein the sheet has a thickness between about 1 mil and about 50 mil, a Brinnell hardness between about 50 HB and about 2500 HB, and a Young's Modulus between about 60 GPa and about 350 GPa; and

abrasive grains deposited on the first side of the sheet, wherein the abrasive grains have a grit size between about U.S. mesh 20 and about U.S. mesh 600, and a Vickers hardness between about 500 kg/mm² and about 10,000 kg/mm².

110. The apparatus of claim 109, wherein the abrasive grains are further deposited on the first side of the sheet in a random fashion.

111. The apparatus of claim 109, wherein the abrasive grains are further deposited on the first side of the sheet in a regular array.

112. The apparatus of claim 109, where the grains are deposited on the sheet with nickel plating.

113. The apparatus of claim 109, where the grains are deposited on the sheet with chromium plating.

114. The apparatus of claim 109, where the grains are deposited on the sheet with iron plating.

115. The apparatus of claim 109, where the grains are deposited on the sheet with silver plating.

116. The apparatus of claim 109, where the grains are deposited on the sheet with copper plating.

117. The apparatus of claim 109, where the grains are deposited on the sheet with tin plating.

118. The apparatus of claim 109, where the grains are deposited on the sheet with zinc plating.

119. The apparatus of claim 109, where the grains are deposited on the sheet with aluminum plating.

120. The apparatus of claim 109, where the grains are deposited on the sheet with tungsten plating.

121. The apparatus of claim 109, where the grains are deposited on the sheet with cadmium plating.

122. The apparatus of claim 109, where the grains are deposited on the sheet with bismuth plating.
123. The process of claim 109, wherein the recesses have a major dimension between about 3 mil and about 500 mil.
124. The process of claim 123, wherein the spacing of the recesses is between about 3 mil and about 500 mil.
125. The apparatus of claim 123, where the recesses are circular.
126. The apparatus of claim 123, where the recesses are elliptical.
127. The apparatus of claim 123, where the recesses are polygonal.
128. The apparatus of claim 127, where the polygon is a three-sided polygon.
129. The apparatus of claim 127, where the polygon is a four-sided polygon.
130. The apparatus of claim 127, where the polygon is a five-sided polygon.
131. The apparatus of claim 127, where the polygon is an irregular polygon.
132. The apparatus of claim 109, where the sheet comprises steel.
133. The apparatus of claim 109, where the sheet comprises copper.
134. The apparatus of claim 109, where the sheet comprises aluminum.
135. The apparatus of claim 109, where the abrasive grains comprise diamond.
136. The apparatus of claim 109, where the abrasive grains comprise aluminum oxide.
137. The apparatus of claim 109, where the abrasive grains comprise silicon carbide.
138. The apparatus of claim 109, where the abrasive grains comprise tungsten carbide.
139. The apparatus of claim 109, where the abrasive grains comprise zirconium oxide.

140. The apparatus of claim 109, where the abrasive grains comprise comprises garnet.
141. An apparatus comprising:
a disk comprising a first face, a second face, and a plurality of recesses, wherein the disk has a major dimension between about 0.5 in. and about 8 in., a thickness between about 1 mil and about 50 mil, a Brinnell hardness between about 50 HB and about 2500 HB, and a Young's Modulus between about 60 GPa and about 350 GPa; and
abrasive grains deposited on the first face, wherein the abrasive grains have a grit size between about U.S. mesh 20 and about U.S. mesh 600, and a Vickers hardness between about 500 kg/mm² and about 10,000 kg/mm².
142. The apparatus of claim 141, where the abrasive grains are further deposited in a random fashion.
143. The apparatus of claim 141, where the abrasive grains are further deposited in a regular array.
144. The apparatus of claim 141, further comprising a spindle coupled to the second face.
145. The apparatus of claim 141, where the first face of the disk has a surface area less than about 52 in.².
146. The apparatus of claim 141, where the spindle is a quick-lock spindle.
147. The apparatus of claim 141, further comprising a backsheet coupled to the spindle and the second face.
148. The apparatus of claim 147, where the backsheet comprises a polymer resin.
149. The apparatus of claim 148, where the backsheet further comprises woven fibers.
150. The apparatus of claim 147, where the backsheet comprises a metal wire mesh.
151. The apparatus of claim 141, further comprising a coating applied to the second face.
152. The apparatus of claim 151, where the coating comprises a polymer.

- 153. The apparatus of claim 151, where the coating comprises a metal.
- 154. The apparatus of claim 151, where the coating comprises a metal alloy.
- 155. The process of claim 109, wherein the recesses have a major dimension between about 3 mil and about 500 mil.
- 156. The process of claim 123, wherein the spacing of the recesses is between about 3 mil and about 500 mil.
- 157. The apparatus of claim 155, where the recesses are circular.
- 158. The apparatus of claim 155, where the recesses are elliptical.
- 159. The apparatus of claim 155, where the recesses are polygonal.
- 160. The apparatus of claim 159, where the polygon is a three-sided polygon.
- 161. The apparatus of claim 159, where the polygon is a four-sided polygon.
- 162. The apparatus of claim 159, where the polygon is a five-sided polygon.
- 163. The apparatus of claim 159, where the polygon is an irregular polygon.
- 164. The apparatus of claim 141, where the sheet comprises steel.
- 165. The apparatus of claim 141, where the sheet comprises copper.
- 166. The apparatus of claim 141, where the sheet comprises aluminum.
- 167. The apparatus of claim 141, where the abrasive grains comprise diamond.
- 168. The apparatus of claim 141, where the abrasive grains comprise aluminum oxide.
- 169. The apparatus of claim 141, where the abrasive grains comprise silicon carbide.
- 170. The apparatus of claim 141, where the abrasive grains comprise tungsten carbide.
- 171. The apparatus of claim 141, where the abrasive grains comprise zirconium oxide.

- 172. The apparatus of claim 141, where the abrasive grains comprise comprises garnet.
- 173. The process of claim 141, where the disk is a circle.
- 174. The process of claim 146, where the disk is an ellipse.
- 175. The process of claim 146, where the disk comprises two, three, four, five, six, seven, eight, nine or more lobes.

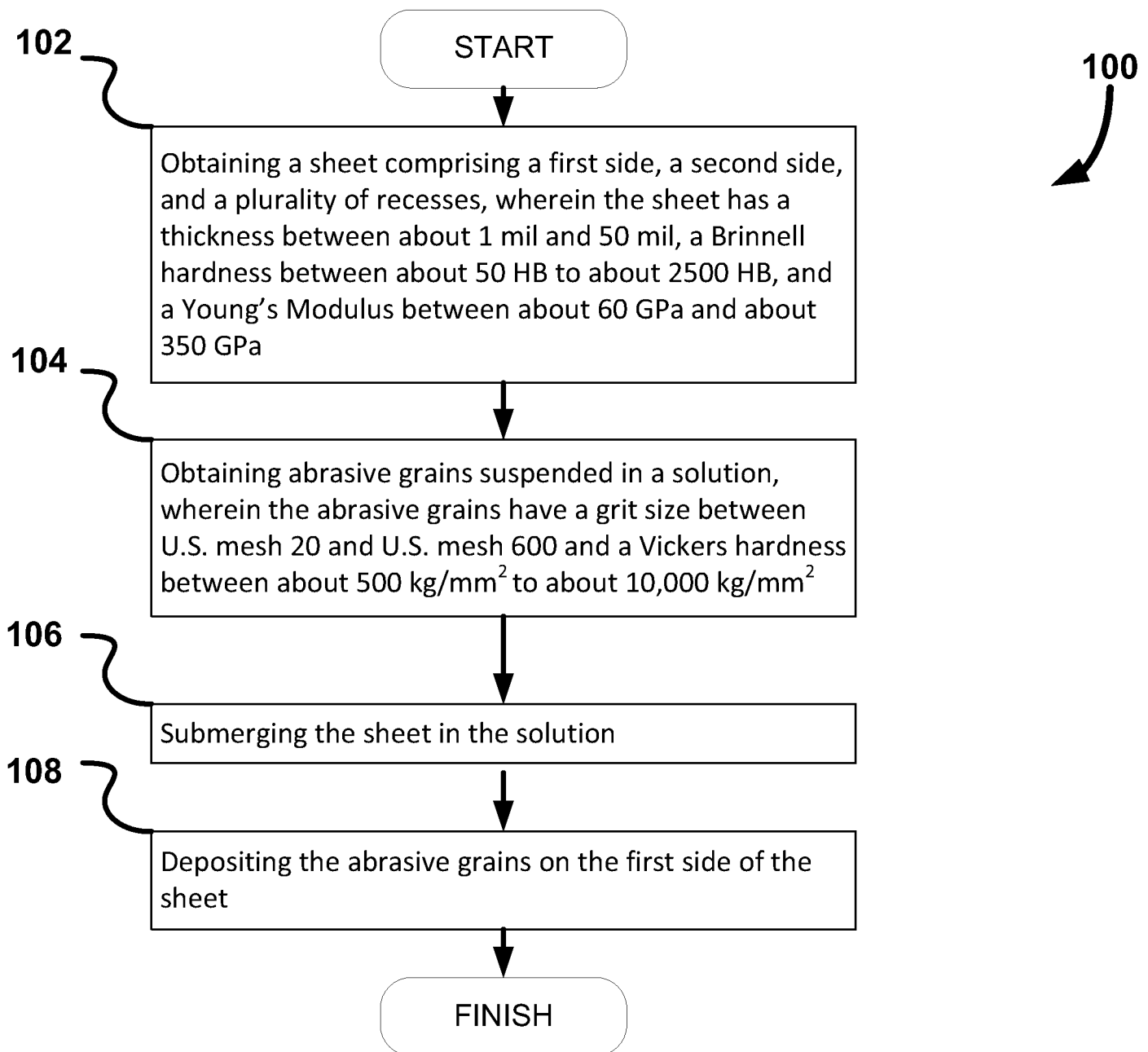


FIG. 1

124

Obtaining a sheet comprising a first side, a second side, and a plurality of recesses, wherein the sheet has a thickness between about 1 mil and about 50 mil, a Brinnell hardness between about 50 HB and about 2500 HB, and a Young's Modulus between about 60 GPa and about 350 GPa

126

Obtaining abrasive grains suspended in a solution, wherein the abrasive grains have a grit size between about U.S. mesh 20 and about U.S. mesh 600 and a Vickers hardness between about 500 kg/mm² and about 10,000 kg/mm²

128

Submerging the sheet in the solution

130

Depositing the abrasive grains on the first side of the sheet

132

Cutting a disk from the sheet, wherein the disk comprises a first face and a second face

134

Applying a coating to the second face of the disk

136

Coupling a backsheet to the second face of the disk

Coupling a fastener to the disk

FINISH

FIG. 2

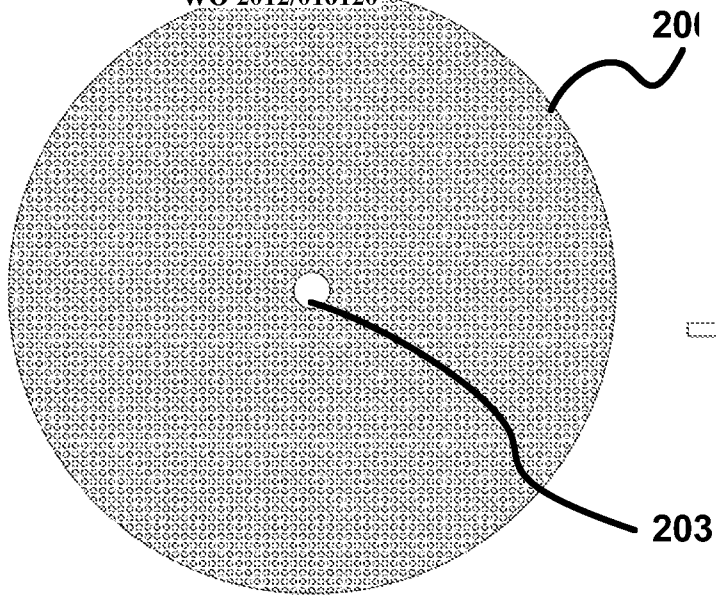


FIG. 3

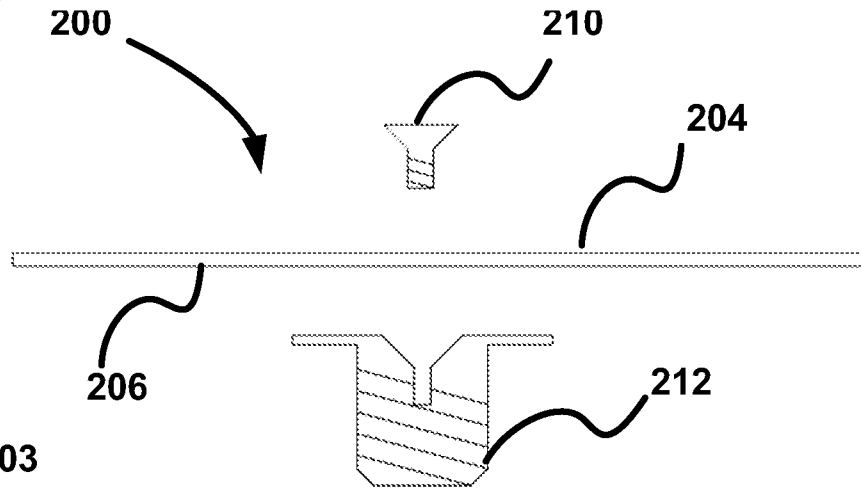


FIG. 4A

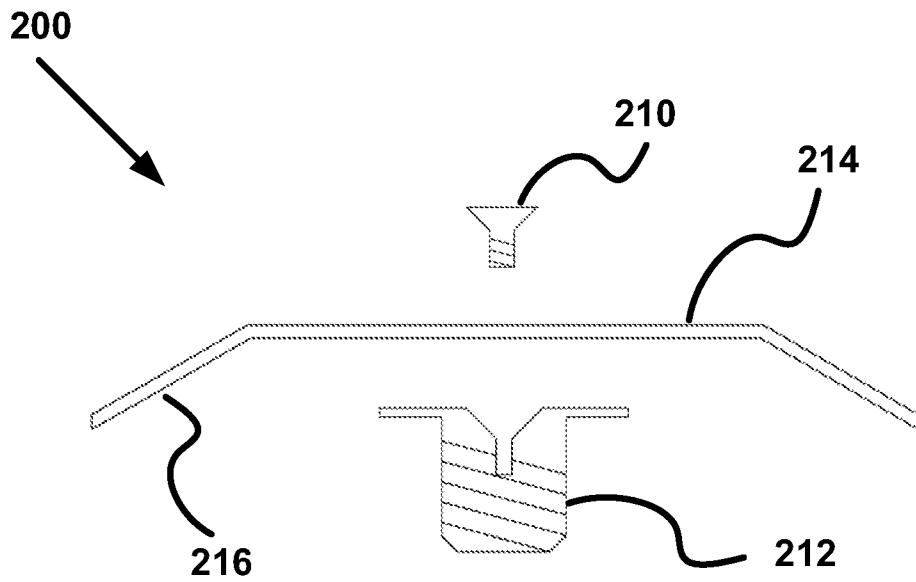


FIG. 4B

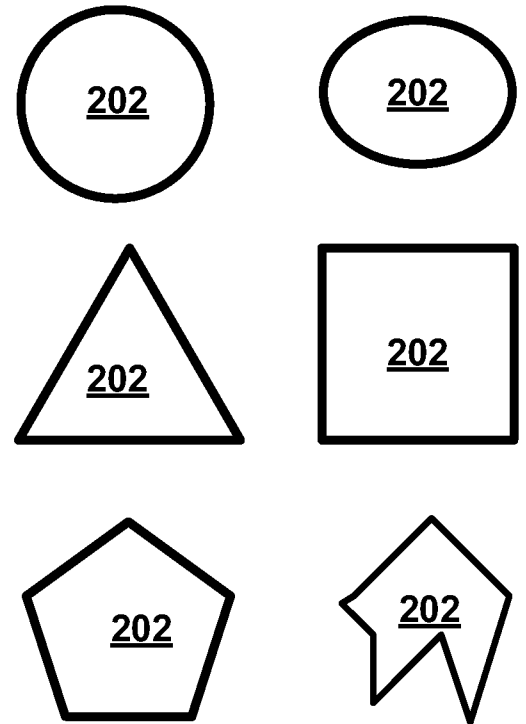


FIG. 5

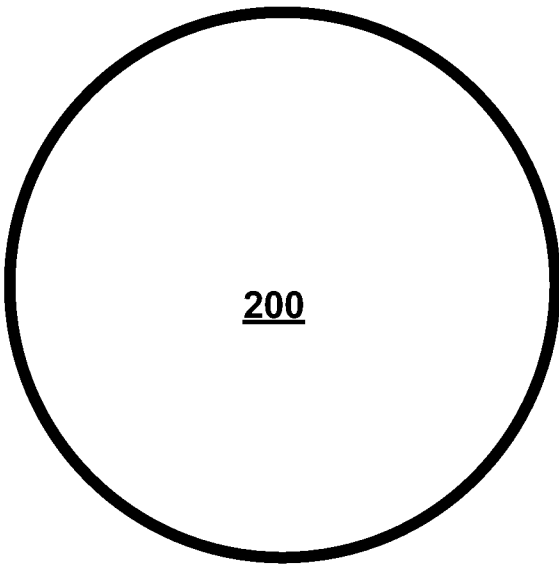


FIG. 6A

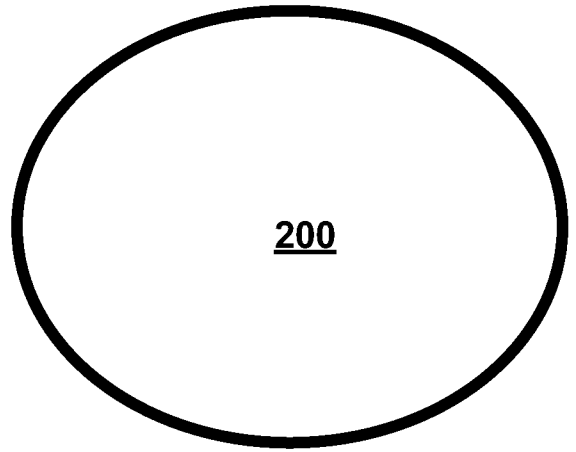


FIG. 6B

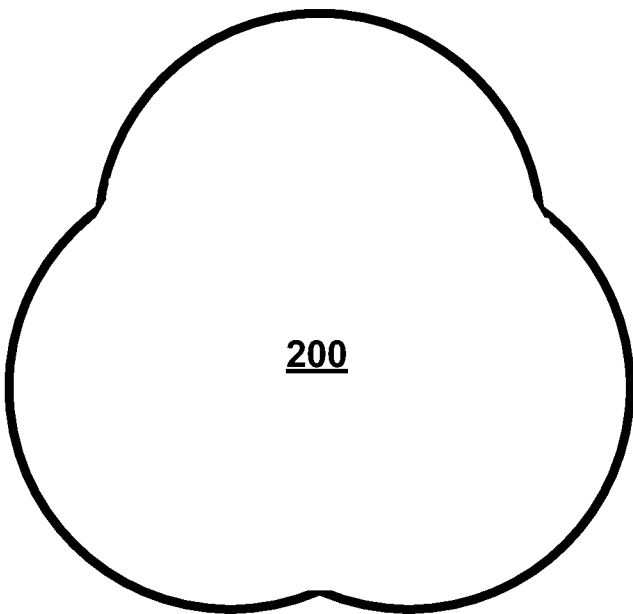


FIG. 6C

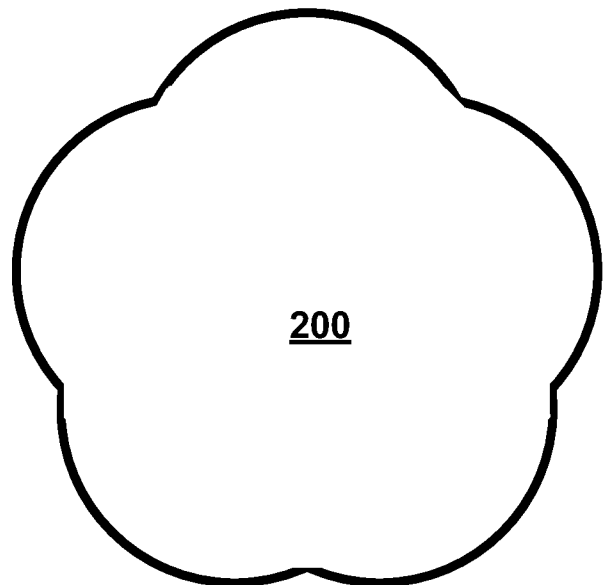


FIG. 6D