

tralized acid polymer composition(s) of inner core layer **440** have Vicat softening temperatures of from 50° C. to 60° C.

Suitable highly neutralized acid polymer compositions for use in forming inner core layer **440** may comprise a highly neutralized acid polymer composition and optionally additives, fillers, and/or melt flow modifiers. The acid polymer is neutralized to 70% or higher, including up to 100%, with a suitable cation source, such as magnesium, sodium, zinc, or potassium.

Suitable additives and fillers include, for example, blowing and foaming agents, optical brighteners, coloring agents, fluorescent agents, whitening agents, UV absorbers, light stabilizers, defoaming agents, processing aids, mica, talc, nanofillers, antioxidants, stabilizers, softening agents, fragrance components, plasticizers, impact modifiers, acid copolymer wax, surfactants; inorganic fillers, such as zinc oxide, titanium dioxide, tin oxide, calcium oxide, magnesium oxide, barium sulfate, zinc sulfate, calcium carbonate, zinc carbonate, barium carbonate, mica, talc, clay, silica, lead silicate, and the like; high specific gravity metal powder fillers, such as tungsten powder, molybdenum powder, and the like; regrind, i.e., inner core material that is ground and recycled; and nanofillers. Suitable melt flow modifiers include, for example, fatty acids and salts thereof, polyamides, polyesters, polyacrylates, polyurethanes, polyethers, polyureas, polyhydric alcohols, and combinations thereof.

Inner core layer **440** may be made by a fabrication method such as hot-press molding or injection molding. In embodiments of the disclosure, the diameter of inner core layer **440** may be in a range of about 21 millimeters to about 28 millimeters, or in a range of about 24 millimeters to about 28 millimeters. Inner core layer **440** may have a surface Shore D hardness of 45 to 55. Inner core layer **440** has a Shore D cross-sectional hardness of from 45 to 55 at any single point on a cross-section obtained by cutting inner core layer **440** in half, and has a Shore D cross-sectional hardness difference between any two points on the cross-section of within ± 6 . By controlling the Shore D hardness difference of inner core layer **440**, the ball over-all performance may be stable. To have a lower ball spin rate, inner core layer **440** may have a compression deformation of from about 3.4 millimeters to about 4.2 millimeters.

To protect thermoplastic inner core layer **440** during core-forming process, it is preferred that outer core layer **430** has a thickness of from 5 millimeters to 9 millimeters and has a volume which is greater than any other layers of golf ball **400**. Outer core layer **430** typically has a surface Shore D hardness of between about 50 to about 60, and the hardness of the outer core layer is greater than the Shore D hardness of inner core layer **440**.

The material making up outer core layer **430** may be thermoset materials selected from the group consisting of polyurethane elastomer, polyamide elastomer, polyurea elastomer, diene-containing polymer (such as polybutadiene), cross-linked metallocene catalyzed polyolefin, silicone, and a mixture thereof. Outer core layer **430** may be made by cross-linking a polybutadiene rubber composition. When other rubber is used in combination with a polybutadiene, it is preferred that polybutadiene is included as a principal component. Specifically, a proportion of polybutadiene in the entire base rubber is preferably equal to or greater than about 50 percent by weight, and particularly preferably equal to or greater than about 80 percent by weight. A polybutadiene having a proportion of cis-1,4 bonds of equal to or greater than about 60 mol percent, and further, equal to or greater than about 80 mol percent, is preferred.

In some embodiments, cis-1,4-polybutadiene may be used as the base rubber and mixed with other ingredients. In some embodiments, the amount of cis-1,4-polybutadiene may be at least about 50 parts by weight, based on 400 parts by weight of the rubber compound. Various additives may be added to the base rubber to form a compound. The additives may include a cross-linking agent and a filler. In some embodiments, the cross-linking agent may be zinc diacrylate, magnesium acrylate, zinc methacrylate, or magnesium methacrylate. In some embodiments, zinc diacrylate may provide advantageous resilience properties. The filler may be used to increase the specific gravity of the material. The filler may include zinc oxide, barium sulfate, calcium carbonate, or magnesium carbonate. In some embodiments, zinc oxide may be selected for its advantageous properties. Metal powder, such as tungsten, may alternatively be used as a filler to achieve a desired specific gravity. In some embodiments, the specific gravity of outer core layer **430** may be from about 1.05 g/cm³ to about 1.25 g/cm³. Further, outer core layer **430** may have a surface Shore D hardness of from about 30 to about 75.

In some embodiments, a polybutadiene synthesized using a rare earth element catalyst is preferred. By using this polybutadiene, excellent resilience performance of golf ball **400** can be achieved. Examples of rare earth element catalysts include lanthanum series rare earth element compound, organoaluminum compound, and alumoxane and halogen containing compound. A lanthanum series rare earth element compound is preferred. Polybutadiene obtained by using lanthanum rare earth-based catalysts usually employ a combination of lanthanum rare earth (atomic number of 57 to 71) compounds, but particularly preferred is a neodymium compound.

Outer core layer **430** is preferably made by hot-press molding process. Suitable vulcanization conditions include a vulcanization temperature of between 130° C. and 190° C. and a vulcanization time of between 5 and 20 minutes. To obtain the desired rubber cross-linked body for use as the core in the present invention, the vulcanizing temperature is preferably at least 140° C.

When outer core layer **430** of the present invention is produced by vulcanizing and curing the rubber composition in the above-described way, advantageous use may be made of a method in which the vulcanization step is divided into two stages. The outer core layer material is placed in an outer core layer-forming mold and subjected to initial vulcanization so as to produce a pair of semi-vulcanized hemispherical cups, and then a prefabricated inner core layer is placed in one of the hemispherical cups and is covered by the other hemispherical cup, in which state complete vulcanization is carried out.

The surface of inner core layer **440** placed in the hemispherical cups may be roughened before the placement to increase adhesion between inner core layer **440** and outer core layer **430**. In some embodiments, inner core layer surface is pre-coated with an adhesive or pre-treated with chemical(s) before placing inner core layer **440** in the hemispherical cups to enhance the durability of the golf ball and enable a high rebound.

Alternatively, the inner core layer may comprise the aforementioned thermoset material while the outer core layer may comprise the thermoplastic material, or any combination thereof.

In embodiments where the core construction is multilayered, the COR of the inner core layer, such as inner core layer **440** in FIG. 1, at forty (40) meters per second may be from about 0.78 to about 0.92, and may be higher than that of the