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Claim Drafting Exercises

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Door stop

BACKGROUND AND SUMMARY OF THE INVENTION

In certain situations, such as when attempting to extinguish a fire in a building or a dwelling, it is often desirable to maintain doors in open positions to provide routes of egress and to control air flow. A commonly known way to accomplish this is to simply insert a wedge between the bottom of the door and the floor. This method, while relatively simple and inexpensive, does have some disadvantages. Specifically, to insert the wedge, the person must typically bend to the surface of the floor and adjust the wedge to hold the door in place. Also, these types of wedges are easily displaced and rendered ineffective.

Another type of known door stop, such as that disclosed in U.S. Pat. No. 4,831,688 to Deininger, is mounted on a hinge between the door and door jam. As can be seen in FIG. 1, this prior art door stop 1 includes a quadrilateral base portion 2 connected to a J-shaped support portion 3. The J-shaped portion 3 hooks over a pivot portion 4 of a door hinge 5 which includes the ring portions 6 of the hinge 5 and the hinge pin 7 directed therethrough. The base 2 extends horizontally outwardly from the J-shaped support portion 3 and prevents the hinge plates 8, and thus the door, from closing.

This prior art door stop is somewhat of an improvement over the simple wedge described above, however, it has some significant limitations. Specifically, the J-shaped support 3 is too short and too wide to accommodate various hinge designs. Since the J-shaped support 3 is relatively wide, it must mount over the pivot portion 4 of the hinge 5, as shown in FIG. 2. If the pivot 4 is too wide, the door stop 1 will not work. Also, as shown in FIG. 3, since the free end of the J-shaped support 3 is relatively short, the door stop 1 can become dislodged, rendering it ineffective.

Another significant limitation of this prior art design is that it cannot be handled or carried easily, especially while wearing gloves, such as fire fighter's gloves. Also, as best seen in FIG. 1, the pointed edges and corners 9 of this prior art design can become embedded in the door and door jam surfaces thereby causing damage and possibly hindering removal. Moreover, this type of door stop cannot be easily stacked and cannot be easily carried on a loop or belt. Finally, the process of making this type of prior design is a two-step manufacturing process. First, the material must be stamped, then the material must be bent.

BRIEF DESCRIPTION OF THE DRAWINGS

For a complete understanding of the above and other features of the invention, reference shall be made to the following detailed description of the preferred embodiments of the invention and to the accompanying drawings, wherein:

FIG. 1 is a perspective view of a Prior Art door stop;

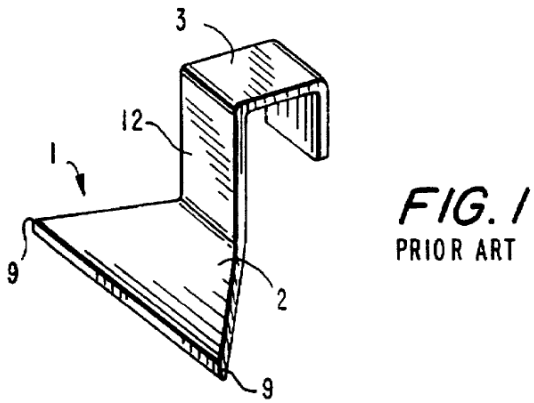


FIG. 2 is a perspective view of the Prior Art door stop of FIG. 1 mounted on a door hinge;

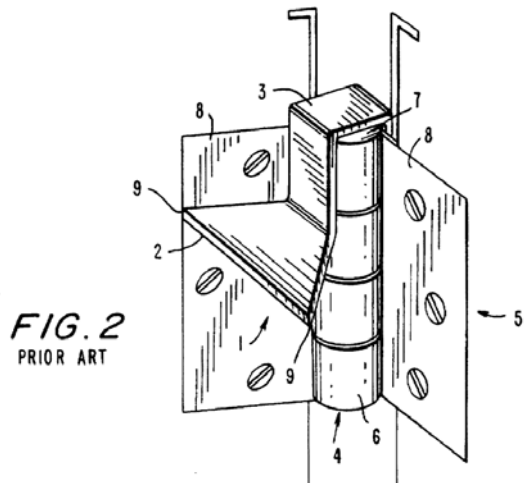


FIG. 3 is a perspective view of the Prior Art door stop of FIG. 1 showing the door stop becoming dislodged by a closing door;

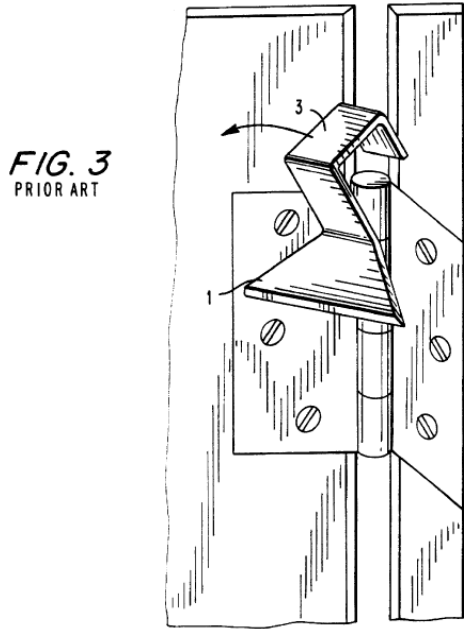


FIG. 4 is a perspective view of the door stop of the present invention;

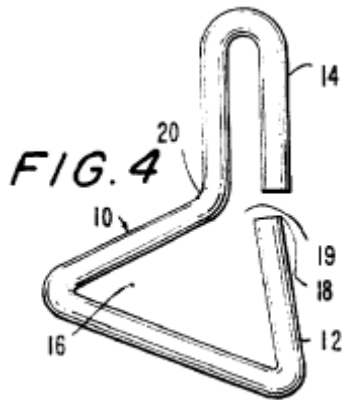


FIG. 5 is a perspective view of the door stop of FIG. 4 mounted on a door hinge; and

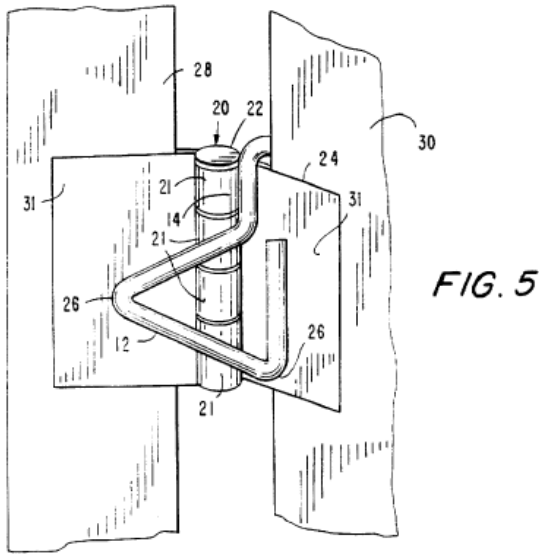
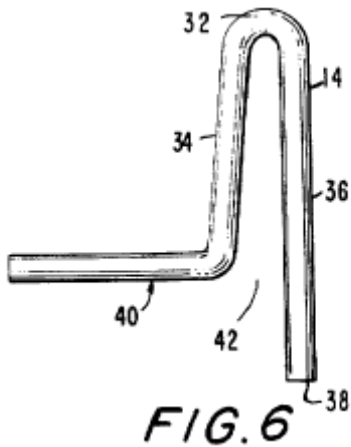


FIG. 6 is a side view of the door stop of FIG. 1.



DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. 4, the door stop 10 of the present invention includes a base 12 and a U-shaped support 14 connected thereto. The door stop 10 is preferably formed of a unitary piece of metal rod having at least four bends forming the U-shaped support 14 aligned perpendicularly to the base 12.

The base 12 is preferably triangular and has a center opening 16 bounded by the rod forming the door stop 10. The opening 16, in addition to decreasing weight, allows the door stop 10 to be mounted on a carrying means, such as a loop or belt. In addition, the opening is preferably large enough to accept a finger covered by a protective glove so that the door stop 10 can be easily and confidently handled while it is being installed and removed. The free end 18 of the base 12 can be spaced from an opposing section 20 of the rod at the junction between the base 12 and the U-shaped support 14 thereby forming

a resiliently deformable gap 19 through which a carrying means can be urged. Alternately, the end 18 can be fixedly connected to the section 20 of the rod forming a closed loop.

Referring to FIG. 5, the door stop 10 can be installed on a door hinge 20 by mounting the U-shaped support portion 14 over the pivot portion of the hinge 20, that is, over the ring portions 21 and hinge post 22. However, preferably the cross section of the rod forming the door stop 10 is narrow such that the support 14 can be mounted over a planar portion 31 of a hinge plate 24 between the ring portions 21 and the door jam 30 (or door 28). Thus, the door stop 10 of the present invention can accommodate many hinge configurations regardless of the dimension of the hinge pin 22 and ring portions 21. In any case the base 12 extends horizontally perpendicularly from the U-shaped support 14 and prevents the door 28 from closing. Preferably, the base 12 has rounded corners 26 which will not puncture or otherwise damage the surfaces of the door 28 or doorjamb 30.

Referring to FIG. 6, the U-shaped support 14 has a trough 32 and two side portions 34, 36. A shorter side portion 34 connects integrally with the base 12. A second side portion 36 is longer than the first side portion 34 and has a free end of 38 which extends below the bottom 40 of the horizontal base 12. In other words, a plane defined by the bottom 40 of the base 12 lies between the free end 38 of the second side portion 36 and the trough 32. When the door stop 10 is mounted on a door hinge, this added length improves stability. Also, some doors are hinged only at the bottom and top of the door jam. In these cases, the door stop can be placed on the floor between the door and door jam and the longer side 32 of the door stop 10 will maintain the base 12 at an inclined angle sufficient to engage the door 28 and prevent its closing. Alternatively, the door stop 10 can be placed underneath the door 28 and used as a simple wedge as described above.

Preferably, the support 14 has an opening 42 with a width less than a width of the ring portions 21 or the hinge pin 22 of the hinge 20 and greater than a width of the planar portions 31 of the hinge 20 such that when the door stop 10 is mounted to the hinge 20, it mounts onto the planar portion 31 in a secure fashion. Also, preferably the length of the support 14 is greater than the opening 42 thereof to enhance stability.

It should be understood, of course, that the specific form of the invention herein illustrated and described is intended to be representative only as certain changes may be made therein without departing from the clear teachings of the disclosure. Accordingly, reference should be made to the following appended claims in determining the full scope of the invention.

Design and fabrication of inductors on a semiconductor substrate

BACKGROUND OF THE INVENTION

An important trend in modern semiconductor technology is the design and fabrication of an integrated circuit (IC) on a semiconductor substrate that includes not only components processing digital signals, e.g., programmable logic devices (PLD), but also components that manipulate analog signals, e.g., capacitors and inductors. Such a mixed-signal type of IC device is particularly useful in wireless applications. For example, a key component of a digital cellular phone is a radio frequency (RF) tuned circuit that can pass or reject analog signals at a certain frequency band. If the tuned circuit is integrated with other components of the phone on a substrate surface, it may significantly reduce the size of the phone as well as its noise level and power consumption.

A crucial component in the tuned circuit is a LC circuit comprising at least one inductor and one capacitor, whose self-resonant frequency determines the frequency range over which the cellular phone can be operated. The LC circuit's self-resonant frequency increases with its inductor's inductance. Since inductance increases with physical size of the inductor, a higher self-resonant frequency requires a physically larger inductor. To attain a required inductance for certain applications, the inductor can be of significant physical size and if implemented in a semiconductor device, requires a large surface area of the semiconductor substrate. To offset this requirement for large physical size, the inductor is typically formed on the surface of a substrate in a spiral form in two dimensions.

FIG. 1 is 2-D a plain view of a prior art horizontal *spiral inductor* fabricated on the surface of a semiconductor substrate 100. The *spiral inductor* includes four turns and two input/output terminals 120 and 140, all formed in the same layer of metallization on top of a semiconductor substrate. Since all four legs of each turn of the *spiral inductor* are located on the same horizontal surface close to the substrate, this may cause a serious parasitic capacitance between the *spiral inductor* and the underlying substrate. This parasitic capacitance not only may increase the noise level and power consumption of the application including the *spiral inductor* but also may reduce the self-resonant frequency of any tuned circuit incorporating the *spiral inductor*.

In view of the discussion above, it is highly desirable to design an inductor has a large inductance, but occupies limited area on the surface of a semiconductor substrate. It is also desirable that this inductor cause little noise in its neighboring components.

BRIEF DESCRIPTION OF THE DRAWINGS

The aforementioned features and advantages of the invention as well as additional features and advantages thereof will be more clearly understood hereinafter as a result of a detailed description of preferred embodiments of the invention when taken in

conjunction with the drawings.

FIG. 1 is a 2-D plain view of a prior art horizontal *spiral inductor* fabricated on the surface of a semiconductor substrate.

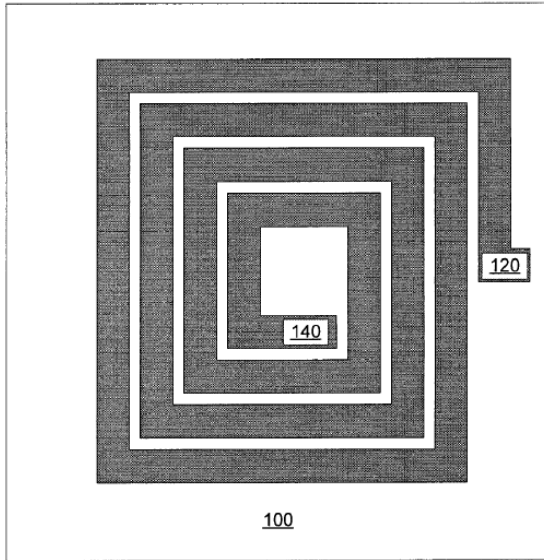


Fig. 1
(Prior Art)

FIGS. 2A and 2B are respective 3-D perspective and 2-D plain views of an inductor fabricated in a circular form on the surface of a semiconductor substrate in accordance with a first embodiment of the present invention.

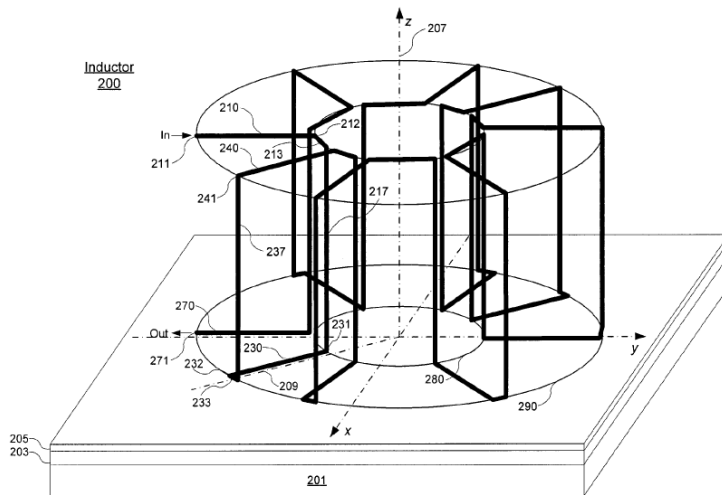


Fig. 2A

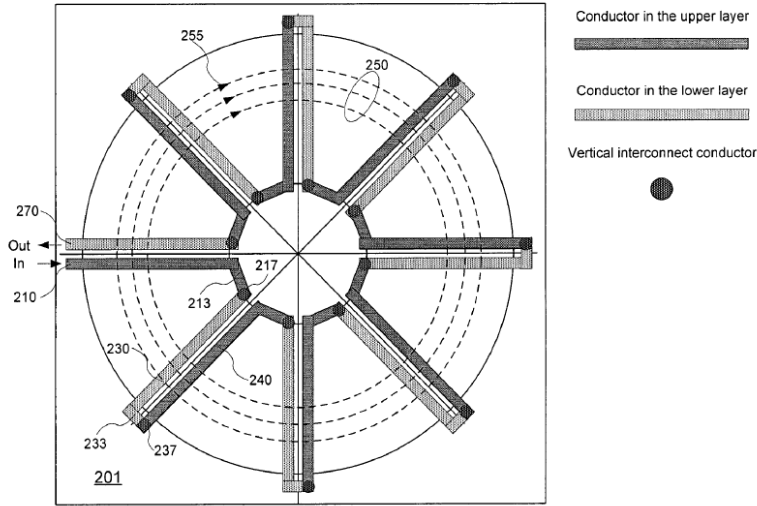


Fig. 2B

FIGS. 3A and 3B are respective 3-D perspective and 2-D plain views of an inductor fabricated in a circular form on the surface of a semiconductor substrate in accordance with a second embodiment of the present invention.

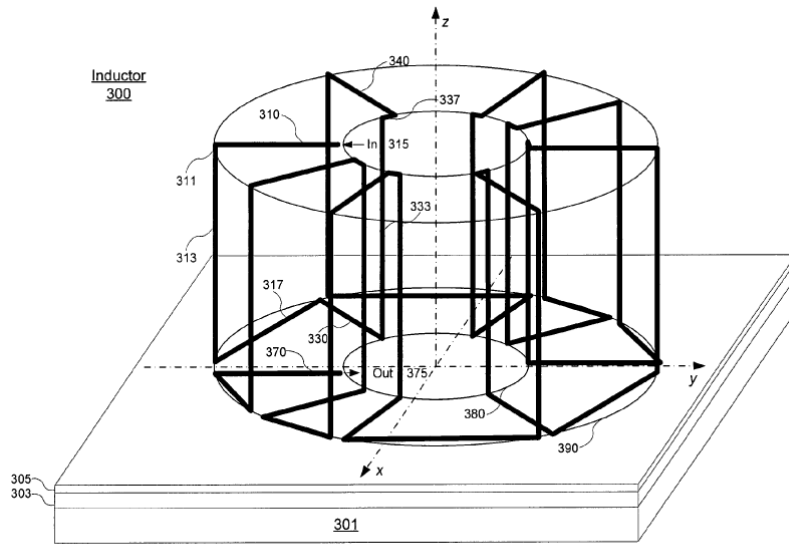


Fig. 3A

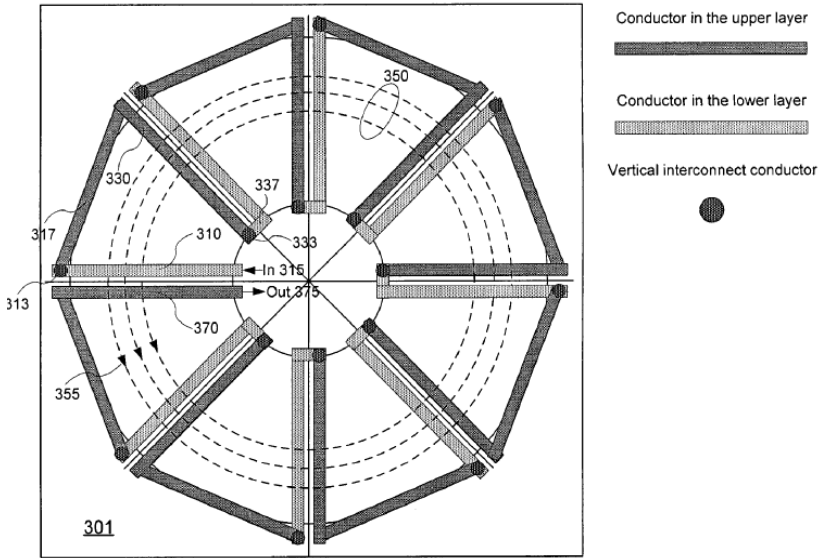


Fig. 3B

FIG. 4 is a 2-D plain view of an inductor fabricated in a circular form on the surface of a semiconductor substrate in accordance with a third embodiment of the present invention.

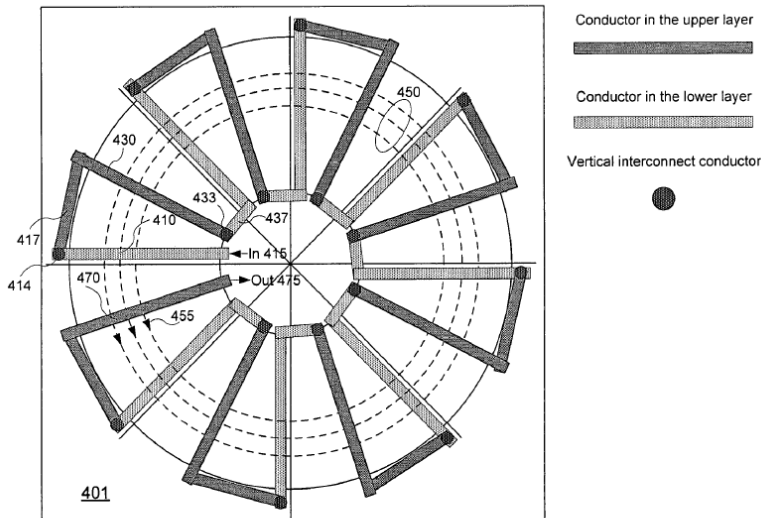


Fig. 4

FIG. 5 is a 2-D plain view of an inductor fabricated in a rectangular form on the surface of a semiconductor substrate in accordance with a fourth embodiment of the present invention.

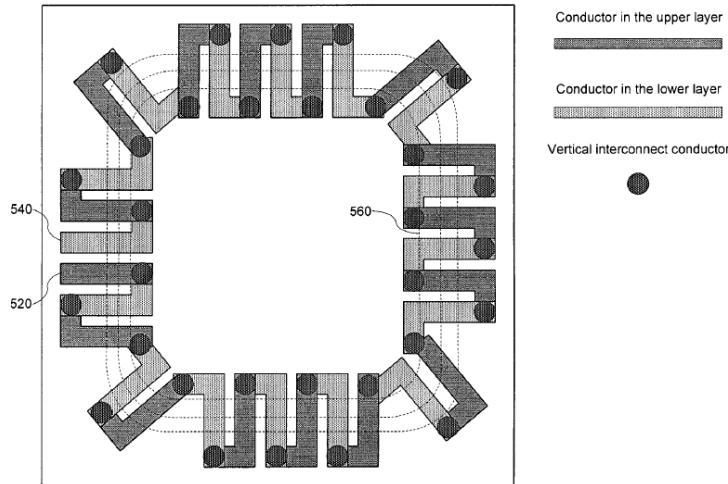


Fig. 5

DETAILED DESCRIPTION OF THE EMBODIMENTS

The present invention is directed to an inductor fabricated on a surface of a semiconductor substrate. This inductor comprises a first set of conductors in a lower dielectric layer, each conductor extending from a central region in the lower layer, a second set of conductors in an upper dielectric layer, each conductor extending from a central region in the upper layer, and a plurality of interconnects extending between selected ends of individual conductors of the first set and selected ends of individual conductors of the second set so as to form a single continuous helical current path through the conductors and the interconnects. This helical current path comprises multiple turns forming a closed tube surrounding the central regions in the upper and lower layers.

FIGS. 2A and 2B are respective 3-D perspective and 2-D plain views of an inductor 200 fabricated in a circular form on the surface of a semiconductor substrate 201 in accordance with a first embodiment of the present invention. As shown in FIG. 2A, the inductor 200 is separated from the substrate 201 by at least one dielectric layer 203. The bottom of the inductor 200 includes a set of conductors evenly distributed in a lower dielectric layer 205, each conductor extending between an inner circle 280 and an outer circle 290. For example, the conductor 230 extends along the radial line 209 from the central axis 207, and it has an inner end 231 on the inner circle 280 and an outer end 232 on the outer circle 290. The top of the inductor 200 includes another set of conductors deployed similarly in an upper dielectric layer (not shown), each conductor in the upper layer having a counterpart in the lower layer. For example, the counterpart of the conductor 210 in the upper layer is the conductor 270 in the lower layer and the two conductors are actually parallel to each other. In some other embodiments, they may not be parallel to each other.

Starting with the conductor 210, there are a plurality of metal interconnects extending between selected ends of individual conductors in the upper layer and selected ends of

individual conductors in the lower layer. Specifically, the interconnect 217 connects the inner end 212 of the conductor 210 in the upper layer with the inner end 231 of the conductor 230 in the lower layer, and the interconnect 237 connects the outer end 232 of the conductor 230 with the outer end 241 of the conductor 240. Note that there are small conductive segments 213 and 233 linking the conductor 210 with the interconnect 217 and the conductor 230 with the interconnect 237, respectively. As a result, the two interconnects 217 and 237 are actually vertical to the upper and lower layers. In some other embodiments, these interconnects may not be vertical to the upper and lower layers. Furthermore, the two conductors (210 and 230) linked by the interconnect 217 are actually not counterparts to each other, while the two conductors (230 and 240) linked by the interconnect 237 are counterparts to each other. This connecting pattern repeats itself until all the conductors in the upper and lower layers are serially connected by the interconnects into a continuous helical current path that terminates at the conductor 270, forming a circular solenoid on the substrate surface that has eight turns.

FIG. 2B shows that the eight turns of the circular solenoid are evenly spaced in a radiating manner above the substrate 201 and they define a circular tube 250 inside the circular solenoid. Note that different fill patterns in the figure represent conductors and interconnects at different locations. An electric current entering the circular solenoid at the conductor 210 and leaving at the conductor 270 generates a magnetic field inside the circular cube 250 as represented by the clockwise magnetic field lines 255. In contrast, an electric current entering the circular solenoid at the conductor 270 and leaving at the conductor 210 will generate a magnetic field inside the circular cube 250 whose direction is opposite to that of the magnetic field lines 255, i.e., counter-clockwise.

There are a number of structural features that distinguish the inductor 200 from a conventional horizontal *spiral inductor* shown in FIG. 1. For example, the light fill represents conductors in the lower layer and the dark fill conductors in the upper layer. Each turn of the inductor includes two horizontal legs (e.g., the horizontal conductors 230 and 240) and two vertical legs (e.g., the vertical conductors 217 and 237). Since there is only one leg, i.e., the conductor 230, close to the substrate 201, the parasitic capacitance between each turn of the inductor and the substrate can be reduced significantly. Second, there is more free space in the upper and lower layers, because each layer only hosts one horizontal leg of each turn of the inductor. As a result, it is possible to increase the width of the conductors in the upper and lower layers and thereby reduce the total series resistance of the inductor and an application incorporating this type of low-resistance inductor may consume less power. Third, the magnetic field generated by the inductor is substantially confined within the circular tube defined by the turns of the inductor, which makes it less likely for the inductor to interfere with its neighboring components on the same and/or surrounding substrates.

FIGS. 3A and 3B are respective 3-D perspective and 2-D plain views of an inductor fabricated in a circular form on the surface of a semiconductor substrate in accordance with a second embodiment of the present invention. As shown in FIG. 3A, the deployment of the conductors in the upper and lower layers according to the second embodiment is similar to that of the first embodiment. There are two sets of conductors,

one in the upper layer and the other in the lower layer, each conductor extending along a radial line from a central axis. What is unique in the second embodiment is that the two conductors (e.g., 310 and 330) whose outer ends are linked together by an interconnect (e.g., 313) using a conductive segment (317) are not parallel to each other, while two conductors (e.g., 330 and 340) whose inner ends are linked together by an interconnect (e.g., 333) using a conductive segment (337) are actually parallel to each other. As a result, the conductive segments (e.g., 317) linking two outer ends in this embodiment are longer than those (e.g., 233) in the first embodiment.

FIG. 3B further illustrates that an electric current that enters the inductor on the conductor 310 and leaves on the conductor 370 generates a magnetic field inside the circular tube 350 as represented by the counter-clockwise magnetic field lines 355. Therefore, the inductor in accordance with the second embodiment shares a similar set of structural features as discussed above in connection with the first embodiment.

What is common among the previous two embodiments is that each turn of the inductor comprises two parallel horizontal legs (e.g., the conductors 230 and 240) and two parallel vertical legs (e.g., the conductors 217 and 237). In contrast, FIG. 4 illustrates a third embodiment in which the two horizontal legs are not parallel to each other. Instead, the projection of a conductor (e.g., 410) in the upper layer forms a fixed angle with the projection of its counterpart conductor (e.g., 470) in the lower layer. The two sets of conductors are linked together by metal interconnects between the two layers, forming a single continuous helical current path that has eight turns. Accordingly, an electric current that enters the current path on the conductor 410 and exits on the conductor 470 generates a counter-clockwise magnetic field in a circular tube 450.

In the previous three embodiments, the helix-shaped current path defines a circular tube above the substrate surface, because all the conductors are arranged to extend outwards from a circle. Practically speaking, the tube defined by the conductors and interconnects does not have to be circular. The benefits discussed above in conjunction with the circular tube can be readily found in other types of configuration, e.g., a polygon-shaped tube, as long as they generate a closed-loop magnetic field. For example, FIG. 5 is a 2-D plain view of an inductor fabricated in a rectangular form on the surface of a semiconductor substrate in accordance with a fourth embodiment of the present invention. In this case, there are also two sets of conductors in two horizontal layers, and each set is deployed along the four edges of the underlying substrate. These two sets of conductors are linked together by metal interconnects between the two layers at selected locations to form an inductor having multiple turns. Accordingly, when an electric current enters into the inductor on conductor 520 and exits on conductor 540, a magnetic field is generated in a rectangular tube defined by the inductor, which has little interference with other components on the same or surrounding substrates. In some embodiments, the conductors in the each layer are arranged to extend outwards from an oval or an ellipse. Accordingly, the magnetic field generated by the conductors will be in an oval or an elliptical tube.

In some other embodiments, the two ends of the inductor are on the same horizontal layer. In this case, the number of conductors in the two layers may be different. In yet some

other embodiments, the inductor may comprise four sets of conductors in four different layers with two sets of conductors in the uppermost and lowermost layers forming a first helical current path and the two sets of conductors in the two inner layers forming a second helical current path which is serially connected with the first helical current path. Depending upon the electric current directions in these two paths, the magnetic field generated by the second helical current path may strengthen or attenuate the magnetic field generated by the first helical current path.