CLAIMS

1. A radio frequency identification (RFID) tag comprising:

a loop antenna that includes:

a first conductive portion having a length and width that substantially exceed a thickness of the first conductive portion, wherein the length and width of the first conductive portion substantially lie in a first plane; and

a second conductive portion having a length and width that substantially exceed a thickness of the second conductive portion, wherein the length and width of the second conductive portion substantially lie in a second plane that is substantially parallel to the first plane, the second conductive portion being electrically coupled to the first conductive portion and configured to couple to a conductive surface of an article to which the RFID tag is attached; and

an RFID circuit electrically connected to the loop antenna, wherein a current is excited through the loop antenna to flow through the first conductive portion, the second conductive portion, and the conductive surface of the article to which the RFID tag is attached in a current loop that lies in a third plane that is substantially perpendicular to the first plane and the second plane.

2. A radio frequency identification (RFID) system comprising:

a reader unit configured to output an interrogating radio frequency (RF) field; and the RFID tag of claim 1.

3. An article comprising:

an electrically conductive surface, and the RFID tag of claim 1, wherein the RFID tag is coupled to the electrically conductive surface of the article.

4. The invention of claims 1, 2, 3, or 3, wherein the second conductive portion electrically or electro-magnetically couples to the conductive surface of the article to form the current loop.

5. The invention of claims 1, 2, 3, or 4, wherein the RFID tag is configured such that the third plane is substantially perpendicular to a surface of an article when attached to the surface of the article.

6. The invention of claims 1, 2, 3, 4, or 5, wherein the RFID tag is configured such that the current flowing through the loop antenna induces a current on a conductive surface of an article to which the RFID tag is attached to enhance a magnetic field generated by the loop antenna.

7. The invention of claim 6, wherein the current induced on the conductive surface of the article substantially doubles an area enclosed by the current loop of the loop antenna.

8. The invention of claim 7, wherein the loop antenna defines an inner space, the RFID tag further comprising a spacer material disposed within the inner space.

9. A method comprising:

at least partially filling a cavity with a curable resin;

pressing a shaping tool into the cavity to shape the resin;

removing the shaping tool after the material has cured thereby defining a plurality of mounting structures extending from a base member;

removing the base member and plurality of mounting structures from the cavity, the base member being substantially flat and comprising an upper surface configured to attach to an radio frequency identification (RFID) tag attaches and a lower surface, the mounting structures extending from the lower surface; and

coupling one or more RFID tags to the upper surface of the base member.

10. The method of claim 9, wherein coupling the one or more RFID tags to the mounting structure comprises placing an RFID tag and one or more protective films into a bottom of the cavity, and wherein at least partially filling the cavity comprises pouring the curable resin over the protective films and RFID tag, the protective films preventing the RFID tag from being damaged by the resin.

11. The method of claim 9, wherein coupling the one or more RFID tags to the mounting structure comprises attaching one or more RFID tags to the upper surface of the mounting structure.

12. The method of claim 11, wherein attaching the RFID tags involves applying an adhesive to the upper surface of the mounting structure, and rolling a roll of RFID tags over the upper surface.

13. The method of claim 9, wherein the plurality of mounting structures comprise at least one of a plurality of ribbed sections positioned along a length of the RFID tag, a plurality of ribbed sections positioned across a length of the RFID tag, a plurality of pillar-like sections that protrude from the lower surface of the flat structure, and a plurality of sections that form one or more channels in at least direction with reference to the RFID tag.

CLAIMS

1. A radio frequency identification (RFID) tag comprising:

a loop antenna that includes:

a first conductive portion having a length and width that substantially exceed a thickness of the first conductive portion, wherein the length and width of the first conductive portion substantially lie in a first plane; and

a second conductive portion having a length and width that substantially exceed a thickness of the second conductive portion, wherein the length and width of the second conductive portion substantially lie in a second plane that is substantially parallel to the first plane, the second conductive portion being electrically coupled to the first conductive portion and configured to couple to a conductive surface of an article to which the RFID tag is attached; and

an RFID circuit electrically connected to the loop antenna, wherein a current is excited through the loop antenna to flow through the first conductive portion, the second conductive portion, and the conductive surface of the article to which the RFID tag is attached in a current loop that lies in a third plane that is substantially perpendicular to the first plane and the second plane.

2. The RFID tag of claim 1, wherein the RFID tag is configured such that the third plane is substantially perpendicular to a surface of an article when attached to the surface of the article.

3. The RFID tag of claim 1, wherein the second conductive portion includes a pair of contact points that couple to the conductive surface to form the current loop.

4. The RFID tag of claim 1, wherein the second conductive portion electrically couples to the conductive surface of the article to form the current loop.

5. The RFID tag of claim 1, wherein the second conductive portion electromagnetically couples to the conductive surface of the article to form the current loop.

6. The RFID tag of claim 1, the loop antenna defining a length, wherein the RFID circuit is centered along the length.

7. The RFID tag of claim 1, the loop antenna defining a length, wherein the RFID circuit is offset from a center of the length of the loop antenna.

8. The article of claim 1, wherein the first conductive portion includes at least one slit that forms a gap in the first conductive portion that functions as the tuning element for tuning the impedance of the antenna to substantially match an impedance of the RFID circuit to which the antenna is coupled.

9. The article of claim 8, wherein the RFID circuit is coupled to the first conductive portion of the loop antenna at a location offset from a center of the loop antenna and the slit that forms the gap in the first conductive portion of the loop antenna is offset from the RFID circuit in the same direction as the RFID circuit is offset from the center of the loop antenna.

10. The article of claim 1, wherein the first conductive portion includes a first conductive trace that substantially overlaps at least a portion of a second conductive trace to form the tuning element for tuning the impedance of the antenna to substantially match an impedance of the RFID circuit to which the antenna is coupled.

11. The article of claim 10, further comprising a non-conductive material separating the overlapping conductive traces.

12. The article of claim 10, wherein the RFID circuit is coupled to the first conductive portion of the loop antenna at a location offset from a center of the loop antenna and the overlapping conductive traces are offset from the RFID circuit in the same direction as the RFID circuit is offset from the center of the loop antenna.

13. The RFID tag of claim 1, wherein the loop antenna is tuned to operate in an ultra high frequency (UHF) range of the radio spectrum.

14. The RFID tag of claim 1, wherein the length of the first conductive portion and the length of the second conductive portion are at least approximately 50 millimeters (mm), the width of the first conductive portion and the width of the second conductive portion are between approximately 12-50 mm, and the thickness of the first and second conductive portion is less than approximately 1 mm.

15. The RFID tag of claim 1, wherein the loop antenna defines an inner space, the RFID tag further comprising a spacer material disposed within the inner space.

16. The RFID tag of claim 1, wherein the RFID circuit comprises one of an integrated circuit (IC), a surface acoustic wave (SAW), and an organic circuit.

17. A radio frequency identification (RFID) system comprising:

a reader unit configured to output an interrogating radio frequency (RF) field; and

an RFID tag comprising:

a loop antenna that includes:

a first conductive portion having a length and width that substantially exceed a thickness of the first conductive portion, wherein the length and width of the first conductive portion substantially lie in a first plane; and

a second conductive portion having a length and width that substantially exceed a thickness of the second conductive portion, wherein the length and width of the second conductive portion substantially lie in a second plane that is substantially parallel to the first plane, the second conductive portion being electrically coupled to the first conductive portion and configured to couple to a conductive surface of an article to which the RFID tag is attached; and

an RFID circuit electrically connected to the loop antenna, wherein a current is excited through the first conductive portion, the second conductive portion and the

conductive surface of the article to which the RFID tag is attached in a current loop that lies in a third plane that is substantially perpendicular to the first plane and the second plane to output an RF signal in response to the interrogating RF signal.

18. The system of claim 17, wherein the RFID tag is configured such that the third plane is substantially perpendicular to a surface of an article when attached to the surface of the article.

19. The system of claim 17, wherein the second conductive portion includes a pair of contact points that couple to the conductive surface to form the current loop.

20. The system of claim 17, wherein the second conductive portion couples to the conductive surface of the article to form the current loop via one of an electrical coupling and an electromagnetic coupling.

21. The system of claim 17, the loop antenna defining a length, wherein the IC chip is centered along the length.

22. The system of claim 17, the loop antenna defining a length, wherein the IC chip is offset from a midpoint of the length of the loop antenna.

23. The system of claim 17, wherein the first conductive portion includes at least one slit that forms a gap in the first conductive portion that functions as the tuning element for tuning the impedance of the antenna to substantially match an impedance of the RFID circuit to which the antenna is coupled.

24. The system of claim 23, wherein the RFID circuit is coupled to the first conductive portion of the loop antenna at a location offset from a center of the loop antenna and the slit that forms the gap in the first conductive portion of the loop antenna is offset from the RFID circuit in the same direction as the RFID circuit is offset from the center of the loop antenna.

25. The system of claim 17, wherein the first conductive portion includes a first conductive trace that substantially overlaps at least a portion of a second conductive trace to form the tuning element for tuning the impedance of the antenna to substantially match an impedance of the RFID circuit to which the antenna is coupled.

26. The system of claim 17, further comprising a non-conductive material separating the overlapping conductive traces.

27. The system of claim 26, wherein the RFID circuit is coupled to the first conductive portion of the loop antenna at a location offset from a center of the loop antenna and the overlapping conductive traces are offset from the RFID circuit in the same direction as the RFID circuit is offset from the center of the loop antenna.

28. The system of claim 17, wherein the loop antenna operates in an ultra high frequency (UHF) range of the radio spectrum.

29. The system of claim 17, wherein the length of the first conductive portion and the length of the second conductive portion are at least approximately 50 millimeters (mm), the width of the first conductive portion and the width of the second conductive portion are between approximately 12-50 mm, and the thickness of the first and second conductive portion is less than approximately 1 mm.

30. An article comprising:

an electrically conductive surface; and

an radio frequency identification (RFID) tag coupled to the electrically conductive surface of the article, the RFID tag comprising:

a loop antenna comprising:

a first conductive portion having a length and width that substantially exceed a thickness of the first conductive portion, wherein the length and width of the first conductive portion substantially lie in a first plane; and

a second conductive portion having a length and width that substantially exceed a thickness of the second conductive portion, wherein the length and width of the second conductive portion substantially lie in a second plane that is substantially parallel to the first plane, the second conductive portion being electrically coupled to the first conductive portion and configured to couple to a conductive surface of an article to which the RFID tag is attached; and

an RFID circuit electrically connected to the loop antenna, wherein a current is excited through the loop antenna to flow through the first conductive portion, the second conductive portion and the conductive surface of the article to which the RFID tag is attached in a current loop that lies in a third plane that is not substantially parallel to the electrically conductive surface of the article.

31. The article of claim 30, wherein the RFID tag is configured such that the third plane is substantially perpendicular to the electrically conductive surface of the article.

32. The article of claim 30, wherein the second conductive portion includes a pair of contact points that couple to the electrically conductive surface of the article.

33. The article of claim 30, wherein the second conductive portion couples to the electrically conductive surface of the article to form the current loop via one of an electrical coupling and an electromagnetic coupling.

34. The article of claim 30, wherein the first conductive portion includes at least one slit that forms a gap in the first conductive portion that functions as the tuning element for tuning the impedance of the antenna to substantially match an impedance of the RFID circuit to which the antenna is coupled.

35. The article of claim 34, wherein the RFID circuit is coupled to the first conductive portion of the loop antenna at a location offset from a center of the loop antenna and the slit that

forms the gap in the first conductive portion of the loop antenna is offset from the RFID circuit in the same direction as the RFID circuit is offset from the center of the loop antenna.

36. The article of claim 30, wherein the first conductive portion includes a first conductive trace that substantially overlaps at least a portion of a second conductive trace to form the tuning element for tuning the impedance of the antenna to substantially match an impedance of the RFID circuit to which the antenna is coupled.

37. The article of claim 36, further comprising a non-conductive material separating the overlapping conductive traces.

38. The article of claim 36, wherein the RFID circuit is coupled to the first conductive portion of the loop antenna at a location offset from a center of the loop antenna and the overlapping conductive traces are offset from the RFID circuit in the same direction as the RFID circuit is offset from the center of the loop antenna.