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(54) RADIO FREQUENCY (RF) ANTENNA CONTAINING ELEMENT AND METHODS OF MAKING THE SAME

RF-ANTENNENELEMENT UND VERFAHREN ZU DESSEN HERSTELLUNG

ELEMENT CONTENANT UNE ANTENNE DE RADIOFRÉQUENCE (RF) ET SES PROCÉDES DE FABRICATION

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Description

TECHNICAL FIELD

[0001] The present invention relates generally to communications, and more particularly to a radio frequency (RF) antenna containing element and a method of making the same.

BACKGROUND

[0002] There is an increasing demand for providing products with radio frequency (RF) circuits, such as radio frequency identification (RFID) tags and labels. RFID tags and labels can have a combination of antennas and analog and/or digital electronics, which may include, for example, communication electronics, data memory, and control logic. RFID tags and labels are widely used to associate an object with an identification code. For example, RFID tags are used in conjunction with security locks in cars, for access control to buildings, and for tracking inventory and parcels. RFID tags and labels can include active tags, which include a power source, as well as passive tags and labels, which do not.

[0003] An important element of RF circuits is the RF antenna. An RF antenna can have a configuration where two substantial bodies of conductive material are properly spaced from each other so as to define two antenna portions, which are bridged by a circuit chip comprising an RF transponder. The antennas can be produced by utilizing conductive ink, or may be in the form of etched conductive foil. While products made from such structure function properly, the conductive ink does not provide a high grade antenna since it cannot be as thick or as conductive, in general, as can a conductive foil. However, the conventional etching techniques for applying foil do not lend themselves to high speed production.


SUMMARY

[0004] In one aspect of the invention, a radio frequency (RF) antenna containing element according to claim 1 is provided. The RF antenna containing element comprises a metal foil laminate antenna that includes a metal foil layer bonded to a reinforcement layer, and a carrier layer bonded to the metal foil laminate antenna.

[0005] In yet another aspect of the invention, a method of forming an RF antenna containing element according to claim 9 is provided. The method comprises providing a metal foil laminate having a metal foil layer bonded to a reinforcement layer, patterning an antenna adhesive pattern to the reinforcement layer, and laminating a carrier layer with the reinforcement layer. The method further comprises cutting an antenna pattern in registration with the antenna adhesive pattern through the metal foil laminate to the carrier layer, and removing an undesired matrix portion of the reinforced metal foil laminate to provide a metal foil laminate antenna disposed on the carrier layer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. 1 illustrates a cross-sectional view of an RFID inlay in accordance with an aspect of the present invention.

[0007] FIG. 2 illustrates a top view of an RFID inlay in accordance with an aspect of the present invention.

[0008] FIG. 3 illustrates a roll-to-roll process in accordance with an aspect of the present invention.

[0009] FIG. 4 illustrates another roll-to-roll process in accordance with an aspect of the present invention.

[0010] FIG. 5 illustrates a top view of an RFID inlay with antenna connection extensions in accordance with an aspect of the present invention.

[0011] FIG. 6 illustrates a cross-sectional view of an RFID inlay with foil strips bonded to contact ends of an antenna structure in accordance with an aspect of the present invention.

[0012] FIG. 7 illustrates a cross-sectional view of the RFID inlay of FIG. 6 after undergoing a weld process in accordance with an aspect of the present invention.

[0013] FIG. 8 illustrates a cross-sectional view of an RFID inlay with contact extensions in accordance with an aspect of the present invention.

[0014] FIG. 9 illustrates a cross-sectional view of an RFID inlay with electrodeposited contact extensions in accordance with an aspect of the present invention.

[0015] FIG. 10 illustrates a top view of cross-cut antenna structure in accordance with an aspect of the present invention.

[0016] FIG. 11 illustrates a die cross-cut gap portion in accordance with an aspect of the present invention.

[0017] FIG. 12 illustrates a top view of the cross-cut antenna structure of FIG. 10 after a through hole is registered within the gap of the antenna structure in accordance with an aspect of the present invention.

[0018] FIG. 13 illustrates methodology of forming an antenna containing element in accordance with an aspect of the present invention.

[0019] FIG. 14 illustrates another methodology of forming an antenna containing element in accordance with an aspect of the present invention.

DETAILED DESCRIPTION

[0020] The present invention relates to RF antenna containing elements and methods of making the same. The RF antenna containing element includes a reinforced metal foil laminate antenna bonded to a carrier layer. The reinforced metal foil laminate antenna includes a metal foil layer bonded to a reinforcement layer. The reinforcement layer mitigates tearing of the metal foil layer during formation of the antenna.
Although the present examples are illustrated with respect to fabrication of an RFID inlay, the present invention is applicable to a variety of RF antenna containing elements including other intermediate assemblies for a RF antenna or final assemblies (e.g., an RFID tag).

FIG. 1 illustrates a cross-sectional view of an RFID inlay 10 in accordance with an aspect of the present invention. The RFID inlay 10 includes an antenna structure 12 supported by a carrier sheet (or layer) 14. The antenna structure 12 may be releasably attached or permanently bonded to the carrier sheet 14. The antenna structure 12 can be in the form of a variety of different shapes, sizes and types. For example, the antenna structure 12 can be a dipole antenna with opposing antenna connection ends. The antenna structure 12 includes a gap 16 for placement and bonding of an RFID chip (not shown) to connection ends 11 and 13 of the antenna structure 12. The carrier sheet or layer 14 can be in the form of a polymeric film having a thickness in the range of about 0.02mn (1.0 mils) to about 0.08 mm (3.0 mils) (e.g., about 0.05 mm (2 mils)). Examples of materials that can be used to form the carrier sheet 14 include, but are not limited to, polyester films, polyethylene terephthalate (PET) films and polyimide films.

Examples of other of materials that can be used to the carrier sheet or layer 14 include, but are not limited to, polycarbonate, polylactylate, polysulfone, a norbornene copolymer, polyphenylsulfone, polyetherimide, polyetherenaphthalate (PEN), polyethersulfone (PES), polycarbonate (PC), a phenolic resin, polyetherester, polyetheramide, cellulose acetate, aliphatic polyurethanes, polycrylonitrile, polytetrafluoroethylene, polyvinylidene fluorides, high density polyethylene (HDPEs), poly(methyl methacrylates), a cyclic or acyclic polyolefins. Alternatively, the carrier sheet or layer 14 can be formed of a paper material, such as a card stock paper, a bond paper or other paper type. The carrier sheet 14 can be formed of materials that are flexible, such that the carrier sheet 14 can be manufactured as a continuous web, which can be wound into roll form for use in a roll-to-roll process.

The antenna structure 12 is formed from a reinforced metal foil laminate 18. The reinforced metal foil laminate 18 includes a metal foil layer 20 bonded to a reinforcement layer 24. The metal foil layer 20 can be formed from an aluminum foil, a copper foil, a steel foil or other metal foil. The metal foil layer 20 can have a thickness in the range of about 1.5 microns to about 20 microns (e.g., about 10 microns). Furthermore, the metal foil layer can have a tensile strength of about 100 to about 140 megapascals (MPa) (e.g., about 120 Mpa) and an elongation at break of about 20% to about 30% (e.g., 25%). The metal foil layer 20 can be bonded to the reinforcement layer 24 by an adhesive, such as a temperature and/or pressure activated adhesive. A wide variety of adhesives may be employed to bond the metal foil layer 20 to the reinforcement layer 24. For example, a general-purpose, permanent pressure sensitive adhesive and/or laminating adhesive may be employed. By way of example, the adhesive can be an acrylic based and/or elastomeric based temperature and/or pressure activated adhesive. In one aspect of the invention, the adhesive is an ethylene-acrylic acid (EAA) copolymer adhesive, which exhibits excellent bonding characteristics between metal foils and polymeric materials. The adhesive can be flood or roll coated to form an adhesive layer 22 having a thickness in the range of about 1 micron to about 3 microns (e.g., about 2 microns) with a coatweight of about 2 grams per square meter (gsm).

The reinforcement layer 24 can be in the form of a polymeric film having a thickness in the range of about 0.02 mm (0.1mils) to about 0.05 mm (2.0 mils) (e.g., about 0.25 mm (1 mil)). Examples of materials of that can be used for forming a reinforcement layer include, but are not limited to, polyester films, polyethylene terephthalate (PET) films and polyimide films. Other polymeric materials can be employed such as those suggested above with respect to the carrier layer 14. Alternatively, the reinforcement layer 24 can be formed of a paper material. The reinforcement layer 24 can be formed of materials that are flexible, such that the reinforcement layer 24 in combination with the adhesive layer 22 and metal layer 20 can be manufactured as a continuous web, which can be wound into roll form for use in a roll-to-roll process.

In one aspect of the invention, the antenna structure 12 is formed on the carrier sheet 14 by performing a partial die cut with a die (not shown) having a shape generally matching a shape of the desired antenna structure. The die cuts through the reinforced metal foil laminate 18 and an adhesive layer 26 to the underlying carrier layer 14. In this aspect of the invention, the carrier layer 14 can have a release coating, such that the undesired portions or waste material (hereinafter referred to as the "matrix material" or "matrix portion") of the reinforced metal foil laminate 18 and underlying adhesive material 26 are readily removed, such that only the reinforced metal foil laminate portion of the desired antenna structure 12 remains on the carrier layer 14. The adhesive layer 26 can be a rubber based pressure activated adhesive. The adhesive can be flood or roll coated to form the adhesive layer 26 having a thickness in the range of about 5 micron to about 25 microns (e.g., about 15 microns) with a coatweight of about 25 gsm.

In another aspect of the invention, the antenna structure 12 is formed on the carrier layer 14 by applying a patterned adhesive 26 having a shape generally matching a shape of the desired antenna structure 12 on a back side of the reinforcement layer 24 of the reinforced metal foil laminate 18. The carrier layer 14 can be laminated with the reinforcement layer 24, and the patterned adhesive 26 can then be cured. In one aspect of the invention, the patterned adhesive 26 is an ultra-violet (UV) curable adhesive. A partial die cut with a die having a shape generally matching a shape of the desired antenna structure 14 is performed. The die cuts through the reinforced met-
al foil laminate 18 to the underlying carrier layer 14 in registry with the patterned adhesive 26 to form the antenna structure 12. The undesired portions or "matrix material" of the reinforced metal foil laminate 18 and undesired adhesive material are readily removed, such that only the reinforced metal foil laminate portion of the desired antenna structure 12 remains on the carrier layer 14. The remaining adhesive layer 28 of the antenna structure 12 can have a thickness in the range of about 5 micron to about 25 microns (e.g., 15 microns) with a coating weight of about 25 gsm.

[0028] FIG. 2 illustrates a top view of an RFID inlay 30 in accordance with an aspect of the present invention. The RFID inlay 30 includes a carrier layer 32 and an antenna structure 34 formed of a reinforced metal foil laminate 35. The antenna structure 34 includes a generally T-shaped opening 36 that defines antenna contact ends 40 and 42, which are spaced apart via a gap 38. It is to be appreciated that the present invention is applicable to a variety of antenna types, shapes and sizes. The gap 38 is sized to allow placement of an RFID chip (not shown) that can be bonded to the carrier layer 32 with bonding pads or contacts of the RFID chip coupled to respective antenna contact ends 40 and 42 via contact extensions (not shown). The antenna structure 34 can be formed employing a partial die cut in the shape of the antenna structure 34 on a reinforced metal foil laminate 35 bonded to the carrier layer 32 with the remaining matrix material of the reinforced metal foil laminate being removed. The materials and dimensions of the reinforced metal foil laminate, adhesives and carrier layer 32 can be selected to be formed of materials that are durable and flexible, such that the carrier sheet 32, adhesives and reinforced metal foil laminate 35 can be manufactured as a continuous web which can be wound into roll form for use in a roll-to-roll process.

[0029] It is to be appreciated that the die employed in the partial die cut may have certain feature size limitations, such that the gap 38 formed between the antenna connection ends 40 and 42 is too large to directly connect the RFID chip. Therefore, contact extensions can be provided to couple the contact pads of the chip to the antenna connection ends 40 and 42. A number of methodologies can be employed to form contact extensions, such as the use of straps, interposers and carriers as is known in the art.

[0030] FIG. 3 illustrates a roll-to-roll process 50 for forming an antenna structure in accordance with an aspect of the present invention. The roll-to-roll process, a web 51 comprising a reinforced metal foil laminate bonded to a carrier layer via an adhesive layer is unwound via an unwinder 52 and fed to a die cutter 54. The reinforced metal foil laminate includes a metal foil layer bonded to a reinforcement layer via an adhesive layer as discussed above with respect to FIGS. 1-2. The reinforcement layer provides the metal foil layer with additional support to mitigate tearing or ripping of the metal foil during the removal of the undesired matrix portion of the web 51. The die cutter 54 repeatedly performs a partial die cut with a die having a shape generally matching a shape of the desired antenna structure as the web 51 passes through the die cutter 54. The die cutter 54 can be a mechanical die cutter, such as a rotary die anvil. It is to be appreciated that although the antenna pattern described herein is formed via a die cutter, other methodologies of performing a die cut through the reinforced metal foil laminate to the carrier layer may be employed, such as laser die cutting, microperforation, and other cutting techniques.

[0031] The die of the die cutter 54 cuts through the reinforced metal foil laminate and an adhesive layer to the underlying carrier layer to provide a cut that defined the desired antenna structure and the undesired matrix portion of the reinforced metal foil laminate. The web 51 is then passed through a stripper 60 that strips and separates the undesired matrix portion of the reinforced metal foil laminate from the desired reinforced metal foil laminate antenna structures and the supporting carrier layer.

The reinforced metal foil laminate antenna structure and carrier layer form a web 61 that is wound into an antenna/carrier roll via a first rewinder 58. The matrix portion of the reinforced metal foil laminate form another web 63 that is wound into a matrix roll via a second rewinder 56. It has been determined that the above process can produce antenna structures at a rate of about 250 feet per minute.

[0032] FIG. 4 illustrates a roll-to-roll process 80 for forming an antenna structure in accordance with another aspect of the present invention. A reinforced metal foil laminate in the form of web 81 is unwound via an unwinder 82 and fed to an adhesive pattern coater 86. The adhesive pattern coater 86 can be any conventional pattern coating equipment employed for that purpose. The reinforced metal foil laminate includes a metal foil layer, bonded to a reinforcement layer via an adhesive layer as discussed above with respect to FIGS. 1-2. The adhesive pattern coater 86 repeatedly applies an adhesive pattern substantially in the shape of the desired antenna pattern to a back of the reinforcement layer of the web 81 as it passes through the adhesive pattern coater 86. The adhesive employed on the adhesive pattern is, for example, a UV curable adhesive.

[0033] The web 81 is then fed through a set of laminating rollers 88 along with a carrier web 85. The carrier web 85 is unwound via an unwinder 84 and fed to the set of laminating rollers 88, such that the web 81 and the carrier web 85 are sandwiched together and laminated. Alternatively, as illustrated with dashed lines, the carrier web 85 can be fed to an adhesive pattern coater 87 to repeatedly apply an adhesive pattern substantially in the shape of the desired antenna pattern to a front of the carrier web 85 as it passes through the adhesive pattern coater 87. A resultant web 91 includes the reinforced metal foil laminate and carrier web with adhesive antenna patterns formed therebetween.

[0034] The resultant web 91 passes through a UV sta-
tion 90 that provides UV light through the carrier layer of the resultant web 91 to cure the adhesive antenna patterns. The carrier layer is selected to be a UV-transparent layer that can be formed from a UV-transparent material, such as a UV-transparent polymeric material. The resultant web 91 is then fed to a die cutter 92. The die cutter 92 repeatedly performs a partial die cut with a die having a shape generally matching a shape of the desired antenna structure, as the resultant web 91 passes through the die cutter 92. The partial die cut is in registration with the antenna adhesive patterns, such that the partial die cut is substantially aligned with the adhesive antenna pattern. The die cutter 92 can be a variety of different mechanical die cutters, such as a rotary die anvil. The die cuts through the reinforced metal foil laminate and the adhesive of the adhesive antenna pattern of the resultant web 91 to the underlying carrier layer to provide a cut generally at or within the outside perimeter of the adhesive antenna pattern. The resultant web 91 is separated, such that the reinforced metal foil laminate antenna structure and carrier layer form a web 97. The web 97 is then wound into an antenna/carrier roll via a first rewinder 96. The undesired matrix portion of the reinforced metal foil laminate and excess adhesive form another web 95 that is wound into a matrix roll via a second rewinder 94. It has been determined that the above process can produce antenna structures at a rate of at least about 50 feet per minute.

As previously stated, the die employed in the partial die cut may have certain feature size limitations, such that the gap formed between the antenna connection ends is too large to directly connect the RFID chip. Straps and/or interposers can be attached to the chip prior to placement on an RFID inlay, but at significant costs to the inlay and the final RFID tag. In accordance with an aspect of the present invention, extensions may be employed to provide electrical coupling between the RFID chip and the antenna. These extensions can be fabricated at a low cost in a manner that allows for direct chip placement.

Additionally, if the metal foil layer employed to form the antenna structure is aluminum foil or copper foil, an oxide layer that readily forms on the aluminum foil or copper foil can create additional resistances in bonding the RFID chip to the antenna. Therefore, portions of the oxide layer on the antenna for which contact is to be made can readily be removed. Removal of portions of the oxide layer can be accomplished by a variety of techniques. For example, removal can be accomplished by scratching, applying pressure, and/or puncturing contact areas or contact ends on the antenna. Alternatively, conductive bumps can provided at the contact areas or contact ends. The conductive bumps can include a multitude of small, hard particles (e.g., diamond particles) with a multitude of sharp points for penetrating the oxide layer at the contact area. Additionally, copper contacts can be electroplated to the contact area of the antenna to penetrate the oxide layer.

FIGS. 5-8 illustrate the formation of extensions on an antenna structure to allow for direct RFID chip placement. In the illustrated examples, the oxide layer over the antenna contact area has been removed or can be removed during formation of the extensions by any of the techniques discussed above.

FIG. 5 illustrates a top view of an RFID inlay 100 with antenna connection extensions in accordance with an aspect of the present invention. The RFID inlay 100 includes a carrier layer 102 and an antenna structure 104 formed of a reinforced metal foil laminate 105. The antenna structure 104 includes a generally T-shaped opening 106 that defines antenna contact ends 110 and 112 spaced apart via a gap 108. The gap 108 is sized to allow placement of an RFID chip 118 (shown with dashed lines) with bonding pads or contacts coupled to respective antenna contact ends 110 and 112 via contact extensions 114 and 116, respectively.

In one aspect of the invention, the contact extensions 114 and 116 can be formed by transferring foil (e.g., copper foil) in the requisite pattern onto the surface of the contact ends 110 and 112 of the antenna and/or the carrier layer to either enhance the foil of the antenna for bonding or to build an adjoining feature for chip bonding. The transferred foil can be welded to the metal foil using, for example, electrical or magnetic induction welding or impact/explosive welding or ultrasonic welding. The weld head can be selected to provide the desired shape of the contact extensions 114 and 116. Alternatively, the transferred foil can be bonded to the contact ends 110 and 112 via an adhesive, or temporarily bonded via an adhesive prior to welding. The transferred foil can be in the form of a web that can be transferred (e.g., heat transferred) from a substrate via a release layer in a roll-to-roll process.

In another aspect of the invention, the contact extensions 114 and 116 can be formed by printing conductive inks and/or adhesives of the appropriate thicknesses in the extension feature areas, for example, from the carrier layer to the contact ends 110 and 112. Alternatively, chip bond pads can be formed on the carrier layer employing conductive inks and/or adhesives with a transferred foil contact extension providing electrical conductivity between the chip bond pads and the antenna contact ends 110 and 112.

In yet another aspect of the invention, the contact extensions 114 and 116 can be formed by electro-plating or electro-deposition of copper onto the contact ends 110 and 112 of the antenna structure, such that the copper extends over the gap providing chip bond pads for direct chip placement. Alternatively, chip bond pads can be formed on the carrier layer employing conductive inks and/or adhesives with an electroplated copper contact extension providing electrical conductivity between the chip bond pads and the antenna contact ends 110 and 112.

FIG. 6 illustrates a cross-sectional view of an RFID inlay 130 in accordance with an aspect of the
present invention. The RFID inlay 130 includes an antenna structure 132 supported by a carrier sheet (or layer) 134. The antenna structure 132 includes a gap 136 for placement and bonding of an RFID chip to contact ends 147 and 149 of the antenna structure 132. The antenna structure 132 is formed from a reinforced metal foil laminate 138. The reinforced metal foil laminate 138 includes a metal foil layer 140 bonded to a reinforcement layer 144 via an adhesive layer 142. The metal foil layer 140 can be formed, for example, from an aluminum foil, a copper foil, steel foil or other metal foil. The reinforced metal foil laminate 138 is bonded to the carrier layer 134 via an adhesive layer 146. [0043] A first foil strip 148 is bonded to a first contact end 147 of the antenna structure 132 with a portion of the first foil strip extending over the gap 136, and a second foil strip 150 is bonded to a second contact end 149 with a portion of the second foil strip extending over the gap 136. The first and second foil strips 148 and 150 can be formed of, for example, copper. The first and second foil strips 148 and 150 can have a thickness in the range of about 1 micron to about 3 microns (e.g., 2 microns). The first and second foil strips 148 and 150 can reside on a web and can be transferred from a substrate via a release layer and/or a heat transfer in a roll-to-roll process. [0044] The first and second foil strips 148 and 150 can be bonded to the first and second contact ends 147 and 149, respectively via an adhesive. The oxide layer over the first and second contact ends 147 and 149 can be removed by scratching, applying pressure and/or puncturing contact areas on the first and second contact ends 147 and 149 on the antenna structure 132. Alternatively, the first and second foil strips 148 and 150 can be bonded to the first and second contact ends 147 and 149 by welding (e.g., a spot weld), thus concurrently bonding the foil strips 148 and 150 and penetrating the oxide layer over the first and second contact ends 147 and 149. Furthermore, contact pads can be formed over the first and second contact ends 147 and 149 by employing conductive bumps with a multitude of hard particles, or electroplating copper to form contact pads prior to placement and bonding of the foil strips 148 and 150. [0045] FIG. 7 illustrates a cross-sectional view of the RFID inlay 130 of FIG. 6 after undergoing a weld process in accordance with an aspect of the present invention. The weld process includes employing a weld head having a shape that forms contact extensions 152 and 156 into a desired pattern that allows for direct chip placement. The weld head can concurrently shape the first and second foil strips 148 and 150 into contact extensions and weld the contact extensions 152 and 156 to the first and second contact ends 147 and 149 of the antenna 132 (i.e., metal-to-metal weld) and to the carrier layer 134 (i.e., metal-to-plastic weld). As illustrated in FIG. 7, the contact extensions 152 and 156 have generally right angle bends at contact ends 147 and 149 of a top surface of the antenna 132 and generally right angle bends at a top surface of the carrier layer 134. A first end of each respective contact extension 152 and 156 (foil strip) is electrically coupled to a respective contact area of the antenna 132 with a second end of each respective contact extension 152 and 156 (foil strip) provide bonding pads for direct placement of an RFID chip illustrated with dashed lines. [0046] It is to be appreciated that the contact extensions 152 and 156 can be bonded with adhesive and the weld head being replaced with a print head or shaping tool for forming the shape of the contact extensions 152 and 156. Additionally, the first and second foil strips 148 and 150 can be replaced with a single foil strip that is cut and removed during or after the shaping process. [0047] FIG. 8 illustrates a cross-sectional view of an RFID inlay 170 in accordance with an aspect of the present invention. The RFID inlay 170 includes an antenna structure 172 supported by a carrier sheet (or layer) 174. The antenna structure 172 includes a gap 176 for placement and bonding of an RFID chip to connection ends of the antenna structure 172. The antenna structure 172 is formed from a reinforced metal foil laminate 178. The reinforced metal foil laminate 178 includes a metal foil layer 180 bonded to a reinforcement layer 184 via an adhesive layer 182. The metal foil layer 180 can be formed, for example, from an aluminum foil, a copper foil, a steel foil or other metal foil. The reinforced metal foil laminate 178 is bonded to the carrier layer 174 via an adhesive layer 186. [0048] A first contact extension 188 and a second contact extension 190 extend from antenna contact ends 187 and 189 of the antenna 172 into the gap 176. The contact extensions 188 and 190 can be formed by building up conductive ink and/or conductive adhesive layers from the carrier layer 174 to the contact ends 187 and 189 of the antenna 172. Alternatively, conductive ink and/or conductive adhesive can be built up on the carrier layer 174 with contact pads on the contact ends 187 and 189 of the antenna 172 being formed by employing additional layers of conductive ink and/or adhesive extending from the contact ends 187 and 189 of the antenna 172 into the gap 176. Furthermore, copper extensions can be electroplated from the contact ends 187 and 189 of the antenna 172 to the conductive ink and/or adhesive residing in the gap 176. An RFID chip 192 illustrated with dashed lines can be directly placed on a surface of the first and second contact extensions 188 and 190. Furthermore, the contact extensions 188 and 190 can be formed by providing bond pads that extend from the contact extensions 188 and 190 via conductive ink or conductive adhesive on the carrier layer 174 in the gap 176, such that the RFID chip 192 can be directly placed on the bond pads on the carrier layer 174 in the gap 176. [0049] FIG. 9 illustrates a cross-sectional view of an RFID inlay 200 in accordance with an aspect of the present invention. The RFID inlay 200 includes an antenna structure 202 supported by a carrier sheet (or layer) 204. The antenna structure 202 includes a gap 206 for...
placement and bonding of an RFID chip to antenna connection ends 217 and 219 of the antenna structure 202. The antenna structure 202 is formed from a reinforced metal foil laminate 208. The reinforced metal foil laminate 208 includes a metal foil layer 210 bonded to a reinforcement layer 214 via an adhesive layer 212. The metal foil layer 210 can be formed from an aluminum foil, a copper foil, steel foil or other metal foil. The reinforced metal foil laminate 208 is bonded to the carrier layer 204 via an adhesive layer 216.

A first contact extension 218 and a second contact extension 220 extend from respective contact ends 217 and 219, respectively, of the antenna 202 into the gap 206 via an electroplating or electro-deposition process. As illustrated in FIG. 9, a voltage potential (V+) is applied to antenna contact ends across the gap 206 immersed in an electrolytic medium. The voltage potential causes electro-deposition of contacts on the tips of the contact ends 217 and 219 of the antenna 202 into the gap 206. In the example of FIG. 9, the electrolytic medium is copper sulfate (CuSO₄) resulting in the electro-deposition of copper on the metal foil layer 210 to form the first contact extension 218. The polarity of the voltage potential at the antenna contact ends 217 and 219 to form the second contact extension 220. The first and second contact extensions 218 and 220 form bonding pads for direct placement of an RFID chip 222 illustrated in dashed lines.

FIG. 10 illustrates a top view of a cross-cut antenna structure 230 in accordance with an aspect of the present invention. The cross-cut antenna structure 230 is formed from a reinforced metal foil laminate. The cross-cut antenna structure 230 provides for direct RFID chip placement without the need for contact extension. The cross-cut antenna structure 230 includes a generally T-shaped opening 232 that forms antenna contact ends 234 and 236 spaced apart via a gap 235. The T-shaped opening 232 is formed from a die cut that employs a die having a generally T-shape with a generally X-shaped gap portion.

FIG. 11 illustrates a die cross-cut gap portion 250. The generally X-shaped gap portion of the die separates the reinforced metal foil laminate into four distinct quadrants 1, 2, 3, and 4. The undesired matrix portion of the reinforced metal foil laminate can be removed in quadrants 2 and 4 leaving the reinforced metal foil laminate in quadrant 1 and 3 with opposing generally pointed contact end tips separated by the width (e.g., about 6 microns to about 8 microns) of the die cut. The die can be selected to provide a desired width between the tips of opposing contact ends 234 and 236.

Referring again to FIG. 10, bond pads 238 and 240 can be provided on contact ends 234 and 236, respectively. The bond pads 238 and 240 can be formed from an electrolytic process to form copper contact bond pads. An RFID chip 242 as illustrated with dashed lines can be placed directly across the tips of the opposing contact ends 234 and 236. However, the metal foil under the RFID chip can lead to problems associated with electrical interaction with the chip functions, for example due to capacitance associated with the metal foil. Therefore, an RFID chip 244 can be rotated as illustrated with dashed lines and placed across the tips of the opposing contact ends 234 and 236 at an offset to mitigate the amount of metal foil under the RFID chip 244. Furthermore, another methodology to mitigate the amount of metal foil under the chip is to register a through hole 246 within the gap 235 as illustrated in FIG. 12. The through hole 246 can be formed by punching through and removing a predetermined amount of materials of the tips of opposing contact ends 234 and 236 to define a predetermined width across the gap 235. An RFID chip 248 as illustrated with dashed lines can be directly placed across the opposing contact ends 234 and 236.

In view of the foregoing structural and functional features described above, methodologies will be better appreciated with reference to FIGS. 13-14. It is to be understood and appreciated that the illustrated actions, in other embodiments, may occur in different orders and/or concurrently with other actions. Moreover, not all illustrated features may be required to implement a method.

FIG. 13 illustrates a methodology of forming an antenna containing element in accordance with an aspect of the present invention. The methodology begins at 300 where a reinforced metal foil laminate disposed on a carrier layer is provided. The reinforced metal foil laminate can be formed from a metal foil layer bonded to a reinforcement layer via an adhesive layer. The reinforced metal foil laminate can be bonded to the carrier via an adhesive layer. At 310, an antenna pattern is die cut through the reinforced metal foil laminate to the carrier layer. At 320, the undesired matrix portion of the reinforced metal foil laminate is removed, such that an antenna structure in the shape of the antenna pattern remains on the carrier layer.

FIG. 14 illustrates another methodology of forming an antenna containing element in accordance with an aspect of the present invention. The methodology begins at 400 where an adhesive antenna pattern is printed on one of a reinforcement layer side of a reinforced metal foil laminate and a carrier layer. The reinforced metal foil laminate can be formed from a metal foil layer bonded to a reinforcement layer via an adhesive layer. At 410, the carrier layer is laminated to the reinforcement layer side of a reinforced metal foil laminate. At 420, an antenna pattern is die cut through the reinforced metal foil laminate to the carrier layer in registration with the adhesive antenna pattern. At 430, the undesired matrix portion of the reinforced metal foil laminate is removed, such that an antenna structure in the shape of the antenna pattern remains on the carrier layer.

What have been described above are examples of the present invention. It is, of course, not possible to describe every conceivable combination of components or methodologies for purposes of describing the present
invention, but one of ordinary skill in the art will recognize that many further combinations and permutations of the present invention are possible. Accordingly, the present invention is intended to embrace all such alterations, modifications and variations that fall within the scope of the appended claims.

Claims

1. A radio frequency (RF) antenna (12) containing element comprising:

   a metal foil laminate antenna (18) that includes a metal foil layer (20) bonded to a reinforcement layer (24); and
   a carrier layer (14) bonded to the metal foil laminate antenna (18); characterized by
   the metal foil laminate having a generally T-shaped opening (36) that defines antenna contact (40,42)

   wherein the antenna contact ends (40,42) are spaced apart via a gap (38) which is sized to allow for placement of a chip.

2. The element of claim 1, wherein the metal foil layer (20) is formed from one of aluminum foil, copper foil and steel foil, the metal foil layer has a thickness in the range of about 1.5 microns to about 20 microns.

3. The element of claim 1, wherein the reinforcement layer (24) has a thickness in the range about 0.00254 mm (0.1 mils) to about 0.0254 mm (1 mil).

4. The element of claim 1, wherein the reinforcement layer (24) is formed from one of a polymeric film comprising one of a polyester film, polyethylene terephthalate (PET) film, and polyimide film and paper.

5. The element of claim 1, wherein the carrier layer (14) is one of a polymeric film and paper, the carrier layer (14) having a thickness in the range of about 0.0254 mm (0.1 mil) to about 0.0762 mm (3 mil).

6. The element of claim 1, further comprising an adhesive layer that bonds the metal foil layer (20) to the reinforcement layer (24), the adhesive layer having a thickness in the range of about 1 micron to about 3 microns.

7. The element of claim 1, further comprising a chip conductively coupled to the contact ends (40,42) of the metal foil laminate antenna (18).

8. The element of claim 1, further comprising an adhesive layer that bonds the metal foil laminate antenna (18) to the carrier layer, the adhesive layer that bonds the metal foil laminate antenna (18) to the carrier layer having a thickness in the range of about 5 microns to about 25 microns:

9. A method of forming a radio frequency (RF) antenna (12) containing element, the method comprising:

   providing a metal foil laminate (18) having a metal foil layer (20) bonded to a reinforcement layer (24), the metal foil laminate (18) having a generally T-shaped opening (36) that defines antenna contact ends (40,42) wherein the antenna contact ends (40,42) are spaced apart via a gap (38) which is sized to allow for placement of a chip;
   providing a carrier layer (14);
   patterning an antenna adhesive pattern to one of the reinforcement layer (24) and carrier layer (14);
   laminating the carrier layer (14) and the reinforcement layer (24);
   cutting an antenna pattern in alignment with the antenna adhesive pattern through the metal foil laminate (18) to the carrier layer (14); and
   removing an undesired matrix portion of the reinforced metal foil laminate (18) to provide a metal foil laminate antenna (18) disposed on the carrier layer (14).

10. The method of claim 9, wherein antenna adhesive pattern is formed from an ultra-violet (UV) curable adhesive, the antenna adhesive pattern being exposed to a UV light source prior to the cutting an antenna pattern.

11. The method of claim 9, wherein the cutting an antenna pattern through the metal foil laminate (18) to the carrier layer (14) comprises performing a partial die cut with a die cutter.

12. The method of claim 11, wherein the performing a partial die cut comprises performing a cross-cut with a die having a generally X-shaped gap portion that separates a gap area into four distinct quadrants, wherein the removing an undesired matrix portion of the reinforced metal foil laminate comprises removing two of the four distinct quadrants to provide opposing generally pointed antenna contact end tips.

13. The method of claim 12, further comprising registering a through hole within the gap area to remove portions of the antenna contact end tips to define a gap of a desired width between the antenna contact end tips (40,42).

14. The method of claim 9, wherein the metal foil laminate (18) is unwound from a first web and a carrier layer is unwound from a second web, one of the first
web and second web being fed to an adhesive pattern coater (86) for patterning an antenna adhesive pattern to one of the reinforcement layer (24) and the carrier layer (14) and laminated the carrier layer (14) and the reinforcement layer (24) to provide a resultant web (91), the resultant web (91) is fed to a die cutter (92) for repeatedly die cutting antenna patterns in the adhesive antenna patterns through the metal foil laminate (18) to the carrier layer to form a plurality of reinforced metal foil laminate antenna structures, the resultant web being stripped to separate an undesired matrix portion from the plurality of reinforced metal foil laminate antenna structures (18), the plurality of reinforced metal foil laminate antenna structures (18) being wound into an antenna/carrier roll via a first rewinder (96) and the undesired matrix portion being wound into a matrix roll via a second rewinder (94).

15. The method of claim 9, wherein the metal foil layer (20) is formed from one of aluminum foil that has a thickness in the range of about 1.5 microns to about 20 microns, the reinforcement layer is formed from one of a polymeric film and paper, the reinforcement layer having a thickness in the range of about 0.00254 mm (0.1 mils) to about 0.0254 mm (1 mil), and an adhesive layer that bonds the metal foil layer to the reinforcement layer, the adhesive layer has a thickness in the range of about 1 micron to about 3 microns.

Patentansprüche

1. Radiofrequenz (RF) Antenne (12)-enthaltendes Element, umfassend:

eine Metallfolienlaminantenne (18), welche eine Metallfolienschicht (20) einschließt, gebunden an eine Verstärkungsschicht (24), und eine Trägerschicht (14), gebunden an die Metallfolienlaminantenne (18), gekennzeichnet dadurch, daß das Metallfolienlaminat eine im allgemeinen T-förmige Öffnung (36) aufweist, welche Antennenkontaktenden (40, 42) definiert, wobei die Antennenkontaktenden (40, 42) über eine Lücke (38) voneinander beabstandet sind, welche in der Größe ausgelegt ist, die Anordnung eines Chips zuzulassen.

2. Element gemäß Anspruch 1, wobei die Metallfolienschicht (20) aus einer von einer Aluminiumfolie, Kupferfolie und Stahlfolie gebildet ist, wobei die Metallfolienschicht eine Dicke in dem Bereich von etwa 1,5 Mikrometer bis etwa 20 Mikrometer aufweist.

3. Element gemäß Anspruch 1, wobei die Verstärkungsschicht (24) eine Dicke in dem Bereich von etwa 0,00254 mm (0,1 mil) bis etwa 0,0254 mm (1 mil) aufweist.


5. Element gemäß Anspruch 1, wobei die Trägerschicht (14) eine von einer Polymerfolie und Papier ist, wobei die Trägerschicht (14) eine Dicke im Bereich von etwa 0,0254 mm (1 mil) bis etwa 0,0762 mm (3 mil) aufweist.

6. Element gemäß Anspruch 1, weiter umfassend eine Haftschicht, welche die Metallfolienschicht (20) an die Verstärkungsschicht (24) bindet, wobei die Haftmittelschicht eine Dicke in dem Bereich von etwa 1 Mikrometer bis etwa 3 Mikrometer aufweist.

7. Element gemäß Anspruch 1, weiter umfassend einen Chip, der leitend an die Kontaktenden (40, 42) der Metallfolienlaminantenne (18) gekoppelt ist.

8. Element gemäß Anspruch 1, weiter umfassend eine Haftmittelschicht, welche die Metallfolienlaminantenne (18) an die Trägerschicht bindet, wobei die Haftmittelschicht, welche die Metallfolienlaminantenne (18) an die Trägerschicht bindet, eine Dicke in dem Bereich von etwa 5 Mikrometer bis etwa 25 Mikrometer aufweist.

9. Verfahren zum Bilden eines Radiofrequenz (RF) Antenne (12)-enthaltenden Elements, wobei das Verfahren umfaßt:

das Bereitstellen eines Metallfolienlaminats (18) mit einer Metallfolienschicht (20), gebunden an eine Verstärkungsschicht (24), wobei das Metallfolienlaminat (18) eine im allgemeinen T-geformte Öffnung (36) aufweist, welche Antennenkontaktenden (40, 42) definiert, wobei die Antennenkontaktenden (40, 42) über eine Lücke (38) voneinander beabstandet sind, welche in der Größe ausgelegt ist, die Anordnung eines Chips zuzulassen, das Bereitstellen einer Trägerschicht (14), das Bemustern einer Antennen-Haftmusters auf eine der Verstärkungsschicht (24) und der Trägerschicht (14), das Laminieren der Trägerschicht (14) und der Verstärkungsschicht (24), das Schneiden eines Antennenmusters in Ausrichtung mit dem Antennenhaftmuster über das Metallfolienlaminat (18) auf die Trägerschicht (14), und das Entfernen eines ungewünschten Matrixab-
schnitts des verstärkten Metallfolienlaminats (18) unter Bereitstellung einer Metallfolienlaminantenne (18), angeordnet auf der Trägerschicht (14).

10. Verfahren gemäß Anspruch 9, wobei das Antennenhaftmittel aus einem Ultraviolet (UV)-härtbarem Haftmittel gebildet ist, wobei das Antennenhaftmittel vor dem Schneiden eines Antennenmusters einer UV-Lichtquelle ausgesetzt wird.

11. Verfahren gemäß Anspruch 9, wobei das Schneiden eines Antennenmusters durch das Metallfolienlaminat (18) auf die Trägerschicht (14) das Durchführen eines teilweisen Ausstanzen mit einem Ausstanzer umfaßt.


13. Verfahren gemäß Anspruch 12, weiter umfassend das Einschreiben eines Durchgangslochs innerhalb des Lückenbereichs, um Abschnitte der Antennenkontaktendspitzen zu entfernen, um eine Lücke einer gewünschten Breite zwischen den Antennen kontaktendspitzen (40, 42) zu definieren.


15. Verfahren gemäß Anspruch 9, wobei die Metallfolien schicht (20) aus einer von einer Aluminumfolie gebildet wird, die eine Dicke in dem Bereich von etwa 1,5 Mikrometer bis etwa 20 Mikrometer aufweist, wobei die Verstärkungsschicht aus einer von einer Polymerfolie und Papier gebildet wird, wobei die Verstärkungsschicht eine Dicke im Bereich von etwa 0,00254 mm (0,1 mils) bis etwa 0,0254 mm (1 mil) aufweist, und einer Haftmutschicht, welche die Metallfolienschicht an die Verstärkungsschicht bindet, wobei die Haftmutschicht eine Dicke in dem Bereich von etwa 1 Mikrometer bis etwa 3 Mikrometer aufweist.

Revendications

1. Un élément contenant une antenne de radiofréquence (RF) (12) comprenant :

une antenne laminaire à feuille métallique (18) qui comprend une couche de feuille métallique (20) collée à une couche de renforcement (24) ; et
un film porteur (14) collé à l’antenne laminaire à feuille métallique (18) ;

2. L’élément de la revendication 1, dans lequel la couche de feuille métallique (20) est formée de l’une d’une feuille d’aluminium, d’une feuille de cuivre et d’une feuille d’acier, la couche de feuille métallique a une épaisseur dans la gamme d’environ 1,5 micron à environ 20 microns.

3. L’élément de la revendication 1, dans lequel la couche de renforcement (24) a une épaisseur dans la gamme d’environ 0,00254 mm (0,1 mil) à environ 0,0254 mm (1 mil).

4. L’élément de la revendication 1, dans lequel la couche de renforcement (24) est formée de l’un d’un film polymère comprenant l’un d’un film de polyester, d’un film de polyéthylène téréphtalate (PET) et d’un film de polyamide et de papier.

5. L’élément de la revendication 1, dans lequel la couche portée (14) est l’une d’un film polymère et de
10. La méthode de la revendication 9, dans laquelle le motif adhésif d’antenne est formé à partir d’un adhésif durcissable aux ultraviolets (UV), le motif adhésif d’antenne étant exposé à une source de lumière UV avant le découpage d’un motif d’antenne.

11. La méthode de la revendication 9, dans laquelle le découpage d’un motif d’antenne à travers la feuille métallique laminée (18) jusqu’à la couche porteuse (14) comprend la réalisation d’un estampage partiel avec une découpeuse.

12. La méthode de la revendication 11, dans laquelle la réalisation d’un estampage partiel comprend l’estampage avec une découpeuse ayant généralement une portion interstitielle en forme de X qui sépare une zone interstitielle en quatre quadrants distincts, dans laquelle le retrait d’une portion de matrice indésirable de la feuille métallique laminée renforcée comprend le retrait de deux des quatre quadrants distincts pour fournir des extrémités de contact d’antenne généralement pointues et opposées.

13. La méthode de la revendication 12, comprenant en outre le repérage d’un trou débouchant à l’intérieur de la zone interstitielle pour enlever des portions des extrémités de contact d’antenne afin de définir un écartement d’une largeur définie entre les extrémités de contact d’antenne (40, 42).

14. La méthode de la revendication 9, dans laquelle la feuille métallique laminée (18) est déroulée d’une première bande et une couche porteuse est déroulée à partir d’une seconde bande, l’une de la première bande et de la seconde bande étant introduite dans un appareil de formation de motifs adhésifs (86) pour la réalisation d’un motif adhésif d’antenne sur l’une de la couche de renforcement (24) et de la couche porteuse (14) et le laminage de la couche porteuse (14) et de la couche de renforcement (24) pour fournir une bande résultante, la bande résultante (91) est alimentée vers une découpeuse (92) pour le découpage répété de motifs d’antenne dans les motifs adhésifs d’antenne à travers la feuille métallique laminée (18) jusqu’à la couche porteuse pour former une pluralité de structures d’antenne laminaire à feuille métallique renforcée, la bande résultante étant enlevée pour séparer une portion de matrice indésirable de la pluralité des structures d’antenne laminaire à feuille métallique renforcée, la bande résultante étant enlevée pour séparer une portion de matrice indésirable de la pluralité des structures d’antenne laminaire à feuille métallique renforcée (18), la pluralité des structures d’antenne laminaire à feuille métallique renforcée (18) étant enroulée dans un rouleau porteur/antenne par l’intermédiaire d’une première rebobineuse (96) et la portion de matrice indésirable étant enroulée dans un rouleau de matrice par l’intermédiaire d’une seconde rebobineuse (94).

15. La méthode de la revendication 9, dans laquelle la couche de feuille métallique (20) est formée à partir d’un film d’aluminium qui a une épaisseur dans la gamme d’environ 1,5 micron à environ 20 microns, la couche de renforcement est formée à partir de l’un d’un film polymère et de papier, la couche de renforcement ayant une épaisseur dans la gamme d’environ 0,0254 mm (1 mil) à environ 0,0762 mm (3 mils).
ron 0,00254 mm (0,1 mil) à environ 0,0254 mm (1 mil), et une couche adhésive qui colle la couche métallique mince sur la couche de renforcement, la couche adhésive a une épaisseur dans la gamme d'environ 1 micron à environ 3 microns.
FIG. 13

PROVIDING A REINFORCED METAL FOIL LAMINATE DISPOSED ON A CARRIER LAYER

DIE CUTTING AN ANTENNA PATTERN THROUGH THE REINFORCED METAL FOIL LAMINATE TO THE CARRIER LAYER

REMOVING THE UNDESIRE MatRiX PORTION OF THE REINFORCED METAL FOIL LAMINATE

FIG. 14

PRINTING AN ADHESIVE ANTENNA PATTERN ON ONE OF A REINFORCEMENT LAYER SIDE OF A REINFORCED METAL FOIL LAMINATE AND A CARRIER LAYER

LAMINATING A CARRIER LAYER TO THE REINFORCEMENT LAYER SIDE OF THE REINFORCED METAL FOIL LAMINATE

DIE CUTTING AN ANTENNA PATTERN THROUGH THE REINFORCED METAL FOIL LAMINATE TO THE CARRIER LAYER IN REGISTRATION WITH THE ANTENNA ADHESIVE PATTERN

REMOVING THE UNDESIRE MatRiX PORTION OF THE REINFORCED METAL FOIL LAMINATE
REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description


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