[0013] **FIG. 2A** illustrates a perspective view of a RFID tag in accordance with one embodiment of the present invention; and

[0014] **FIG. 2B** illustrates a cross sectional view of the RFID tag of **FIG. 2A**.

Detailed Description

[0015] Embodiments of the present invention shall now be described in detail, with reference to the attached drawings. It is to be understood that no limitation of the scope of the invention is thereby intended, such alterations and further modifications in the illustrated device, and such further applications of the principles of the invention as illustrated therein being contemplated as would normally occur to one skilled in the art to which the invention relates.

[0016] The inventors found that when an RFID tag is pasted on the windscreen with a solar ~~firm~~film in between, the metallization on the solar ~~firm~~film attached to the windshield would cause antenna tuning shift to the antenna of the RFID tag and attenuation to the RF energy received by the RFID tag. The tuning shift affects the originally intended parameters, such as inductance, capacitance and Q-factor, of the tuned antenna of the RFID tag, which in turn adversely impacts its functional characteristics, such as resonance and power transfer efficiency, which is further made worse by the RF attenuation of the tinted film, thereby greatly reducing its reception range/distance.

[0017] With a large variety of brands and grade of the tinted film available, it is impractical to customise each RFID tag with its antenna tuned to the film. Therefore, it

further apart from the underlay **210** so that it has very little or no adverse influence exerted by the metallization on the solar film that affects the RFID antennas' frequency response. In other words, by bringing the antenna **242** further apart from the underlay **210**, it eliminates or minimizes the metallization on the solar ~~firm~~film that would cause a tuning shift of the tuned antenna, which in turn affects its characteristics such as resonance and power transfer efficiency of the antenna and thereby reducing the working distance and the intended frequency response. This layer effectively uncouples the metalized films' undesired properties from influencing the desired properties of the RFID tag, such as resonance frequency, RF attenuation, eddy current losses, Q-factor.

[0021] In one embodiment of the present invention, the non-conducting layer **208** can be any generic foam sheets. One advantage selecting foam sheet as the non-conducting layer **208** is that it allows the tag **200** to be adhered snugly against the curved profile of a typical vehicle windscreen, unlike conventional rigid tags. Further the non-conducting layer **208** can be finely diced by precision laser to have tamper-proof cuts, such as criss-crossed cuts throughout the entire surface of the non-conducting layer **208**.

[0022] The above embodiment selects generic foam at least because it is cheaper in cost and easy to handle. The thickness of the layer **208** is also selected to be sufficiently thick so that any metallization on the tinted ~~firm~~film would not affect or is only negligibly affected the tuning of the antenna. It is to be understood that other materials can also be used as long as the materials is capable of isolating the effects of the tinted ~~firm~~film metallization to cause any tuning shift to the tuned antenna of the RFID tag **200**.

[0027] Both antenna **242** and the extended antenna **246** are connected in a manner that they are tuned as one unified tuned antenna for the RFID tag **200**. Relatively, the antenna **242** occupies more surface area across the tag **200** while the extended antenna **246** contains only minor portion of the antenna that has only negligible effect on the tuned antenna of the RFID tag, thus even when there is any tuning shift over at the extended antenna **246** part caused by the metalized solar ~~firm~~film, it would not affect the overall tuning of the tuned antenna of the RFID tag.

[0028] The extended antenna **246** offers a provision of a three-dimensional (3D) antenna structure, as opposed to a planer antenna structure, which extend across the extrusion antenna layer **204** and the non-conducting layer **208**, which can be formed during lamination of the multi-layered between the overlay **202** and underlay **210**. Any attempt to slice the tag (usually through the non-conducting layer because it is ticker and forms the main body) to remove it from the windscreen will cut broken the antenna rendering it no longer functional.

[0029] It is further desired that the extended tongue **244** be attached to the inlay **204** through a conductive adhesive tape having lesser adhesion force than that of the adhesive provided on the underlay **210** for attaching the tag **200** under the windshield **220**. In such configuration, any attempt to peel the tag **100** off the windshield **220** would result in the separation of the extended tongue **244** from the inlay **204**, thereby rendering the tag **200** not longer useable.

[0030] Further to prevent removal of the tag from the installed vehicle windscreen, the entire RFID inlet antenna is finely cut with precision laser in a criss-cross fashion, just short of reaching the antenna trace which has to be left in-tact. Being

very fine and hidden from outside view as the antenna inlet is sandwiched in between the layers, anybody who attempts to remove would not be able to do so with the tag intact.

[0031] In one embodiment, preferably, the overlay **202** and underlay **210** are made up of temper-evident materials. For example, a tamper-evident fragmentable eggshell label may be used. These layers will crumble and fragment into pieces upon any attempted removal or temper. In yet a further embodiment, when the ~~temper~~tamper-evident material incorporate with the finely diced inlet embedded within, it works even better for making unauthorized access to the tag easily detectable.

[0032] In one example, the RFID tag may be fabricated based on ISO/IEC 15693 standard in about **113**mm die-cut diameter with about 3mm thickness tag. The tag may be made of a high temperature flexible substrate and/or face stock for example. In one implementation, the RFID tag may be operated at a carrier frequency of 13.56MHz. The chip of the RFID tag may have a 1kbits memory. Preferably, the RFID tag can be made for Anti-UV Printing for single/double sides.

[0033] The present invention offers an improved configuration of an RFID tag that is suitable for attaching on a windshield of a vehicle. It can be attached to the windshield with better conformance and the radio transmission of the RFID tag is less influenced by any tinted film installed on the windshield of the vehicles. The RFID tag is also adapted with ~~temper~~tamper-deterrent features, which allows any tempering to be easily detected. The RFID tag can be made as one time use tag, of which, once broken it has to be replaced.

Claims

1. An in-vehicle RFID tag for attaching under a windshield that has a tinted solar film installed thereto, the in-vehicle RFID tag comprising:

a RFID inlay having a RFID chip and a tuned antenna embedded therein;

a non-conducting layer attaching to one side of the RFID inlay;

an overlay attaching on the other side of the RFID inlay; and

an underlay attaching to the non-conducting layer, wherein the underlay and the overlay sandwiched the RFID and the non-conducting layer there between,

wherein, when in use, the ~~underlay~~ RFID tag is to be placed with the underlay in adjacent to an attaching surface, such that the RFID inlay is spaced apart from the attaching surface via the non-conducting layer.

2. The RFID tag according to claim 1, wherein the tuned antenna comprises ~~further comprising~~ an extended antenna ~~extended~~ extending from the RFID inlay through to the other side of the non-conducting layer, wherein the extended antenna is embedded in an extrusion inlay ~~, wherein the extended antenna is~~and connected as one tuned antenna for the RFID tag.

3. The RFID tag according to claim 1, wherein the RFID inlay is an extrusion inlay.

4. The RFID tag according to claim 1, wherein the RFID tag is fabricated through a precision lamination process.

5. The RFID tag according to claim 1, wherein the non-conducting layer is made up of flexible material.

6. The RFID tag according to claim 1, wherein the non-conducting layer is finely cut with precision laser in a criss-cross fashion.

7. The RFID tag according to claim 1, wherein the ~~two printable layer~~underlay and the overlay is made up of tamper-evident material.

8. The RFID tag according to claim 7, wherein the tamper-evident material is an eggshell label.

~~9. The RFID tag according to claim 7, wherein the temper-evident material is incorporate with diced inlet embedded within.~~

~~10.~~9. The RFID tag according to claim 1, further comprising a further non-conducting layer attaches to the other side of the RFID inlay under the overlay.

~~11.~~10. A method for forming an in-vehicle RFID tag for attaching under a windshield that has a tinted solar film installed thereto, the method comprising:

forming an RFID inlay having a RFID chip and a tuned antenna embedded therein;

attaching one side of the RFID inlay to an overlay;

attaching a non-conducting layer to other side of the RFID inlay; and

attaching an underlay to the other side of the conducting layer, wherein the underlay and overlay sandwiched the RFID and the non-conducting layer therebetween;

wherein, when in use, the ~~underlay I~~ RFID tag is to be placed with the underlay in adjacent to an attaching surface, such that the RFID inlay is spaced apart from the attached surface via the non-conducting layer.

~~12.~~11. The method according to claim ~~11~~10, further comprising forming an extended antenna extending from the tuned antenna of ~~from~~ the RFID inlay through to the other side of the non-conducting layer, wherein the extended antenna is embedded in an extrusion inlay~~, wherein the extended antenna is~~ and connected as one tuned antenna for the RFID tag.

~~13.~~12. The method according to claim ~~11~~10, wherein the RFID inlay is an extrusion inlay.

~~14.~~13. The method according to claim ~~11~~ 10 is a precision lamination process.

~~15.~~14. The method accordingly to claim ~~11~~10, wherein the non-conducting layer is made up of flexible material.

~~16.~~15. The method according to claim ~~11~~10, wherein the non-conducting layer is finely cut with precision laser in a criss-cross fashion.

~~17.~~16. The method according to claim ~~11~~10, wherein the two printable layer is made up of tamper-evident material, such as an eggshell label.

~~18.~~17. The method according to claim ~~11~~10, further comprising attaching a further non-conducting layer ~~attaches~~ to the other side of the RFID inlay.

~~19.~~18. An in-vehicle RFID tag for attaching under a windshield that has a tinted solar film installed thereto, the in-vehicle RFID tag comprising:

a RFID inlay having a RFID chip and a tuned antenna embedded therein;

a non-conducting layer attaching to one side of the RFID inlay;

an overlay attaching on the other side of the RFID inlay;

an underlay attaching to the non-conducting layer, wherein the underlay and the overlay sandwiched the RFID and the non-conducting layer there between; and

an extended antenna extending from the RFID inlay through to the other side of the non-conducting layer and connected to the tuned antenna as one tuned antenna for the RFID tag,

wherein, when in use, the ~~underlay~~ RFID tag is to be placed with the underlay in adjacent to an attaching surface, such that the RFID inlay is spaced apart from the attaching surface via the non-conducting layer.

~~20.~~19. The RFID tag of claim ~~19~~18, wherein the ~~overlay~~ underlay has adhesive on the outer surface for adhering the underlay onto the attaching surface.