INJECTION-MOLDED-METAL SMART CARD WITH NON-METAL DISCONTINUITY

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority to United States Provisional Application No. 63/565,897, filed March 15, 2024, and the contents of which are incorporated herein by reference in their entireties for all purposes.

BACKGROUND OF THE INVENTION

Some metal cards have a discontinuity between the cavity for receiving the communication/transaction chip and the outside perimeter of the metal card. This discontinuity, often in the form of a slit, decreases the structural integrity of the card and it does not look pleasing aesthetically.

SUMMARY OF THE INVENTION

One aspect of the invention relates to a transaction card comprising an injection-molded metal layer having a top surface, a bottom surface, a thickness between the top surface and the bottom surface, and an outer periphery. At least one through-hole extends from the top surface to the bottom surface and has an inner periphery located entirely inside the outer periphery of the metal layer. A discontinuity extends from the top surface to the bottom surface of the metal layer and from the periphery of the metal layer to the inner periphery of the through-hole. The discontinuity may comprise a void or a non-metal fill component.

The non-metal fill component may have a first edge having a first lateral dimension at the outer periphery of the card, and a second edge having a second lateral dimension greater than the first dimension at the inner periphery of the through-hole. The non-metal fill component may have an exposed portion in at least an interior portion of the fill component, and an unexposed portion embedded within the thickness of the metal layer, wherein the unexposed portion comprising one or more anchoring features. The anchoring features may include one or more anchoring cavities defined within the unexposed portion or one or more anchoring flanges defined within the unexposed portion.

In one embodiment, the one or more anchoring flanges each comprises an unexposed protrusion along at least part of an exterior periphery of the non-metal fill component, and the non-metal fill component has a first thickness at least co-extensive with the thickness of the metal layer. The non-metal fill component has a top exposed surface aligned with or extending beyond the top surface of the metal layer and a bottom surface aligned with or extending beyond the bottom surface of the metal layer. The unexposed protrusion has a second thickness less than the exposed thickness, a top surface of the unexposed protrusion located interior to the top surface of the metal

body and a bottom surface of the unexposed protrusion located interior to the bottom surface of the metal layer.

The non-metal fill component as disclosed herein may comprise ceramic or glass, and the transaction card may comprise a product of a process of injection-molding the metal body about the non-metal fill component. In embodiments, the transaction card comprises a product of a process of first injection-molding the metal body with a space for receiving the non-metal fill component; and then overmolding the non-metal fill component into the space in the metal body.

In some embodiments, the first edge and the second edge of the discontinuity are parallel to one another, and a third edge connects a first end of the first edge to a first end of the second edge, and a fourth edge connects a second end of the first edge to a second end of the second edge. The third edge and fourth edge define an acute angle relative to one another such that the discontinuity has a trapezoidal geometry.

In other embodiments, the third edge and fourth edge are parallel to one another and spaced apart by a width to define a linear feature extending from the outer periphery of the metal body to the inner periphery of the through-hole. The linear feature of the discontinuity may be aligned with and may visually form an extension of a groove defined in the injection-molded metal body, the groove having a first end located adjacent to the second edge of the linear feature of the non-metal fill component and a second end distant from the first end, the groove extending from the top surface of the metal body to a depth less than a full thickness of the metal body from the top surface to the bottom surface. The second end of the groove may be located on the outer periphery of the transaction card. The linear feature of discontinuity and the groove together may define a straight line extending from a first edge of the outer periphery of the transaction card to a second edge of the outer periphery of the transaction card.

In embodiments, the discontinuity is aligned with a decorative element defined by a raised or indented feature in the injection-molded metal body such that the discontinuity visually appears to be an extension of the decorative element.

Another aspect of the invention relates to a process for making a transaction card. The process comprises the step of (a) injection molding a metal layer, including injecting metal material into a mold to form the metal layer having a top surface, a bottom surface, a thickness between the top surface and the bottom surface, an outer periphery, at least one through-hole that extends from the top surface to the bottom surface and has an inner periphery located entirely inside the outer periphery of the metal layer, and a discontinuity extending from the top surface to the bottom surface and from the outer periphery to the inner periphery of the through-hole.

In embodiments, the process further comprises the step of (b) disposing a non-metal fill component in the discontinuity. The non-metal fill component may comprise ceramic or glass, wherein step (a) comprises providing the non-metal fill component in the mold and injection-molding the metal layer about the non-metal fill component. The process may include embedding at least one additional non-metal feature embedded in the metal layer other than in the discontinuity, wherein step (a) comprises providing the at least additional non-metal feature in the mold and injection-molding the metal body about the at least one additional non-metal feature. The non-metal fill component and the at least one additional non-metal feature may connected to one another along a non-metal pathway including at least one non-metal connector between the at least one additional non-metal feature and the at least one through-hole. At least one of the additional non-metal feature and the at least one non-metal connector may comprise ceramic or glass.

Step (b) may be performed after completion of step (a), wherein the discontinuity is formed during step (a) without the non-metal fill component disposed in the mold, leaving a space in the discontinuity upon removal of the metal body from the mold, in which case wherein step (b) may comprise a nonmetal overmolding process, such as overmolding the metal body with plastic to form at least one plastic layer over each of the top surface and the bottom surface of the metal body and a plastic fill in the discontinuity.

Other aspects of the invention may comprise cards embodying a product made by the process of any one of the foregoing processes.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1A is a schematic perspective view of an injection molded metal layer of an exemplary card with a non-metal insert in a portion of the discontinuity between the payment module pocket and an adjacent edge of the card in accordance with one aspect of the invention.

FIG. 1B is a schematic cross-sectional view of the metal layer of FIG. 1A taken across line 1B-1B in FIG. 1A, wherein the insert has anchoring features in the nature of protrusions.

FIG. 1C is a schematic cross-sectional view of the metal layer of FIG. 1A taken across line 1B-1B in FIG. 1A, wherein the insert has anchoring features in the nature of indentations.

FIG. 2 is a schematic perspective view of an injection molded metal layer of an exemplary card having a discontinuity between the payment module cavity and an adjacent edge of the card that is aligned with a decorative feature injection molded into the metal layer in accordance with another aspect of the invention.

FIG. 3 is a schematic plan view of an injection molded metal layer of an exemplary card having a first discontinuity between the payment module cavity and an adjacent edge of the card, a non-metal insert in a central region of the card, and a non-conductive connector between the non-metal insert and the payment module cavity, forming a continuous non-metal pathway from the non-metal insert to the edge of the card adjacent the payment module.

FIG. 4A is a schematic plan view of an injection molded metal layer of an exemplary card having a discontinuity between the payment module cavity and an adjacent edge of the card, wherein the discontinuity may be a void or a non-metal insert.

FIG. 4B is a schematic longitudinal section along line 4B-4B of the metal layer of Fig. 4A, after performance of a non-metal overmolding step in accordance with one method embodiment as described herein, wherein the discontinuity depicted in FIG. 4A was a void, and the non-metal overmolded material fills the void.

FIG. 4C is a schematic longitudinal section along line 4C-4C of the metal layer of Fig. 4A, after performance of a non-metal overmolding step.

FIG. 4D is a schematic longitudinal section along line 4B-4B of the metal layer of Fig. 4A, showing an absence of overmolded material in the pocket and cavity for housing the payment module, either after performance of a non-metal overmolding step in accordance with one method embodiment as described herein for avoiding such overmolding material therein, or after performing an overmolded material removal step after the method step depicted in FIG. 4B.

FIG. 4E is a schematic longitudinal section along line 4B-4B of the metal layer of Fig. 4A, prior to performance of the non-metal overmolding step, wherein the discontinuity may be a void or a non-metal insert.

FIG. 5 depicts a plan view of an injection molded metal card embodiment framing a non-metal embedded insert.

FIG. 6 depicts an exemplary cross-sectional view of an injection molded metal card embodiment framing a non-metal embedded insert.

DETAILED DESCRIPTION OF THE INVENTION

Aspects of the invention include injection molding the metal body of a metal card and using aspects of the injection molding process or other features to hide the discontinuity and increase the strength of the card having such a discontinuity.

In one embodiment, depicted in FIG. 1A, a non-metal, non-conductive insert, such as but not limited to ceramic or glass, is disposed in the discontinuity 100 between the periphery of the blind pocket 107 and the periphery of the card 116 during an injection molding process, after the metal body of the card 110 has been injection

molded (e.g. as liquid metal) around the insert. Although depicted as a trapezoidal insert in the embodiment depicted in FIG. 1A, it should be understood that the insert may have any geometry, including a long, thin, slit-like geometry. Preferably, the insert comprises a non-conductive, high-temperature resistant material (e.g. resistant to deformation at up to 750 C or higher). A further, slit-like discontinuity 101 is shown in the blind pocket 107 between the edge of cavity 105 and the inside edge of the insert in the discontinuity.

As depicted in FIG. 1B, the non-metal fill component may have an exposed portion in at least an interior portion of the fill component, such as exposed top surface 103, and one or more unexposed portions 106 along at least part of an exterior periphery of the non-metal fill component, the exposed portion having an exposed thickness co-extensive with the thickness of the metal body 110, a top surface 103 aligned with (or disposed slightly above) the top surface 112 of the metal body and a bottom surface 109 aligned with (or disposed slightly below) the bottom surface of the metal body 114. The one or more unexposed portions 106 have an unexposed thickness less than the exposed thickness, a top surface 106t located interior to the top surface of the metal body and a bottom surface 106b located interior to the bottom surface of the metal body, each of the one or more unexposed portions 106 defining an anchoring flange. As used herein, the term "exposed" refers to being open to the top surface of the metal layer, whereas "unexposed" refers to being embedded within the metal layer. Although depicted as flanges (protruding from the insert into the metal) in FIG. 1B, the anchoring features may instead be grooves, such as features 106i that are indented within the insert so that the injected metal fills the grooves in the insert, as depicted in FIG. 1C. In some embodiments, the anchoring features may include a combination of indents and protrusions.

In other embodiments, no material may be placed in the discontinuity 100 during metal molding, leaving a void. An over-molding process, with a non-conductive, non-metal material such as plastic or resin, may then be performed following the metal injection molding process, creating the card depicted in FIGS. 4A-4E, in which the metal layer 410 is covered in non-metal overmold at least in part, or entirely, forming a top layer 420 and a bottom layer 430, with the overmolded material also filling the cavity 405 and pocket 407 surrounding the cavity (present in certain embodiments for receiving a payment module having a corresponding stepped geometry), as well as the void 400 corresponding to the discontinuity, as depicted in cross section in FIGS. 4B and 4C. After the overmolding step, at least a portion of the overmolded material may be removed from at least the top layer, the cavity 405 and the pocket 407 (e.g. by milling or laser ablation) to make room for later insertion of the

payment chip in the pocket / cavity, resulting in the intermediate construction depicted in FIG. 4D, which corresponds to FIG. 4B after the partial overmold removal step. Or, in other embodiments, the non-metal overmolding step may utilize a mold configured to avoid overmolding over the payment module pocket/cavity, in which case the result of the overmolding step resembles that of FIG. 4D without a material removal step. In some embodiments, the upper and lower overmolded layers may be removed entirely (where the overmold is desired only to fill the discontinuity), whereas in other embodiments, the overmold layer may be left on the card as a print-receiving layer. Multiple overmold steps may be performed, such as first overmold step to fill the discontinuity (e.g. with a first non-conductive material), and a second overmold step to form print receiving layers (e.g. with a second non-conductive material). The first and second materials may the same materials or different materials, or different types or grades of a similar material.

The metal layer of FIG. 4A / 4E may be described as comprising an injection-molded metal layer 410 having a top surface 412, a bottom surface 414, a thickness T between the top surface and the bottom surface, an outer periphery 416, and at least one through-hole 405 that extends from the top surface to the bottom surface and has an inner periphery located entirely inside the outer periphery of the metal body. Discontinuity 400 extends from the top surface to the bottom surface of the metal layer and from the outer periphery of the metal layer to the inner periphery of the through-hole. Notably, the portion of the discontinuity extending through the blind pocket 401 (i.e. beneath the later-inserted payment module) may have a generally slit-like geometry, to maximize the amount of metal disposed beneath the antenna of the payment module after the module is inserted in the pocket, whereas the portion of the discontinuity 400 extending between the edge of the pocket and the edge of the card may be substantially wider or may have a different geometry, such as the geometries depicted in FIGS. 1A and 4A. Prior art metal layers having a discontinuity typically required a milling or ablation step to form the discontinuity in the metal layer, rather than having a metal discontinuity formed within the mold during the injection molding process as described herein.

Discontinuity 400 as depicted in FIGS. 4A and 4E may comprise a void or a non-metal fill component disposed in the discontinuity during the injection molding process. The geometry of the void may have any of the features discussed herein with respect to the non-metal fill component as discussed herein. In particular, the void may include one or more anchoring cavities defined within the one or more unexposed portions of the card, that are ultimately filled with the non-metal overmolding material during the non-metal overmolding process as described herein. After the overmolding

step, the corresponding card in cross section may resemble the section depicted in FIGS. 1B or 1C, wherein instead of an insert having been placed in the mold during the metal injection molding process, the mold defines a void such that material 100 as depicted (i.e. with anchoring flanges 106 or 106i as depicted in FIGS. 1B and 1C comprise overmolded material rather than a non-metal insert disposed in the mold during the metal injection molding step. In such embodiments, when the card is removed from the mold following the liquid metal injection molding step, it has features that are configured to receive the overmolding material, wherein the overmolding material fills in or around the protruding or indented anchoring features during the overmolding step.

As depicted in FIG. 1A, non-metal fill component 100 has a first edge 102 having a first lateral dimension at the outer periphery of the card, and a second edge 104 having a second lateral dimension greater than the first dimension at the inner periphery of the blind pocket 107. Portion 101 of the discontinuity and corresponding fill component extending between the leftmost edge of the blind pocket 107 and the leftmost edge of the thorough hole 105 as depicted in Fig. 1A, may have more of a slit-like geometry to maximize the area of metal underneath the module antenna after insertion of the module in the pocket. As depicted in FIG. 1A, the first edge 102 and the second edge 104 are parallel to one another, and the discontinuity / insert 100 has a trapezoidal geometry, defined by a third edge 122 connecting a first end of the first edge to a first end of the second edge, and a fourth edge 124 connecting a second end of the first edge to a second end of the second edge, wherein the third edge 122 and the fourth edge 124 define an acute angle relative to one another. By contrast in the configuration depicted in FIG. 4A, the discontinuity / insert 400 has corresponding first edge 451 and second edge 452 that are parallel and of the same length, and a third edge 453 and a fourth edge 454 that are parallel to one another and spaced apart by a width to define a linear feature extending from the outer periphery 416 of the metal body 410 to the inner periphery of the pocket 407, and then a slit-like geometry from the edge of the pocket to the through-hole 405.

Although not limited to any particular geometry, an insert having a trapezoidal geometry as depicted in FIG. 1A with the shorter edge on the periphery of the card has certain advantages in that the geometry minimizes or eliminates any tendency for the insert to naturally pop out toward the outer periphery of the card. Likewise, the use of anchoring flanges or features minimizes or eliminates any tendence for the insert to naturally pop out from the upper surface or the lower surface. Especially for inserts with a relatively wide lateral dimension (e.g. not a thin, rodlike or slit-like geometry) that may be subject to isolated upward, downward, or

outward forces caused by the fingers of a user, the trapezoidal geometry with anchoring features may be particularly important.

It should be understood that the non-metal overmolding step may also be performed in connection with any of the embodiments as discussed herein. For example, overmolding performed on the embodiment depicted in FIG. 1A results in a card with a similar configuration as that depicted in FIGS. 4A-4D, except that area 400 comprises a non-metal, non-conductive insert rather than a void filled with the non-metal overmold material. In embodiments in which non-metal overmolding is performed over the metal body, but a non-metal (e.g. ceramic or glass) insert is desired to be tactilely perceptible on the outer surface of the card, the thickness of the insert may be slightly greater than the thickness of the metal body, so that after the overmolding step, the non-metal insert has a surface even with the surface of the overmolded plastic. Additional steps, such as polishing, may be performed to facilitate a smooth tactile transition from the surface of the insert to the surface of the overmold material.

In another embodiment depicted in FIG. 2, a discontinuity 200 in the form of a slit that extends from a top to a bottom surface of the metal layer of the card may be aligned to form a continuation of a decorative pattern formed in the injection-molded metal layer 210. For example, decorative features (e.g. lines 200a and 200b) may comprise portions of the metal layer that are slightly indented (e.g. grooves) or slightly raised relative to the remaining surface of the card. As depicted in FIG. 2, the lines formed by those indented or raised portions align with slit 220. The decorative lines may be formed as features in the mold so that the metal is injection molded to form the pattern, or the lines may be printed (including 3D printed metal), or mechanically or laser engraved. Although depicted as straight lines for ease of illustration, it should be understood that the decorative features and the slit are not limited to any particular geometry or alignment therebetween. Aligning decorative features with the discontinuity may thus enable a user to perceive the presence of the discontinuity as a continuation of the decorative features, rather than an independent element, thereby hiding the presence of the discontinuity in plain sight.

Thus, in one embodiment as depicted in FIG. 2, the linear feature of the discontinuity 220 is aligned with and visually forms an extension of a groove 200a defined in the injection-molded metal body 210. The groove extends from the top surface of the metal body 210 to a depth less than a full thickness of the metal body from the top surface to the bottom surface of the metal body. Discontinuity has a first edge 221 at the periphery of the card 216 and a second edge 222 at the inner periphery of the through-hole 205 for holding the payment chip. Discontinuity may

have a non-metal fill component therein, including a fill that is created by overmolding or formed by a non-conductive insert, as described herein. Groove 200a has a first end 201 located adjacent to the second edge of the linear feature of the discontinuity 222 and a second end 202 distant from the first end, depicted in FIG. 2 ending at the outer periphery 216 of the metal body. As depicted in FIG. 2, the linear feature of discontinuity 220 and the groove 200a together define a straight line extending from a first (left) edge 217 of the outer periphery of the transaction card to a second (bottom) edge 218 of the outer periphery of the transaction card. In should be understood, however, that the invention is not limited to any particular geometry of the decorative features or the discontinuity, or top any particular alignment between those elements. Rather, although linear alignment is one type of alignment, any disposition between the discontinuity and the decorative features that leads a viewer's eye to perceive the discontinuity to be a continuation of the decorative features injection molded into the card may be considered "alignment" as that term is used herein.

Although including a non-metal, non-conductive feature to form a discontinuity between the interior periphery of the payment chip cavity and the outer periphery of the card as depicted in FIGS. 1A – 1C has certain advantages, it should be understood that an injection-molded metal card body may have one or more inserts in any location in the card body, which insert may be of any material of construction that is different than the remainder of the card body (including a different conductive metal). In the embodiment depicted in FIG. 3, a top surface of a metal layer 310 is depicted showing the payment chip 300 and a ceramic insert 320 having a hexagonal geometry. The insert is not limited to any particular geometry, proportion relative to the rest of the metal body, or materials. As depicted, ceramic insert 320 is located in a central area of the card, spaced away from the payment module 300. Rather than ceramic, the inserts may be gemstones or non-precious crystals, stones, or other natural or man-made materials suitable for surviving the injection molding process in a desired configuration (which may be unchanged from their state prior to the molding process, or modified in a desired way – controlled or random -- due to the metal injection molding process).

In some implementations of the card depicted in FIG. 3, the chip pocket may have a first discontinuity 330 between the outer edge of the card 316 and the cavity 305 within the chip pocket 307 for receiving the payment module (not shown). If the ceramic insert, 320, extends entirely through the injection molded metal card layer 310 from a top surface of the body to a bottom surface of the body, a second discontinuity 340 preferably extends between the cavity 305 and the ceramic insert 320. If the ceramic insert 320 does not extend entirely through the injection molded

card layer 310, the second slit 340 may not be present. The first discontinuity 330 and second discontinuity 340 may have any of attributes of any of the embodiments as described herein (e.g. glass or plastic insert; void injection molded and then filled with non-metal overmold) in any geometry. Although depicted with only a single insert 320, it should be understood that multiple such inserts may be present. The inserts may be decorative or may also have functional attributes. The insert 320 may have anchoring features such as those described and discussed for the discontinuity insert with reference to FIGS. 1B and 1C herein.

Thus, an exemplary process for making a transaction card includes injection molding a metal body, including injecting liquid metal into a mold to form the metal body 410 having a top surface 412, a bottom surface 414, a thickness T between the top surface and the bottom surface, an outer periphery 416, at least one through-hole 405 that extends from the top surface to the bottom surface and has an inner periphery located entirely inside the outer periphery of the metal body, and a discontinuity 400 extending from the top surface to the bottom surface and from the outer periphery to the inner periphery of the through-hole. The process may include further disposing a non-metal fill component (e.g. such as ceramic or glass insert 100) in the discontinuity, in which case the process comprises providing the non-metal fill component in the mold and injection-molding the metal body about the non-metal fill component. Although aspects of the invention as described herein may be particularly useful for the use of liquid metal injection molding, the invention is not limited thereto. For example, the metal layer may comprise a combination of metal and epoxy, as described in U.S. Patent No. 11,663,433, titled METAL-DOPED EPOXY RESIN TRANSACTION CARD AND PROCESS FOR MANUFACTURE, incorporated here by reference, which may permit the use of lower temperature molding and thus may accommodate inserts with lower temperature thresholds.

As depicted in FIG. 3, the card may further include at least one additional insert, preferably a non-metal (e.g. ceramic or glass) feature 320, embedded in the metal body 310 other than in the discontinuity 330 (which may include a ceramic or glass fill component therein), wherein the process comprises providing the at least one additional insert 320 in the mold and injection-molding the metal body about the at least one additional insert. The non-metal material in discontinuity 330, the at least one non-metal feature 320, and non-metal connector 340 form a continuous non-metal path with cavity 305 between each non-metal feature 320 and the periphery of the card. In other embodiments, the non-metal path between each non-metal feature 320 and the periphery of the card may not pass through cavity 305, but may go directly to the card periphery, such as direct path 341 shown in FIG. 3. Although depicted as a

straight line, it should be understood that the term "direct" means only that path 341 does not connect to the periphery of the card via cavity 305 and discontinuity 330. In embodiments with multiple non-metal features (including voids, ceramic members, etc.) disposed in the card, non-metal paths may connect multiple features to one another and may together form a connected path from each feature to the periphery of the card. Such paths may be straight, curved, sinuous, or in any geometry desired. While each non-metal feature typically has only one path that connects that feature to the periphery of the card directly or indirectly (e.g. connected to other non-metal features or cavities before terminating at the periphery), embodiments may include cards having multiple such paths including multiple paths connecting non-metal features to one another. The non-metal path(s) may comprise any combination of non-metal materials or voids (e.g. plastic, glass, non-metal fill such as plastic) in first discontinuity 330 and second discontinuity (connector 340 or direct 341) and an unfilled or filled void 305.

The process of creating the non-metal fill within the discontinuity may be performed after completion of metal injection-molding step, wherein the discontinuity is formed during the metal injection-molding step without a non-metal fill component disposed in the mold, leaving a space in the discontinuity upon removal of the metal body from the mold. An overmolding process then may form the non-metal fill within the discontinuity. In particular, as depicted in FIGS. 4A-4D, the overmolding process may form at least one (e.g. plastic) layer 420, 430 over each of the top surface 412 and the bottom surface 414 of the metal body and a plastic fill in the discontinuity 400.

Referring now to FIG. 5, a card embodiment 500 is depicted comprising a ceramic (or other high-temperature-resistant non-metal) material 510 is embedded in a metal surround 520 formed by disposing the non-metal material in a mold, and over-molding metal around the non-metal material. In one embodiment, the ceramic (or other non-metal) insert 510 may have features that facilitate using the metal layer 520 as an antenna. Such antenna embodiments have at least one discontinuity in the metal frame (such as the discontinuity as depicted in Fig. 3 or any one or, optionally, two or more but not all, of the discontinuities depicted in FIG. 5 or 6). However, too many discontinuities (such as in the embodiment depicted in Fig. 5) may reduce or eliminate functionality as an antenna and may be desired for other reasons. By "high-temperature-resistant" non-metal, it is meant that the integrity of the non-metal material is not materially compromised during its short presence in contact with the liquid metal of the mold. While optionally, some such non-metal materials may have a melting point higher than the melting point of the metal, this is not strictly necessary,

as the liquid metal cools quickly within the mold. Accordingly, materials such as glass, having a lower melting point than metal, may also be acceptable.

In other embodiments, the metal may have a plurality of discontinuities 521-528 in the metal frame to minimize electromagnetic interference caused by the metal. As depicted in FIG. 5, each discontinuity is depicted as having a straight linear geometry that extends underneath the non-metal insert 510. The geometry of the discontinuities is not limited to straight lines, but may include curves, zig zags, or other geometries, without limitations. The chip pocket 550 and through-hole 560 may be milled in a later step to provide a cavity for embedding the payment chip.

FIG. 6 depicts a cross sectional view of a card 600 similar to card 500, having a ceramic (or other non-metal) insert 610 and metal surround 620 with discontinuities 621-625 in the metal, but with the discontinuities in different locations and/or different in number than for card 500. As shown in FIG. 6, the metal surround 620 forms a pocket that surrounds the insert on its lateral edges and on one of its two surfaces. Chip pocket 650 is formed at least in the non-metal layer (depending upon the thickness of that layer) and the through-hole 660 extends through the metal layer. Notably, as depicted in FIG. 6, one or more of the discontinuities 621-625 have a cross-sectional orientation that is non-perpendicular to the opposite planar surfaces defined by the metal layer. The invention is not limited to any particular sectional orientation of the discontinuities relative to the surfaces of the metal layer, and may include all perpendicular orientations, all non-perpendicular orientations, or a combination thereof. The foregoing is applicable to any of the discontinuity embodiments as discussed herein.

One benefit of having a large piece of non-metal material (e.g. ceramic) that defines an area that forms the majority of the surface area on one side (i.e. the front) of the card is that the non-metal insert provides continuity and structure to support a number of possible design options on the other (i.e. back) side of the card, while allowing different electromagnetic design options that facilitate better secure element communication at the point of sale. Another advantage is that the metal frame may facilitate the use of machinable engineering ceramics or other non-metal materials that are brittle or subject to shattering from impact. The edges of the insert 510, 610 encapsulated as shown in FIGS. 5 and 6 are protected from impact by the surrounding metal 520, 620.

In other embodiments, the non-metal layer and metal layer may be coextensive from edge-to-edge (i.e. the metal does not frame the non-metal insert). In embodiments with a frame of metal surrounding the lateral edges of the non-metal insert, the width of the frame is not limited to any particular dimension. In

embodiments, such as that depicted in FIGS 5 and 6, the ceramic insert covers an area that at least includes the payment module pocket, including embodiments in which the width of the metal frame may have a width less than or equal to the distance between the edge of the chip pocket and the peripheral edge of the card. Although depicted in embodiments in which the distance between the edge of the metal layer and the edge of the insert is constant on all edges, the distance may be different on one or more edges as compared to others.

In embodiments, the metal layer 520 may be divided into a plurality of disjointed pieces (i.e. separated by discontinuities 521-528, etc.), in particular around the chip module as depicted in FIGS. 5 and 6, effectively eliminating any electromagnetic interference from the metal layer. In such an implementation, a separate antenna (not shown) may be coupled with the chip module. As with the other embodiments as described herein, the discontinuities 521-528 and 621-625 may comprise voids or may comprise non-metal materials, which may comprise materials disposed in the mold during the injection molding process, non-metal materials overmolded after creation of the injection molded metal layer, or combinations thereof. Also, as with the other embodiments as described herein, the non-metal insert 510, 610 as shown in FIGS. 5 and 6 may have one or more anchoring features as described above that cooperate with the injection-molded metal to interlock the metal and non-metal components together.

Although the invention is illustrated and described herein with reference to specific embodiments, the invention is not intended to be limited to the details shown. In particular, specific types of materials and geometries as discussed herein are not intended to be limiting for all embodiments but may have specific benefits in certain embodiments. Although certain layers are expressly discussed herein, it should be understood that additional layers or fewer layers may be present in certain embodiments, or certain embodiments may consist of only the layer or layers as described. Elements discussed with respect to one embodiment may be combined with elements discussed with respect to other embodiments, unless mutually exclusive or such combinations are expressly disclaimed. Certain combinations may have benefits not present in other combinations. Various modifications may be made in the details within the scope and range of equivalents of the claims and without departing from the invention.

What is Claimed:

1. A transaction card, comprising:

an injection-molded metal layer having a top surface, a bottom surface, a thickness between the top surface and the bottom surface, an outer periphery;

at least one through-hole that extends from the top surface to the bottom surface and has an inner periphery located entirely inside the outer periphery of the metal layer; and

a discontinuity extending from the top surface to the bottom surface of the metal layer and from the periphery of the metal layer to the inner periphery of the through-hole.

2. The transaction card of claim 1, wherein the discontinuity comprises a void.

3. The transaction card of claim 1, wherein the discontinuity is defined by a non-metal fill component.

4. The transaction card of claim 3, wherein the non-metal fill component has a first edge having a first lateral dimension at the outer periphery of the card, a second edge having a second lateral dimension greater than the first dimension at the inner periphery of the through-hole.

5. The transaction card of claim 3, wherein the non-metal fill component further comprises an exposed portion in at least an interior portion of the fill component, and an unexposed portion embedded within the thickness of the metal layer, the unexposed portion comprising one or more anchoring features.

6. The transaction card of claim 5, wherein the non-metal fill component further comprises one or more anchoring cavities defined within the unexposed portion.

7. The transaction card of claim 5, wherein the non-metal fill component further comprises one or more anchoring flanges defined within the unexposed portion.

8. The transaction card of claim 7, wherein the one or more anchoring flanges each comprise an unexposed protrusion along at least part of an exterior periphery of the non-metal fill component, the non-metal fill component having a first thickness at least co-extensive with the thickness of the metal layer, the non-metal fill component having a top exposed surface aligned with or extending beyond the top surface of the metal layer and a bottom surface aligned with or extending beyond the bottom surface of the metal layer, and the unexposed protrusion having a

second thickness less than the exposed thickness, a top surface of the unexposed protrusion located interior to the top surface of the metal body and a bottom surface of the unexposed protrusion located interior to the bottom surface of the metal layer.

9. The transaction card of claim 3, wherein the non-metal fill component comprises ceramic or glass, and the transaction card comprises a product of a process of injection-molding the metal body about the non-metal fill component.

10. The transaction card of claim 3, wherein the transaction card comprises a product of a process of first injection-molding the metal body with a space for receiving the non-metal fill component; and then overmolding the non-metal fill component into the space in the metal body.

11. The transaction card of claim 4, wherein the first edge and the second edge are parallel to one another.

12. The transaction card of claim 11, wherein the discontinuity is defined by a third edge connecting a first end of the first edge to a first end of the second edge, and a fourth edge connecting a second end of the first edge to a second end of the second edge.

13. The transaction card of claim 12, wherein the third edge and fourth edge define an acute angle relative to one another and the discontinuity has a trapezoidal geometry.

14. The transaction card of claim 12, wherein the third edge and fourth edge are parallel to one another and spaced apart by a width to define a linear feature extending from the outer periphery of the metal body to the inner periphery of the through-hole.

15. The transaction card of claim 14, wherein the linear feature of the discontinuity is aligned with and visually forms an extension of a groove defined in the injection-molded metal body, the groove having a first end located adjacent to the second edge of the linear feature of the non-metal fill component and a second end distant from the first end, the groove extending from the top surface of the metal body to a depth less than a full thickness of the metal body from the top surface to the bottom surface.

16. The transaction card of claim 15, wherein the second end of the groove is located on the outer periphery of the transaction card.

17. The transaction card of claim 16, wherein the linear feature of discontinuity and the groove together define a straight line extending from a first edge of the outer periphery of the transaction card to a second edge of the outer periphery of the transaction card.

18. The transaction card of claim 1, wherein the discontinuity is aligned with a decorative element defined by a raised or indented feature in the injection-molded metal body such that the discontinuity visually appears to be an extension of the decorative element.

19. A process for making a transaction card, the process comprising the steps of:

(a) injection molding a metal layer, comprising injecting metal material into a mold to form the metal layer having a top surface, a bottom surface, a thickness between the top surface and the bottom surface, an outer periphery, at least one through-hole that extends from the top surface to the bottom surface and has an inner periphery located entirely inside the outer periphery of the metal layer, and a discontinuity extending from the top surface to the bottom surface and from the outer periphery to the inner periphery of the through-hole.

20. The process of claim 19, further comprising the step of:

(b) disposing a non-metal fill component in the discontinuity.

21. The process of claim 20, wherein the non-metal fill component comprises ceramic or glass, and step (a) comprises providing the non-metal fill component in the mold and injection-molding the metal layer about the non-metal fill component.

22. The process of claim 20 or 21, further comprising at least one additional non-metal feature embedded in the metal layer other than in the discontinuity, wherein step (a) comprises providing the at least additional non-metal feature in the mold and injection-molding the metal body about the at least one additional non-metal feature.

23. The process of claim 22, wherein the non-metal fill component and the at least one additional non-metal feature are connected to one another along a non-metal pathway including at least one non-metal connector between the at least one additional non-metal feature and the at least one through-hole.

24. The process of claim 23, wherein at least one of the at least one additional non-metal feature and the at least one non-metal connector comprise ceramic or glass.

25. The process of claim 20, wherein step (b) is performed after completion of step (a), wherein the discontinuity is formed during step (a) without the non-metal fill component disposed in the mold, leaving a space in the discontinuity upon removal of the metal body from the mold.

26. The process of claim 20, wherein step (b) comprises a nonmetal overmolding process.

27. The process of claim 26, wherein step (b) includes overmolding the metal body with plastic to form at least one plastic layer over each of the top surface and the bottom surface of the metal body and a plastic fill in the discontinuity.

28. A card comprising a product made by the process of any one of claims 20-27.

29. The transaction card of any one of claims 1-18, further comprising at least one additional non-metal feature embedded in the metal layer other than in the discontinuity extending from the periphery of the metal layer to the inner periphery of the through-hole.

30. The transaction card of claim 29, wherein the non-metal fill component and the at least one additional non-metal feature are connected to one another along a non-metal pathway including at least one non-metal connector between the at least one additional non-metal feature and the at least one through-hole.

31. The transaction card of claim 30, wherein at least one of the at least one additional non-metal feature and the at least one non-metal connector comprises ceramic or glass.

32. The transaction card of claim 30, further comprising a second discontinuity extending from the top surface to the bottom surface of the metal layer and from the periphery of the metal layer to the at least one additional non-metal feature.

33. A transaction card, comprising:

an injection-molded metal layer having a top surface, a bottom surface, a thickness between the top surface and the bottom surface, an outer periphery; and

at least one non-metal feature embedded in the metal layer.

34. The transaction card of claim 33, further comprising at least one through-hole that extends from the top surface to the bottom surface and has an inner periphery located entirely inside the outer periphery of the metal layer; and

35. The transaction card of claim 34, wherein the at least one non-metal feature comprises a discontinuity extending from the top surface to the bottom surface of the metal layer and from the periphery of the metal layer to the inner periphery of the through-hole.

36. The transaction card of claim 35, wherein the at least one non-metal feature comprises at least one additional non-metal feature embedded in the

metal layer other than in the discontinuity extending from the periphery of the metal layer to the inner periphery of the through-hole.

37. The transaction card of claim 34, wherein the at least one through-hole is configured for insertion of a payment module, and the at least one non-metal feature is located in an area of the metal layer other than between the through-hole and an edge of the metal layer closest to the through-hole.

38. The transaction card of claim 36, further comprising least one non-metal connector between the at least one non-metal feature and the at least one through-hole.

39. The transaction card of any one of claims 36-38, further comprising a discontinuity extending from the top surface to the bottom surface of the metal layer and from the periphery of the metal layer directly to the at least one non-metal feature.

40. The transaction card of claim 33, wherein the injection-molded metal layer has a first thickness in a first region extending between the outer periphery of the metal layer and an outer periphery of the at least one non-metal feature and a second thickness extending between the bottom surface of the metal layer and a bottom surface of the at least one non-metal feature.

41. The transaction card of claim 40, wherein the metal layer defines a pocket that frames the non-metal feature peripherally on a top surface of the card and that extends beneath a bottom surface of the non-metal feature.

42. The transaction card of any one or claims 40-41, wherein the transaction card comprises a product of a process of injection-molding the metal body about the non-metal insert component.

43. The transaction card of any one of claims 40-42, wherein the non-metal feature comprises ceramic or glass.

44. The transaction card of any one of claims 40-43, further comprising one or more discontinuities in the metal layer extending from one peripheral edge of the metal layer to another peripheral edge of the metal layer along the bottom surface of the non-metal feature.

45. The transaction card of claim 44, wherein the one or more discontinuities comprise voids.

46. The transaction card of claim 44, wherein the one or more discontinuities comprise non-metal material.

47. The transaction card of claim 45, wherein at least one non-metal feature comprises one or more anchoring features.