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**A METHOD OF MANUFACTURING A CONTACTLESS SMART
CARD**

The invention relates to the manufacture of smart
5 cards, and more particularly cards capable of operating
without contact by means of an antenna integrated into
the card. This term "contactless card" will refer on
the one hand to cards which can communicate with the
outside only by means of the antenna, and also and in
10 particular mixed cards which can communicate with the
outside either by means of the antenna or by means of
conventional standardised contacts.

Such cards are intended to perform various
operations, such as, for example, banking operations,
15 telephone communications, identification operations,
debiting operations or recharging units of account, and
all kinds of operations which can take place either by
inserting the card into a reader or at a distance by
electromagnetic coupling (in principle of the inductive
20 type) between a transmission/reception terminal and a
card placed in the area of action of this terminal.

Contactless cards must preferably have
standardised dimensions identical to those of
conventional smart cards provided with contacts. This
25 is obviously particularly essential for mixed cards,

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and is desirable for cards operating solely without contacts.

The usual standard ISO 7810 defines a card 85 mm long, 54 mm wide and 0.76 mm thick. The contacts fit
5 flush at well defined positions on the surface of the card.

These standards impose severe constraints in manufacture. The very slight thickness of the card is in particular a major constraint, and more severe still
10 for contactless cards than for cards simply provided with contacts, since it is necessary to provide for the incorporation of an antenna in the card.

The technical problems which are posed are problems of positioning the antenna with respect to the
15 card, since the antenna occupies almost the entire surface of the card, problems of positioning the integrated circuit module (comprising the chip and its contacts) which provides the electronic functioning of the card, and problems of precision and reliability of
20 the connection between the module and the antenna; finally, constraints of mechanical behaviours, reliability and manufacturing cost must be taken into account.

The aim of the invention is to propose a
25 manufacturing method which as far as possible resolves the various constraints of sizing, manufacturing precision, mechanical behaviour and more generally reliability, cost and efficiency of manufacture of the card.

For this purpose, according to the invention, a method of manufacturing a smart card including the following steps is proposed:

- 5 - assembling sheets of plastic material placed one on top of the other, enclosing in the superimposition an antenna having two conductive access areas;
- 10 - opening up a cavity in a top face of the assembly, and revealing the conductive access areas at the time of this opening;
- 15 - bonding an electronic module in the cavity, the module having, on its bottom face, turned towards the inside of the cavity, conductive surfaces coming into electrical contact with the conductive access areas of the antenna.

20 The conductive access areas of the antenna will preferably consist of the ends, covered with conductive glue, of an antenna conductor. This conductive glue will in principle be deposited after opening the cavity, but it could also be deposited between two phases of a rolling carried out in several passes.

25 Preferably, the assembly of sheets includes a sheet provided with perforations coming above the ends of the antenna, the perforations being revealed when the cavity is opened up and the conductive glue being deposited in these perforations.

30 As will be seen, the electronic module can be of a single-face or double-face type and, in the latter case, provision can advantageously be made for this to be a double-face circuit without a contact via between

the two faces, with wires welded between the chip and the conductors of the two faces. Whatever the design of the module, provision is preferably made for the cavity to define a housing in the shape of the module, so that conductors of the module are flush with the top surface of the card and thus constitute the access contacts to the smart card.

The antenna conductor is preferably a conductor printed on an insulating sheet, but it can also consist of a coiled wire enclosed in the assembly of sheets of plastic material.

Other characteristics and advantages of the invention will emerge from a reading of the following detailed description given with reference to the accompanying drawings, in which:

- Figures 1 to 5 depict the successive operations of the method according to the invention in one embodiment;

- Figure 6 depicts the constitution of a double-face electronic module without conductive vias between the two faces;

- Figures 7 to 9 depict the method according to the invention in a second embodiment.

In general terms, contactless chip cards will be produced by bonding (hot or cold rolling) sheets of plastic material in which the antenna conductor will have been inserted or interposed, and then opening up a cavity in the assembled sheets in order to create therein a housing for an integrated circuit module, or for completing a housing already partially created, and

fitting the module so that two conductive areas of the module come into electrical contact with two ends of the antenna conductor, either directly or more usually by means of a conductive glue.

5 Figures 1 to 5 depict a first embodiment of the method according to the invention.

 The starting point is several sheets of plastic material, here four sheets 10, 20, 30, 40, which are placed one on top of the other by hot or cold rolling
10 in order to connect them together. It would be possible to use only two or three sheets placed on top of each other, as will be seen later. The rolling operation consists in pressing the sheets flat one against the other in the presence of any binding
15 substances between the sheets. Cutting the card to standardised dimensions can be done either before or after the rolling operation, preferably after.

 The sheet 10, underneath the stack, constitutes a rear cladding of the smart card.

20 The sheet 20 carries a printed circuit antenna 22, i.e. a conductor deposited and etched, or screen-printed, on the sheet. The antenna 22 in general makes several turns, following the external periphery of the card, in order to cut an electromagnetic flux which is
25 as great as possible. The antenna has two ends 24 and 26 slightly spaced apart from each other. The spacing is chosen according to the conductive areas of the electronic module which will be inserted in the card.

 The sheet 30 preferably has two perforations 34
30 and 36 each situated above a respective end, 24, 26, of

the antenna. The electrical contact between the antenna and the integrated circuit module will take place through these perforations.

5 Finally, the sheet 40 constitutes a front face cladding of the chip (Figure 1).

10 The rolling operation forms, from the four sheets, a wafer of plastic material 50 in which there are enclosed the antenna 22 and its ends 24, 26, the latter being underneath the perforations 34, 36 (Figure 2).

15 A cavity 52 is then hollowed out, having the general shape of the electronic module which it will be necessary to insert therein, the depth of the cavity being such that the external access contacts of the module, which will become the access contacts of the card for insertion into a reader with contacts, are flush with the top surface of the wafer. In the general case, the cavity has the shape of a double bowl with two flat bottoms, one of the bottoms, 54, being less deep, the other, 56, being deeper. The less deep part arrives above the ends 24 and 26, whilst the deeper part is situated entirely between the ends.

20 The cavity is preferably formed by two successive milling operations. After formation of the cavity, the ends 24 and 26 of the antenna conductor are accessible through the perforations 34 and 36; this means that the depth of the bottom 54 is at least sufficient to pierce the entire thickness of the sheet 40 and reach the sheet 30 and its perforations (Figure 3).

Then a drop of conductive glue 60, 62 is preferably placed in each of the perforations 34 and 36. The ends of the antenna thus covered constitute the conductive areas of access to the antenna (Figure 4).

Then the electronic module M containing the integrated circuit providing the electronic functioning of the smart card is positioned. This module can be a single-face printed circuit module or a double-face printed circuit module, and in the latter case it can have two possible configurations, which will be dealt with later. A module M is depicted in Figure 4 above the cavity 52. In this example it is a case of a double-face printed circuit module having top conductors 70 on the face which will be turned towards the outside of the cavity and bottom conductors 72 on the face which will be turned towards the inside of the cavity. The conductors are formed on an insulating sheet and conductive vias connect the top and bottom conductors. A chip embedded in a protective resin 74 is mounted on the bottom face and connected to the conductors 72 (and thereby to the conductors 70).

The module fits in the cavity 52, which has been machined to its dimensions. Figure 5 shows the module mounted in the card. Two conductive areas of the bottom face of the module, disposed just above the ends 24, 26 of the antenna, are electrically connected to these two ends by virtue of the conductive glue present in the perforations 34 and 36.

The conductive glue holds the module in place, but it is also possible to envisage a supplementary holding by a non-conductive glue deposited on the bottom of the cavity or on the bottom face of the module outside the places reserved for contact with the antenna ends. An anisotropic conductive glue, conducting perpendicularly to the layer of glue but not parallel to the layer, can also be used for preventing short-circuits between certain electrical parts of the module or of the antenna which must not be connected together. This anisotropic glue could be deposited both in the perforations 34, 36 and in the remainder of the cavity 52 without any special precautions.

The method can also be used easily with a single-face integrated circuit module. In this case, the chip is deposited on a metallic grid whose top face will constitute the access contacts of the smart card and whose bottom face, turned towards the antenna ends, will allow the connection with these ends by means of the conductive glue. This metallic grid will in general be covered, on the bottom side, with an insulating sheet. The insulating sheet is perforated where contact must be made with the antenna, the other conductive parts of the bottom face of the grid preferably being protected either by this insulating sheet or by the protective resin of the chip.

In a particularly advantageous variant embodiment, the module consists of a double-face printed circuit carrying the integrated circuit chip, but this double-face circuit is produced without a

conductive via between the conductors of the two faces, which makes it less expensive.

Figure 6 depicts in detail the design of such a double-face module without a via. The module comprises an insulating sheet 80 with first conductors 70 deposited and etched on its top face (the external face when the module is placed in the card), and second conductors 72 deposited and etched on the bottom face. The first conductors will serve as access contacts of the smart card. The second are intended to provide the connection of the chip with the antenna. The integrated-circuit chip 82 is glued to the bottom face and is connected by wires welded on the one hand directly to conductors on the bottom face and on the other hand, through openings in the insulating sheet, to the rear of the conductors 70 on the top face.

More precisely, two welded connecting wires start from the chip and end at two conductors 72 on the bottom face, these conductors being intended to be connected to the ends of the antenna. Only one of these wires, 84, is depicted in Figure 6. And other connecting wires start from the chip and are welded to the rear of the conductors 70 on the top face with a view to producing the accesses to the card in a contactless reader. Only one of these welded wires, 86, is depicted in Figure 6.

The example embodiment described in Figures 1 to 6 uses a rolling of four sheets of plastic material. It will be understood that the sheets 10 and 20 can be replaced by a single sheet 20, possibly thicker, and

likewise the sheets 30 and 40 can be replaced by a single sheet 30, possibly thicker. In the latter case, the perforations 34 and 36 are flush with the surface of the rolled wafer 50; the perforations are then revealed whatever the depth of the bottom 54 of the cavity.

In another variant embodiment, the depositions of conductive glue 60 and 62 can be made before gluing the top sheet 40 onto the sheet 30, but after gluing the sheet 30 onto the sheet 20. The rolling takes place in this case in two passes, the deposition of glue being made between the two passes. The glue is then enclosed in the perforations 34 and 36 and is bared when the cavity 52 is machined. It is then possible, if desired, to place a measure of glue on the perforations 34 and 36 already filled with glue, before fitting the electronic module.

In another variant embodiment, depicted in Figure 7, provision is made for an anti-adherent substance to be placed between two sheets of the assembly in the region provided for the cavity so as to prevent bonding of the two sheets in this region and to facilitate the removal of material in this region when the cavity is opened; one of the sheets is the one which carries the antenna so that the opening in the cavity bares the antenna ends. More precisely, the top sheet 30 does not have perforations 34 and 36 but has, above the cavity 52, this anti-adherent substance 90 which will prevent the bonding of the sheet 30 to the ends of the antenna. After rolling, the plastic of the sheet 30 is

scaled where it is not adherent, baring the contacts and partly establishing the cavity 52 (Figure 8).

5 The definitive shape of the cavity can be obtained by machining, notably in order to define a deeper part. A drop of conductive glue can then be deposited on the ends of the antenna conductor before gluing the module (Figure 9).

10 Finally, in certain cases, it may be preferred to use an-antenna made of a coiled wire rather than an antenna printed on an insulating sheet. In this case, the coiled antenna is pressed against a sheet of plastic material similar to the sheet 20 and is thus enclosed in the smart card during the hot or cold rolling. Perforations such as 34 and 36 can be
15 provided in the sheet 30, but are not obligatory since it is possible to make provision for the ends of the coil antenna to be bared during the operation of machining the cavity. This solution is in fact possible because the coiled wire is thicker than the
20 printed conductor and it is therefore possible to limit the machining when the wire is bared. A drop of conductive glue can then be deposited on the bared wire ends before fitting the electronic module.

**CLAIMS**

1. A method of manufacturing a smart card including the following steps:

5 - assembling sheets of plastic material (10, 20, 30, 40) placed one on top of the other, enclosing in the superimposition an antenna (22) having two conductive access areas (60, 24; 62, 26);

10 - opening up a cavity (52) in a top face of the assembly, and revealing the conductive access areas at the time of this opening;

15 - bonding an electronic module (M) in the cavity, the module having, on its bottom face, turned towards the inside of the cavity, conductive surfaces (72) coming into electrical contact with the conductive access areas of the antenna.

20 2. A manufacturing method according to Claim 1, characterised in that the conductive access areas of the antenna consist of two conductive ends (24, 26) of the antenna covered with conductive glue (60, 62).

3. A manufacturing method according to Claim 2, characterised in that the conductive glue is deposited on the ends of the antenna after opening up of the cavity.

25 4. A manufacturing method according to one of Claims 2 and 3, characterised in that the assembly of sheets includes a sheet (30) provided with perforations (34, 36) coming above the ends of the antenna, the perforations being revealed when the cavity is opened



up and conductive glue (60, 62) being deposited in these perforations.

5 5. A manufacturing method according to Claim 2, characterised in that the assembly includes at least one sheet (20) carrying the conductive antenna (22), a sheet (30) provided with perforations (34, 36) above the ends (24, 26) of the antenna, and a top closure sheet (40), in that first of all the first two sheets (20, 30) are assembled, conductive glue is deposited in
10 the perforations, and the third sheet (40) is assembled, and then, when the cavity is opened up, the conductive glue is revealed, and the electronic module is fitted.

15 6. A manufacturing method according to one of Claims 1 to 5, characterised in that the electronic module (M) has an integrated circuit chip (82) and a double-face printed circuit without conductive vias between the two faces, the double-face circuit having an insulating sheet (80) carrying, on one face, first
20 conductors (70) intended to serve as access contacts of the smart card and on the other face second conductors (72) intended to be connected to the antenna, connecting wires (86) being welded between the chip and the first conductors (70) through perforated areas of
25 the insulating sheet and other connecting wires (84) being welded between the chip and the second conductors (72) without passing through the insulating sheet.

7. A manufacturing method according to one of Claims 1 to 6, characterised in that the antenna is

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produced in the form of a conductor printed on one of the sheets of plastic material (20) of the assembly.

8. A manufacturing method according to one of Claims 1 to 6, characterised in that the antenna is
5 produced in the form of a coiled wire.

9. A manufacturing method according to Claim 1, characterised in that an anti-adherent substance (90) is placed between two sheets of the assembly in the region provided for the cavity so as to prevent the
10 bonding of the two sheets in this region and facilitate the removal of material in this region when the cavity is opened up, one of the sheets carrying the antenna so that the opening up of the cavity bares the antenna ends.

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