

Process of manufacturing smart cards and the cards thus obtained.

The invention concerns a process of manufacturing smart cards; it comprises a card body and an electronic module, and the cards obtained through the implementation of the process.

Among the existing processes, we know one process that consists of providing a card body made up of a cavity, an electronic module comprising mainly contact points and a semiconducting chip containing an integrated circuit, and in fixing the electronic module in the aforementioned cavity by means of glue such as a cyanocrylate glue. In general, the gluing operation includes a prior operation of putting on the glue, an operation of inserting the module in the cavity and an operation of pressing it for a predetermined time.

However, the practical implementation of such a process, generally called inserting, on an automatic industrial scale requiring distinct paced operations carried out at different work stations as well as transfers of cards from one station to the other at a high speed in the order of a few thousand cards per hour, is the source of various problems that have an influence on the quality of the final product.

In particular, we have noticed that the cards obtained through gluing by following the operations detailed above often showed major defects.

Among these defects, we find that the main defect is centring the module in the cavity. Indeed, in spite of the module being correctly centred in the cavity, we have noticed that the modules were decentred at the end of the gluing stage, that is to say that they had shifted in relation to the initial inserting position. The typical shifting gave rise to either a slight rotation, a translation, or both simultaneously inside the cavity, or even in extreme cases, in coming out of the cavity by overlapping one side of the contact points on the surface of the card body.

We have found that the shifting away from the centre is the result of forces generated on the card during its movement from one station to the next, in particular, the sudden forces of acceleration and deceleration respectively generated by the departure from the insertion station and the stopping at the pressing station.

The shifting from the centre can also be the result of residual pressure present in the module that tends to give it a slightly upward curvature. In that case, the module might come out of the cavity on each acceleration or deceleration above.

We also find defects relating to poor adhesion of the module on the card body. In such situations, the card cannot fulfil certain criteria of mechanical resistance under bending/ twisting or pulling out as imposed by the norms in force (ISO, AFNOR).

It is therefore necessary to solve these problems without reducing the production rate.

The purpose of the present invention is to propose a process for gluing the electronic module in the card body that can be compatible with automatic and rhythmic industrial production at a very high speed, without resulting in centring or gluing defects.

To this effect, the purpose of the invention is to create a process for manufacturing cards with an electronic module, of the type consisting of providing a card body with a cavity, an electronic module with dimensions similar to the cavity, a cyanocrylate glue, and comprised of stages according to which we put the aforementioned glue in the aforementioned cavity, we insert the aforementioned module in a roughly centred position and we press the aforementioned glue between the card and the module.

The process is characterized by the fact that the aforementioned glue is put in a quantity enabling us to cover a gluing area representing between 50% and 100% of the aforementioned cavity, after pressing, and under a temperature between 15 and 30 °C and a hydrometric rate between 50 and 75%.

With the help of these measures, the process is defined on the level of surrounding conditions likely to be compatible with an industrial production at high speed. We will avoid, in particular, the defects of poor adhesion of the glue, the risks of clogging the means of distribution and the risks of static electricity explained later.

The quantity of glue enables us to meet the demand for sufficient adhesion area in order to fulfil the criteria of mechanical resistance previously aimed at, and the requirement to sufficiently maintain the module against the forces that tend to shift it off centre during its transfer or before the glue has been pressed.

Better results can be achieved when the area mentioned above is between 60 and 80%, the temperature between 18 and 24 °C and the hygrometric rate between 50 and 75%.

We can improve the quality of gluing while ensuring a sufficient level of maintenance of the module when the above area is equal to about 70%, the temperature about 20 °C and the hygrometric rate equal to about 55%. Under those conditions, the glue has an opening time of about 60 seconds.

According to another characteristic, the process includes an extra stage, according to which, we wet the surface under the module with alcohol prior to inserting it in the aforementioned cavity.

The purpose of this characteristic is to artificially create catching points between the cyanocrylate glue and the module. This enables the glue to better hold the module in a centred position during its transfer from one station to the next at high speed.

According to another characteristic, the insertion of the module takes place within a period of time between 300 and 600 m.s.

This timeframe enables the glue to create even more catching points under the module, which will hold it better in a central position during its transfer. By operating in this way, the invention process allows for the glue to be dropped at high speed and with full control.

According to another favourite characteristic, we drop glue at least five points, one central point of one drop with a weight between 0.002 and 0.004 grams, and four lateral points, with each point representing one drop with a weight between 0.0005 and 0.0015 grams.

These values enable us to ensure that the module is well maintained during the transfer. In addition, it is proven to be faster to drop it in this form rather than in another form, for example, with a string of the same quantity. For a maximum support, these values are about 0.003 and 0.001 grams respectively.

A better adhesive quality is obtained when we drop the four lateral gluing points after dropping the central point.

According to another characteristic, the process consists of carrying out the final pressing by means of pressing devices exerting a pressure on the periphery of the contact areas.

Owing to this measure, we can exert the pressure necessary for the choice of a given thickness of glue and create an adhesion of the module without risking the introduction of pressure constraints at the level of the semiconductor chip, which could damage it.

The purpose of the present invention is also to create a smart card with an electronic module in compliance with the above process.

Other characteristics and advantages of the invention will appear more clearly while reading the following description concerning the two main modes of implementation given solely as examples. It must be read in reference to the diagrams in the appendix in which:

- Diagram 1 represents a card body to be used in the invention process;
- Diagram 2 represents in section view an electronic module to be used in the invention process;
- Diagram 3 represents, as seen from above, a support film for the electronic module;
- Diagram 4 represents a schematic view showing the layout of the module in relation to the card;
- Diagram 5 represents the drawing of a cavity, as seen from above, with the marks for the gluing points;
- Diagram 6 represents the adhesion areas of the glue after pressing;
- Diagram 7 to 11 represent the various steps of the process, or different operation station of the setting up;
- Diagram 12 represents the means of pressing;

- Diagram 13 represents a view from above of an example of installation for the implementation of the process at high speed;
- Diagram 14 represents the means of wetting with alcohol.

The process of manufacturing the smart cards requires us to provide a card body with a cavity and an electronic module with dimensions corresponding to the aforementioned cavity.

Diagram 1 represents an example of a card body to be used for the process. It includes a cavity 2 that can be obtained by moulding together with the card body or by machining.

The card bodies of this type are standardized to ISO or AFNOR norms, and therefore have predetermined dimensions.

The cavity must be able to receive the module. It can therefore have variable forms in accordance with the module chosen. In this example, it is made up of two hollows, the first one (3) generally with a rectangular shape appearing at the front surface of the card, and the second hollow (4) with a generally circular shape and deeper than the first one, placed at the center of the rectangle and appearing at the bottom of the first one. The second hollow has a diameter d of 8.2 mm and a height h of 0.6 mm (diagram 4).

The material used, generally plastic, depends on the applications. For example, telephone smart cards are made of ABS (acrylonitrile butadiene styrene); they can also be made of PVC (polyvinyl chloride), or in layers with polycarbonate (PC), for example, in PC/ABS, or in PC/PVC.

In this example, we have used a cavity in compliance with ISO standards, and ABS for the material of the card body.

The electronic module (5) (diagram 2 and 3) generally includes a support film (6a) in insulating synthetic material, contact areas (7) in conductive material, a silicium chip (8) containing an integrated circuit, wires (9) connecting the chip to the contact areas and a coating resin (10) covering the chip and the connecting wires.

The coating, generally in thermo hardening epoxy resin, forms a boss that can have irregular dimensions, particularly in thickness. In the best of cases, that boss can be erased through milling according to more precise curve so as to facilitate the operation of gluing the module in the card body. Preferably, the invention aims at using the boss directly without milling.

The module (diagram 2 and 3) can be of several types, for example, of the type called "LFCC" (Lead Frame Against Glue) with a support film in polyimide, or of the type comprising a support film in epoxy.

In the example, the module is of the LFCC type and therefore shows an inner surface in polyimide. It is provided from a continuous film (diagram 3) and presented on a coil.

The cavity of the card is meant to receive the module as shown in diagram 4. For this, the hollow (4) corresponds to the boss (10), while the hollow (3) corresponds to the contact areas (5) with a necessary play (j) for assembling. This play is such that a simple rotation of the module on the level of the card or a simple translation on this same level is noticeable to the naked eye and therefore represents a centring defect.

According to the invention, the process consists also of providing a cyanocrylate glue.

It can be of a different nature according mainly to the quantity of accelerators it contains. It is preferable, in order to guarantee good gluing, that the glue be as pure as possible and polymerize as slowly as possible. On the other hand, we have found that the glue must not polymerize too slowly in the operation conditions used if we want to catch the module and maintain it in a centred position.

We have noticed that if the quantity is too important, there is the risk of overflow. Besides this, the glue did not sufficiently hold the module in place during its transfer.

Consequently, the type of cyanocrylate glue, the quantity and the surrounding operation conditions have been determined in order to maintain the module in position during industrial production in high speed.

A good compromise between the capacity of the glue to hold the module in place and to resist the pulling and bending/twisting efforts has been achieved with a glue that presents an opening time between 30 and 60 seconds in the surrounding conditions and the quantities corresponding to the broadest intervals of the example. By definition, the opening time of the glue is the time during which the glue can still adhere. An optimal compromise for all these values has been reached with a glue that possesses an opening time of about 30 seconds. Such a cyanocrylate glue is available under the "Henkel" brand and under reference 8400.

According to the invention, the process comprises steps according to which the cyanocrylate glue is dropped in the cavity, we insert the module in the cavity in a sensibly centred position and we maintain a pressure tending to bring the aforementioned module closer against the aforementioned card in order to press the glue. These steps are described in details after in an example of this application illustrated in diagrams 7 to 11.

In compliance with the invention process, the cyanocrylate is dropped in a quantity enabling it to cover a gluing surface between 50 and 100% of the flat surface of the aforementioned cavity after pressing, under temperature between 15 and 30 °C and a hygrometric rate between 50 and 75%.

We obtained better results when we used a gluing area between 60 and 80%, a temperature between 18 and 24 °C and a hygrometric rate between 50 and 75%.

In diagram 6, we see a cavity with the marks left by the glue after pressing. The spreading of the glue takes place in such a way that the mark left by each lateral gluing point shows a semi-circular area (12c) to (14c) with a generally U shape that spreads roughly radial-wise from near the second hollow (4) to the border of the boundary of the rectangle formed by the first hollow, with the base of the U directed toward the angle. The mark left by the central point has a circular area (11c).

Thus, with gluing areas as defined by those marks and with the above proportions, we obtain a sufficient adhesion for the module to resist the efforts imposed by the norms previously aimed for.

In the example, we used values for a sufficient grip of the module and a maximum gluing quality: the glue was dropped in a quantity that covered 70% of the surface of the cavity that is to say of the rectangle of diagram 6, under a temperature of 20 °C and a hygrometry of 55%. The pressing was carried out in such a way as to have the glue as thin as possible. Good results were obtained with a thickness, after pressing, between 0.01 and 0.03 mm. In the example we obtained a thickness of 0.02 mm. For these precise values, the opening time of the glue is then around the higher values of the interval 30 to 60 seconds, with 60 seconds being the maximum.

Conversely, we can obtain a maximum grip of the module and a satisfactory quality of gluing by choosing a cyanocrylate glue that has an opening time at among the lowest values of the interval 30 to 60 seconds, for example, 30 seconds, with the values of the other parameters above being maintained.

Concerning the determination of surrounding conditions above, we have noticed that a too low temperature and hygrometry resulted in too slow a polymerization of the glue which consequently lead to risks for the module to come off and to shift from its centred position (with risks of pollution on the surface due to polymerization of the glue: "blooming"). Conversely, we noticed that too high a temperature and hygrometry resulted in too fast a polymerization of the glue, which leads, on one hand, to risks of the module coming off, and, on the other hand, had the disadvantage of dirtying and clogging the needle used to drop the glue. Besides this, we also noticed that a too low hygrometry resulted in risks of static electricity. The static electricity has the disadvantage of strongly attracting drops of cyanocrylate glue that might then collect at random and generate defects.

According to a favourite characteristic of the invention process, the glue is dropped in the form of at least five gluing points between 0.002 and 0.004 grams at, at least four lateral points, each point comprising one drop of glue with a weight between 0.0005 and 0.0015 grams. These values lead to a good grip of the module before the pressing station.

In the example, we obtained a maximum grip with only five points and a quantity corresponding roughly to a weight of 0.003 grams for the central point and about 0.001 gram for each lateral point.

Dropping the glue in dot form is preferable to string form, for it is easier to implement on an industrial scale at high speed. The number five as well as a particular layout enables us to ensure that the module achieves a good grip. A number of five equal points is also more convenient and faster to implement, given the total quantity of glue to use.

An example of maximum layout is shown in diagram 5. It comprises one central point (11a) where the chip is lodged, and four other lateral points (12a to 15a) situated in the location of the contact areas and in the angles of the rectangle representing the cavity. Other layouts of gluing points are also possible.

We are now going to describe the stages of the process in reference to an example of implementation as shown in diagrams 7 to 11.

In the example, the diagram 7 to 11 can represent stages of the process as well as successive operation stations in a plant as described below.

At a first station (diagram 7) and according to a first step a), we first release a drop of glue (11b) at the center of the cavity by means of a distribution device (16), then we transfer the card to the next station (diagram 8).

At this station and according to a second step b), we drop four drops of cyanocrylate glue (12b) to (14b) in the four lateral angles of the hollow by means of other distribution devices (17) and (18), and the card is transferred to an insertion station (diagram 9).

At the insertion station, according to another step of the process c), we insert an electronic module (6), by means of an insertion device (19) and by exerting a light pressure called insertion pressure. In this example, the insertion period is equal to 300 ms.

We get a better grip with an insertion period above 500 ms. afterwards, the card is transferred to the pressing station (diagram 10) or (according to a favourite alternative: diagram 11).

At the pressing station (diagram 10), according to another step of the process d), we press the adhesive substance by applying a force equal to 34 daN for a duration of 22 seconds by means of pressing devices acting all over the surface of the module.

According to a favourite alternative (diagram 11) and another characteristic of the process, we press only on the periphery of the contact areas, which has the advantage of pressing properly the glue without introducing mechanical constraints that might damage the semiconducting chip or the connection wires. Pressing devices are described below in diagram 12.

As already explained earlier, the coating boss (10) can be of slightly variable thickness. But in extreme cases, the boss can come up against the bottom of the cavity and thus create a central point of the module slightly higher than the contact areas that are almost

level with the surface of the card body. Such configurations that happen frequently in industrial production forbid us from applying the pressure necessary for a good quality gluing.

In the example, a force of only 34 daN was spread solely on the peripheral zone of the contact points that lean on the first hollow.

At the next stage, the card is evacuated and this ends the inserting operation.

According to another characteristic of the process, there is a stage during which we treat the surface of the module so as to activate the polymerization of the glue when the latter comes into contact with the module.

Other treatments known by professionals can also be used.

For convenience and due to a good immediate grip of the glue to the module, we wet the surface below the module with alcohol prior to its insertion in the aforementioned cavity. Ethyl alcohol at 95% gave good activation results.

This operation ensures that the polymerization of the glue is immediately and locally activated on contact with the polyimide treated with alcohol, and that grip points are artificially created in order to maintain even better the module in its position during its transfer.

In order to ensure that we have enough grip spots and to maintain the module correctly, we use the period of inserting the module to our advantage as explained above. The insertion period is purposely limited to 600 ms as a maximum value so as to maintain the industrial compatibility for high speed.

Wetting with alcohol enables us also to artificially restore the difference in surface humidity between the surface of a card in ABS and the surface of the film of the module that would have resulted in a difference in adhesion. Indeed, ABS has an absorbent performance different from polyimide. ABS stores water molecules on the surface while polyimide stores them inside. Water, being an influent parameter in the activation of the glue, it is preferable to activate the polymerization on the surface of the film so as to have in the end a level of glue adhesion as good on the module as on the card.

We are now going to describe an example of setting up for an industrial production at high speed according to the invention process in reference to diagram 13.

The setup includes equipment (21) to feed a multiplicity of cards bodies, devices to feed a multiplicity of modules (22), (23), a first station (24) to deposit a drop of glue equipped with a distribution device (24b) comprising a needle (16), a second station (25) to distribute four drops of glue equipped with distribution devices (25b) comprising two needles (17) and (18), a station (26) for inserting the module, equipped with inserting devices (26b), pressing stations (27) equipped with pressing devices positioned on the

periphery of a carousel (28) where the cards can stay for the pressing period, devices to cut (29) and to transfer the modules to the insertion station, devices for wetting with alcohol (30) if necessary, then evacuation devices (31). The setup includes also an enclosure to control the temperature and the hygrometry of the atmosphere.

The equipment to feed the modules are made up of two reels, a first reel (22) loaded with a film (6b) carrying the modules and a second reel (23) carrying a film empty of modules, one unwinding while the other is being winded. The film passes successively through the devices for wetting with alcohol (30) described here above and through the devices to cut the modules (29).

The modules are removed from that film by means of cutting devices and lead through transfer equipment towards the insertion station where they are inserted in a centred manner in the cavity of each card.

The device (30) to wet with alcohol the bottom surface of the module is made in this example of a sponge (30) plunged in a vat filled with ethyl alcohol (33). The sponge is maintained permanently in contact with the film feeding the modules.

The needles of the distribution device are vertically and crosswise mobile.

Each pressing station (27) is equipped with pressing devices (27a) comprising one tip (20a) (diagram 12) that comes into contact with the module. In order to carry out the pressing in compliance with the process, that tip is equipped with a blanket (20b) with a hole in the center to enable it to exert pressure solely on the periphery of the module. The blanket is made of a material capable of distributing the pressure without damaging the contact areas, for example, an elastomer, and possesses a rectangular shape corresponding to the form of the module.

Running

When a card arrive in position at each gluing station, the needles come in position above the gluing points corresponding to the layout provided for (diagram 5), come down near the surface of the cavity and a control system (not shown) controls the quantity of glue to be dropped; then the needles go up in a way as to break the residual thread of glue that tends to hang on the needle, and they return to waiting position for the next card. They are adjusted in a way so as to ensure a movement down, distribution and movement up in 1.5 seconds.

Afterwards, the cards are transferred to the inserting station where they receive the module. The insertion period lasts 500 ms.

Next, the cards are transferred to the pressing station where the module is pressed against the card body; the force applied is 34 daN. They stay 22 seconds in the carousel, and then they are ejected to the next station.

At the exit of the carousel, the cards are generally tested and evacuated towards the evacuation equipment (31).

The progression of the cards from one station to the next is mechanized to ensure a rhythm of a minimum of 1500 cards per hour.

CLAIMS

1. Process of manufacturing cards with an electronic device of a type consisting of supplying a card body with a cavity, an electronic module with dimensions corresponding to the aforementioned cavity, a cyanocrylate glue, and comprising steps according to which we deposit the aforementioned glue in the aforementioned cavity, we insert the aforementioned module in the cavity in a roughly centred position and we press the aforementioned glue between the card and the module characterized by the fact that:
 - The aforementioned glue is distributed in a quantity such as to ensure the coverage of an area between 50 and 100% of the area of the aforementioned cavity, after pressing, at a temperature between 15 and 30 °C and a hygrometric rate between 50 and 75%.
2. Process according to claim 1, characterized by the fact that the aforementioned gluing area is between 60 and 80%, the temperature between 18 and 24 °C.
3. Process according to claim 2, characterized by the fact that the aforementioned gluing area is equal to about 70%, the temperature is about 20 °C and the hygrometric rate is about 55%.
4. Process according to claim 1, characterized by the fact that it includes one stage that consists in wetting the bottom surface of the module with alcohol before inserting it in the cavity or bringing it in contact with the glue.
5. Process according to claim 1, characterized by the fact that it includes one stage that consists in distributing the glue in the form of five gluing points, one central point made up of one drop called central drop weighing between 0.002 and 0.004 gram, and at least four lateral points with each lateral point made up of one drop of glue called lateral drop weighing between 0.0005 and 0.0015 gram.
6. Process according to claim 5, characterized by the fact that the weights of each central drop of glue and of each lateral drop of glue are equal to 0.003 and 0.001 grams respectively.
7. Process according to claim 5, characterized by the fact that we deposit the four lateral gluing points after depositing the central gluing point and right before inserting the module.

At the exit of the carousel, the cards are generally tested and evacuated towards the evacuation equipment (31).

The progression of the cards from one station to the next is mechanized to ensure a rhythm of a minimum of 1500 cards per hour.

CLAIMS

1. Process of manufacturing cards with an electronic device of a type consisting of supplying a card body with a cavity, an electronic module with dimensions corresponding to the aforementioned cavity, a cyanocrylate glue, and comprising steps according to which we deposit the aforementioned glue in the aforementioned cavity, we insert the aforementioned module in the cavity in a roughly centred position and we press the aforementioned glue between the card and the module characterized by the fact that:
 - The aforementioned glue is distributed in a quantity such as to ensure the coverage of an area between 50 and 100% of the area of the aforementioned cavity, after pressing, at a temperature between 15 and 30 °C and a hygrometric rate between 50 and 75%.
2. Process according to claim 1, characterized by the fact that the aforementioned gluing area is between 60 and 80%, the temperature between 18 and 24 °C.
3. Process according to claim 2, characterized by the fact that the aforementioned gluing area is equal to about 70%, the temperature is about 20 °C and the hygrometric rate is about 55%.
4. Process according to claim 1, characterized by the fact that it includes one stage that consists in wetting the bottom surface of the module with alcohol before inserting it in the cavity or bringing it in contact with the glue.
5. Process according to claim 1, characterized by the fact that it includes one stage that consists in distributing the glue in the form of five gluing points, one central point made up of one drop called central drop weighing between 0.002 and 0.004 gram, and at least four lateral points with each lateral point made up of one drop of glue called lateral drop weighing between 0.0005 and 0.0015 gram.
6. Process according to claim 5, characterized by the fact that the weights of each central drop of glue and of each lateral drop of glue are equal to 0.003 and 0.001 grams respectively.
7. Process according to claim 5, characterized by the fact that we deposit the four lateral gluing points after depositing the central gluing point and right before inserting the module.



8. Process according to any of the previous claims, characterized by the fact that we exert the pressure by means of a blanket comprising one central hole that we position between the module and the pressing device.
9. Process according claim 8, characterized by the fact that we use a pressing device with a blanket that has a hole in the center.
10. Process according to any of the previous claims, characterized by the fact that the insertion is carried out within a time period between 300 and 600 ms.
11. Process according to any of the previous claims, characterized by the fact that the cyanocrylate glue possesses an opening time between 30 and 60 seconds.
12. Card obtained by implementing the process according to any of the claims 1 to 11.

