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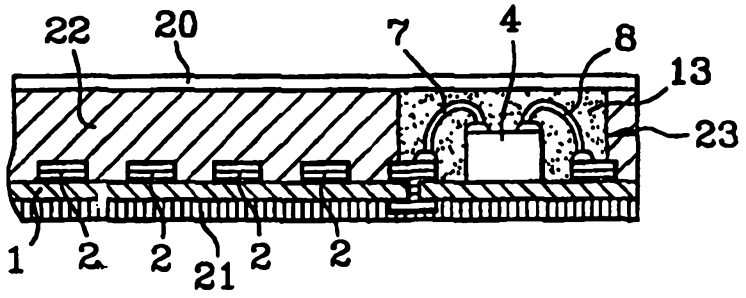
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(54) Title: ELECTRONIC DEVICE WITH DISPOSABLE CHIP AND METHOD FOR MAKING SAME

(54) Titre: DISPOSITIF ELECTRONIQUE A PUCE JETABLE ET PROCEDE DE FABRICATION



(57) Abstract

The invention concerns an electronic device with chip comprising film support including a film support with interface and at least a plane conducting interface, and a microcircuit connected to said interface. The invention is characterised in that the film support and the interface have such characteristics that they can be crumpled or folded together without deteriorating. It is further characterised in that it comprises a compensating film (22) arranged on said film support, said compensating film comprising a recess (21, 23) containing said microcircuit (4), its connections (7, 8) and a coating material (13). The invention also concerns a method for making the label.

(57) Abrégé

La présente invention concerne un dispositif électronique à puce comprenant, un film support à interface comportant un film support et au moins une interface conductrice plane disposée sur ledit film support, ainsi qu'un microcircuit connecté à ladite interface. Il se distingue en ce que le film support et l'interface possèdent des propriétés telles qu'ils sont aptes à être froissés ou pliés ensemble sans dégradation. Il se distingue également en ce qu'il comprend un film de compensation (22) disposé sur ledit film support, ledit film de compensation comportant un évidement (21, 23) contenant ledit microcircuit (4), ses connexions (7, 8) et un matériau d'enrobage (13). L'invention concerne également un procédé de fabrication de l'étiquette.

Disposable electronic chip device and process of manufacture

The present invention concerns the field of electronic chip devices comprising a communication interface and their manufacturing process. It concerns in particular chip devices, the interface of which is by contact and/or aerial, such as chip card, label micromodule. It relates particularly to aerial devices which are disposable or used once only which can communicate over distances of more than 50 cm especially at frequencies of several mega-herz to several giga-hertz.

The international patent application WO 97/26621 describing a chip and aerial module which can be scanned as a label if required is known. Cards are produced by inserting the aerial module in a cavity of a card body and certain labels are produced by packaging the aerial module in some kind of support such as a tally for example.

These modules comprise an interface support film, commonly called a printed circuit, which contains at least one interface under the form of aerial and/or under the form of connection pads, a microcircuit such as a chip connected to the said interface and an encapsulating material to protect the microcircuit and its connections. The aerial is placed on one face of the micromodule especially on the reverse side of the latter, while the other face can possibly be equipped with connection pads.

The interface support film should possess minimum mechanical properties due especially to the requirements of modern production processes. In particular, it is so flexible that it can be rolled up on reels but equally rigid so that it can be transported by sprockets engaging the side perforations. The rigidity of the interface support film is also such that it will break if folded.

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The support films presently in use are selected from among epoxy glass, polyimide, polyethylene terephtalate (PET). They have the following typical properties and characteristics: a thickness of between 75 µm and 125 µm, elongation at break of less than 75%, temperature resistance up to at least 160°C.

The interface itself is generally copper; it presents a hard surface, the tracks are in general narrow (50 to 200 µm) and have precise definition in the order of a few microns. The interface in general undergoes surface treatment for example of the Ni-Au type which makes it even harder, easier to weld and protects it from oxidation.

The discussion of the background to the invention herein is included to explain the context of the invention. This is not to be taken as an admission that any of the material referred to was published, known or part of the common general knowledge in Australia as at the priority date of any of the claims.

The devices produced according to the above requirement have the disadvantage of being too bulky for the use envisaged in the invention.

The present invention may make use of an interface support film having properties totally distinct and opposite to those required for interface support films in the field of the chip cards presented above. The present invention may also adopt a manufacturing process in a roll, then by adapting this process especially in regard to the connection of the chip to take into account the new properties of the film.

According to one aspect of the present invention, there is provided an electronic device with a chip including a support film and at least one flat conductive interface placed on one side of said support film as well as at least one microcircuit connected to said interface, said chip device also including a height compensation film placed on said one side of said support film, said compensation film having a recess containing said microcircuit and its connections to said interface, and an encapsulating material for protecting said microcircuit and said connections.

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Good results have been obtained with a support film and an interface which can be creased or folded together according to a radius of curvature of less than 2.5 mm and preferably less than 1 mm.

This definition corresponds to the choice of a support film, the properties of which are intrinsically downgraded in comparison to state of the art support films and/or the reduced thickness combined with an interface, the intrinsic properties of which are equally downgraded in comparison to state of the art interfaces or those of reduced thickness. The properties of each (support film and/or interface(s)) should be considered in combination. They can in particular be enormously downgraded for both, or those of one very much downgraded and those of the other less so; the thickness of each can also be reduced to a greater or lesser

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extent according to the degree of downgrading of the support film and interface materials.

Due to such an association and combination a reliable, low-cost device is provided in spite of the handling which it can be made to undergo.

It is stressed that in certain cases the downgrading, for example in regard to rigidity, can be accompanied by other qualities in the final product, for example in regard to elasticity but which cause manufacturing difficulties. The downgrading must be understood in the context of the invention in relation to the properties presently sought in the field of the chip card.

According to one characteristic, the support film possesses a thickness of less than 75 μm, the best results being obtained with a thickness of between 10 μm and 30 μm.

With such a thin support film the invention provides not only a saving in material with a potential bearing on the price and especially a saving in the weight of the final device, thus providing new opportunities of application described below.

According to other characteristics of the invention the support film can be preferably a polymer with an elongation at break of more than 80 %, and/or Shore hardness of less than 80 and/or a vitreous transition temperature Tg of less than 0°C and/or a fusion temperature of less than 130°C.

Preferably the support film is selected from among polypropylene (PP), polyethylene (PE), polyethylene teraphtalate (PET). In other cases it can contain fibrous material, for example cellulose or textile.

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The metal of the interface is preferably natural with no surface treatment aimed at hardening it, for example the Ni-Au type. Preferably it is less than 50 µm in thickness. Aluminum and its alloys are the preferred metal.

Materials such as PE, PP ... are very economically advantageous since they are produced in very long and wide rolls in a distinct field of the chip-card, that of packaging. The PE / aluminum or PP / aluminum combinations the use of which the invention proposes as a base to create an interface support film are equally very common, especially in the field of food packaging (for yogurt lids, champagne corks...)

According to another characteristic, the device comprises the microcircuit preferably situated outside the turns, especially in a corner of the support film. Preferably again the microcircuit is placed directly on the support film.

Preferably the device also comprises an interface element known as «strap» on the other face to pull back at least one end of the aerial (6) in the vicinity of the chip.

Thus it is possible to keep free the largest printing surface possible and create a very thin device with a view to the applications detailed below, the chip being in contact with the support film. The use of the «strap» is an interesting solution explained in detail below.

The recess contains material to encapsulate the microcircuit and its connections. The encapsulating material is preferably contained at least in part by the walls of the recess.

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The compensation film can be used in relation with any other existing support film of the earlier type but it is more interesting to use it in relation with an interface support film which can be folded in line with the invention.

The compensation film also has advantages when manufacturing the device below, that of compensating for the height of the microcircuit and of protecting it, especially to enable printing over the entire surface of the device without damaging the microcircuit.

Its function is to level out the surface of the device in such a way as to create a device without projection and to receive, if necessary, another decorative and/or adhesive layer over the microcircuit.

It also protects the microcircuit from the compression which is exerted on it when it is fixed on any kind of support by an adhesive applied especially on the compensation film.

It also allows the low mechanical strength of the interface support film to be compensated in particular during its various uses.

It can be selected from among the most varied materials and adapted to any use, without in any way changing the process described below.

The present invention is also aimed at chip tickets and cards containing the device. Preferably they comprise a card or ticket body made up by the said compensation film. This means that they have a recess which contains the microcircuit, the compensation film, the support film and the interface extending outside the recess over the surface of the compensation film.

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Thus economic chip cards and tickets with protection of the microcircuit if required are obtained.

According to an alternative version, the recess is a non through-penetrating cavity or one enclosed by an additional film.

According to a further aspect of the present invention there is provided a process for manufacturing an electronic device with a chip including a support film and at least one flat conductive interface placed on one side of said support film, as well as at least one microcircuit connected to said interface, said process including the steps of:

providing at least said support film;

fixing said at least one microcircuit upon said support film; and

connecting said at least one microcircuit to said interface;

said process further including the steps of:

securing a height compensation film upon both said support film and at least a portion of said interface, said height compensation film having at least one recess which corresponds with a location of said microcircuit and its connections to said interface; and

coating said microcircuit and said connections with an encapsulating

The invention is preferably implemented according to the economic method of engraving printed or lithographed designs on one or several of the conductive surfaces, previously combined with the support film.

Due to the choice of this support film and interface but equally due to the choice of the manufacturing method of the interface, a low-cost interface support film may be produced, thus contributing a reduction in the overall price of the device.

The operation of securing a compensation film can be used in relation with any other existing support film of the earlier type but it is particularly interesting to use it in relation with an interface support film which can be folded in line with the invention.

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The compensation film may reinforce the interface support film which thus risks being more mechanically resistant during the stages of the process in particular in the course of transport by traction.

It may enable the support film to be coiled up flat between each stage, if necessary, or for delivery to the customer. It thus cuts out the wasted use of an interlayer film presently acting as protection between the different manufacturing stages below.

Printing can be carried out on both sides of the device without damaging the microcircuit.

If the microcircuit and its connections are encapsulated, the recess of the compensation film can have a containing function. The compensation film can serve if necessary to receive side perforations for transporting and positioning sprockets and will facilitate coiling on reels with the use of present means of transport.

The compensation film enables the device to be made from various materials. It can especially be based on cellulose or any polymer, fabric or any other material in film form.

According to another method of implementing the invention without compensation film, the interface support film may be supplied as rolled strip and means of transport controlled by the tension of the support film are used for feeding it to at least one work station corresponding to the stages of the process, especially the transfer of the microcircuit and/or its possible encapsulation.

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Due to this arrangement it is possible to convey an interface support film at worst ultra-supple and elastic as it is without damaging it, without resorting to a compensation film, without side transporting perforation being necessary and without disturbing its positioning and/or indexation before the various work stations of the process.

According to another characteristic the microcircuit is connected by ultrasonic welding of conductor wires. More particularly, it is possible to resort to welding by aluminum wire for aluminum pads or interfaces.

Resorting to this method of connection is particularly advantageous since it is reliable, standard and economic. As explained below, this method creates difficulties which would not recommend it for use on an interface support film having properties conforming to the invention.

According to another characteristic an interface support film having interface elements on both faces is used. In particular it is possible to fit a capacitor plate on each side and/or «straps» at the same time as the interface.

Thus it is possible to reduce the manufacturing cost of these interface elements since they can be manufactured at the same time with the same technology indicated above. A less economic alternative would consist of making a bridge connection above the turns in a specific operation or the addition of a discreet capacitor.

According to another characteristic the interface elements on each side of the support film can be connected through the support film by mechanical tears and mechanical contacts. If necessary it is possible to make these connections by ultrasonic methods.

The choice of thin interface support film and the choice of materials conforming to the invention make it possible to use such a connection process. It is particularly

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advantageous and economic as no additional materials are needed and it can be done in one operation which can be concealed in the manufacturing process of the device.

Preferred embodiments of the present invention will now be described with reference to the accompanying drawings, in which:

- Figure 1 represents a simplified label according to the invention identifiable at close range by radio frequency signals;
- Figure 2 represents a sectional view of the label in Figure 1 with detail of the micromodule;
- Figure 3 represents a variant of Figure 2;
- Figure 4 represents a variant of Figure 1,
- Figure 5 represents the reverse side of the label in Figure 4;
- Figure 6 represents a view of the upper part of a label with connection pads;
- Figure 7 represents a card structure conforming to the invention
- Figure 8 represents a sectional view of another variant of the card structure
- Figure 9 represents another structure of the device concerned by the invention
- Figure 10 represents a general view concerning the execution of the process of the invention:
- Figure 11 represents a general view of a variant of the process of the invention for the manufacture of chip and aerial cards
- Figure 11A represents a card structure obtained according to the process illustrated in the previous Figure;
- Figure 12 represents a folding test designed to characterise the device of the invention.

Figure 1 shows an example of a simplified method to make an electronic chip device conforming to the invention in the form of an electronic chip and aerial label (coil and capacitor). It comprises a support film 1, a flat conductive interface up in this example by turns 2 of a flat aerial 3 twisted on the said

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support film 1 from the edge of the latter inwards, and a microcircuit 4 such as an integrated circuit chip connected to the said interface. The aerial has two ends, terminating respectively internally and externally, or forming each of the contact pads 5, 6. The connection in this example is created by connecting wires 7, 8.

The device also comprises an adaptation capacitor made in this example by conductive surfaces 9, 10 placed facing each side of the support film. If required, the capacitor can comprise adjustment tracks such as perforations or other removed parts of the surface which can be achieved especially by laser. In other cases, a discreet capacitor can be bonded to the film or integrated in the microcircuit.

It is equally possible to resort to circuit elements 11, 12 (straps) placed on the rear side of the support film (Figure 5) to bring the contact 6 of one end of the aerial or of the capacitor plate situated inside the turns to the other end 5 situated outside the turns or vice versa. In fact, the «strap» enables at least one end of the aerial to be pulled back in the vicinity of the space for the chip situated in this case at the end of the aerial on the edge of the label, In the case of a compensation film described below, the position of the chip is not important. It can be completely inside the turns.

According to one characteristic of the invention, an encapsulating material 13 covers at least the micro circuit and/or the connection wires in such a way as to protect them at least mechanically. In the example, (Figures 1, 2) the material only covers one microcircuit place zone (zp), including the connections, leaving the rest of the device bare.

In this example, the microcircuit zone occupies an area equivalent to about 4 mm x 5 mm, while the label has a total surface area of 40 mm x 40 mm.

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Conforming to the invention the interface support film has such properties that it can be creased or folded over itself without deterioration.

Figure 12 shows a folding test intended to characterise the invention. According to this test the interface support film must be able to be folded outside the zone of the chip for example into two or four, the opposite edges 14, 15 touching each other flat to form a fold with a shallow radius of curve. In other cases, it should be possible to crumple or crease at random, the folds having at least the radius quoted above.

Deterioration is understood to mean breakage or tear of the support film leaving it unable to support the turns. It is also understood to be a serious loss of capacity to deform, then such plastic deformation which leads to breakage after renewing some of the folds. The interface itself is damaged if it loses its electrical conductive properties, especially by reduction in width, or rupture or by serious loss of elasticity which causes it to break after a few bends (for example ten).

Preferred products are obtained if they support folds with a curve radius R of less than 1 mm and especially 0.2 mm.

To achieve these performances, a support film of a material with elongation at break of more than 80% and/or Shore hardness of less than 80 and/or a Tg of less than zero degrees Celsius, and/or a fusion temperature of less than 130°C, linked to a thickness of less than 75 μm.

The best results are obtained with a thickness of the support film of between 10 μm and 30 μm.

The interface support films in the example are advantageously films with very downgraded properties (classified as low performance) such as PP, PE, or less

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downgraded such as PET) in comparison to those currently used in card and aerial modules such as epoxy glass or the polyimides.

Conforming to the invention, the interface must also be appropriately dimensioned and/or have mechanical properties, especially ductility/elasticity/hardness compatible with those of the support film in order to satisfy the folding test of the invention.
In the example the interface is aluminum without surface treatment, especially nickel / gold etc. Its thickness is less than or equal to 50 μm and preferably between 7 and 30 μm.

If necessary, according to an alternative, the support film can comprise a fibrous material especially cellulose or textile. It can for example be simply very thin paper as above. Textile fibre materials have the property of bending without breaking and folding in a reversible way.

In Figure 3 the thickness of protection material 13 used is the finest possible to cover all the surface of the label. The thickness obtained of the chip zone (zp) can be less than 400 μm and especially less than 300 μm for a chip having a thickness in the order of 150 μm. The thickness obtained of the zone excluding the chip (zhp) is less than 150 μm and especially less than 100 μm.

In the case of Figure 3 it is preferable to use a protection material which keeps some elasticity and flexibility in order to satisfy the criterion of the invention defined above. Certain epoxy and acrylate resins may be suitable.

In the example of Figure 2 tests carried out by way of at least 100 repetitive folds with a curve radius equal to 0.5 mm have been undertaken with a label without encapsulation of the aerial. In the example of Figure 3 other folding tests with a radius of 2 mm did not affect the function of the above labels.

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Such handling is impossible and/or not recommended with chip and interface devices of the earlier type.

The label of the invention has the advantage that it can be incorporated in very fine and/or very flexible products and remain unnoticed to the human eye and touch while its mechanical characteristics may be close to or lower than those of the product. The product obtained especially can feel like a cigarette packet film or foil. Such a device can find application as an insertable discreet electronic device or one which can be placed on top especially in fine products such as textile clothing fabric, leather, foil, film or cloth products, cardboard products and packaging but also and firstly acting as labelling for the whole item.

The device of the invention in the form of a label can also form part of the film making up the product or packaging, the aerial for example being attached to a fabric or packaging film itself.

To the extent the support itself can be fine and subject to repetitive folding, the device of the invention is capable of undergoing the resultant deformation without deterioration. It thus provides an identification function with more reliability than devices of the earlier type under such conditions of use.

In Figure 4 the interface is created on a continuous strip 24 of support film 1. The microcircuit is placed advantageously in a corner of the support film and directly above. Preferably the choice is to position the chip in the corner of the label to reduce mechanical stresses linked to handling but also to have the largest possible surface free for printing.

Strip 24 comprises a continuous conductor frame (C) around the interface and target points (p) intended for reference and indexation/positioning of the interface during the

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various stages of the process described below. The conductor frame enables the strip of the support film to be made more rigid and to reduce the costs and time of printing if necessary. Fictitious lines traced on the strip represent outlines demarcating the device.

The designs of the aerial are conceived as a function of the operating frequency chosen and to optimise the range (case of close range communication).

In the example the aerial 2 is designed on the support film in such a way as to be able to communicate over a distance of more than 8 cm and preferably more than 50 cm (not powered i.e. without battery) and more than 1 to 2 m (powered i.e. with battery). The turns are as large as possible and their number optimised to achieve the distances anticipated, (in general 4 to 6 turns are necessary at frequencies of about 13 Mhz).

The gap between the turns depends on the manufacturing process of the aerial. In the example the distance between the turns is 1 mm compared with present devices where rather gaps of 0.05 mm to 0.4 mm are normal.

To connect the ends of the aerial with the microcircuit the invention preferably resorts to a design with «strap» as shown in Figure 5.

According to another variant not shown, the device advantageously includes a capacitor not in the form of plates on each side of the film, but integrated in the chip. This provides freedom from parameter variations of the capacitor linked especially with variations in the thickness of the film and from operations of adjusting the aerial which are often tedious. This is equally preferable if the support film does not have good dielectrical strength.

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According to a characteristic not shown aimed at simplifying the device the support film comprises interface elements on a single side, it being possible for the capacitor to be bonded onto the support film or better still in the chip as above.

To avoid having long connection wires if the aerial has more than one turn and a relatively large pitch, the turns can be designed in such a way that their width is thinner locally than elsewhere uniquely around the mircocircuit and its connections.

Again preferably to reduce the length of the connecting wires while keeping the device to a minimum thickness, the microcircuit can be placed directly on the support film and between the turns which encircle it. The accumulation of the characteristics of this above variant again enables the costs to be reduced.

The microcircuit can also be placed over the turns but to the detriment of the height of the device and good seating for the microcircuit.

In other cases the microcircuit can be placed on an interface area in such a way as to increase stability and for better adhesion using an adhesive.

Figure 6 shows that the interface of the device D comprises at least connecting pads 16 on the face visible on the drawing. The microcircuit is placed on the other face, perforations through the film providing access in the known way to the connection pads. If necessary the chip can be incorporated in the recess of a compensation film described below.

It also has in the example printing, such as bar codes 17 placed on its largest section, the connections and the chip being at the edge of the support film.

As a variant the interface can comprise both contacts and an aerial (not shown). The aerial can for example be placed on the other face not visible on the drawing.

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Figure 7 shows a chip card 18 outside the ISO standards in force. It comprises the device (D) with the support film 2 placed on a support card body 19 which can have dimensions equal to or larger than the film, for example equal to at least twice those of the support film 2. The face of the device not carrying the chip preferably has contact with the card body 19. The microcircuit points towards the top opposite the card body 19.

The card can also have a second film 20 arranged above the support film and be of the same size as the card 19 or only cover the device.

According to a preferred variant (Figure 8) the card 19 makes up a compensation film. It comprises a closed recess 21 in which the coated microcircuit 4 is inserted, the interface support film (1, 2) extending outside the cavity on the surface of the card body. The extension of the device outside the cavity is in no way apparent to the touch or eye due to the thinness of the interface support film. Thus a card which is flat to the touch also with a microcircuit protected by the cavity is obtained.

Conforming to other characteristics the device can also comprise a supplementary miniature resonant circuit including an emergency aerial and/or an integrated capacitor placed in the microcircuit in such a way as to compensate for any failure of the aerial or the capacitor placed on the interface support film. Thus it would be possible to recover information stored in the chip using a specific non-contact proximity reader which makes the device more reliable.

For this purpose the microcircuit can be powered and communicate without direct contact via the emergency aerial if the aerial circuit of the support film fails.

Figure 9 shows that the device comprises a compensation film 22 placed on an interface support film. The compensation film can be placed on all types of interface

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support film as known from the earlier type but it is more suitable and more interesting (as detailed above) with those which can be folded or creased in line with the invention.

The compensation film comprises a recess 23 in which the microcircuit 4, its connections 7, 8 and the encapsulating material 13 are located. The wall of the recess is in contact with the encapsulating material to the extent that it contains the material at last partly.

Its thickness is preferably such that the recess 23 just exceeds the microcircuit and its encapsulation.

The compensation film can be any material, preferably flexible for the applications intended. In the example a PE polymer with a thickness equal to 200 μm for a 150 μm chip and connection with wires has been used. It has been shown that it was possible to use a compensation film of less than 50 μm for a 50 μm chip and connection of the «Flip chip» type or by applying conductive adhesive of the type «Silver glue» (Patent Application No. 97 04093 or No. 97 04094). This allows a chip device of 110 μm to be obtained in this case. It is possible to print on the film 22 itself.

The device can also comprise at least one protection/personalisation layer 20 and/or adhesive layer 21 on at least one of the faces of the support film or the compensation film.

The label made in this way can comprise all the functions and finish of a normal label apart from its electronic identification function with the greatest discretion in view of its thinness and flexibility. If necessary a self-adhesive film can be applied on the compensation film in such a way as to direct the recess towards an object to be labelled and thus hide the presence of a chip.

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As a variant the compensation film itself is a mass of adhesive of a completely known type, preferably thick and with or without a peelable protection film. In this case it is the mass of adhesive itself which compensates at least to some extent the height of the microcircuit.

The label can comprise dual identification especially by a bar code printed on the film 20 (Figures 9 and 6) and by a corresponding digital code stored in the memory of the integrated circuit.

The manufacturing process for the devices of the invention will now be described with reference to Figures 10, 11 and 11A.

According to a first stage an insulating support film 1 having at least one flat conductive interface 2, 9 is provided. It is called «interface support film» in the description.

It can be obtained by a variety of known processes such as engraving, screen printing with conductive ink, selective application of conductive material, cutting out of laminated metal and lamination on a support film, the printed circuit technique, encapsulation of conductive wires on an insulated base etc.

In the example and according to one characteristic of the invention preferably an engraving process for printed or lithographed designs is used on at least one conductor film previously fixed to the support film especially by lamination or extrusion. Thus it is possible to obtain if necessary interfaces on each of the faces of the support film.

The support film and the interface are selected in line with the details given above relating to their mechanical properties and their thickness. The material of the metallic

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film in the example is aluminum, preferred over copper due especially to its price and ductility in spite of electrical performance lower than that of copper.

The choice of the engraving method requires the use of ink to mask the tracks which creates a costly removal operation after engraving. It is preferable to keep this ink on the interface to protect the aluminum against oxidation and for an aesthetic appearance apart from around the pads for connection with the microcircuit to allow welding. Local removal can be carried out especially by mechanical scrapping or laser.

As a variant the interface can be formed with a conductive substance based on elastic polymer and loaded with metal particles such as conductive ink. The elasticity of the polymer base is which can satisfy the folding criteria of the invention. Application for example can be screen printing.

Finally at least one microcircuit is fixed on the interface support film and is connected to the interface.

All the operations are preferably carried out using strips of interface support film comprising a number of interfaces (aerial designs for example) and supplied as a roll or on reels 24. The strips are fed to the various existing stations 25 for fixing microcircuits 4, connection 26 and if necessary encapsulation 27.

Conforming to the invention as the support film is particularly thin, fragile or tearable, it is not possible to use sprocket transport means which engage the side perforations of the films. According to the invention transport means suitable for the properties of the film are used. In particular means of transport controlled by tension of the support film and which comprise means to measure and/or regulate the tension of the support film to avoid damage by tearing are used. The transport can for example be provided by transport rollers 28 or by grips.

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In the example two interface designs following the width are shown but preferably widths of more than 80 mm with more designs especially under consideration of mechanical strength and productivity are used.

Fixing and connection of the microcircuit

The microcircuit can be fixed by any means, especially two-pack adhesives, thermo adhesives, photo activated compounds etc. In the example an adhesive which can be activated by ultra-violet rays is preferred especially due to its fast setting time, low temperature requirement and a reduced need for energy.

For connection there are several known ways which are proven to a greater or lesser extent and new methods such as welding by gold wire or aluminum wire, application of conductive adhesives or those of the «Flip chip» type with the microcircuit upturned, pads facing downwards etc. In these two latter cases encapsulation can be omitted and the connecting heights are low.

Conforming to one characteristic of the invention, the microcircuit is connected by ultrasonic welding of conductor wires, preferably aluminum.

This technique is not recommended especially on interface support films in line with the invention (very flexible and/or soft). In the field of the chip card in fact ultrasonic welding of conductor wires is reserved for hard and rigid interface support films based on epoxy glass, polyimides and interfaces of copper with surface treatment of the Ni-Au type.

With the present state of ultrasonic welding it is possible to use a welding tool in the shape of a point from where the welding wire emerges. During welding the point is pressed on the metal interface pads or of the silicone chip resting on the support film.

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The inventors found that attempts of ultrasonic welding carried out on interface supports based on soft materials such as PE or PP or even PET (depending on its quality) as a substitute for those currently in use and with a thickness of more than about 75 μm for example 100 μm were destined to failure, the welding not succeeding or being of a non-industrial or non-reproducible mediocre quality.

The inventors nevertheless have succeeded in carrying out reproducible welds of industrial quality but having to deviate on this side of a certain threshold of thickness. In fact within this threshold they discovered that the thinner the material, the better the weld. This is true even with aluminum wire which is very difficult to weld.

The distinct threshold depending on material is defined at about 75 μm for PE and PP.

It was possible to improve the reproducibility of the weld by lying, at least the zone of the support film (welding zone) on which the welding is to be carried out, flat on a firm and hard reference surface.

The support film is laid by mechanical means or preferably by suction. In the latter case a suction circuit is placed in the area around the welding zone.

Thus it was possible to adapt a particularly economic standard welding technique in such a way as to make it reliable in the case of the invention.

An interspace film (not shown) is placed on the interface support film when the microcircuit has been fixed to it in such a way as that it can be rolled up correctly without damaging the microcircuits.

Connection of the interface elements

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The interface connection elements arranged possibly each side of the support film can be connected through the support film by various methods known from the state of the art especially by making metallised holes by filling a hole with a conductive material or by electric discharge etc.

Nevertheless due to the thinness of the support film of the invention and the interfaces and to their aforementioned characteristics, these connections are made advantageously by mechanical action with local perforations or tears, stamping or more advantageously by riveting or ultrasound with special tools.

This method is particularly economic as far as it does not require any extra material in an operation which can be easily integrated and in general within a time concealed in the manufacturing process of the device or of the interface support film.

Encapsulation

For the encapsulating stage the encapsulating material can be localised over a zone for placing the microcircuit or extended over all the surface of the support film. In the first case a drop of the material for example a resin is applied. In the second case the material can be applied by coating, screen printing etc. Preferably it is applied by spraying.

The adhesives and resins, conductive or otherwise, varnishes, can be polymerised by applying heat (thermal) localised or otherwise and/or without heat source, especially by radiation at certain wave lengths for example UV or by mixing two reactive agents.

The cold method especially at a temperature of less than 80°C with a fast setting time is used for all hardening of adhesives and/or resins even intended for purposes other

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than encapsulating. This is assisted in certain cases by UV radiation. Preferably this is carried out at ambient temperature.

Operation to fix the compensation film

Conforming to another aspect of the invention and an alternative way of implementation the process comprises a stage according to which a compensation film 22 also shown on Figure 10 is fixed on the interface support film (1, 2). This compensation film has at least one perforation 23 corresponding to a place for a microcircuit. In the example illustrated in Figure 10 a strip 22 from a roll 29 comprising a number of perforations is laminated on. For this purpose pressure sensitive-adhesives and/or non-polymerizing glues are used.

This stage is preferably carried out before the microcircuit is fixed. It is also possible but more difficult to bond or fix the compensation film after the operation to fix or connect or encapsulate the microcircuit.

As already mentioned above this stage can be carried out in regard to any interface support film but it is more interesting and more significant with the interface support film which can be folded in line with the invention.

The recess advantageously serves to define a protection space for the microcircuit during later rolling up operations and storage but also serves to contain an encapsulating material which is applied in operation 27.

Supplementary stages

The process can also include a supplementary stage consisting of applying an extra layer 30 for decoration, protection or adhesion on at least one of the two faces of the

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label. In the example an adhesive film 30 with its protection film is applied after transfer of the microcircuit.

Alternatively a support film already comprising at least an extra layer for example adhesive and protected by a peelable membrane can be provided.

Cutting out and cleaning up stage

Following the engraving operation a continuous frame (frame C in Figure 4) can exist around the devices which has the advantage of reinforcing the support film during the stages of the process. This frame will finally be removed by cutting. The device can be cut for example by punching in order to extract it in bulk from a strip 24 of interface support film.

In another case it is preferable to keep the devices on a strip or roll. For this purpose it is advisable previously to fix under the strip 24 of Figure 4, a two-sided adhesive strip with removable protection film. It is cut in such a way that the protection film is left intact. A cleaning up stage then follows the cutting stage and the adhesive devices remain on the protection film.

The strip is also cut longitudinally to the desired size (splitting).

Thus rolls comprising adhesive labels in the required format with regular spacing are obtained on the protective roll of the adhesive. The label can be stuck to any product. In other cases adhesives with temporary adhesive power or non re-adhering adhesives are used which enables all the process to be carried out in a roll and allows the devices, cards, tickets, non-adhesive labels etc to be supplied in a roll.

Manufacture of large area products containing the device

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In Figure 11 for example chip cards conforming to the invention are made. The stages and references are identical to those in Figure 10 accept that the roll 24 comprises a single interface design row 2. The compensation film is a foil with greater dimension that the support film and comprises a single row of perforations. The film 30 is still an optional protective and/or decorative or adhesive layer.

It is noted that this process enables cards on reels to be processed as for the tickets and labels obtained above. Processing on rolls can also extend as far as packaging and delivery up to the final user.

The compensation film can be of any kind especially paper, leather, non-woven or woven fibres, polymers etc. In the example the compensation film is PE with a thickness equal to 200 μm and which has a surface area equal to twice that of the device.

After cutting, a chip card of Figure 11A is obtained. If necessary a film 20 equivalent to the film 30 can be placed on the card in such a way as to hide the perforation 23.

To obtain the card in conformity with Figure 8 the procedure illustrated in Figure 11 with the difference that the compensation film is bonded after the fixing and connection stages with encapsulation if necessary is carried out in an identical manner. In this case the recesses 23 do not penetrate all the way through and thus form cavities 21, the compensation film becoming the card body 19 after this has been cut.

It is stressed that the remarks made about Figure 10 are valid for Figure 11.

Conversely not shown, a compensation film 29 which is narrower than the interface support film, in particular at the edge of the latter can be used.

<u>Details relating to certain problems overcome by the inventors are given below</u>

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The aim of long range is a problem as it is incompatible with the aim of reducing cost.

The aim of long range implies having a good electrical conductor as interface (a round wire is a better conductor than a rectangular cut or engraved film; copper is a better conductor than aluminum and considerably better than ink or conductive compound.....).

It also implies increasing the number of turns and the aerial surface which would imply increasing the surface of the circuit and space required for this.

It also implies having optimised dimensions and track definition (the narrower the tracks the closer the aerial turns, the larger the configuration of the turns and therefore more important the flow).

The solution to the problem of cost which is to downgrade the properties of interface support films is contrary to the above.
Besides this solution which culminates in retaining a very flexible interface support film (notably made from PE or PP and aluminum) especially creates the problems below.

The present processes are fundamentally not suitable for such support films, never having been used to manufacture semi-conductor modules.

The flexibility of the support film is fundamentally compatible with the hardness of a silicone chip and with the fragility of the chip and its connection.

The flexibility and thinness of the support films cause problems for collective processing in the form of rolls. For example collective processing implies very good positioning necessary for the transfer and chip protection stage and more particularly

for wire welding. Since such support films cannot be given transport perforations, no mechanical guide as for 35 mm films is possible.

The use of downgraded conductive materials (for example aluminum or copper without specific surface treatment in particular of the Ni-Au type) creates welding problems aggravated by oxidation problems.

The PP or PE / aluminum combinations envisaged by the inventors to serve as a base for the interface support films have printing inks which are left on the surface of the metal and which cannot be welded. Their removal is costly and causes the formation of an insulating oxide layer.

The use of interface support film specially downgraded in regard to rigidity (absence of Ni) leads to involving soft materials which causes the welding problems described above. In addition very flexible materials in general melt at the temperatures used in the processes of the earlier type.

The solution is ideally suited, by adapting present processes for 35 mm reels, to larger reels of more than 80 mm.

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THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. Electronic device with a chip including a support film and at least one flat conductive interface placed on one side of said support film as well as at least one microcircuit connected to said interface, said chip device also including a height compensation film placed on said one side of said support film, said compensation film having a recess containing said microcircuit and its connections to said interface, and an encapsulating material for protecting said microcircuit and said connections.

2. Device according to Claim 1 characterised in that the support film and the interface can be creased or folded over itself according to a radius of curvature less than 2.5 mm and preferably less than 1 mm substantially without deterioration.

3. Device according to Claim 1 or 2 characterised in that the encapsulating material is contained at least partly by said recess.

4. Device according to any one of the preceding Claims characterised in that the support film has a thickness of less than 75 μm and preferably between 10 μm and 30 μm.

5. Device according to any one of the preceding Claims characterised in that the support film has an elongation at break of more than 80% and/or Shore hardness of less than 80 and/or a vitreous transition temperature Tg of less than 0° and/or a fusion temperature of less than 130°C.

6. Device according to any one of the preceding Claims characterised in that the support film can be especially selected from among PP, PE, PET.

7. Device according to any one of the preceding Claims characterised in that the interface is aluminum.

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8. Device according to any one of the preceding Claims characterised in that the conductive interface is made of windings belonging to an aerial disposed in a spiral shape upon the support film, and the microcircuit is disposed outside of said windings.

9. Device according to Claim 8 characterised in that the support film comprises an interface element known as a «strap» on the other face to pull back at least one end of the aerial in the vicinity of the chip.

10. Device according to any one of the preceding Claims characterised in that the width of the turns around the microcircuit are thinner than elsewhere in such a way as to connect the microcircuit directly on the ends with a small length of connecting wire.

11. Device according to any one of the preceding Claims characterised in that the microcircuit is placed between the turns directly over the support film.

12. Device according to any one of the preceding Claims characterised in that the microcircuit is placed in a corner of the support film and directly above.

13. Device according to any one of the preceding Claims characterised in that the interface has at least one aerial turn formed in such a way as to be able to communicate over a distance of more than 8 cm and preferably more than 50 cm.

14. Device according to any one of the preceding Claims characterised in that the interface has connection pads.

15. Device according to any one of the preceding Claims characterised in that it has encapsulating material over at least the microcircuit, its connections and at least a portion of the interface.

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16. Device according to any one of the preceding Claims characterised in that it has at least a protection/personalisation film and/or adhesive film over at least one of its faces.

17. Device according to any one of the preceding Claims characterised in that it has a resonance capacitor made up of two conductive plates placed on both sides of the support film.

18. Device according to Claim 19 characterised in that the capacitor has an adjustment facility.

19. Device according to any one of the preceding Claims characterised in that an integrated capacitor and/or an emergency aerial is contained in the microcircuit.

20. Device according to Claim 19 characterised in that the microcircuit can be powered and can communicate at close range via the emergency aerial if the aerial circuit of the support film fails.

21. Chip card characterised in that it includes a card body on which a device according to any one of the preceding Claims is fixed, the card body having an area of more than or equal to and preferably at least double that of the device.

22. Chip card characterised in that it has two external films between which a device according to any one of Claims 1 to 20 is inserted.

23. Chip card including a card body having a cavity characterised in that it has a device according to any one of Claims 1 to 20, the microcircuit being located in the cavity, the support film and the interface extending outside the cavity over the surface of the card body.

24. A process for manufacturing an electronic device with a chip including a support film and at least one flat conductive interface placed on one side of said

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support film, as well as at least one microcircuit connected to said interface, said process including the steps of:

providing at least said support film;

fixing said at least one microcircuit upon said support film; and

connecting said at least one microcircuit to said interface;

said process further including the steps of:

securing a height compensation film upon both said support film and at least a portion of said interface, said height compensation film having at least one recess which corresponds with a location of said microcircuit and its connections to said interface; and

coating said microcircuit and said connections with an encapsulating material.

25. Process according to claim 24 characterised in that the support film and the interface can be creased or folded over itself according to a radius of curvature of less than 2.5 mm and preferably less than 1 mm substantially without deterioration.

26. Process according to Claim 24 or 25 characterised in that the compensation film is placed before the microcircuit is fixed.

27. Process according to Claim 24, 25 or 26 characterised in that the encapsulating material is only flowed into the recess of the compensation film.

28. Process according to any one of Claims 24 to 27 characterised in that the compensation film is placed after the microcircuit is fixed or the latter is encapsulated.

29. Process according to any one of Claims 24 to 28 characterised in that the interface support film is provided in strips on a roll and that means of transport controlled by the tension of the support film to feed it to at least one work station are used.

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30. Process according to any one of Claims 24 to 29 characterised in that the microcircuit is connected by ultrasonic welding of conductor wires.

31. Process according to Claim 30 characterised in that aluminum conductor wires are used.

32. Process according to Claim 30 or 31 characterised in that for welding at least the space of the microcircuit on the film support is laid on a firm reference surface.

33. Process according to Claim 32 characterised in that the support film is laid by suction.

34. Process according to any one of Claims 24 to 33 characterised in that the interface on the support film is made by an aluminum engraving technique.

35. Process according to any one of Claims 24 to 34 characterised in that the interface elements and contact pads are connected through the support film by mechanical perforations/tears.

36. Process according to any one of Claims 24 to 35 characterised in that it also comprises a stage according to which the encapsulating material is placed over the microcircuit and its connections.

37. Process according to any one of Claims 24 to 33 characterised in that the encapsulating material is flowed into the at least one recess formed by a perforation of the compensation film.

38. Process according to any one of Claims 24 to 37 characterised in that it comprises at least one extra stage consisting of applying an adhesive layer with a peelable protection film on at least one face of the label.

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39. Process according to any one of Claims 28 to 38 characterised in that the strip has a number of interfaces and that it comprises a stage consisting of cutting each device.

40. Process according to Claim 38 or 39 characterised in that said adhesive layer of the protection film is provided in continuous strip, in that the devices are cut while remaining fixed on the protection film and in that a cleaning up operation is carried out between the devices.

41. Electronic device with a chip substantially as herein described with reference to the accompanying drawings.

42. A process for manufacturing an electronic device with a chip substantially as herein described with reference to the accompanying drawings.

DATED: 27 March 2002

PHILLIPS ORMONDE & FITZPATRICK
Attorneys for:
GEMPLUS S.C.A.

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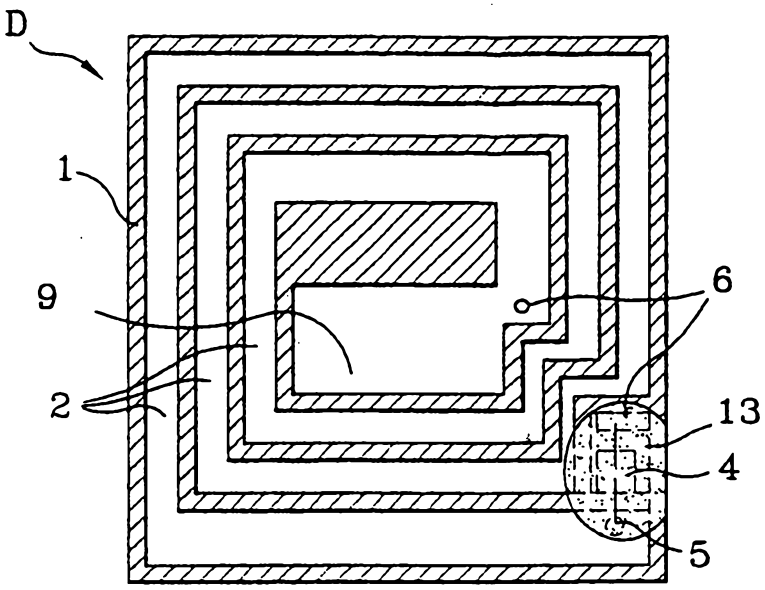


FIG.1

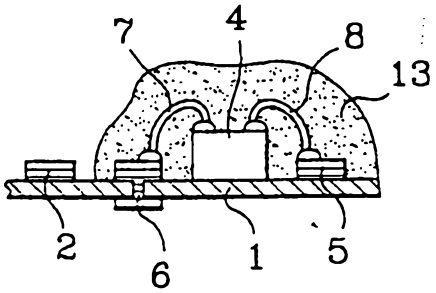


FIG.2

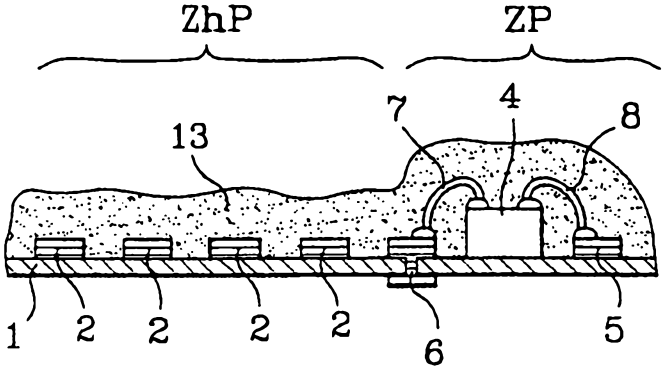


FIG.3

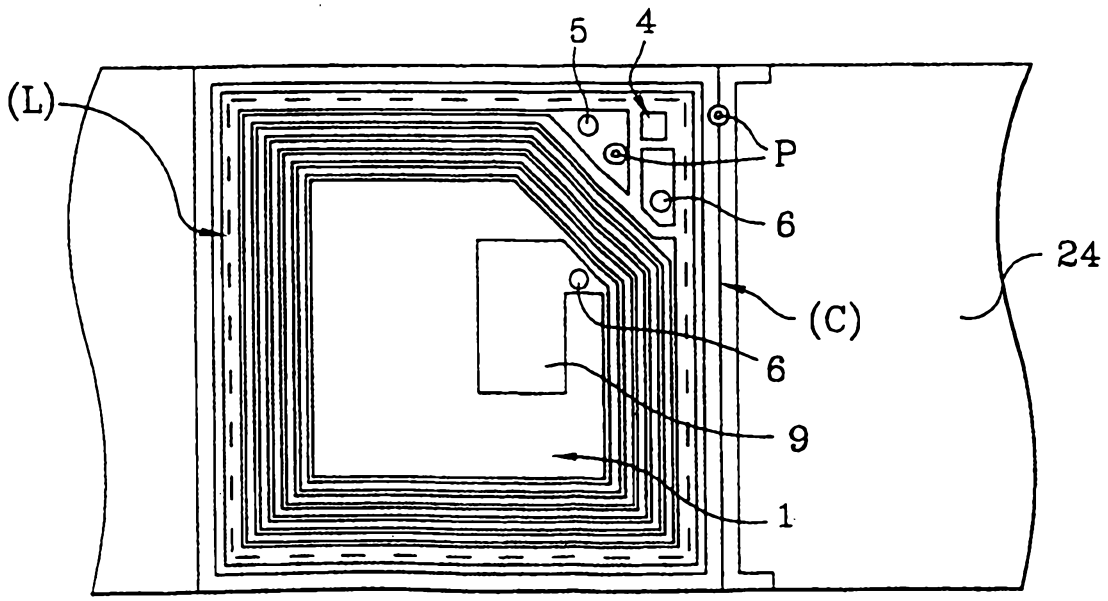
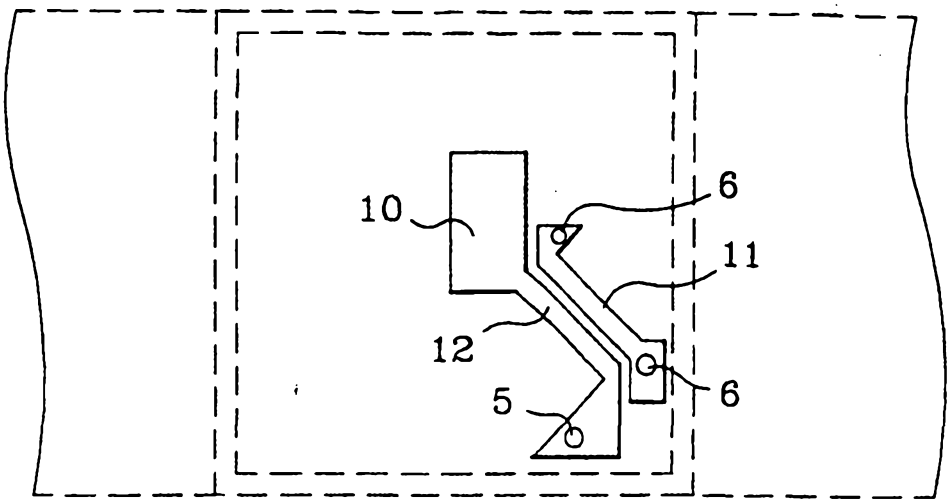


FIG.4

FIG.5



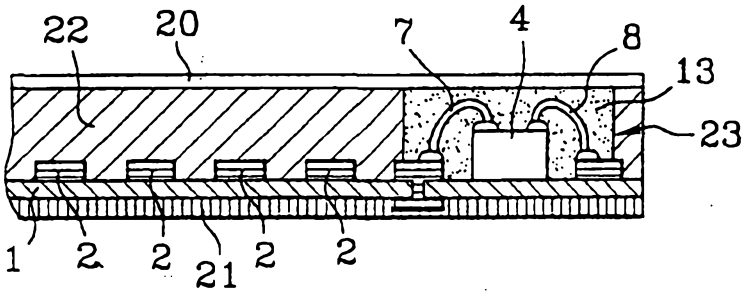
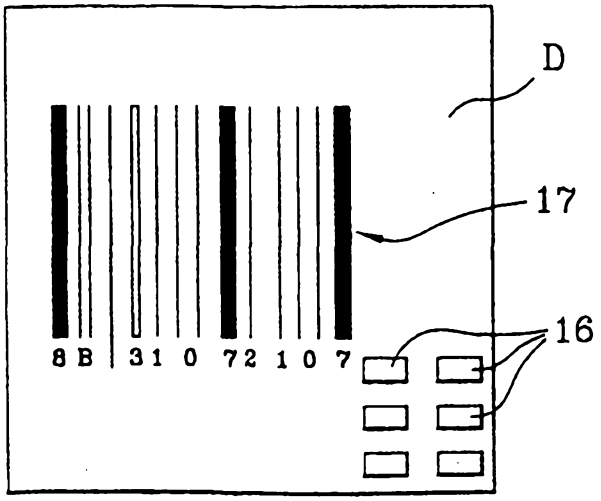


FIG.9

FIG.6



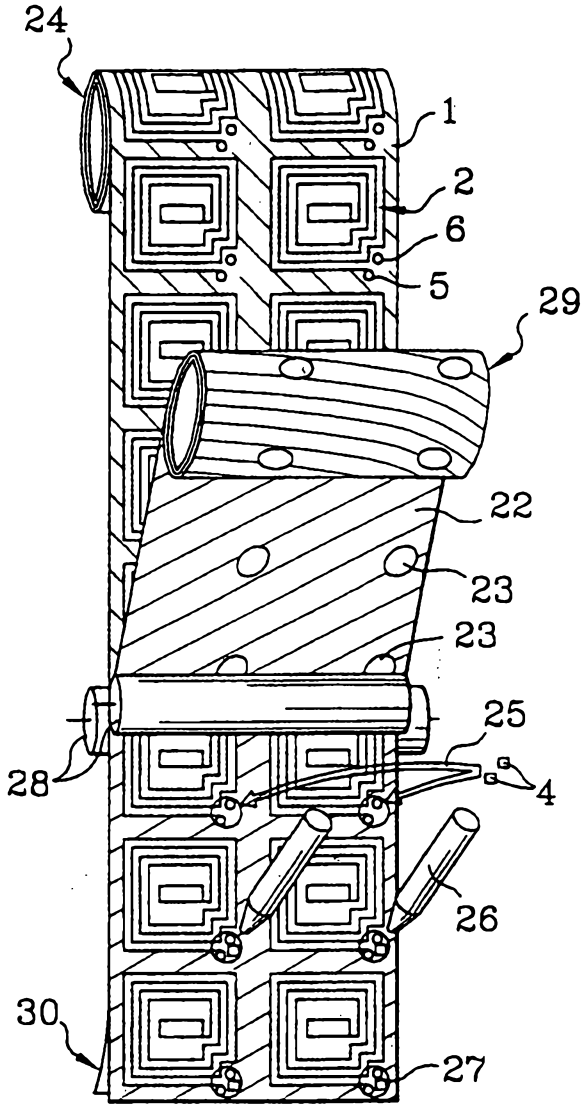


FIG.10

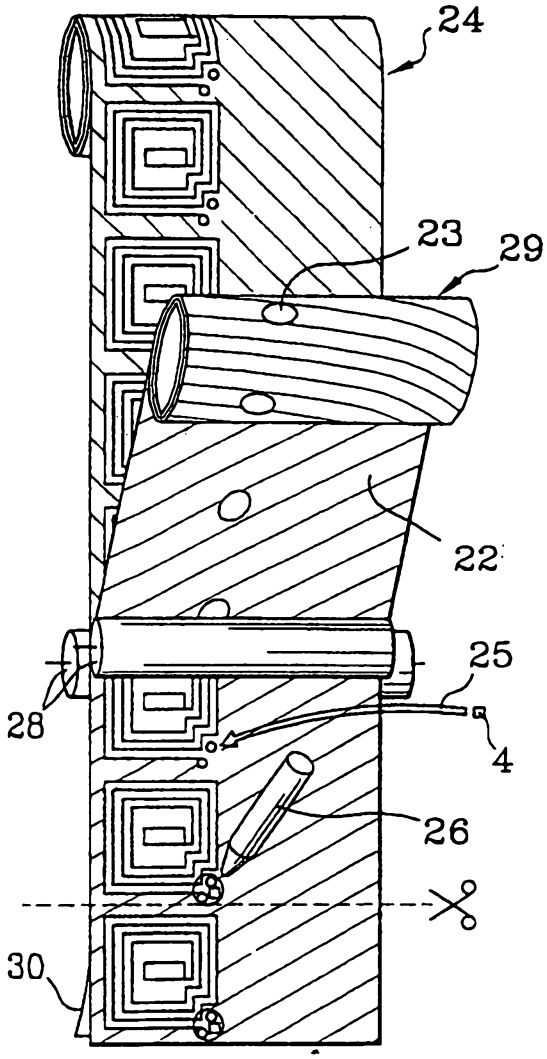


FIG.11

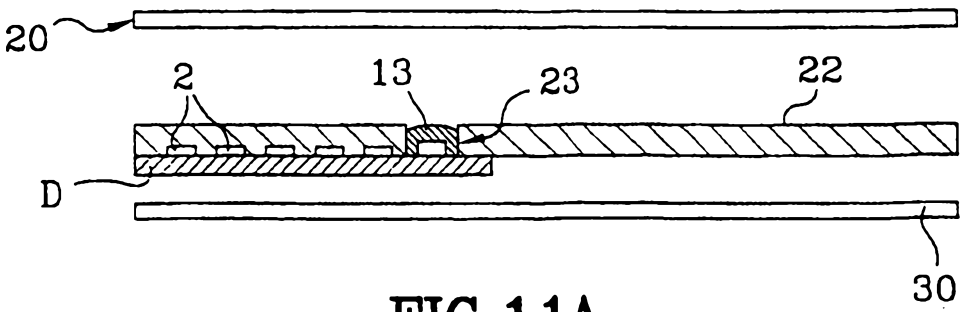


FIG.11A

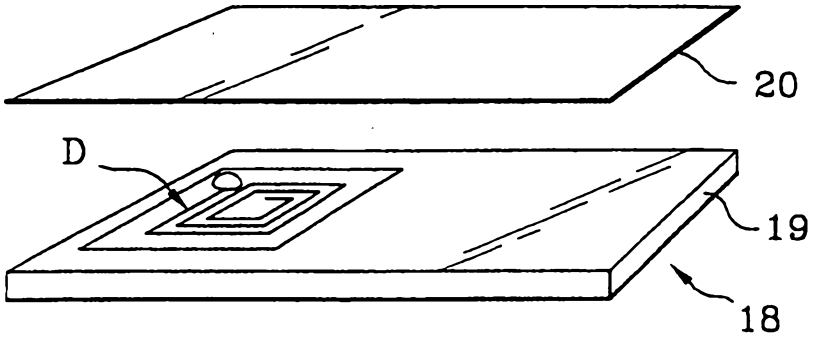


FIG.7

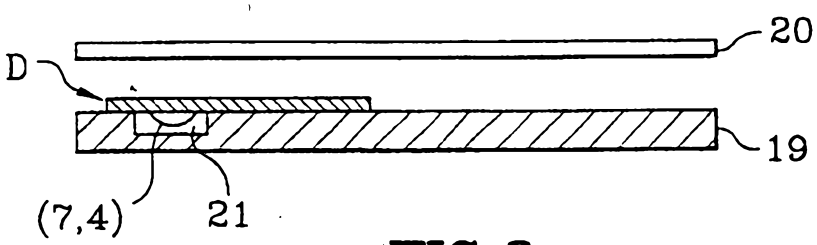


FIG.8

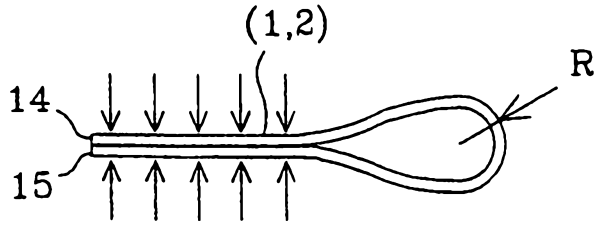


FIG.12