

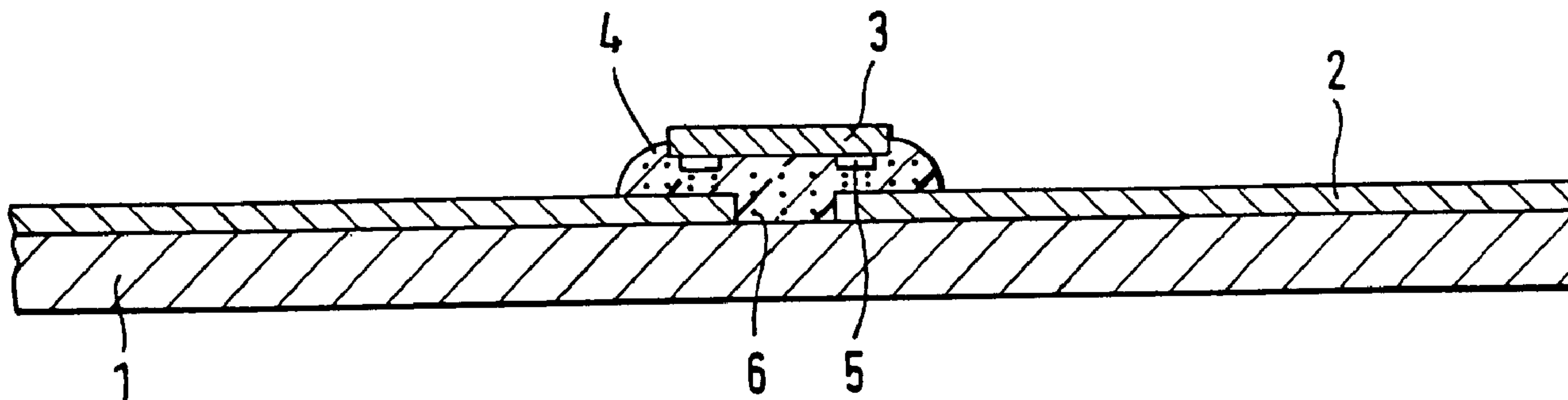


(86) Date de dépôt PCT/PCT Filing Date: 2001/12/19
(87) Date publication PCT/PCT Publication Date: 2002/06/27
(45) Date de délivrance/Issue Date: 2008/08/26
(85) Entrée phase nationale/National Entry: 2003/06/20
(86) N° demande PCT/PCT Application No.: EP 2001/015018
(87) N° publication PCT/PCT Publication No.: 2002/050890
(30) Priorité/Priority: 2000/12/21 (DE100 64 411.2)

(51) Cl.Int./Int.Cl. *H01L 21/60* (2006.01),
C09J 11/04 (2006.01), *C09J 9/02* (2006.01),
D21H 21/48 (2006.01), *G06K 19/077* (2006.01),
H01L 23/48 (2006.01), *H01L 23/58* (2006.01)
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(54) Titre : LIAISON ELECTROCONDUCTRICE ENTRE UNE PUCE ET UN ELEMENT DE COUPLAGE, AINSI QU'ELEMENT DE SECURITE, DOCUMENT DE SECURITE, ET DOCUMENT DE VALEUR COMPORTANT UNE TELLE LIAISON

(54) Title: ELECTRICALLY CONDUCTIVE CONNECTION BETWEEN A CHIP AND A COUPLING ELEMENT, AND SECURITY ELEMENT, SECURITY PAPER AND DOCUMENT OF VALUE WITH SUCH A CONNECTION



(57) Abrégé/Abstract:

A document of value has a chip and is connected to a coupling element for the transmission of data and/or energy from and/or to the chip via an adhesive. According to a first embodiment, the adhesive contains electrically conductive particles which are smaller than the distance between the contact surfaces 5 of the chip 3 and the coupling element 2. According to a second embodiment, the conductive adhesive contains electrically conductive particles which are soft at an elevated temperature at which the chip 3 is applied to the coupling element 2. According to a third embodiment, it is possible to dispense with the electrically conductive particles in the adhesive. Instead, the transmission of data/energy is carried out via an alternating field coupled in capacitively at high frequencies of about 2 GHz.

Abstract

A document of value has a chip and is connected to a coupling element for the transmission of data and/or energy from and/or to the chip via an adhesive. According to a first embodiment, the adhesive contains electrically conductive particles which are smaller than the distance between the contact surfaces 5 of the chip 3 and the coupling element 2. According to a second embodiment, the conductive adhesive contains electrically conductive particles which are soft at an elevated temperature at which the chip 3 is applied to the coupling element 2. According to a third embodiment, it is possible to dispense with the electrically conductive particles in the adhesive. Instead, the transmission of data/energy is carried out via an alternating field coupled in capacitively at high frequencies of about 2 GHz.

Electrically conductive connection between a chip and a coupling element, and security element, security paper and document of value with such a connection

5 The invention relates to an electrically conductive connection between an integrated circuit, formed as a chip, and a coupling element for transmitting data and/or energy from and/or to the chip. The invention likewise relates to documents of value, in particular
10 banknotes, and security papers for the production of these documents of value, and security elements to be applied to or incorporated in the security paper, which in each case have such an electrically conductive connection between chip and associated coupling
15 element. Finally, the invention also relates to a method for the capacitive transmission of data and/or energy between connected chip and coupling element.

The documents of value in the sense of the present
20 invention can be banknotes, certificates or else credit cards and the like. The invention is particularly suitable for use in thin, papery documents of value such as banknotes, but can also be used in conjunction with other documents of value.

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The application of integrated circuits in form of chips in or on a banknote is proposed, for example, in EP 0 905 657 A1, in order to increase the security of banknotes against forgeries by means of information
30 stored in the chip. The chip is a transponder chip with which, therefore, contact is not made directly by external data processing devices, but in which the data interchange is carried out via a coupling element formed as an open or closed dipole antenna, for which
35 purpose, for example, the security thread contained in the banknote or a closed coil provided separately in the banknote can be used.

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The production of an electrically conductive connection between the chip and the coupling element is subject to certain restrictions, because of the low paper layer thickness and because of the low thickness of the chip.

5 A connection by means of final (gold) wires in the wire bonding technique is ruled out because of these limiting conditions. Instead, the flip-chip technique, known from smart card technology, is suitable, in which the chip with its contact elements is immersed in an

10 electrically conductive compound applied to the coupling element. The use of an electrically conductive adhesive is mentioned, for example, in DE 44 16 997 A1.

15 In order to ensure that the adhesive used does not lead to a short-circuit link, in particular in the case of closely adjacent chip contact elements, in connection with smart cards it is proposed in EP-A-512 546 and DE 199 57 609 A1 to use anisotropic conductive adhesives,

20 which are therefore conductive in only one direction, specifically between chip and contact element. Such an anisotropic adhesive layer can cover all the contact elements together without this leading to the formation of a short circuit. For this purpose, DE 199 57 609 A1

25 proposes the provision of spherical, possibly resilient, conductive bodies beside one another and spaced apart from one another in a compressible heat-seal adhesive layer which can be handled. In the case in which the chip is applied to the coupling element

30 using the hot punching technique, the application of pressure and temperature means that the spherical conductive bodies form an electrically conductive connection between the contact elements of the chip and the coupling element, but the conductive bodies not

35 being connected to one another, so that the formation of a short circuit is avoided. Practical statements relating to the resilient conductive bodies are not contained in DE 199 57 609 A1.

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The aforementioned proposals cannot readily be transferred from smart card technology to the technology of documents of value, which is attributed in particular to the extremely low material thickness
5 of the documents of value and chips. The risk of chip fracture during the application of the extremely thin chip to the coupling element has proven to be a particular problem.

10 It is therefore an object of the present invention to propose an electrically conductive connection with which, in particular in conjunction with documents of value, chips and associated coupling elements can be connected reliably to one another.

15 Further objects of the invention consist in proposing corresponding security elements for document of value, documents of value as such and security papers for the production of such documents of value, and also a
20 method for the transmission of data and/or energy.

According to the invention, these objects are in each case achieved by the features of the dependent secondary claims. In claims dependent on these,
25 advantageous refinements and developments of the invention are specified.

The solutions according to the invention are based on the finding that the electrically conductive connection
30 between the chip and coupling element is to produce as few mechanical stresses as possible in the frangible chip, in particular at the time of chip application.

According to a first embodiment of the invention, this
35 finding is implemented, in order to achieve the aforementioned object, by the adhesive that connects the chip and coupling element being an anisotropic conductive adhesive which contains electrically conductive particles whose maximum size is less than

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the distance between the chip and the coupling element, preferably less than one μm . These particles are preferably oriented in the adhesive, for example in a magnetic field, such that they conduct only in the direction between chip and coupling element and are otherwise insulated from one another by the adhesive material. Given an adhesive layer thickness of about 2 μm , it is thus ensured that the particles can exert no mechanical stresses on the chip, because of their small size.

10

According to a second embodiment of the invention, an anisotropic adhesive with electrically conductive particles is likewise used, but consists of a solder material which is soft at an elevated temperature at which the chip is connected to the coupling element. After it has been cooled down, the solder material solidifies in its form assumed during the application of the chip. It is thus ensured that, in particular during the application of the chip, no mechanical stresses are exerted on the chip by the electrically conductive particles. The solder material particles are arranged beside one another and spaced apart from one another in a suitable adhesive matrix in such a way that they are also still spaced apart from one another following application of the chip. Examples for the manner in which the chip and the anisotropic adhesive are applied to the coupling element, and also the possible alternatives for the configuration of the specific anisotropic adhesive layer comprising particles or conductive bodies spaced apart from one another, can be found in the prior art literature, for example, in DE 199 57 609 A1.

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Instead of the use of an electrically conductive adhesive for making non-reactive contact between chip and contact element, a third embodiment of the invention provides capacitive coupling. This embodiment is suitable for use with high frequency

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automating currents of, for example, about 2 GHz. Any
conductive particles in the adhesive layer which
promote mechanical stresses can be dispensed with.
Instead, the adhesive layer forms a thin, dielectric
5 layer between the chip contact surfaces and the
coupling element. The supply of energy for the chip is
provided by an alternating field coupled capacitively
into the chip, and the chip comprises a rectifier and a
capacitor for storing energy.

10

In the following text, the invention will be explained
by way of example using the appended figures, in which:

Figure 1 shows an electrically conductive connection
15 with anisotropic adhesive according to the first
embodiment of the invention,

Figure 2 shows an electrically conductive connection
with anisotropic adhesive according to the second
20 embodiment of the invention, and

Figure 3 shows an electrically conductive connection
with capacitive coupling according to the third
embodiment of the invention.

25

Figure 1 shows a substrate 1 comprising a coupling
element 2 and an integrated circuit 3 electrically
conductively connected to the coupling element 2 via an
adhesive 4.

30

The substrate 1 can be a document of value, in
particular a banknote, but also a preproduct of such a
document of value, specifically a security paper which
is only later further processed to form a document of
35 value. However, the substrate 1 can also be other
documents of value, for example a smart card. In
particular, the substrate 1 can also be a security
element, for example an optically variable element
(OVD) or a security thread which is only later

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connected to a document of value or security paper. In the case of an OVD, the security element has preferably been applied to the document of value in such a way that the object of the variable side of the OVD points
5 outward and the OVD hides the view of the integrated circuit 3. If the optically variable element is designed as a hologram, the coupling element 2 can at the same time serve as a reflective layer in order to reflect light passing through the optically variable
10 element.

The invention is preferably used in a document of value such as banknotes. The substrate 1 and the coupling element 2 preferably form a security thread therein,
15 the substrate 1 being, for example, a transparent plastic thread, on which the coupling element 2 is present as an aluminum coating. The coupling element 2 then represents an open dipole, via which data and/or energy can be transmitted without contact to the
20 integrated circuit 3 from an external device. Instead of a security thread, the chip 3 can also be applied to another substrate or security element and connected to the banknote, it then being possible, depending on the available area, to form the coupling element 2 as a
25 closed dipole or as a coil. Furthermore, a laminating film, which is not illustrated in the figure, can also be arranged, at least in the region of the integrated circuit 3.

30 Before its application, the integrated circuit is present as a chip which can be handled. This can be, for example, a pure memory chip (ROM), a rewritable chip (EPROM, EEPROM) or else a microprocessor chip. The chips used have a thickness of 5 μm to 50 μm ,
35 preferably 10 μm , and an edge length of about 0.1 mm to 3 mm, preferably 0.6 mm. On the chip 3 there are preferably 2 to 4 contact surfaces 5.

The adhesive 4, by means of which the chip 3 and the coupling element 2 are firmly connected to each other, contains electrically conductive particles 6.

5 According to the embodiment according to Figure 1, the maximum size of these particles 6 is substantially less than the distance between the contact surfaces five and the coupling element 2. This ensures that, when the chip 3 is applied to the coupling element 2, no
10 mechanical stresses occur in the chip 3 on account of particles 6 lying in between. The distance between the contact surfaces 5 and the coupling element 2 is preferably about 2 μm and the maximum particle size is therefore less than about 1 μm , preferably about 0.5
15 μm .

In order to achieve the situation in which the particles 6 within the adhesive 4 are electrically conductive only in the direction from and to the
20 contact surfaces 5 lying closest to the coupling element 2, the particles 6 are oriented before the adhesive 4 has been cross-linked to such an extent that the particles 6 are largely fixed in their oriented position. The orientation of the particles 6 can be
25 carried out, for example, in a magnetic field, so the adjacent particles 6 repel one another and form lines in the preferential electrical direction.

A material that has proven to be suitable for the
30 conductive particles 6 is the conductive powder marketed by DuPont under the trade name "ZELEC ECP-3010XC". Likewise suitable is silver nanopowder with a particle size of preferably about 0.5 μm .

35 The selection of the adhesive is not unimportant either. It must be protected against mechanical overstressing and therefore be flexible within limits. With a layer thickness of 2 μm , the non-reactive volume resistance should be about 5 ohms. Furthermore, it

must be ensured that adequate contact is made with the small contact surfaces 5 of the chip 3, with a size of in each case about $70\text{ }\mu\text{m} \times 70\text{ }\mu\text{m}$. In particular, making contact with aluminum layers with an oxide covering must be ensured, since the contact between the coupling element 2 and air causes natural oxidation of the aluminum. Finally, it must be ensured that the electrical conductivity of the adhesive in the high frequency field in the direction opposite to the preferential direction reaches no more than $100\text{ }\mu\text{m}$. $100\text{ }\mu\text{m}$ is approximately the distance between adjacent contact regions of the coupling element 2.

According to a second embodiment, which is illustrated in figure 2, the electrically conductive particles 6 of the anisotropic adhesive 4 consist of a solder material, for example tin-bismuth. The chip 3 is normally placed on the coupling element 2 using the hot punching technique, the temperature introduced leading to softening and cross-linking of the adhesive 4 and the slight pressure leading to contact between the chip 3 and the connecting regions of the coupling element 2. The temperature of the hot punching and the softening temperature of the solder material are matched to each other in such a way that the solder material also softens during the application of the chip 3 and, in accordance with the pressure of the hot punching, is matched faithfully to the contact surfaces 5. During the application of the chip 3 to the coupling element 2, the electrically conductive solder material particles thus do not exert any substantial stresses on the chip 3, instead are deformed plastically, but ensure an electrically conductive connection between the contact surfaces 5 of the chip 3 and the coupling element 2. The solder particles 6 are distributed in the adhesive 4 in the manner of a matrix, so that they are not transversely connected to one another, even after the application of the chip, as described in DE 199 57 509 A1.

In conjunction with the solder material particles, the adhesive marketed under the designation "Loctite 3440" has proven to be a suitable adhesive.

5

According to a third embodiment, which is illustrated in Figure 3, use is made of an adhesive 4 which does not necessarily contain electrically conductive particles. The transmission of data and/or energy is carried out capacitively between the coupling element 2 and the contact surfaces 5 of the chip 3. This type of transmission is particularly suitable at high frequencies of, for example, 2 GHz for the transmission of energy, the data stream being modulated on, for example at a frequency of about 400 MHz. In this case, the slight distance between the contact surfaces 5 and the respectively immediately adjacent sections of the coupling element 2 acts as a short circuit. It is possible to dispense with making non-reactive contact.

20 The chip has a capacitor and a voltage rectifier, in order to charge up the capacitor with energy via an alternating field coupled in capacitively. The adhesive 4 acts as a dielectric between the coupling element 2 and the contact terminals 5. For the

25 capacitive coupling, it is also necessary to enlarge the connecting areas of the integrated circuit.

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What is claimed:

1. A document of value having an integrated circuit and a coupling element, the electrically conductive connection
5 between the integrated circuit, formed as a chip, and the coupling element for the transmission of data and/or energy from and/or to the chip comprising an anisotropic conductive adhesive which contains electrically conductive particles, wherein the maximum size of the particles is less than the
10 distance between the coupling element and the chip.
2. The document of value as claimed in claim 1, wherein the maximum size of the particles is less than one μm .
- 15 3. The document of value as claimed in claim 1 or 2, wherein the particles have a direction of orientation which is the same as the direction of the connection.
4. The document of value as claimed in one of claims 1 to 3,
20 wherein the electrically conductive connection is formed by the anisotropic conductive adhesive with a layer thickness of 2 μm .
5. The document of value as claimed in one of claims 1 to 4,
25 wherein the particles have a size of 0.5 μm .
6. The document of value as claimed in one of claims 1 to 5, wherein the particles consist of silver nanopowder.
- 30 7. A document of value having an integrated circuit and a coupling element, the electrically conductive connection between the integrated circuit, formed as a chip, and the coupling element for the transmission of data and/or energy from and/or to the chip comprising an anisotropic conductive
35 adhesive which contains electrically conductive particles, wherein the particles consist of a solder material which is

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soft at an elevated temperature at which the chip is connected to the coupling element.

8. The document of value as claimed in claim 7, wherein the
5 solder material comprises tin-bismuth.

9. The document of value as claimed in claim 7 or 8, wherein the particles in the conductive adhesive are arranged beside one another in the manner of a matrix and spaced apart from
10 one another.

10. A document of value having an integrated circuit and a coupling element, the electrically conductive connection between the integrated circuit, formed as a chip, and the
15 coupling element for the transmission of data and/or energy from and/or to the chip, an adhesive layer being provided between the chip and the coupling element, wherein the adhesive layer forms a dielectric between the coupling element and a contact terminal of the chip, and wherein the chip
20 comprises a voltage rectifier and a capacitor.

11. The document of value as claimed in one of claims 1 - 10, wherein the document of value is a banknote.

25 12. A security element for a document of value, comprising an integrated circuit and a coupling element, the electrically conductive connection between the integrated circuit, formed as a chip, and the coupling element for transmission of data and/or energy from and/or to the chip comprising an
30 anisotropic conductive adhesive which contains electrically conductive particles, wherein the maximum size of the particles is less than the distance between the coupling element and the chip, and wherein the coupling element is a constituent part of the security element.

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13. A security element for a document of value, comprising an integrated circuit and a coupling element, the electrically conductive connection between the integrated circuit, formed as a chip, and the coupling element for transmission of data
5 and/or energy from and/or to the chip comprising an anisotropic conductive adhesive which contains electrically conductive particles, wherein the particles consist of a solder material which is soft at an elevated temperature at which the chip is connected to the coupling element, and
10 wherein the coupling element is a constituent part of the security element.

14. The security element as claimed in claim 12 or 13, wherein the security element is a security thread.
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15. The security element as claimed in one of claims 12 to 14, the security element being a transfer film, for example an optically variable element.

20 16. A security paper for producing a paper of value, comprising a security element according to one of claims 12 to 15.

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