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Laminate comprising an electrically conductive layer
5 formed as an antenna structure

The invention relates to a laminate comprising a
carrier layer and an electrically conductive layer.
Laminates of this type are used, for example, for the
10 production of beverage cartons.

Transponder technology permits data to be read from and
stored in a microchip without contact. For this
purpose, the microchip is connected to an antenna, with
15 which the electromagnetic radiation required to write
to or read from the microchip can be received and
transmitted. Using an external transmitting and
receiving unit, it is possible to communicate with the
microchip via electromagnetic radiation. In this case,
20 the microchip generally does not comprise its own power
supply, so the radiation used to write to or read from
the microchip is also used to supply power to the
microchip.

25 The technology needed for this purpose could hitherto
not be produced below a certain cost frame. For this
reason, the corresponding apparatus is at present
profitable only for relatively expensive articles. For
example, the transponder technology is used to find
30 buried pipelines or rapid detection of animals in a
herd. For example, in large herds of cattle, the
animals are given a transponder implanted under the
skin. The animals can then be driven very simply past
a transmitting and receiving station, in which the data
35 stored on the microchip can be read out without
contact, in order for example to identify the animal.
A further field of application is the electronic anti-
theft protection of expensive luxury goods, such as fur
coats, perfumes, CD-ROMs etc. For this purpose,



however, the retail trade has to be equipped with appropriate devices for reading from the microchips.

Further applications are, for example, monitoring
5 important documents and files in government or
administrative buildings, the files being registered
electronically at the individual processing stations in
order to follow their path more easily or in order to
find the files easily again. For this purpose, a
10 transmitting and receiving station can be fitted, for
example, in the door frame, so that the files are
registered electronically when they are moved into the
room and out of the room. Another exemplary
application is the administration of unloading of
15 pieces of luggage in railroad stations, harbors or
airports, it being necessary for the piece of luggage
to be led to a specific location aimed at a specific
destination. For these applications, an individual
price of €0.50 for a label which comprises a memory
20 chip and a transmitting and receiving unit just counts
as profitable.

Hitherto, transponder technology has primarily been
used for goods which have a very long life or a very
25 high value. The comparatively high costs have hitherto
prevented the introduction of transponder technology on
a broader basis.

However, there is interest in technology in many
30 sectors in which a large amount of data has to be
registered in short time periods. Examples are
electronic stamps, or the use of electronic labels in
the retail trade, for example in supermarkets. Here,
the goods, for example located in a shopping trolley,
35 can be registered without contact at an electronic cash
register and an invoice can be drawn up. The data
about the goods registered can then be used, for
example, for stock keeping.

Since these consumer and consumable articles have a value of only a few Euro, the costs for the electronic labels must be reduced considerably. In this connection, there is discussion about a minimum cost
5 limit of about 5 cents per label, which is to be aimed at for an introduction suitable for the market.

In order to be able to produce an electronic label inexpensively, firstly the costs for the microchip have
10 to be reduced, and secondly the costs for the transmitting and receiving unit, such as the antenna. At the present time, coils are mostly used as the antenna. However, these antennas are far too costly for the applications described above. Also known are
15 antennas made of metal foil, the antenna structure being produced first and then being applied to a carrier. In this case, the antenna structure can be produced in various ways:

20 a) a metal film is laminated to the carrier over its entire surface and then structured subtractively by selective etching;

b) the antenna structure is punched out of a metal
25 foil and then laminated to the carrier;

c) the antenna structure is printed or sprayed on to the carrier by using electrically conductive pastes;

30 d) a mask is defined photolithographically on the carrier (for example by using a photoresist); the interspaces not covered by the mask on the carrier are then metalized without using power.

35 In the above-mentioned examples, it is important that an antenna structure is produced separately from a second laminate and that the metal foil is not necessarily a constituent part of a package.

These methods are all too costly for the production of antennas which are suitable for the abovedescribed applications.

5 It is therefore an object of the invention to provide a cost-effective antenna structure which permits the use of transponder technology even for goods which are under high cost pressure.

10 The object is achieved by a laminate comprising at least one carrier layer and an electrically conductive layer applied to the carrier layer, an antenna structure being formed at least in one section of the electrically conductive layer.

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The laminates according to the invention make use of structures such as are already used for the packaging of foodstuffs to provide an antenna structure. In many foodstuff packages, for the purpose of conservation,
20 laminates are used which comprise metal-containing films or metal layers. The metal layer in this case acts as an oxygen barrier and prevents the rapid spoiling of the foodstuffs, whose contents would otherwise oxidize as a result of atmospheric oxygen
25 penetrating in.

In order to impart the necessary stability to the packaging material, the metal layer is applied to a carrier which has the required robustness. For
30 example, packaging boards for the production of beverage packages or plastic films for the production of chip bags are suitable.

The metal layer contained in such a laminate has a
35 sufficient electrical conductivity to be able to produce an antenna structure from this layer. An important constituent part of the laminate according to the invention is, therefore, the presence of an antenna as a constituent part of the electrically conductive

layer, which permits data and information to be written into a memory, which is connected to the antenna structure, or read from said chip by a transmitter or receiver located outside.

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The laminate according to the invention therefore comprises a carrier layer, which is used for mechanical stabilization, and an electrically conductive layer applied to the carrier layer. The antenna structure is formed as part of this electrically conductive layer. In this case, the arrangement of the antenna structure in the electrically conductive layer is not subject to any restrictions. For this purpose, any desired, sufficiently large, free area on the electrically conductive layer is considered. Should it be required, and if the space available permits, a plurality of antenna structures can also be formed on the electrically conductive layer. In this case, it is necessary for the antenna density to be matched to the size of the package. In order to ensure the functionality of the transponder structure produced, it is sufficient for only one antenna structure to be connected to a microchip.

In addition to the number of antenna structures, the size of the antenna within the scope of the space required is also arbitrary, since in principle the entire surface of the laminate or of the electrically conductive layer contained in the latter is available.

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For the production of packages, the laminates according to the invention can be provided in relatively large containers, for example in rolled-up form, or as relatively large sheets of a laminated board. For the production of packages, appropriate pieces, which in each case comprise one or more antenna structures, are then separated from the roll or punched out of a larger board and processed further to form a package. For the

production and filling of packages, the known apparatus can be used.

5 In order to protect the electrically conductive layer against damaging environmental influences (scratches, contaminants), it is advantageous if a covering layer is applied to the electrically conductive layer. This covering layer can be, for example, a varnish layer or a further layer of a board. A layer of a plastic is
10 likewise possible. By means of the additional layer, in addition to the protection against external influences, a higher mechanical stability of the laminate is also achieved.

15 It is particularly advantageous if the covering layer consists of a water-repellent material since, as a result, firstly possible corrosion of the electrically conductive layer is prevented and secondly the penetration of water-soluble contaminants into the
20 laminate and the interior of the package is ruled out. Particularly preferably, the covering layer used is a layer of a plastic, such as is usual, for example, in beverage packages, such as milk cartons. In this preferred embodiment, the laminate therefore comprises
25 a carrier layer, for example of board, an electrically conductive layer, for example an aluminum layer, and a plastic layer, these being arranged on one another in this order. According to the invention, in this case the electrically conductive layer contains the antenna
30 structure.

In order to widen the range of application of the invention, the covering layer can also be formed as an adhesive layer, so that the laminate can be stuck onto
35 an object which is to be provided with corresponding labeling, such as a file or another document. The adhesive layer can also be formed as a separate layer and, for example, applied to the carrier layer or to the covering letter. However, the embodiment as a

packaging material is preferred, the layer having an electrically conductive layer that is continuous in the surface, and sections of the electrically conductive latter being formed into an antenna structure.

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The electrically conductive layer preferably contains at least one metal. Most metals are relatively good electrical conductors and are therefore very suitable for the construction of the antenna structure.

10 Furthermore, the metals needed are relatively easy to produce and uncomplicated to process. In particular, it is possible to shape most metals into thin layers with a conductivity which is still adequate, by which means the expenditure on material is reduced to a low
15 extent and the material costs can be kept low in a countermove.

It is particularly advantageous if the metal is aluminum, since this metal is easily accessible and has
20 a very good electrical conductivity. In addition, this metal has mechanical properties (extensibility, rolling behavior) which are advantageous for processing to form foil material. The use of aluminum is widespread in the production of packages for foodstuffs. In other
25 applications, in which no statutory foodstuffs regulations have to be met, other metals can also be used, for example copper.

As an alternative to the use of metals as carrier of
30 the electrical conductivity, in another embodiment the electrically conductive layer of the laminate according to the invention can also contain at least one conductive organic compound.

35 In this connection, electrically conductive polymers are known, such as condensed aromatic materials or semiconductors based on polythiophene or polyaniline which, in order to increase the electrical conductivity, are provided with doping (for example

camphor-sulfonic acid-doped polyaniline, polystyrene sulfonic acid-doped poly(ethylenedioxy)thiophene).

5 In order to be able to connect the end of the antenna to the microchip, in the case of the coil used as an antenna, either the end in the centre has to be led outward, or the outer end has to be led inward. For this purpose, a bridge structure is needed, with which the end of the coil is led over the turns.

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For this purpose, electrically conductive organic materials, such as polyaniline doped with camphor sulfonic acid or poly(ethylenedioxy)thiophene doped with polystyrene sulfonic acid can advantageously be
15 used, since the bridge structure in this case can be produced very simply by means of printing techniques.

Conductive organic compounds can generally easily be processed by means of printing techniques. Since work
20 is being carried out intensively on the development microchips based on organic semiconductors, the transmitter unit and memory module can be produced simultaneously with such chips. As compared with some metals, in particular noble metals, the production
25 costs of organic semiconductors are also lower. Furthermore, organic materials often have more beneficial deformability characteristics and therefore make further processing easier.

30 It is advantageous if the carrier layer is built up from a paper-like material, since paper has a low weight and nevertheless imparts sufficient stability and strength to the laminate.

35 Paper-like materials are all materials which contain cellulose as a basic constituent part, that is to say, in addition to paper, also paperboard, papier mache, board, wood, etc.

Use of polymers as carrier material is also preferred. In this case, in addition to the plastics which can be produced synthetically with a wide range of material characteristics, polymers is also to be understood to mean naturally occurring polymers such as silk, natural fibers, cotton, etc. In particular, synthetic polymers have a very low specific weight, can be loaded mechanically extremely highly and produced cost-effectively.

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Also conceivable is a mixture of paper-like material and a polymer, in order to combine the advantages of the two generic material types.

15 For use as a carrier material, it is important that the compounds used exhibit good dielectric characteristics, in order to ensure adequate insulation of the conductive structures applied.

20 It is particularly advantageous if the laminate is shaped into a package which encloses a hollow space. As a result, goods of an extremely wide range of types can be enclosed and transported within the hollow space. In this case, the laminate serves as a package and a storage medium for data about the packaged goods, for example their date of manufacture or their price. On the outside, the package can also bear a decorative imprint, for example the product name. Here, as compared with the known packages, there are no restrictions. The production of the package and its filling are carried out in accordance with known methods and with known apparatuses. Specific rebuilding of these apparatuses is therefore not required.

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The laminate configured as a package is suitable in particular for packaging foodstuffs. These have to be protected against external influences or, if required, in the case of liquids, there is in any case the

necessity for the appropriate storage possibility. In essence, the already known foodstuffs packages which contain a metal layer, for example as an oxygen barrier, can be developed further to form a package
5 according to the invention, by an appropriate antenna structure being provided in the metal layer.

Most rotting processes need oxygen, since these processes are basically "silent combustion". It is
10 therefore advantages, in particular if the laminate is used as a package for a foodstuff, if the laminate is impermeable to oxygen. This prevents diffusion of the oxygen in the atmosphere into the interior of package, and slows down spoiling.

15 In a further embodiment, the laminate according to the invention therefore comprises, at least in some sections, a layer of an oxygen-impermeable material. In this way, the passage of oxygen into the interior of
20 package, even into the sections not covered by the electrically conductive layer, can be prevented and, as a result, spoiling and rotting processes which require oxygen, that is to say aerobic processes, can be slowed down and therefore the ability of the relevant
25 foodstuff to be kept can be increased.

The area not metalized, as a result of the antenna being cut out, is extremely small as compared with the total area of the package, so the quality of the
30 foodstuff is generally not impaired. Oxygen diffusion through the cutouts may be prevented completely by the interspaces being filled with a suitable polymer film. Alternatively, oxygen diffusion can also be prevented by the application of a covering film to the antenna
35 structure. For the case in which organic materials are used as conductive materials, a covering film of this type is also needed for mechanical protection of a microchip produced from polymer materials. In the normal case, however, following the structuring, a

packaging board with small cutouts is laminated on. The positioning accuracy of 100 - 200 μm , normally achievable, of the lamination operation is completely adequate for the contact opening.

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In a particularly preferred embodiment of the laminate according to the invention, an information carrier is provided which is conductively connected to the antenna structure. Various items of information about the product contained in the package can be stored on this information carrier, for example type of product, price, date of manufacture, best-before date and the like.

15 Suitable in particular as an information carrier is a microchip which is capable of storage, since the production technology for this type of component is well-developed and production costs are correspondingly low. Particularly preferably, the microchip is based on organic semiconductor materials, since microchips of this type can be produced cost-effectively. Of course, a microchip produced using conventional silicon technology can also be used.

25 In order to improve the electronic characteristics, it is advantageous if an electronic capacitor is provided, which is electrically conductively connected to the antenna structure. The capacitor improves the resonant behavior considerably via its capacitive effect. Should an additional electrode be needed, this can be formed by the electrically conductive layer

In a particularly preferred embodiment, the antenna structure has turns, since in this geometric shape, the resonant behavior is most beneficial. For each frequency, an optimum number of turns exists. In this case, the number of turns that can be produced should lie as close as possible to the optimum value in order to achieve a high efficiency. Here, the efficiency is

higher the greater the enclosed area. Furthermore, the efficiency also depends on the size of the read coil. The efficiency should be selected optimally in order to optimize the injection of the energy of the high
5 frequency with regard to its efficiency. The better the injection of energy into the antenna structure, the higher are the reading distance and the reading integrity that can be achieved.

10 During the maximization of the number of turns, care should be taken that the structure within the antenna does not become too small since otherwise, because of the layer thickness, which is low in any case, of a familiar metal laminate, very high resistances will
15 occur, which lead to a disadvantageous electronic behavior.

On the other hand, the high resistances caused by the low layer thickness of the electrically conductive
20 layer can be balanced out by means of broader structures.

The production of the laminate according to the invention is carried out on normal production lines,
25 which are extended by one stage for structuring the conductive layer, generally an aluminum layer.

The first possible way of producing the substrate according to the invention consists in the use of a
30 shadow mask. This shadow mask has openings which correspond to the antenna structure. The shadow mask is placed on the carrier, for example a plastic film or a board, and fixed. For the purpose of fixing, the shadow mask can be held firmly, for example, by a
35 magnet. For this purpose, the shadow mask should be built up from any magnetizable material. Then, aluminum, for example, can be vapor-deposited directly onto the carrier and the shadow mask arranged thereon. Following the vapor deposition, the shadow mask with

the excess aluminum can be removed, so that only the desired antenna structure remains on the section of packaging film. In this case, vapor-deposition with aluminum is carried out using known apparatuses, such as are already known for the production of packaging materials. The deposition of the metal, for example aluminum, is particularly preferably carried out by means of directed deposition. If the shadow mask has an adequate thickness, then only slight coverage occurs at the edges of the cutouts which correspond to the antenna structure. The shadow mask can then be taken off the carrier very easily again, since the aluminum layer can be severed very easily at the edges of the shadow mask, and the aluminum layer is therefore not lifted off the carrier. A microchip can then be adhesively bonded to the packaging film with an electrically conductive adhesive and connected to the end of the antenna structure. Contact with a microchip can also be made with a nonconductive adhesive, if the contact is produced by appropriate bridge structures (bumps).

In a further production method, the negative image of the antenna is printed onto the carrier with a water-soluble varnish. A suitable water-soluble varnish is, for example, a polymeric alcohol, such as polyvinyl alcohol. A suitable printing process is, for example, pad printing. The layer thickness of the varnish film is about 2 μm in this case. If the mask can be separated again in the subsequent method, then in principle other printing techniques, for example offset, flexographic or gravure printing) are also suitable for the application of the mask.

In a manner analogous to the use of a shadow mask, vapor-deposition of the film with aluminum is then carried out up to a sufficient layer thickness of, normally, 400 nm. In this case, too, the incomplete coverage of the edges during directed deposition of the

metal layer is advantageous, since the necessary area of attack for the printing medium is provided and the mask can easily be separated again. Since the aluminum does not adhere to the varnish layer, the aluminum
5 which is merely weakly adsorbed thereon can easily be removed with water (what is known as the lift-off process) during a subsequent rinsing step. Following the rinsing step, the antenna structure is then obtained at the desired point. A substantial advantage,
10 as compared with the method described above by using a shadow mask, is a considerable increase in the achievable resolution.

In the case of larger packages, the film can also be
15 structured by known mechanical methods.

The structuring can also be carried out during a gas-phase deposition process. Films are usually produced from a polymer material which is built up from non-
20 polar hydrocarbon monomers. The film material consequently has a considerably hydrophobic character. Many types of particle and, in particular, also metal vapors are adsorbed preferentially on hydrophobic surfaces, since they themselves have hydrophobic
25 properties. By means of applying a thin layer of a hydrophilic material to the film to be printed, for which purpose, in particular polymers provided with polar groups are suitable, such as polyvinyl alcohol, polyacrylates or cellulose, the deposition of aluminum
30 on these regions can be prevented by a chemical gas-phase deposition process (CVD). This effect could be shown by T. Kodas, M. Hampden-Smith, The Chemistry of Metal CVD, Wiley-VCH 1994, ISBN 3-527-29071-0, page 454.

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The laminate according to the invention permits a considerable reduction in the production costs and may be produced without difficulty by means of the processes already used in industrial fabrication, these

having to be modified only slightly. The advantages of the laminate according to the invention are summarized once again in the following text:

- 5 a) the costs of an additional metalization, which arise from the separate construction of the antenna, are avoided;
- b) the costs are reduced substantially to the costs
10 of the chip and the costs of an additional connecting step, in which the chip is adhesively bonded to the laminate and connected to the antenna structure;
- c) the antenna can be formed at any desired point on
15 the package; it is possible for a plurality of antennas to be provided on one package, only one antenna being necessary for the electrical function of the transponder; the antenna density merely has to be adapted to the size of the package;
- 20 d) the antenna can be configured to be very large, since the entire surface of the object to be identified is available;
- 25 e) the layer thickness of the metalization of the film is generally low, the higher resistances of the antenna which are produced as a result can be balanced out by broader conductor tracks;
- 30 f) in the laminate according to the invention, immediately behind the antenna there is no metalization which impairs the RF properties of the RF-ID-label, since the antenna is an integral constituent part of the laminate and is not adhesively bonded to the
35 laminate;
- g) the number of turns can be increased as desired within the available area, which increases the

efficiency of the coupling of energy and therefore the reading distance or the reading integrity;

- h) by means of additional capacitors, the resonant behavior can be improved, it being possible for one electrode to be formed by the laminate.

The invention will be explained in more detail with reference to the appended figures, in which:

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Fig. 1 shows a radiofrequency identification label according to the prior art;

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Fig. 2 shows an enlarged view of a shadow mask of the production of an antenna structure;

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Fig. 3 shows a package which has been produced from the laminate according to the invention, and a transmitting and receiving device arranged at a specific distance.

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Fig. 1 shows a radiofrequency identification label according to the prior art. An antenna structure 2 built up from a plurality of turns is applied to a flexible film 1, which serves as a carrier layer. The ends of the antenna structure 2 are conductively connected to a silicon microchip 3. The two ends of the antenna structure are connected to each other via a bridge structure 2a. The carrier layer 1 can be provided with adhesive layer on its rear side, in order to be able to fix the label to an object to be identified, for example a file. The antenna structure 2 is first produced separately and then affixed to the film 1. The production of such a label is therefore complicated.

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Illustrated in Fig. 2 is a shadow mask 4 which can be used for the production of the antenna structure in the laminate according to the invention. The shadow mask 4

comprises shadow regions 5, which are illustrated black in the figure. Also introduced into the shadow mask is a spiral opening 6 illustrated white. The opening 6 corresponds to the turns of the antenna to be represented. The shadow mask therefore constitutes a negative structure of the antenna to be produced. Packaging films are, for example, vapor-deposited with aluminum from the gas phase in the roll-to-roll process. In this case, the shadow mask 4 is placed on the film at previously defined points. If the shadow mask consists of a magnetizable material, the shadow mask can, for example, be held firmly on the film magnetically. The aluminum is then vapor-deposited onto the film over its entire surface, the regions shadowed by the dark sections 5 of the shadow mask 4 remaining free of aluminum. Following the vapor-deposition of aluminum, the shadow mask 4 is removed from the surface of the film again. A microchip can then be adhesively bonded onto the square electrode surface 7 with the aid of a conductive adhesive.

Fig. 3 shows an application of the laminate according to the invention as a package. The laminate comprises a continuous layer of aluminum, which is covered on one side by a board layer and on the other side by a plastic. Provided in the aluminum layer is an area 8 in which an antenna structure 9 is formed from the aluminum layer. The antenna structure 9 is connected to a microchip 10 in which, for example, date of manufacture, keeping date and price of the consumable article contained in the package are stored. The interspace 11 between turns of the antenna structure 9 and between the antenna structure 9 and the aluminum layer surrounding the latter is filled with an oxygen-impermeable layer. For this purpose, a film (not shown) of an oxygen-impermeable material can be adhesively bonded to the antenna structure. Via a transmitting and receiving installation 12, by means of electromagnetic radiation 13, data can be read out from

the microchip 10 without contact via the antenna structure 9 conductively connected to the microchip 10, or can be read into said microchip. The transmitting and receiving installation 12 can, for example, be
5 connected to the cash register of a supermarket, in order to read the data out from the microchip. However, it can also be fitted to a production line and there, for example, read data about the date of manufacture, the type of product or the price into the
10 microchip 10.

List of designations

- 1 Carrier layer
- 2 Antenna structure
- 2a Bridge structure
- 3 Microchip
- 4 Shadow mask
- 5 Shadowed sections
- 6 Opening
- 7 Electrode
- 8 Area
- 9 Antenna structure
- 10 Microchip
- 11 Polymer
- 12 Transmitting and receiving installation
- 13 Electromagnetic radiation

Patent claims

1. A packaging material in the form of a laminate which comprises at least one carrier layer and a
5 conductive layer applied to the carrier layer, comprising a microchip and an antenna structure conductively connected to the microchip, it being possible for the data to be interchanged without
10 contact between the microchip and a transmitting and receiving station, wherein the antenna structure is a constituent part of the conductive layer.
2. The packaging material as claimed in claim 1, wherein a covering layer is applied to the electrically
15 conductive layer.
3. The packaging material as claimed in claim 2, the covering layer consisting of a water-repellent material.
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4. The packaging material as claimed in one of claims 1 to 3, wherein the laminate comprises, at least in some sections, a layer of an oxygen-impermeable material.
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5. The packaging material as claimed in one of claims 1 to 4, wherein the electrically conductive layer contains at least one metal.
- 30 6. The packaging material as claimed in claim 5, wherein the metal is aluminum.
7. The packaging material as claimed in one of claims 1 to 4, wherein the electrically conductive layer
35 contains at least one conductive organic compound.
8. The packaging material as claimed in one of claims 1 to 7, wherein the carrier layer is built up from a paper-like material.

9. The packaging material as claimed in one of claims 1 to 7, wherein the carrier layer is built up from a polymer.

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10. The packaging material as claimed in claims 1 to 9, wherein the laminate is formed into a package which encloses a hollow space, the hollow space containing at least one foodstuff.

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11. The packaging material as claimed in one of the preceding claims, wherein an information carrier is provided which is conductively connected to the antenna structure.

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12. The packaging material as claimed in claim 11, wherein the information carrier is a microchip capable of storage.

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13. The packaging material as claimed in one of the preceding claims, wherein an electronic capacitor is provided which is conductively connected to the antenna structure.

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14. The packaging material as claimed in one of the preceding claims, wherein the antenna structure has turns.