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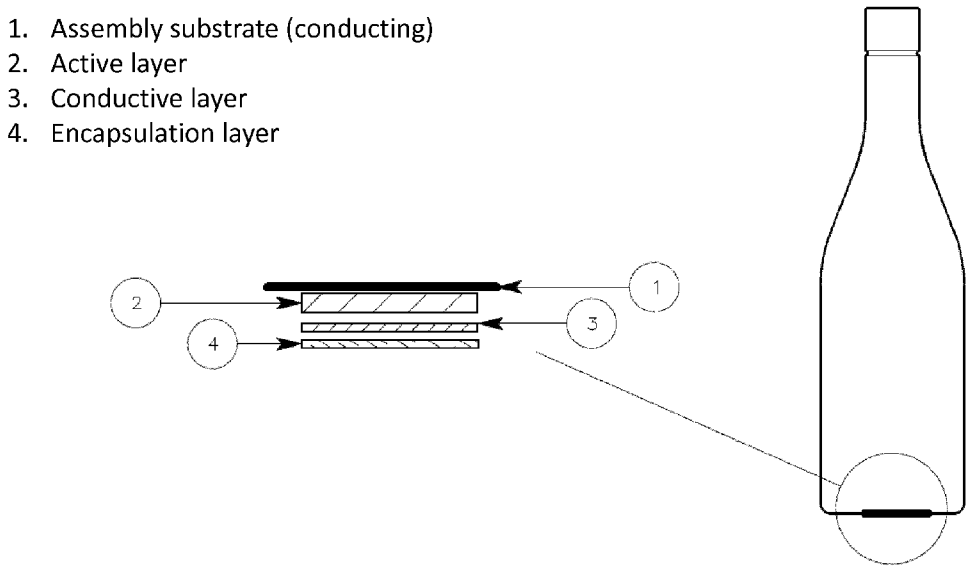

FIG 1

(57) Abstract: The present invention is directed to a smart metal, glass, paper-based, wood-based, or plastic packaging comprising at least one sensor or communication device, characterized in that a structural component of the packaging forms a component of the at least one sensor or communication device. In addition, the present invention is directed to a method for manufacturing a smart packaging is provided comprising the steps of manufacturing a packaging and constituting at least one sensor or communication device on or in the packaging, wherein a structural component of the packaging is taken for constituting a component of the at least one sensor or communication device.

[Continued on next page]

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SMART PACKAGING

FIELD OF THE INVENTION

The present invention relates to smart packaging, in particular to integrated smart packaging for a product of any type, especially suitable for containing food, more specifically for carbonated beverage, and in particular for functioning as a beer container, in particular beer-integrated smart packaging.

BACKGROUND OF THE INVENTION

In general, smart packaging incorporates features that indicate or communicate product status or changes, environmental status or changes, or other information. It is a dynamic and preferably active extension of the static and passive communication function of traditional packaging, and communicates information to the consumer based on its ability to sense, detect, or record external or internal changes in the product's environment.

State of the art smart packaging systems provide health and safety of the product for the consumer and also monitor the condition of packed products to give information about shelf life and regarding the quality of the during transport and storage. In this technique indicators and sensors are used instead of time consuming, expensive quality measurements for improving the shelf life and providing product safety. In smart packaging system indicators give information about product quality by surrounding conditions and head space gases of packagings, also indicators can be attached to the packaging surface or integrate to packagings which are improved for determining metabolite residue formed during storage. Temperature, microbial spoilage, packaging integrity, physical shock, freshness of the packed product can be controlled.

An example thereof is US2015307245 directed to a wine capsule that is configured to be attached to a beverage container and to provide a user with information relating to the temperature history of the beverage. The data logger includes at least one energy storage component (e.g., one or more capacitors), an energy harvester, a temperature sensor, at least one processor, at least one first memory, and at least one wireless communicator. The energy harvester harvests ambient electromagnetic energy. The wireless communicator is configured to transmit the stored information to a personal computer, a smartphone or tablet, or a dedicated reader device which is configured to communicate with and receive information from the wireless communicator.

A obvious drawback of the system of US2015307245 is clearly that such wine capsule is not suitable for being combined with other types of packaging than bottles. In addition, as soon as the wine capsule is removed from the bottle, the bottle itself becomes a normal "stupid" bottle.

A more important general drawback however is that, although the above system covers the basic needs of product containment and quality control, it does not address the clear consumers' demand for packaging that is more advanced with respect to consumer interaction and creativity.

Thanks to the coming of inexpensive electronics and printing technology it recently became possible to create smart packaging that permit amongst others tracking of purchases, inventory control, automatic re-ordering, and assessment of tampering, packaging breeching etc. In addition, smart packaging containing lights, sound production, different types of sensors and corresponding sensory inputs, smart electronics, and interaction between humans, smart devices, vending machines, coupled with wireless communication, results in enhanced and personalized experience for the consumer. Also point of purchase personalized advertising, inducements, prizes, and a game-like environment can integrate at various psychological levels to positively reinforce brand loyalty and promote purchases.

In the above context, the smart packaging described in WO2015147995 contains electronics that can enable a user / purchaser to interact with the packaging and cause actions to happen either on the packaging itself or on a smart device like a smart phone or computer or a vending machine, or communicate or cause communication with a website where a data base might reside. For instance, a soda bottle or can or bag of chips can have the capability of being touched to a smart phone, having a code read, and the smart phone can take one or more actions based on the type of product within its proximity.

The smart packaging includes at least one battery and/or energy storage element and/or energy receiving element; an element configured to store information; an element configured to sense being touched; an element configured to display information and/or an element configured to generate light; an element configured to receive and/or transmit information; and circuitry electrically one or more elements of the packaging to one another.

An aspect that has been neglected in smart packaging as described in WO2015147995, is to integrate smart packaging technology within the existing reality of today including today's industrial packaging processing and their application, i.e. the aspect of integrating intelligent technologies up to the level of industrial processing of for example a beverage can, and the product specifications, and raw materials involved has been neglected. Smart packaging has always been described without efficient implementation of its manufacturing in industrial processing been taken in account.

In addition, WO2015147995 does not address the functionalities specifically associated and required with the content of said packaging, i.e. carbonated beverages, in particular beer. As an example, an underlying objective is to provide for a smart packaging which can communicate time and temperature history of food products such as beer to ensure optimum maturation, proper aging, and to avoid misuse or mishandling. Another example of an underlying objective is to provide for a smart packaging which communicates the state of beverages within the packaging, either visually, either by illumination, either by sound, or haptic experiences, i.e. in case of food products, reaching ideal consumption temperature vs food type is communicated.

Further, smart packaging is a compelling proposition made increasingly relevant by the relentless and fast pace at which digital technologies integrate consumers' lives, and the proliferation of the Internet of Things (IoT). An extensive list of applications in this sense, enabled by the smart packaging in accordance with the present invention will be provided in below description.

Another very important objective of smart packaging according to the present invention is to reduce the production cost, even to the point where it will be cost-effective to put intelligent features and communication means on an inexpensive product, and in particular on disposable products.

SUMMARY OF THE INVENTION

The present invention is directed to a smart metal, glass, paper-based, wood-based, or plastic packaging comprising at least one sensor,
characterized in that a structural component of the packaging forms a component of the at least one sensor.

In addition, the present invention is directed to a method for manufacturing a smart packaging is provided comprising the steps of manufacturing a packaging and constituting at least one sensor on or in the packaging, wherein a structural component of the packaging is taken for constituting a component of the at least one sensor.

The present invention is directed to a smart metal, glass, paper-based, wood-based, or plastic packaging comprising at least one communication device,
characterized in that a structural component of the packaging forms a component of the at least one communication device.

In particular, a smart glass, paper-based, wood-based, or plastic packaging comprising at least one communication device is disclosed, characterized in that a structural component of the packaging forms a component of the at least one communication device. As a person skilled in the art will recognize, integrating intelligent technologies in glass, paper-based, wood-based, or plastic packaging has been neglected even more than in metal packaging, if only because these materials are less easy to integrate in communication devices.

Further in particular, a smart metal, glass, paper-based, wood-based, or plastic packaging comprising at least one optical or sound based communication device is disclosed, characterized in that a structural component of the packaging forms a component of the at least one communication device.

In addition, the present invention is directed to a method for manufacturing a smart packaging is provided comprising the steps of manufacturing a packaging and constituting at least one communication device on or in the packaging, wherein a structural component of the packaging is taken for constituting a component of the at least one communication device.

In certain embodiments, the present invention is directed to a smart metal, glass, paper-based, wood-based, or plastic packaging comprising at least one sensor and at least one communication device,
characterized in that a structural component of the packaging forms a component of the at least one communication device and sensor.

SHORT DESCRIPTION OF THE DRAWINGS:

FIG 1 to 8 illustrate different embodiments in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

As the world is moving increasingly into internet-of-things, smart packaging in accordance with the present invention offers an extensive range of intelligent functionalities in packaging, integrated up to the level of industrial processing, which can be used for consumer engagement and brand enhancement. It can amongst others also be used for proof of product authenticity and origin, tamper evidence and even further to source and delivery tracking and supply chain optimization.

In addition, smart packaging according to the present invention may drive down the cost of smart packaging to produce a smart and connected product to the point where it will be cost-effective to put intelligent features and communication means on an inexpensive product.

Therefore, in a first embodiment, the present invention provides a smart metal, glass, paper-based, wood-based, or plastic packaging comprising at least one sensor,
characterized in that a structural component of the packaging forms a component of the at least one sensor.

Therefore, in a second embodiment, the present invention provides a smart metal, glass, paper-based, wood-based, or plastic packaging comprising at least one communication device,
characterized in that a structural component of the packaging forms a component of the at least one communication device.

The smart packaging may be primary or secondary.

In the context of the present invention, the product to be packed in the smart packaging may be any type of product, solid or not solid, any type of substance, liquid, food, non-food, etc. In particular, liquid products are applicable such as liquid foods, especially drinks (carbonated, not carbonated, alcoholic, non-alcoholic, juices, sport drinks), or paints, agents, chemicals, solvents, oils, etc.

A structural component of a smart primary packaging is understood as a material component which is necessary to the packaging for functioning as a product container, i.e. for enabling the packaging

to contain a product or to be transported, more specifically for functioning as a food container, more specifically as a carbonated beverage container, and in particular for functioning as a beer container.

A structural component of a smart secondary packaging is understood as a material component which is necessary to the packaging for holding a primary packaging .

A component or material layer which does not offer any contribution to enable the packaging to contain a product or to be transported, and for example merely serves as a decorative layer or decorative layer system, such as ink or varnish, is not understood as a structural component.

Contradictory to a packaging with a printed sensor or communication device wherein the packaging is just a substrate for printing on and wherein the outer surface of the packaging as is with regards to constituting the sensor or communication device is only required to be suitable for printing the necessary layers upon, in the present invention a structural component of the packaging is an essential component of the actual sensor or communication device and it must have the necessary material characteristics required for proper functioning of the sensor or communication device.

In other words, the structural component is a component which is essential for the proper functioning of the sensor or communication device and which is inherently already present in the packaging as is before the sensor or communication device is fully constituted thereon. Consequently, it would not be possible to integrate at least partially the process of constituting the sensor or communication device in the manufacturing of a packaging which misses that specific component (specific material layer) because it is necessary for the functioning of the sensor or communication device. Both the smart packaging and the sensor or communication device have a structural component in common, i.e. at least one necessary material layer included in the structure of the packaging, or in the structure of a part of the packaging, and not serving merely as a decorative layer serves as a necessary component of the sensor or communication device.

Consequently, the manufacturing of the sensor or communication device may be at least partially integrated in the manufacturing of the smart packaging, resulting in reduced material cost, reduced production time, and in general reduced production cost, even to the point where it will be cost-effective to put intelligent features and communication means on an inexpensive product, and in particular on disposable products.

In general, the present invention enables intelligent technologies to be integrated up to the level of and into industrial mass production of containers for any type of product.

In the context of the present invention, a sensor is a device that responds to a physical and/or chemical stimulus (such as heat, light, sound, pressure, magnetism, a particular motion, presence of specific ions, etc.) and conveys or records this information in a certain manner, or transmits a resulting impulse (as for measurement or operating a control). Such sensor may be any type of the following list of sensors comprising: a temperature sensor, a pressure sensor, a touch-, push-, or force-sensing sensor, a motion sensor, a liquid level sensor, a sound sensor, a light or color sensor,

an image sensor, a magnetic field sensor, a proximity sensor, a liquid or vapor detection sensor, or any sensor of the following sensor technologies: a photodiode, a thermistor, a resistive or piezo-resistive sensor, a piezoelectric sensor, a magneto-resistive sensor, a conductive strain sensor, a capacitance sensor, a radiation (IR, RF, etc.) sensor, a thermocouple, a sensor array such as a sensor array reacting to volatile compounds on contact (e.g. electronic nose sensors), a biosensor (electrochemical biosensors, optical biosensors, electronic biosensors, piezoelectric biosensors, gravimetric biosensors, pyroelectric biosensors), a chemical sensor, etc.. Such sensor may be integrated in the packaging to detect, to measure, or to indicate amongst others light, color, force or strain, proximity, liquid level, flow, gas presence, presence of smell/aroma/flavor, humidity, viscosity, temperature, pressure, chemical contamination, acceleration, movement, touch, impact, biometric authentication, etc. They also may capture information from or around the human body (e.g. heart rate, breathing rate, physical activity, sleep pattern, etc.).

In the context of the present invention, a communication device may be any type of device capable of sending and/or receiving a data containing signal, and in particular suitable for being used in telecommunication, being the transmission of signs, signals, messages, words, writings, images or information of any nature by wire, radio, magnetic, optical or other electromagnetic systems, or sound, in order to exchange information between communication participants. In a smart packaging according to the present invention, any type of communication device may be implemented that is suitable for communicating via a connectivity protocol standard or via a custom protocol. A number of different connectivity standards have been designed for different physical layers, data throughputs and transmission ranges. For each embodiment of the present invention the most suitable standard may be determined. Numerous communication standards and/or protocols exist today, the front runners in the smart phone dominated market are Bluetooth and NFC, for localised communication. However, as more devices are connected to the IoT, dedicated networks such as SigFox could play an important part in the future by connecting primary and secondary packaging to other connected devices and objects anywhere in the world. Bluetooth, Zigbee, Z-wave, 6LowPan, Thread, Wifi, Cellular, NFC, Sigfox, Neul, LoRaWAN, Li-Fi may be suitable communication standards/protocols. Such communication device may comprise any type of transmitter or receiver or transceiver combined with appropriate transmitter and receiver hardware and software. For example an optical system may use a light source (e.g. LED) and light sensor (e.g. photodiode); an acoustic system may use an acoustic transducer (e.g. piezoelectric or piezo resistive); a near field / magnetic or inductive system may us a coil antenna; or a radio based system may us an RF antenna, or any other type of antenna.

Communication routes that may be applied in embodiments of the present invention are:

- Exchange of data between the smart packaging and another smart packaging. Both may be either containers and/or secondary packaging
- Detection of the presence of another passive device or object and identification of that object through the exchange of data with that object.
- Exchange of data between the smart packaging system and other electronic devices. For example smart phones, WiFi routers, public radio infrastructure such as cellular networks, and local infrastructure explicitly placed in order to communicate with smart packaging

systems. These other devices may in turn relay the data to other internet connected services such as cloud storage, data analytics, and web based interfaces.

Amongst others, point to point communications between two devices, mesh communications networks, and broadcast communications from one object to many are envisaged.

It should be noted that any communications system requires a number of defined protocol layers above the physical layer described here. These, by their nature, will be realised in electronic logic and software.

In an embodiment in accordance with the present invention, a smart packaging may additionally comprise any type of supporting electronic systems, which may include digital logic, processing units, memory, gate arrays including programmable gate arrays, passive components, such as resistors, capacitors, inductors, analogue instrumentation, power control circuits, display driver circuits, or any combination thereof. These supporting electronic systems may be built from discrete components attached to the smart packaging substrate, connected by conductive tracks on the substrate, and/or components printed upon the substrate.

More specifically, a smart packaging in accordance with the present invention may comprise a sensor or a communication device, wherein a structural component, or a plurality of structural compounds of the packaging forms a component or a plurality of components of the at least one sensor or communication device, and/or additionally a combination of a variable number of components of the following functional areas:

• a processing unit: in a smart packaging according to the present invention, any type of processing unit suitable for being integrated in smart packaging may be used. Mainstream chip developers, motivated by the growing IoT market, are launching ultra-small ultra-low powered chips with integrated memory. There are emerging technologies that allow processors to be printed on thin film materials, like flexible polyamide, polyester foils, etc. Other systems, such as communications and memory, can also be printed to create specific solutions, known as system on a chip (SoC).

• a communication unit: a communication unit may be any type of device suitable for being used in telecommunication, being the transmission of signs, signals, messages, words, writings, images and sounds or information of any nature by wire, radio, optical or other electromagnetic systems in order to exchange information between communication participants. In a smart packaging according to the present invention, any type of communication unit may be implemented that is suitable for communicating via a connectivity protocol standard or via a custom protocol. A number of different connectivity standards have been designed for different data throughputs and transmission ranges. For each embodiment of the present invention the most suitable standard may be determined. Numerous communication means standards exist today, the front runners in the smart phone dominated market are Bluetooth and NFC, for localised communication. However, as more devices are connected to the IoT, dedicated networks such as SigFox could play an important part in the future by connecting primary and secondary packaging to other connected devices and objects anywhere in the world. Bluetooth, Zigbee, Z-wave, 6LowPan, Thread, Wifi, Cellular, NFC, Sigfox, Neul, LoRaWAN, Li-Fi.

• a sensory perceptible output: A sensory perceptible output may be any type of device integrated in the packaging enabling a user or consumer to sense any sensory perceptible status change of the packaging or the content . Such output may be visual output, an audio output, a haptic output, or any other output sensible by touch, taste, or smell. More specifically, a visual output may be any device integrated in the packaging enabling an area of the container to emit light, or to change its absorption or transmission of specific wavelengths of light (e.g. colour change), under electrical, electromagnetic, or magnetic control, or triggered by pressure, strain, or temperature variation. Emitting, absorbing, or transmitting light may include showing any kind of colour signal, or presenting a graphic, a text, a logo, a video, including a brand, a label, an interactive label etc., or projecting a graphic, text, logo, etc. onto an object present in the environment. A visual output may be for example any type of display such as amongst others Liquid Crystal Displays (LCD), Electronic Paper Displays (EPD), rigid or flexible organic light-emitting diode (OLED) displays, electrochromic displays, electroluminescent displays, electrophoretic dispays, OLED light sources, LED light sources, or any combination thereof, or any type of projector or beamer with suitable size. A haptic output may be any device integrated in the packaging enabling at least part of the packaging to apply forces, vibrations, or motions, under electrical control, in a way that is felt by a user holding or touching the container, or in a way that the forces, vibration or motions may be transferred to other objects, for example to other bottles in the packaging or on the shelf. Such device may use for example piezoelectric materials. An audio output may by any device integrated in the packaging enabling an area of the packaging to vibrate for transmitting an audio signal into the air, or for transducing an audio signal to other objects surrounding the packaging and allowing transmitting the audio signal in to the air. The frequency range of vibrations may include that of human hearing, as well as ultrasonic and sub-sonic frequencies. An example of an audio output may be electrostatic speakers or thin-film flexible speakers. Other sensory haptic outputs may be any type devices integrated in the packaging enabling a user or consumer to sense any change of surface state of the packaging (e.g. change of roughness, static electricity), to sense a smell which is released upon activation, to sense a taste which is released upon activation, etc.

• a power source: any type of power source suitable for powering an output and being integrated in a smart packaging may be used such as for example discrete batteries, flexible batteries, printed batteries, microbatteries, (super)capacitors, energy harvesting elements such as be antennas, piezoelectric, electrodynamic, or thermoelectric generators, photovoltaics (e.g. organic photovoltaics (OPV), electromagnetic field energy harvesting, etc.

Embodiments in accordance with the present invention may be directed to primary packaging for beverages, such as a bottle made of glass, or metal (eg. aluminum) or plastic, or a metal can, or metal keg, plastic keg, or wooden bottle or barrel. Such primary packaging may in particular be suitable for carbonated beverages and preferably beer.

Other embodiments in accordance with the present invention may be directed to secondary packaging such as a carton, a multipack, a tray, a HiCone, plastic ring carriers, plastic yokes,

paperboard baskets, paperboard overwraps and cartons, corrugated fiberboard boxes, HDPE plastic handles, six pack rings, and shrink packs.

The structural component of the packaging forming a component of the at least one sensor or communication device may be amongst others: the glass of a glass container, hot-end-coating layers (e.g. tin oxide, or other oxide, or other equivalent material applied e.g. by chemical vapour deposition, applied e.g. to increase adherence of the cold end coating), cold-end-coating layers (e.g. polyethylene way, or other equivalent material, applied e.g. by spray coating, in order to e.g. make the surfaces more slippery as bottles pass down the line), the plastic of a plastic container, the plastic of a plastic cap or lid, the metal of a metal can including its body, lid, ring pull, or rivet, the metal of a keg including its valve and stem, metal of a metal cap or crown, the inner polymer coating of a metal container, spray coat epoxy (e.g. applied to the raw metal of a metal can or bottle), the metal oxide layer (e.g. implemented by anodising of metal drinks can or bottle substrate), metallic layers (e.g. deposited by plating onto the metal substrate of a drinks can or bottle),polymer layer (e.g. moulded into inside of crown or screw bottle top to form both seal and corrosion protection), the fiberboard or corrugated board of secondary packaging, or plastic parts of secondary packaging (e.g. rings to hold bottles together, or handles), the wood of wooden barrel, etc.

In a general embodiment in accordance with the present invention, a smart metal, glass, paper-based, wood-based, or plastic smart packaging comprising at least one sensor or communication device may be provided, wherein a structural component of the packaging has suitable chemical, electrical, mechanical, electrochemical, dielectric, magnetic, optical, electromechanical, or semiconducting properties to form a component of the at least one sensor or communication device. In other words, the structural component of the packaging forming a component of the at least one sensor or communication device may be selected on the basis of its electrical properties, its chemical properties, its electrochemical properties, its dielectric properties, its magnetic properties, its optical properties, its electromechanical properties, or its semiconducting properties.

In an embodiment, the present invention provides a smart metal, glass, paper-based, wood-based, or plastic packaging comprising at least one sensor or communication device, wherein a metal structural component of the smart packaging may form an electrically conductive layer of the at least one sensor or communication device.

The metal structural component forming an electrically conductive layer may be a metal layer of a bottle, can or keg, or the aluminum of a bottle, can or keg, in particular the aluminum of the lid, the tab, the body of a can, or a combination thereof.

The metal structural component forming an electrically conductive layer may also be the metal layer of a beverage keg, typically stainless steel, or of any other type of metal container.

The metal structural component forming an electrically conductive layer may also be a component of a paper-based, wood-based or plastic-based smart packaging. A plastic bottle may comprise for

example a metal ring structure in the body or the neck, or a corrugated board tray may comprise a rigidity enhancing metal layer, or a carton packaging may have an integrated metallic (cfr. Tetrapak).

The metal structural component forming an electrically conductive layer may be the metal layer of a closure of a bottle, such as for example the tin plate of a glass bottle crown or the metal of the crown itself, or the aluminum layer of a Roll On Pilfer Proof cap (ROPP).

In an embodiment of the present invention, a metal structural component of the smart packaging may form an electrode layer of a sensor or communication device or as an interconnect between different sensor or communication device elements. A wide range of sensors and communication devices are constructed of at least one conductive layer. A conductive substrate can therefore remove the need to add one in the sensor or communication device construction.

As an example, a smart packaging may be provided wherein a metal structural component of the smart packaging, in particular a metal bottle or can, forms a conductive layer of a resistive force sensor to measure the amount of contents remaining in the container. (see also FIG 1) This force sensor uses a resistive or piezo resistive active layer, upon deposited upon the bottom of the bottle, such that the metal of the can forms both the assembly substrate and one of the conductive layers. Furthermore, the encapsulation layer may be formed by the existing lacquer/varnish applied to the bottle during normal manufacture.

In a variation, a smart packaging may be provided wherein a metal structural component of the smart packaging, in particular a metal bottle or can, forms a conductive layer of a communication device comprising an RF antenna. An RF antenna is shaped to optimally detect electromagnetic fields within a certain frequency range, which induce a voltage across the antenna. The field will typically arise from a transmitter elsewhere. An RF antenna can also be used for transmission of a field, depending upon the attached electronics.

Many possible antenna designs may be possible, for example a patch antenna where two conducting layers are separated by an insulating dielectric, the bottom one of which is a conductive layer of the container, and the top of which is shaped to match the frequency of electromagnetic radiation of interest. Furthermore, the antenna structure may be combined with the shape of the container, including features such as convex shapes, concave shapes and cavities. This may, in principle, allow for tuning of resonant frequencies to optimise antenna performance for the application.
In a further variant of its use, the placement of materials of different permittivity or permeability near to the antenna may change alter the designed frequency response.

As another example, a communication device comprising an inductive (magnetic) antenna may be implemented, such that the metal of the can forms one of the conductive layers. An inductive, or near field, antenna detects varying magnetic fields, including the magnetic component of electromagnetic waves.
One possible construction is in the form of what is effectively a coil. The coil may be constructed as a single spiral shaped conductor, and/or may be wrapped around a can/bottle outside. The two ends

of the coil then need to be joined to the circuit, and consequently a bridge over the coil is required. This bridge may for example be constructed by a conducting layer of a container or a secondary packaging, or by a ring pull of a can.

As another example, a temperature sensor to determine the temperature of the liquid contents may be implemented (see also FIG 2), such that the metal of the can forms one of the conductive layers. Furthermore, the encapsulation layer may be formed by the existing lacquer/varnish applied to the container during normal manufacture. Hence, the only additional layers required may be the thermistor active layer and one additional conductive layer. The area of the thermistor may be adjusted to average the temperature over a wide or small area of the liquid. Alternatively, or in addition, an array of similarly designed temperature sensors maybe distributed across the container, as a means to determine the volume of liquid remaining. This may be achieved by using the fact that, assuming the container is pre-chilled, the parts of the wall in contact with the liquid will be cooler than those where the liquid is not in contact. The same principle may be applied for sensing whether a consumer is holding a container in his/her hand.

Further, a smart packaging may be provided wherein an electronic nose sensor comprising an array of different active sensor layers, each covering two electrodes, one of which is common to all of the array, and one of which is unique to the element, is constituted by using the metal of the container for one element of the array. This forms one of the two electrodes of each element. The second electrode of each element is deposited on top of an insulating layer, so as to electrically isolate it from the assembly substrate common electrode.

As another example, a smart packaging may be provided wherein a liquid chemical / biochemical sensor comprises a structure similar to that shown in Figure 11. In this case, the conductive metal of a can may additional form one of the electrodes for a single sensor element. Or a common electrode for an array of liquid chemical / biochemical sensors.

Also, an environmental condition and/or gas chemical sensor may be realized using the metal of a can as one of the conductive electrodes by which the sensor may be electrically read. Such may include an encapsulation layer over the top of the electrode, made using the existing encapsulation materials used for the container.

In a particular embodiment of the present invention, a metallic structural component of the packaging may form an overlap with another metallic component or layer or structural component. Such overlapping metallic layers could be used to form two electrically conducting layers of an sensor or communication device between which an active layer could be placed.

Examples of metallic overlaps may be:

- The folded seam at the top of a can overlaps 6 layers of the two substrates.
- Seams in a 3- piece can may provide overlap for multiple metal substrate layers. A functional active layer could be added in between

- Overlap of a ring pull with the top of a can could form two electrodes, with an active layer between the ring pull and can top. The rivet may form electrical connection.
- Overlap of aluminum bottle with screw top or crown top
- Overlap of a conductive foil over the top of a metal crown cap, or metal bottle

In an embodiment, the present invention provides a smart metal, glass, paper-based, wooden, or plastic packaging comprising at least one sensor or communication device, wherein a glass, paper-based, wooden, or plastic structural component of the smart packaging may form an electrically non-conductive layer of the at least one sensor or communication device.

As an example a communication device comprising an RF antenna may be integrated in a metallized carton beverage container.
The RF antenna may use the non-conducting packaging substrate as a dielectric, with the two layers of the antenna deposited upon either side of it.
A metallized carton container comprises both a non-conductive packaging substrate with a laminated metal, mostly aluminium, conductive layer. This conductive layer is then additionally used to form the ground plane of the antenna, with an additional antenna element deposited upon the other side of the non-conducting carton substrate. The non-conductive carton substrate then effectively separates the two electrodes, and its permittivity controls the tuning of the antenna.

A glass or plastic structural component of the smart packaging may be for example the glass body or neck of glass bottles, or the plastic body or neck of plastic bottles, or plastic lids, or the plastic of secondary packages.

In an embodiment of the present invention, a glass, paper-based, wooden, or plastic structural component of the smart packaging may form an electrically insulating component, a protective encapsulating layer, or a dielectric layer.

Furthermore, electrically non-conductive structural components of the packaging may also form overlapping structures which may be functionalized as explained further in the text, for functioning as two conductive layers, or as active layer.

Examples of such non-conductive overlapping structures may be:

- Overlap between polymer or glass bottle, and respectively screw or crown lid
- Folds and seams in paper cartons
- Polymer sealing layer currently present inside of a metallic bottle tops (both crown and screw top)
- Overlap between polymer layers in "bottle in bottle" containers
- Shrink wrap of polymer label, paper label, foil, or secondary packaging

In accordance with the present invention, structural components other than metal, glass, paper-based, wooden, or plastic components may be structural coatings. For example, a hot end coating of a glass bottle contains metal oxides and may serve as a semi-conducting layer.

In an embodiment of the present invention, in addition to using a structural component of the packaging as component of the at least one sensor, a component of the packaging having specific mechanical properties may be used as a component of a packaging integrated sensor. As an example, a material of defined elastic modulus may be used for converting applied force, from internal pressure or mass, into strain, which is then detected by a strain sensor. Further, a transducer and/or resonant part of the system may be used for sound or vibration sensing.

In an embodiment of the present invention, in addition to using a structural component of the packaging as component of the at least one communication device, a component of the packaging having specific mechanical properties may be used as a component of a packaging integrated communication device, e.g. an acoustic transducer, where the mechanical resonance of the package would serve to capture, amplify and/or filter the acoustic signal to and/or from the transducer.

In another embodiment of the present invention, in addition to using a structural component of the packaging as component of the at least one sensor, a component of the packaging having specific chemical properties may be used as a component of a packaging integrated sensor. As an example, the packaging material may provide thermoelectric effect inducing a voltage in response to temperature between two dissimilar metals. Further, due to certain chemical properties the material of the packaging component may react with desired analytes to change the electrical, mechanical or optical properties of the material, enabling it to form a component of a chemical sensor.

In an embodiment of the present invention, in addition to using a structural component of the packaging as component of the at least one sensor, a component of the packaging having specific optical properties may be used as a component of a packaging integrated sensor. For example, an optically transparent substrate may provide the window on a light sensor. The optically transparent substrate may be used as isolation between an optically read electrochemical sensor and the electro-optical sensor. Further, an optical layer may be used as a controlled light path for an optical sensor, or as a filter for specific wavelengths of light, or as a lens of an image sensor.
More particularly, an optically read chemical sensor may be positioned upon the inside of a glass bottle, for purposes of detecting specific chemical or biochemical activities in the liquid contents. For example, changes in composition of beer, such as pH to detect oxidation, or alcohol content.

In an embodiment of the present invention, in addition to using a structural component of the packaging as component of the at least one communication device, a component of the packaging having specific optical properties may be used as a component of a packaging integrated communication device, e.g. using glass or transparent plastic as a lens to send/capture optical signals and/or as an optical filter to select the wavelength that optical signals are received /sent at.

In another embodiment of the present invention, in addition to using a structural component of the packaging as component of the at least one sensor, the contents of the container may perform a number of sensor functions, both physical and chemical. For example in case the container contents

comprises a liquid and air gap, as the container is subjected to accelerations, the liquid relative to the air will move around. This may be used for acceleration sensing (also known as inertial).
In case the container liquid is a carbonated beverage, inertial movement of the container will increase the pressure in the container, allowing for sensing of past movement.
Further, the contents may be used as heat reservoir for sensing relative temperature, as inertial damping component for changing response of the container to sound, or as electrolyte or chemically active solution for a liquid chemical / biochemical sensor.
Also, the boundary between liquid and gas defines two distinct areas. The location of that boundary corresponds to fill level, and this may be detected by the acoustic or electrostatic properties of each space.

In an embodiment, the present invention provides a smart metal, glass, paper-based, wooden, or plastic packaging comprising at least one sensor or communication device, wherein a structural component of the smart packaging may be functionalized to form an active layer of the at least one sensor or communication device.

In an embodiment in accordance with the present invention, one or more of the structural components of the smart packaging may contain additives functionalizing the structural component(s) for being used as a component of at least one sensor or communication device.

Additives may comprise electro-mechanical materials such as piezo-electric materials, electrostatic materials, or magnetic materials, for functionalizing an structural component for being used as an active layer of a sensor or communication device.

In an embodiment in accordance with the present invention, one or more of the structural components of the smart packaging may comprise additives functionalizing an electrically non-conductive structural component for being used as an electrically conductive layer of at least one sensor or communication device.

Additives may also be added to a material that allow it to act directly as an electrode in a chosen sensor type, or to make a material semi-conducting, so as to perform as an active layer in a sensor.

Additive may also be added to a material that allow it to act directly as a conducting or semiconducting element in a chosen communication device type.

In an embodiment in accordance with the present invention, one or more of the structural components of the smart packaging may be geometrically functionalized for being used as a component of at least one sensor or communication device. The structural component may be pushed, stamped, or folded, and/or may overlap other structural components for gaining mechanically resonant properties, or create resonant systems or electrically connective structures.

In an embodiment in accordance with the present invention, a method for manufacturing a smart packaging is provided comprising the steps of manufacturing a packaging and constituting at least

one sensor or communication device on or in the packaging, wherein a structural component of the packaging is taken for constituting a component of the at least one sensor or communication device.

In method of the present invention, the component constituted from a structural component of the packaging may be any component of the at least one sensor or communication device, such as active layer, an electrically conductive layer (e.g. an electrode), an insulating layer, and encapsulating layer, etc.

The remaining parts of the at least one sensor or communication device, i.e. parts other than the component constituted from the structural component of the packaging or part of it, may be added to the smart packaging by any available technique. Any printing, deposition, or shaping technique may be used including amongst others screen printing, flexography, gravure printing, offset printing, ink jet printing, xerography, lithography, evaporation, sputtering etching, coating, chemical vapour deposition, embossing, stamping, laser patterning, mould patterning, electroplating, anodizing, dip coating, spin coating, gluing, blow moulding of polymers inside containers, etc.

The remaining parts of the at least one sensor or communication device, may also be constituted from a component of the packaging other than a structural component, such as decoration layers, varnishes, lacquers, etc. In such case, besides the fact that the manufacturing of the packaging and constituting the at least one sensor or communication device uses a common structural component, additional process steps may be shared for constituting the remaining parts, for example printing a decoration layer which is also an electrically conductive layer, or spraying a coating which is also an electrically insulating layer.

In an embodiment in accordance with the present invention, a method may be provided comprising the step of functionalizing the structural component for being used as a component of at least one sensor or communication device. Such step of functionalizing the structural component of the packaging may be performed in the process of constituting the at least one sensor or communication device after providing the packaging, or may be performed in the process of manufacturing the packaging.

In an embodiment in accordance with the present invention, the step of functionalizing the structural component for being used as a component of at least one sensor or communication device comprises adding additives altering the chemical and/or physical properties of the structural component.

The additives may be added to the raw materials during the raw material production process, for example the additives may be added to glass, plastic or metal before solidifying, or to paper-based pulp. Such additives may be micro-encapsulated for enhancing its functionality.

Additives may also be embedded in the raw materials by rolling or embossing, or bound to the surface by chemical reaction.

In an embodiment in accordance with the present invention, metal, glass, plastic, or paper-based structural components of a packaging may contain additives functionalizing the structural component for being used as an active layer of at least one sensor or communication device.

In still another embodiment in accordance with the present invention, a method may be provided comprising the step of geometrically functionalizing the structural component for being used as a component of at least one sensor or communication device by exposing the structural component to a shaping step, such as punching, stamping, folding etc. during manufacturing of the packaging. Such process step may for sensors give a structural component mechanically resonant properties, or create resonant systems or electrically connective structures. For communication devices, such process step may give a structure component mechanically resonant properties, RF properties when combined with an appropriate antenna, optical properties that guide light, or electrically connective structures.

In still another embodiment in accordance with the present invention, a method may be provided comprising the step of functionalizing the structural component for being used as a component of at least one sensor or communication device by exposing the structural component to heat, such as for example baking or curing, or to annealing, laser irradiation, etc. In addition, the structural component may be directly applied at higher temperature than conventionally done (particularly in the case of glass or metal containers) in order to functionalize it.

A power source, and/or a communication means, and/or one or more sensors, and/or a processing unit, and/or any sensory perceptible output, or any other type of supporting electronic component, may be established by adding discrete components to the smart packaging, or preferably by at least partially printing them onto the smart packaging.

In addition, a structural component of the smart packaging may be a component of any type of sensory perceptible output, or any type of power source. Such may be the same structural component of the packaging serving as a component of the sensor or communication device, or may be another structural component of the packaging.

Specifically, with regards to embodiments wherein a structural component of the packaging forms a component of an optical communication device, communication devices are envisaged wherein optical frequency electromagnetic waves are used to communicate between a light source or a device that modulates an existing light source, and a device that detects that light, or the modulation.
Such devices may comprise a transmitter based on any of the optical light emitting or modulating technologies to encode data, such as an electroluminescent transducer, semiconductor light emitters, including Light Emitting Diode (LED) or Organic Light Emitting Diode (OLED) devices, electrochromic or electrophoretic transducers, or liquid crystal technology.
Further, such devices may comprise a receiver such as a light sensor, and in particular a photodiode. The transmission path may be through free space, and/or through optically functional packaging materials that can act as a guided optical path.

To achieve data communication involving a smart packaging according the present invention using an optical communication device, the transmitting light source may be amplitude modulated. (For a digital signal this effectively means it is switched on and off). The receiving light detector (photodiode) detects this modulation, and the signal is decoded as part of the protocol in the processing capability of the device.

It should be noted that the light source may also perform the function of decorative lighting to create a visual effect for the user, and the data signal may be encoded in such a way that it is not visible - e.g. modulated at a rate that is faster than can be resolved by the human eye.

Multiple channels may be achieved by using different transmitters to transmit light at different wavelengths, or by using different photodiodes, or optical filters using transparent packaging materials to select the different wavelengths at the receiver, or by using different polarisation stages for different light signals, or by time multiplexing whereby different signals are transmitted in different time slots which may be synchronised by clocks at both end of the link.

Further, such data communication may include or may be established upon optically sensing the proximity of a neighbouring object or another smart packaging. For example, a neighbouring object or smart packaging may emit a signal with data encoded either by transmitting light or modulating ambient light to be detected and identified by a smart packaging in accordance to the present invention.

Specifically, with regards to embodiments wherein a structural component of the packaging forms a component of a sound based communication device, communication devices are envisaged wherein by the transmission of sound pressure waves, or mechanical vibrations, from one object to another data exchange occurs. This may in principle be achieved at any frequency, including those below, within, and above (ultrasonic) the human range of hearing.

Such devices may comprise a transmitter based on any sound emitting or vibration technologies, such as piezoelectric, electrostatic or magnetic transducers.

Furthermore, such package may respond to either self-generated or externally incident sound or vibration to transmit data as follows:

- The package may, due to its mechanical properties, cause ambient sound incident on said package to be modulated or augmented in a characteristic way, indicative of that package or a specific message from that package. For example by mechanically resonant effects which result in the creation of additional harmonics, which can then be detected by a separate sound detector.
- The mechanically resonant effects as described above may be controlled by an actuator, which is deliberately controlled so as to encode data onto the incident sound signal.

Further, such devices may comprise a receiver using sound detection technologies, and in particular piezo resistive and piezoelectric sensors.

The transmission path may be through air, and/or through mechanically/acoustically functional packaging materials that can amplify and/or transmit the corresponding vibrations.

To achieve data communication involving a smart package according the present invention using a sound based communication device the transmitter emits sound or vibration in a manner encoded

with information. This sound or vibration is sensed by a sound sensor on the receiver, and the signal is decoded as part of the protocol in the processing capability of the device. It should be noted that the transmitted sound may also contain an audio signal intended for the user to hear; and the data may be encoded within it in a manner that is inaudible to humans.

Multiple channels may be achieved by transmitting data signals at different frequencies, which are then detected by receivers using different filters, by transmitting data over different physical paths that conduct the vibration and are acoustically isolated from each other, or by time multiplexing whereby different signals are transmitted in different time slots which may be synchronized by clocks at both end of the link.

Further, such data communication may include or may be established upon sound based sensing of the proximity of a neighbouring object or another smart packaging. For example, a neighbouring object or smart packaging may emit a signal with data encoded either by transmitting sound or vibration to be detected and identified by a smart packaging in accordance to the present invention.

Specifically, with regards to embodiments wherein a structural component of the packaging forms a component of a near field communication device, communication devices are envisaged wherein by the creation and/or modulation of a magnetic field from one object to another exchange of data occurs. This may be either a static (DC) or alternating (AC) field, including use of the magnetic component of an electromagnetic wave in the near field.

As a transmitter, a permanently DC magnetized magnetic material, which may be a structural component of the packaging, or a magnetic/inductive antenna may be used.

As a receiver, any magnetic field detection technologies, and in particular packaging integrated technologies including a magnetic/inductive antenna coil and a magneto-resistive sensor may be used. The transmission may be through free space, and/or through magnetically functional packaging materials that can amplify and/or transmit the corresponding field.

To achieve data communication involving a smart package according the present invention comprising a near field communication device, the transmitter may comprise an AC magnetic field which is modulated in frequency and/or amplitude and/or phase to encode data. (Many well-known techniques and protocols exist to do this.) The receiver detects this AC magnetic field, and the signal is decoded as part of the protocol in the processing capability of the device.

Multiple channels may be achieved by transmitting data signals at different frequencies, which are then detected by receivers using differently tuned receivers or one receiver with different filtered channels, by transmitting data over different physical paths that conduct the magnetic field and are otherwise isolated from each other, by creating fields in the same path but in different spatial locations, or by time multiplexing whereby different signals are transmitted in different time slots which may be synchronised by clocks at both end of the link.

Further, such data communication may include or may be established upon sensing of the proximity of a neighbouring object or another smart package. For example, a neighbouring object or smart packaging may emit a magnetic field with data encoded to be detected and identified by a smart packaging in accordance to the present invention.

Specifically, with regards to embodiments wherein a structural component of the packaging forms a component of a Radio Frequency communication device, communication devices are envisaged wherein by electromagnetic wave, and most typically an RF antenna driven by AC electrical signal, from one object to another exchange of data occurs.

As a transmitter, any means that creates an electromagnetic wave, and most typically an RF antenna driven by AC electrical signal may be used.

As a receiver, any means that detects a electromagnetic wave, and most typically an RF antenna may be used. The transmission may be through free space, and/or through magnetically functional packaging materials that can amplify and/or transmit the corresponding field, or through dielectric functional packaging materials that control and/or transmit the electric field component.

To achieve data communication involving a smart package according the present invention comprising a Radio Frequency communication device, the RF signal transmitted by the transmitter will be modulated with a signal that includes the data to be sent. The receiver picks said signal up, and the signal is decoded as part of the protocol in the processing capability of the device.

There are a wide range of well-known modulation techniques, multiplexing techniques and communications protocols to achieve radio frequency communications using electromagnetic waves, and consequently they are not described further here. However, all may be considered to be of potential for use in this application.Further, such data communication may include or may be established upon sensing of the proximity of a neighbouring object or another smart package. For example, a neighbouring object or smart packaging may emit an RF signal with data encoded to be detected and identified by a smart packaging in accordance to the present invention.

Specifically, with regards to embodiments wherein a structural component of the packaging forms a component of wired communication device, communication devices are envisaged wherein by a varying electrical voltage and/or current source, and variation encoding, data exchange occurs. Different types of transmitters and receivers for wired communication are well-known.

With regards to the transmission path between a transmitter and a receiver, a wide range of connectors and connection techniques are well known for making such electrical connections. In particular, for applications of the present inventions, connection techniques may include:

- Contact pins, which may be spring loaded, which make contact to pads on the other side that are mechanically held in close proximity.
- 'Edge' connectors which make contact to a thin or flexible substrate such as packaging materials.
- Mating connectors, matched on each half. A wide variety are manufactured and exist.

In addition, particular scenarios of interest for this application may include:

- Contact pins or pads from one container to another, such that the containers are electrically connected when in close proximity. For example, when on a shelf together, or held together in secondary packaging, or when cans are stacked upon one another. Patterns of electrodes and pins are possible to ensure connection in multiple geometries. For example ring electrodes on the top of a container, with corresponding pins of matching radius on the bottom of another container that is stacked on top

- Connection of containers using electrical wires or thin film substrates printed with conductive tracks, which are used to connect packages at the time of manufacture, and they remain connected for example in their secondary package. When separated, such as when removed from the secondary package or otherwise separated, the wires or connections break.

In a further embodiment, the two electrical contacts may either or both be potentially replaced by capacitive contacts, realised by close proximity of two electrodes, and using a communications system at an AC frequency sufficient to transmit across this capacitance. Scenarios of interest for this application may include:

- Containers are connected to a conducting surface, such as a metal or metallised shelf, using an electrode on the bottom of said container. The sides of said containers also have another electrode that couples by capacitance to the container. This enables them to be connected whilst in close proximity.

Embodiments in accordance with the present invention seek to provide a smart packaging enabling amongst other the following applications:

- Sensing ambient light levels
- Sensing colour of the light present. By applying filters in front of the photodiode, or selecting the mix of active layers, the wavelength light detected, and hence colour, may be made specific.
- Detecting proximity to other objects that emit light, or assessing relative position to other objects based on their reflected light.
- Sensing liquid presence in a container, by detecting light reflected from the liquid in the container, where the liquid is a different colour / brightness to that of the container with no contents. Liquid level may further be determined by an array of light sensors. This concept may operate using light that is ambient, or an additional deliberate light source also integrated into the packaging.
- Detecting motion of a liquid filled container, by monitoring the relative movement of the liquid vs air gap in the container relative to the walls of the container.
- detect the ambient temperature and/or the temperature of the contents of a container
- Sensing of pressure in a container through measurement of strain in the walls of the container
- Sensing of user touch or force applied to a button, through change in resistance due to applied force/strain on the sensor.
- Sensing of motion of the container through changes in its pressure (as described above), in the event that the liquid contents of the container is a carbonated beverage, the pressure of which changes with motion.
- Sensing of the amount of liquid present in a container by sensing the weight of the container. This may be achieved by depositing a resistive force sensor on the bottom of the container, and measuring the force applied.
- Sensing sound through measuring strain induced in the container walls by air pressure waves resulting from sound. The same principle also applies to externally applied vibrations.

- Sensing of user force applied to specific points on the container, by measurement of strain, deformation or force in the walls of the container at this point.
- Sensing of user touch, by detection the very different permittivity of a human finger, compared to air.
- Sensing of liquid level due to the difference in permittivity of the liquid vs air in the container.
- Sensing motion of a liquid filled container, by monitoring the relative movement of the liquid vs air gap in the container relative to the walls of the container, using the same principle of level measurement above.
- Sensing the presence of other objects in close proximity, by detecting their different permittivity relative to air.
- detecting ions and/or molecules in the liquid contents of the container. For example, if the contents were beer, then substances of interest might include those responsible for flavour, such as 'hop' flavours or 'beer skunk'; oxidation; changes in pH, and ethanol content.
- External communication to the smart packaging to active an effect (e.g. sound/light), using one of the communication devices as described above, e.g. RF, sound, light communications.
- Smart packaging detection of which other packages are in close proximity nearby, in exchange data regarding its status in the supply chain.
- Communication devices on secondary packaging reading data, processing and communicating data from sensors implemented upon primary packages to monitor the condition of the primary packaging in the supply chain.
- Communications from a packaging back to the cloud to, for example, indicate that the product has been used, and so to trigger auto-replenisment.

EXAMPLE 1:

A force sensor is constituted on the bottom of a metal beverage container, as a means to measure the amount of contents remaining in this container by its weight, or to identify the number of or weight of additional containers stacked on top.

As illustrated in the structure shown in FIG 1, the metal (1) of the container forms one of the conductive layers. The resistive or piezo resistive active layer (2) is printed on the outer side of the bottom. Furthermore, the encapsulation layer (4) may be formed by the existing lacquer/varnish applied to the bottle during normal manufacture. Hence, the only additional layers required may be the active layer (2) and one additional conductive layer (3).

EXAMPLE 2:

A temperature sensor is constituted onto an area of the wall of a metal can, as a means to determine the temperature of the liquid contents.

As illustrated in FIG 2, the metal (1) of the can forms one of the conductive layers. Furthermore, the encapsulation layer (4) may be formed by the existing lacquer/varnish applied to the container during normal manufacture. Hence, the only additional layers required may be the (3) thermistor active layer (2) and one additional conductive layer.

EXAMPLE 3:

A chemical sensor is constituted on the inside of a metal keg.

The sensing mechanism is an electrochemical reaction which only occurs when the appropriate material is present in the liquid contents.

The structure is as shown in FIG 3. The metal (6) of the keg forms the current collector layer, and may also form one of the electrodes (5) in case the sensor cell chemistry matches the keg metal material.

On top of keg metal, on a separate defined area that is also in contact with the liquid contents (4) serving actually as electrolyte, the following layers are provided:.

- Insulating layer (3)
- Current collector layer (2)
- Second electrode (1)

EXAMPLE 4:

As illustrated in FIG 4, a light sensor is constituted using the glass of a glass bottle as the window wherein the colour of the glass is tuned to match the frequency of interest. Hence, the amount of light of specific wavelength is detected. A transparent conducting electrode is deposited onto the glass as a part of the hot end coating process that the bottle goes through.

During normal production of the bottle, after forming the glass, it is hot end coated by a metallic oxide. In this case, a transparent conducting layer of for example Indium Tin Oxide (ITO) or Fluorine doped Tin Oxide (FTO) is applied using this process. This layer forms the bottom electrode of the light sensor.

After this stage, active photovoltaic layers are deposited, using any of the techniques as described above. On top of the active layers, the second electrode is deposited.

The final layer is encapsulation and may be formed by the existing packaging coatings already applied to the glass.

EXAMPLE 5:

As illustrated in FIG 5, a communication device comprising an RF antenna may be integrated in a metallized carton beverage container.

The RF antenna may use the non-conducting packaging substrate as a dielectric, with the two layers of the antenna deposited upon either side of it.

A metallized carton container comprises both a non-conductive packaging substrate with a laminated metal, mostly aluminium, conductive layer. This conductive layer is then additionally used to form the ground plane of the antenna, with an additional antenna element deposited upon the other side of the non-conducting carton substrate. The non-conductive carton substrate then effectively separates the two electrodes, and its permittivity controls the tuning of the antenna.

EXAMPLE 6:

As illustrated in FIG 6, a communication device comprising an RF antenna is integrated into an aluminium can. The aluminium substrate acts as the ground plane for a 'patch' antenna. On top of the substrate, an insulating dielectric layer is deposited, followed by a conductive layer in the

shape of the other antenna electrode, designed for the frequency of operation desired. The antenna is encapsulated using an encapsulation layer, which may be the same as the varnish and/or lacquer already used to protect the beverage container.

EXAMPLE 7:
In FIG 7 a communications device comprising an acoustic transducer integrated into an alumninium can is illustrated according to the present invention. The metal metal of the can forms the base electrode. A piezo electric active layer is then deposited on it, followed by another electrode, and then encapsulation. It can be used as either a transmitter or receiver or both.

EXAMPLE 8:
As illustrated in FIG 8, a magnetic antenna is printed as a spiral, around the perimeter of the top of a crown cap, on the inside of the cap, as part of a near field communications system. It is printed on top of an insulating layer, but with an exception such that one end of the antenna makes an electrical connection with the metal of the cap. The other end of the antenna does not make contact with the metal of the cap. Both ends are electrically connected to a chip in the middle of the cap. The metal of the cap serves to bridge one side of the antenna to the other, electrically. The polymer liner inside the cap serves to protect the system as encapsulation.

1. A smart metal, glass, paper-based, wood-based, or plastic packaging comprising at least one communication device, characterized in that a structural component of the packaging forms a component of the at least one communication device.

2. A smart packaging according to claim 1, wherein the smart packaging is a glass, paper-based, wood-based, or plastic packaging.

3. A smart packaging according to claim 1, wherein the at least one communication device is an optical or sound based communication device.

4. A smart packaging according to claim 1, wherein said structural component of the packaging is a metal structural component forming an electrically conductive layer of the at least one communication device.

5. A smart packaging according to claim 4, wherein the metal structural component may be a metal layer of a bottle or can, or the aluminum of a bottle or can, in particular the aluminum of the lid, the tab, the body of a can, or a combination thereof, or a metal layer of a keg or any other type of metal container, or wherein the metal structural component is a component of a paper-based, wood-based or plastic-based smart packaging.

6. A smart packaging according to claim 1, wherein a glass, wood-based, paper-based, or plastic structural component of the smart packaging may form an electrically non-conductive layer of the at least one communication device.

7. A smart packaging according to claim 6, wherein the glass or plastic structural component of the smart packaging is the glass body or neck of glass bottles, or the plastic body or neck of plastic bottles, or plastic lids, or the plastic or paper/cardboard of secondary packaging.

8. A smart packaging according to claim 1, wherein metal, glass, plastic, or paper-based, wood-based structural component of the smart packaging contains additives functionalizing the structural component for being used as an active layer of at least one communication device, or functionalizing an electrically non-conductive structural component for being used as an electrically conductive layer of at least one communication device.

9. A method for manufacturing a smart packaging comprising the steps of manufacturing a packaging and constituting at least one communication device on or in the packaging, wherein a structural component of the packaging is taken for constituting a component of the at least one communication device.

10. A smart packaging according to claim 9, wherein said structural component of the packaging is selected based on its electrical, electrochemical, dielectric, optical, electromechanical, or semiconducting properties to form a component of the at least one communication device.

11. A method according to claims 9 or 10, wherein the manufacturing of the packaging and constituting the at least one communication device share at least one additional process step for constituting the remaining parts of the communication device.

12. A method according to claims 9 or 10, comprising a step of functionalizing the structural component of the packaging for being used as a component of the at least one communication device.

13. A method according to claim 12, wherein the step of functionalizing the structural component of the packaging may be performed in the process of manufacturing the packaging.

14. A method according to claims 12 or 13, wherein the step of functionalizing the structural component of the packaging for being used as a component of the at least one communication device comprises adding additives to the structural component.

15. A method according to claims 12 or 13, comprising the step of geometrically functionalizing the structural component for being used as a component of at least one communication device.

16. A method according to claim 9, comprising the step of adding a power source and/or one or more sensors and/or a processing unit and/or a sensory perceptible output by at least partially printing it onto the smart packaging.

CLAIMS

1. A smart metal, glass, paper-based, wood-based, or plastic packaging comprising at least one sensor, characterized in that a structural component of the packaging forms a component of the at least one sensor, whereby said structural component is necessary to the packaging for functioning as a product container, and whereby said structural component is essential for the proper functioning of the sensor.

2. A smart packaging according to the preceding claim 1, wherein the structural component has suitable electrical, dielectric, magnetic, electromechanical or semiconducting properties to form a component of the at least one sensor.

3. A smart packaging according to any one of the preceding claims 1 or 2, whereby the structural component is inherently already present in the packaging as is before the sensor or communication device is fully constituted thereon.

4. A smart packaging according to any one of the preceding claims 1 to 3, wherein a sensor is any type of the following list of sensors comprising: a temperature sensor, a pressure sensor, a touch-, push-, or force-sensing sensor, a motion sensor, a liquid level sensor, a sound sensor, a light or color sensor, an image sensor, a magnetic field sensor, a proximity sensor, a liquid or vapor detection sensor, or any sensor of the following sensor technologies: a photodiode, a thermistor, a resistive or piezo-resistive sensor, a piezoelectric sensor, a magneto-resistive sensor, a conductive strain sensor, a capacitance sensor, a radiation sensor, a thermocouple, a sensor array, a biosensor, or a chemical sensor.

5. A smart packaging according to any one of the preceding claims 1 to 4, wherein said structural component of the packaging is a metal structural component forming an electrically conductive layer of the at least one sensor.

6. A smart packaging according to claim 5, wherein the metal structural component may be a metal layer of a bottle or can, or the aluminum of a bottle or can, in particular the aluminum of the lid, the tab, the body of a can, or a combination thereof, or a metal layer of a keg or any other type of metal container, or wherein the metal structural component is a component of a paper-based, wood-based or plastic-based smart packaging.

7. A smart packaging according to any one of the preceding claims 1 to 9, wherein a glass, wood-based, paper-based, or plastic structural component of the smart packaging may form an electrically non-conductive layer of the at least one sensor.

8. A smart packaging according to claim 7, wherein the glass or plastic structural component of the smart packaging is the glass body or neck of glass bottles, or the plastic body or neck of plastic bottles, or plastic lids, or the plastic or paper/cardboard of secondary packaging.

9. A smart packaging according to any one of the preceding claims 1 to 8, wherein metal, glass, plastic, or paper-based, wood-based structural component of the smart packaging comprises additives functionalizing the structural component for being used as an active layer of at least one sensor, or functionalizing an electrically non-conductive structural component for being used as an electrically conductive layer of at least one sensor.

10. A method for manufacturing a smart packaging comprising the steps of manufacturing a packaging and constituting at least one sensor on or in the packaging, wherein a structural component of the packaging is taken for constituting a component of the at least one sensor.

11. A smart packaging according to the preceding claim 10, wherein said structural component of the packaging is selected based on its chemical, electrochemical, dielectric, optical, electromechanical, or semiconducting properties to form a component of the at least one sensor.

12. A method according to any one of the preceding claims 10 or 11, wherein the manufacturing of the packaging and constituting the at least one sensor share at least one additional process step for constituting the remaining parts of the sensor.

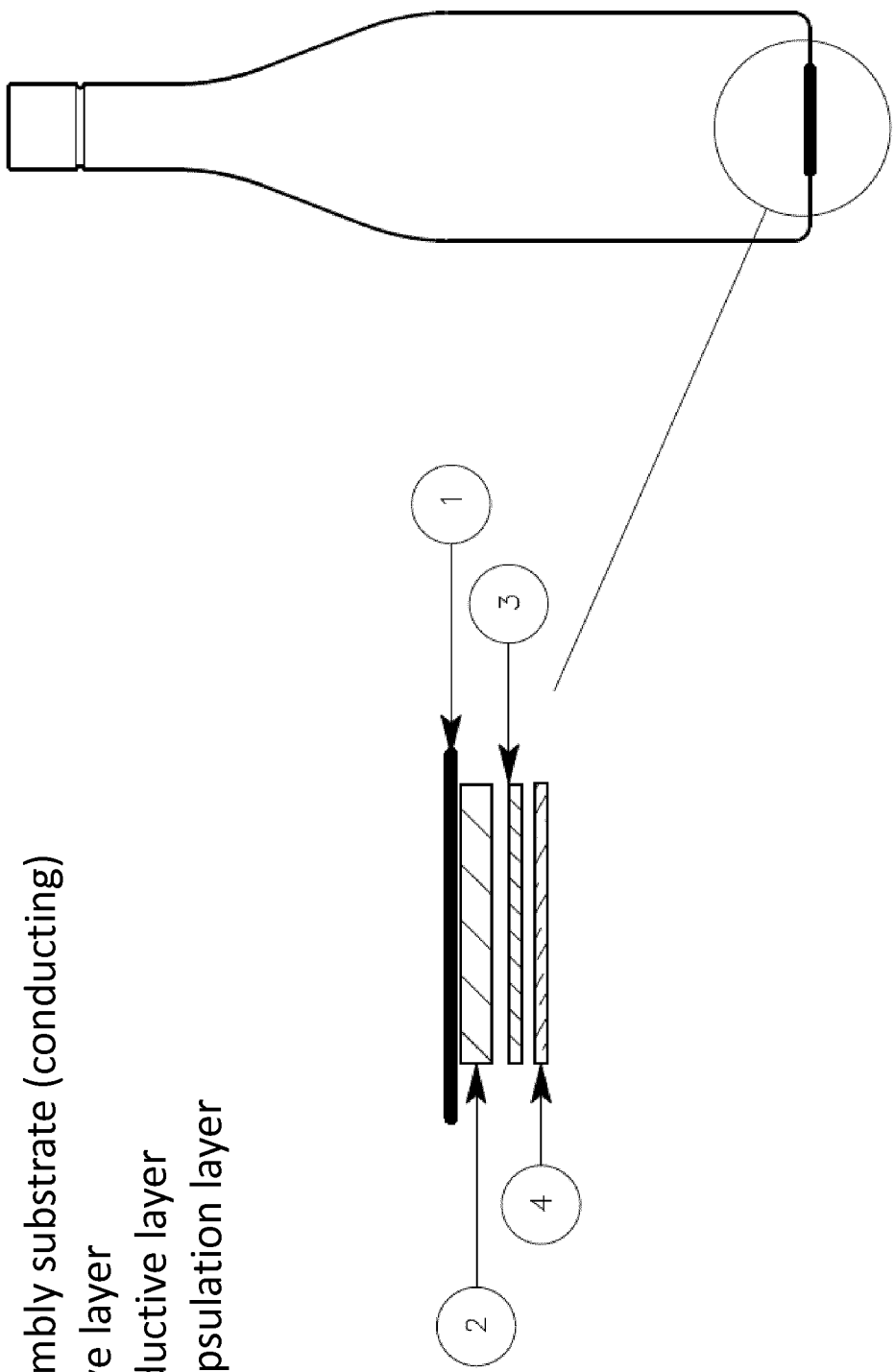
13. A method according to any one of the preceding claims 10 or 11, comprising a step of functionalizing the structural component of the packaging for being used as a component of the at least one sensor.

14. A method according to the preceding claim 13, wherein the step of functionalizing the structural component of the packaging may be performed in the process of manufacturing the packaging.

15. A method according to any one of the preceding claims 13 or 14, wherein the step of functionalizing the structural component of the packaging for being used as a component of the at least one sensor comprises adding additives to the structural component.

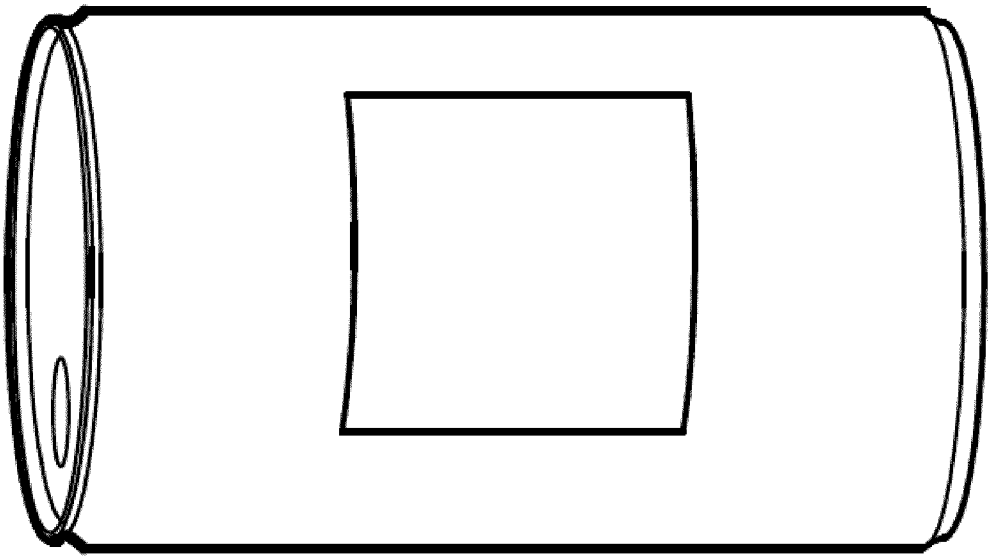
16. A method according to any one of the preceding claims 13 or 14, comprising the step of geometrically functionalizing the structural component for being used as a component of at least one sensor.

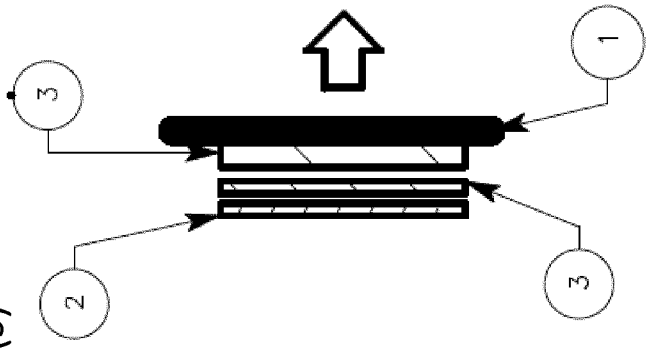
17. A method according to any one of the preceding claims 10 to 16, comprising the step of adding a power source and/or a communication means and/or a processing unit and/or a sensory perceptible output by at least partially printing it onto the smart packaging.



1. Assembly substrate (conducting)
2. Active layer
3. Conductive layer
4. Encapsulation layer

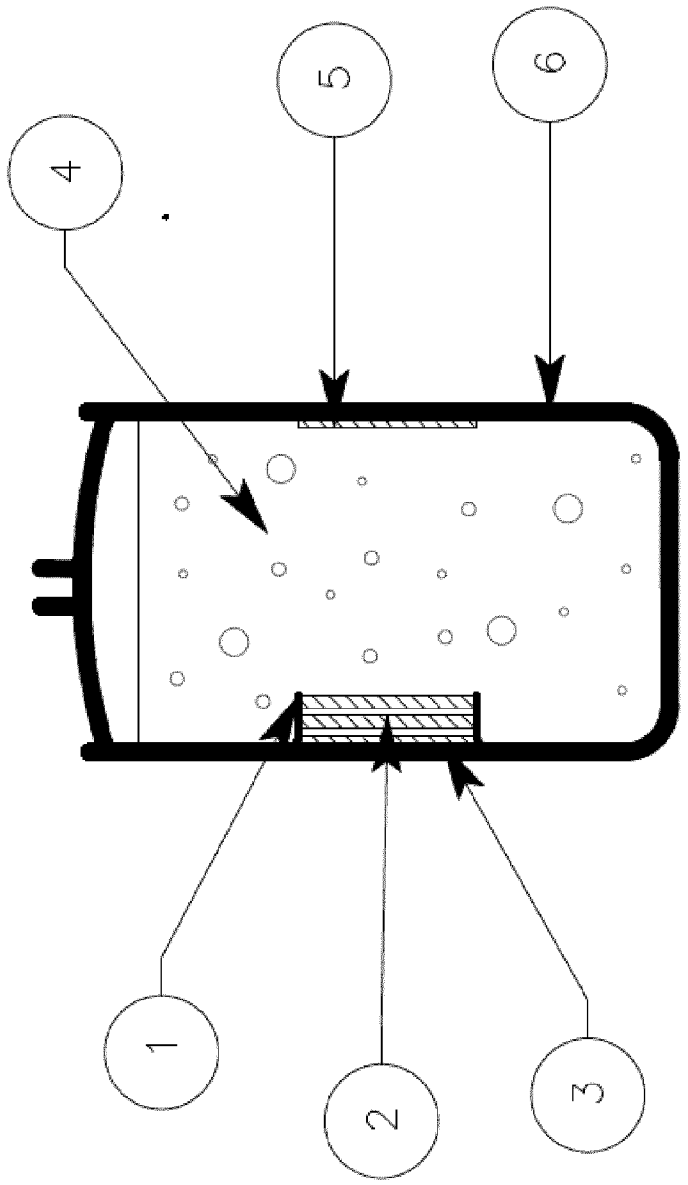
FIG 1





1. Metal substrate of can
2. Active temperature sensor layer(s)
3. Conductive layer
4. Encapsulation layer

FIG 2



1. Cathode (if not same materials as current collector)
2. Current collector layer
3. Insulating layer
4. Electrolyte
5. Electrode
6. Conductive assembly

FIG 3

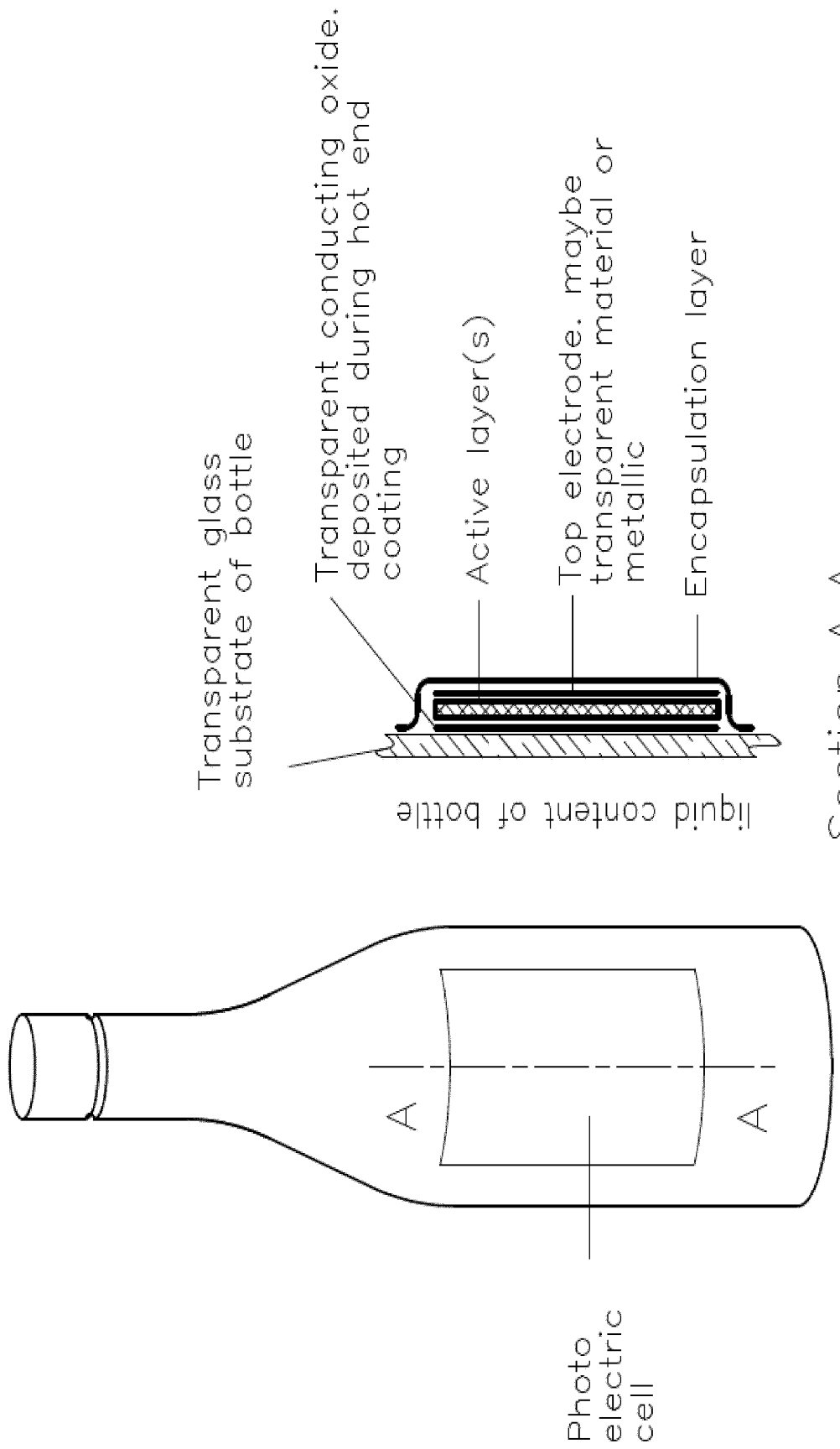
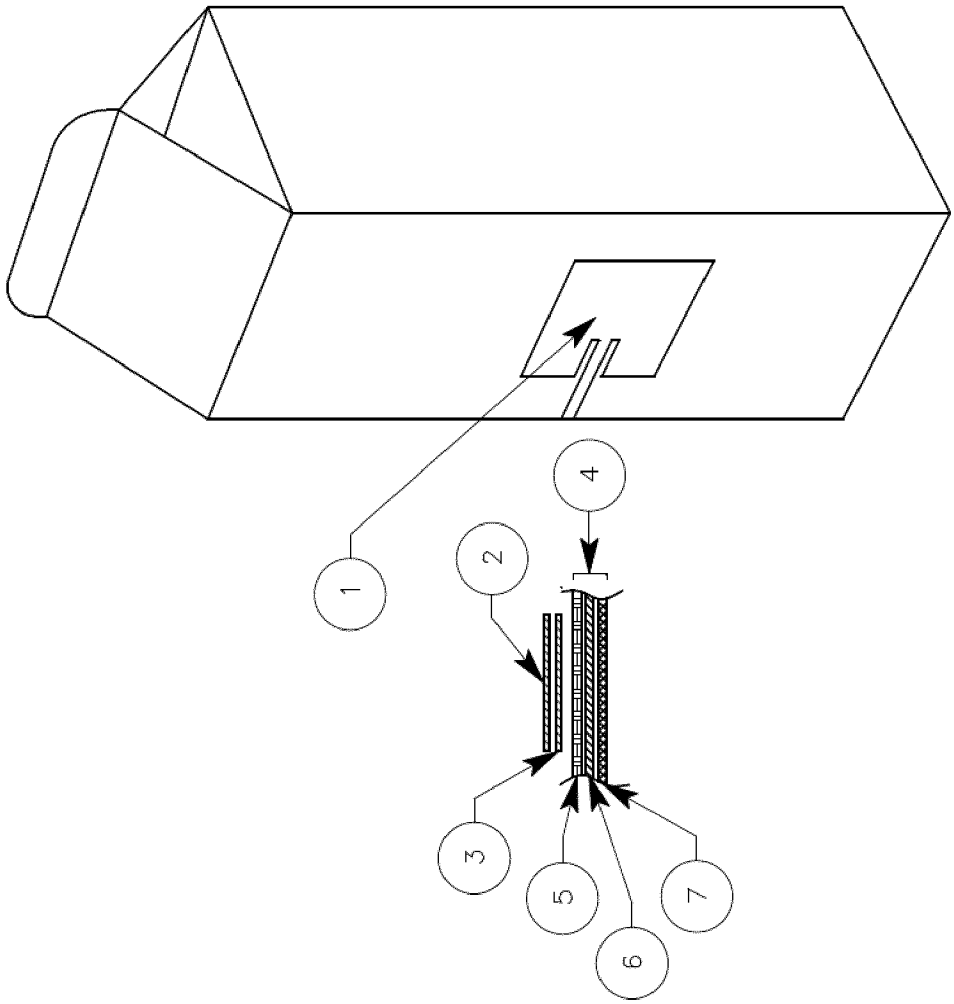
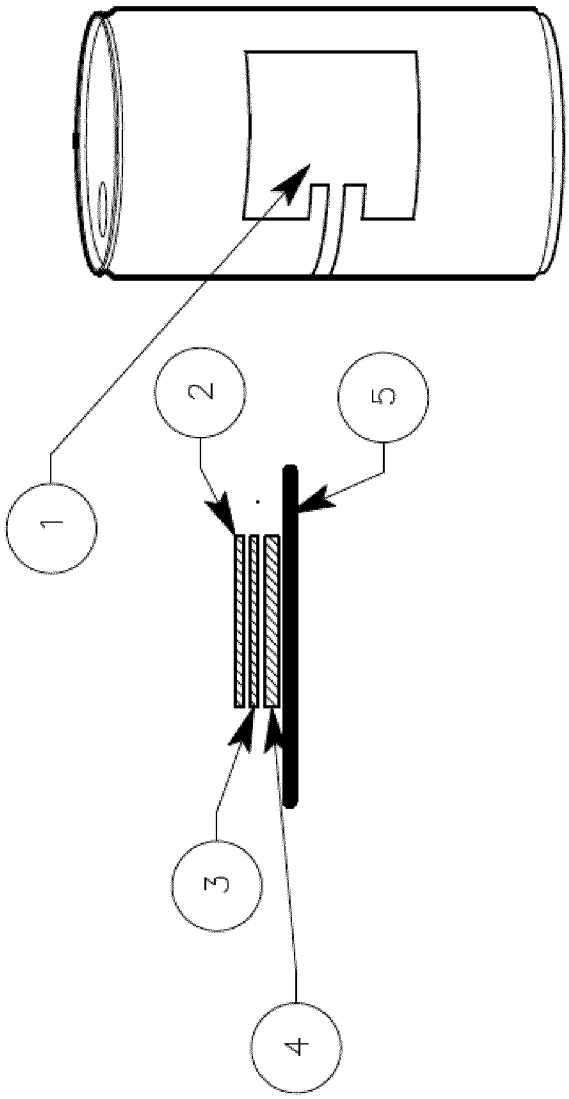

Transparent glass substrate of bottle
Transparent conducting oxide. deposited during hot end coating
Active layer(s)
Top electrode. maybe transparent material or metallic
Encapsulation layer
liquid content of bottle
Section A A
A
A
Photo electric cell

FIG 4



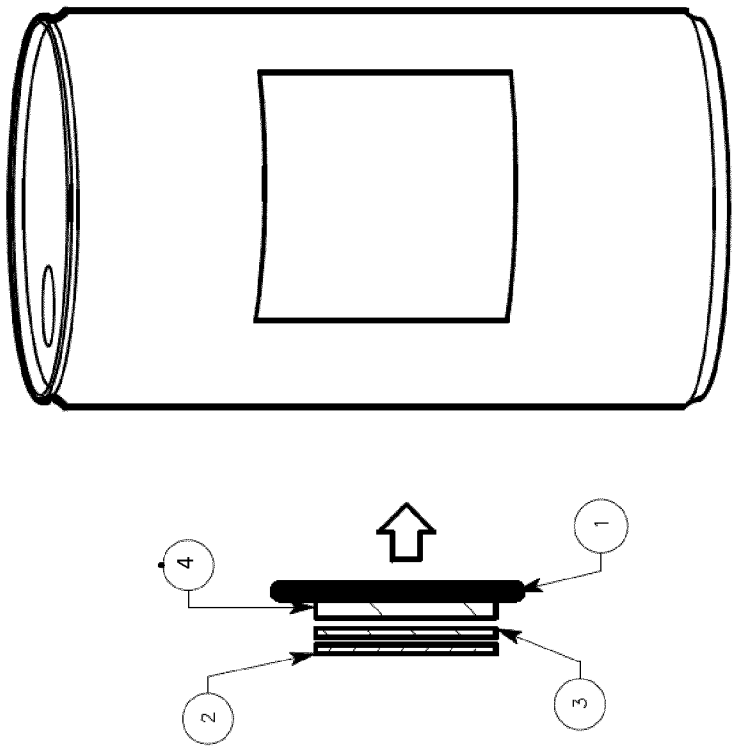
1. Added conductive and encapsulation layers
2. Encapsulation layer
3. Conductive layer (shaped as antenna)
4. Part of carton construction
5. Fibre board or other insulating layer
6. Foil layer
7. Encapsulation

FIG 5



1. Antenna layers added to can
2. Encapsulation layer
3. Conducting layer (top electrode)
4. Insulator / dielectric layer
5. Metal substrate of the can, also ground plane.

FIG 6



1. Aluminium substrate of can
2. Encapsulation layer
3. Conductive layer
4. Active piezo layer(s)

FIG 7

FIG 8

1. Insulating layer
2. Antenna coil
3. Chip
4. Connection to cap metal
5. Crown cap (metal)
6. Connection cap metal
7. Crown cap (metal)
8. Insulator / dielectric layer
9. Antenna coil conductive layer
10. Encapsulation layer

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/065414

A. CLASSIFICATION OF SUBJECT MATTER
INV. B65D23/12 B65D23/14 B65D79/02 B65D85/72 B65D6/00
B65D41/42 B65D5/42 B65D51/24
ADD.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B65D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2006/139928 A1 (GRIFFITHS BRYN [GB] ET AL) 29 June 2006 (2006-06-29)	1-8, 10-14, 16,17
A	paragraphs [0011], [0012], [0013], [0014], [0078], [0082], [0107], [0108], [0115], [0124], [0142], [0143]; figure 7	9,15
X	US 5 464 092 A (SEELEY DENNIS H [US]) 7 November 1995 (1995-11-07)	1-8, 10-14, 16,17
A	column 4, line 47 - line 48 column 5, line 21 - line 23; figures 11,12	9,15
X	EP 2 225 978 A1 (PENG WEI-LUN [TW]) 8 September 2010 (2010-09-08)	1-4,9-17
A	paragraph [0010]; figures 1-5	5-8

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 September 2019	11/09/2019

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/065414

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2012/274470 A1 (SANDVICK WARREN J [US]) 1 November 2012 (2012-11-01) paragraphs [0021], [0022] -----	17

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Information on patent family members

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		WO 2013188356 A1	19-12-2013