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Description

[0001] The invention relates to a cooling box for electrical or electronic components or circuits, which box is made of a thermally conductive material and this material consists of at least one ceramic component, the cooling box being electrically non-conductive, being made up of several pieces and having a cavity encased by the material and this cavity being closed or provided with at least one opening and at least one surface region of the cooling box being defined by the function of electrical conductivity and this surface region being conductor paths.

[0002] According to the prior art, planar structures are constructed for heat dissipation of modules of power electronics, which planar structures dissipate the heat diffusing from a heat source (active or passive electrical component) over numerous intermediate layers (solders, conductive pastes, adhesives, metallizations) into an electrically non-conductive, uniformly shaped simple geometric body (disk, rectangular substrate). Although the geometry of the individual components is simple, the entire layer structure is complicated and requires a consecutive application of a variety of fault-prone methods such as gluing, pressing, screwing and, to a lesser extent, soldering. Each boundary layer of this stacked construction provides a barrier to heat transfer and either reduces the reliability and/or life of the module (oxidation, burn-through, aging) or limits its performance.

[0003] Cooling boxes are described in DE 296 12 943 U1, DE 91 10 268 U1, DE 92 01 158 U1, DE 195 27 674 C2 or DE 295 14 012 U1.

[0004] Organic and ceramic circuit carriers with low or insufficient thermal conductivity must be permanently attached to a metallic heat sink by means of additional measures, such as electrically insulating intermediate layers. With increasing heat loads, the heat sources must be partially relocated from the board and mounted in the classic sense on a metallic heat sink and electrically connected to the circuit carrier.

[0005] The construction of several different materials is complex and a compromise, considering the long-term reliability. An increase in power density is possible only to a small extent.

[0006] The thermal conductivity can be used only conditionally, since it is a plane-parallel structure.

[0007] A direct combination of electrically conductive heat sink and a heat source is also not possible.

5 [0008] Usually, in the case of power thyristors, an alternating construction of the heat sink and the thyristor is selected. So that the heat transfer is optimal, this structure is mechanically braced. This tension is accompanied by a dynamic process of thermal expansion. The control of the bracing forces over time can only be guaranteed by additional effort.

10 [0009] EP 1 225 633 A1 as the closest prior art describes a cooling box according to the preamble of claim 1.

[0010] DE 196 43 717 A1 describes a liquid cooling device for a high-performance semiconductor module, which contains a plurality of heat-generating submodules arranged side
15 by side on a cooling surface, which are connected in a firmly bonded manner to the cooling surface. The liquid cooling device has a housing which encloses a liquid space through which a cooling liquid flows whose upper side forms the cooling surface. The liquid cooling device is equipped with connectors for a heating or cooling medium.

20 [0011] The invention has for its object to significantly improve a cooling box according to the preamble of claim 1 with respect to heat dissipation. Furthermore, the use of a cooling box is to be extended. In a further object, the reliability of the cooling box and its thermal shock-resistance is to be improved.

25 [0012] According to the invention, this object is solved by the features of claim 1.

[0013] By virtue of the fact that at least one and/or several different or identical cooling box/cooling boxes are embedded in a matrix material in any direction or in the same direction, and the cooling box/cooling boxes is/are equipped with connectors for the heating or cooling
30 medium, the cooling box or cooling boxes can be easily positioned and the heating or cooling medium can be easily connected.

[0014] According to the invention, at least one surface area of the cooling box is defined by the functions of electrical conductivity, and this surface area is conductor paths. In a preferred

embodiment, the surface area of the cooling box, which is defined by the functions of electrical conductivity, is a metallization layer sintered with the material of the cooling box.

[0015] This sintered metallization layer significantly improves the heat dissipation of the (soldered) components connected to the metallization layer.

[0016] In the case of small-area power semiconductors, as components with extreme waste heat, the combination of cooling box and semiconductor with adjusted coefficients of expansion can provide a significantly higher level of reliability.

[0017] The surface region may be a circuit board. Surface region is understood to mean that part of the cooling box which is defined by the functions of electrical conductivity and which has the conductor paths. Thus, the cooling box at the same time has the function of a board with an extremely high thermal conductivity.

[0018] The conductor paths are applied to the cooling box through the metallization layer, i.e. the sintered metallization layers can be applied in such a way that they form a printed circuit board. The conductor paths of the printed circuit board are thus closely connected to the cooling box via a thermal process (sintering). In addition, metallic conductor paths can also be glued on and conductive adhesives can be used. It is also possible to use combinations of different conductor path types.

[0019] The components have a direct heat flow into the cooling box. The components may, for example, be connected directly or via one or more layers to the cooling box.

[0020] The terms elements and components describe the same items below.

[0021] According to the invention, the cavity of the cooling box is equipped with connectors for a heating or cooling medium. The heating or cooling medium may remain permanently in the cavity or be exchanged via at least one input to the cavity steadily or as needed with a similar or different heating or cooling medium with the same or different temperature.

[0022] The heating or cooling medium is preferably a gas such as air or nitrogen or a liquid such as water or oil.

[0023] According to the invention, the cooling box consists of at least one ceramic component. The ceramic components can occur in the crystallographic sense in monocrystalline or polycrystalline forms or in combinations thereof.

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[0024] Preferably, portions of a multi-piece cooling box are interconnected by gluing, sintering, soldering, reaction soldering, jamming, riveting, bracing and preferably by sealing with additional sealing material. There may also be combinations of at least two different joining techniques for assembling an assembled cooling box consisting of at least two sections.

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[0025] Ceramic components or ceramics may, for example, be alumina, technical alumina, zirconia, differently doped zirconia, aluminum nitride, silicon nitride, silica, glass ceramics, LTCC (Low Temperature Cofired Ceramics) ceramics, silicon carbide, boron nitride, boron oxide.

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[0026] Of particular technical importance is technical 96% alumina with thermal conductivity of about 24 W/mK, and technical >99% alumina with about 28 W/mK, technical or pure aluminum nitrides with, for example, about 180 W/mK, zirconia-reinforced aluminum oxides with approx. 24 W/mK and glass ceramics with approx. 2 W/mK.

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[0027] High thermal conductivities are of particular technical importance in applications such as power electronics, high power LEDs, sluggish high-voltage fuses, processors, power resistors. Low thermal conductivities are of particular technical importance for fast high-load resistances, as well as for applications in which the most uniform possible temperature distribution over a surface (the cooling box) must be ensured. Here, for example, thermoanalytical measurement setups should be mentioned.

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[0028] The cooling box can also be made as a hybrid by designing at least one piece of metal in multi-piece cooling boxes. For example, aluminum, copper, nickel, tungsten or stainless steels can be used.

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[0029] The metallization layer on the cooling box is constructed multilayered in one embodiment.

[0030] It makes sense that the electrical or electronic components are connected with the cooling box in an electrically conductive and/or heat-conductive manner. Components may be, for example, electrical or electronic or active or passive or geometric bodies or any combinations thereof.

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[0031] In a further development of the invention, at least one assembly option is connected to the cooling box.

10 [0032] Via the assembly option, the cooling box can be connected to other cooling boxes with or without electrical or electronic components or circuits. The attachment can be done by screwing, riveting, clamping, gluing, crimping, welding, soldering or other fastening options.

[0033] The surface of the cavity of the cooling box can take over the functions of all surfaces that do not belong to the cavity of the cooling box, and vice versa.

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[0034] The surface of the cooling box and/or the cavity-associated surface of the cooling box can carry or comprise any surface structuring that causes the effect of surface change.

20 [0035] Advantageously, one or more surface structures or combinations thereof are arranged on the cooling box, and the surface structures are, for example, roughenings, grooves, waves, breakthroughs in the surface or dendritic or ramifying structures.

[0036] The surface structures are preferably planar or uneven or rough surfaces, which are connected with likewise uneven or planar or rough surfaces of components to be assembled, in particular in a form-fitting and/or permanent and/or temporary manner or as a combination thereof. The connection type can be, for example, soldering or gluing.

25 [0037] In a specific embodiment, the cooling box has a full-surface or partial-surface positive connection with components. The composite may, for example, be permanent or temporary, or a combination thereof. Components may be, for example, electrical or electronic or active or passive or geometric bodies or any combinations thereof.

30 [0038] In one embodiment, the cooling box is flat or provided with recesses or with elevations, which are formed integrally or in several pieces with the respective cooling box element.

[0039] Furthermore, the metallization layers are preferably greater than 5 microns and applied via DCB method (Direct Copper Bonding) or AMB method (Active Metal Brazing). The metallization layers may, for example, consist of copper or aluminum or combinations thereof.

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[0040] The structure with components is present, for example, at rest at room temperature. During operation, local temperature maxima may now be generated on the components as a result of their operation in the shortest possible time. A so-called thermal shock of the environment of the component results. The said structure can survive this state without self-harm. If these states occur alternately, a so-called thermal change, in conventional structures with, for example, glued conductor paths, detachment of conductor paths of the cooling box, for example, results after relatively few cycles. Said structure shows a significantly improved thermal shock resistance over conventional structures.

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[0041] In a further development, identical or different components in the same or different spatial orientation are fastened to the cooling box. Alignment may be performed by, for example, varying amounts of solder or recesses or elevations, or any combination of alignment possibilities. In the case of LED's, for example, their alignment and thus the light can thereby be aligned in a simple manner.

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[0042] The cooling box according to the invention can be used advantageously as an assembly body for components, in particular electrical or electronic components.

[0043] In one embodiment, the cooling box is connected to sensory components. Sensory components can emit signals, for example, from which variables such as pressure, temperature, weight, etc. are derived.

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[0044] In one embodiment, sensory signals are derived from the partial or total deformation of the cooling box.

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[0045] Preferably, the cooling box is partially provided with metallic regions. These areas can electrically connect the top and bottom of the cooling box, for example.

[0046] Preferably, the cooling box builds up almost no electrochemical potential over other materials. Thus, for example, with appropriate coupling, corrosion of the cooling box or the environment can be significantly reduced.

5 **[0047]** In one embodiment, the cooling box is used as a heat source, in which the resulting heat is released via the cooling box to the medium to be tempered. The medium to be tempered may contact the cavity surface or the surface not associated with the cavity.

10 **[0048]** Preferably, the cooling box exhibits, by supplied heat or cold, which is transmitted to the cooling box, a targeted temperature distribution. For example, temperature differences of the environment can thus be compensated in a targeted manner.

[0049] Preferably, substances are applied to the cooling box, which enable bonding processes. By way of example, a metallization structure W-Ni-Au (tungsten-nickel-gold) can be used here
15 in order to allow gold wire bonding. The fabrics may consist of one or more materials that are mixed or applied to at least one layer on the cooling box. The materials may be, for example, materials such as gold or layers of several materials such as copper, nickel and gold or mixtures of at least two different materials such as metals and/or aggregates, as well as layers of the same or different metals or aggregates.

20 **[0050]** In a further development, one or more light-emitting substances or one or more light-emitting components or combinations thereof are connected to the cooling box. For example, this may be a semiconductor or housing with a semiconductor, as it is used for LED lighting.

25 **[0051]** Preference is given to the cooling box metals or metal layers which are closely connected or connected by mechanical positive fit over the entire surface or part of the surface and have the same or different thermal conductivity as the cooling box. Metals or metal layers may be, for example, tungsten, silver, gold, copper, platinum, palladium, nickel in pure or industrial grade, or mixtures of at least two different metals. Metals or metal layers may also be mixed, for
30 example, with adhesion-promoting or other additives such as glasses or polymeric materials. For example, metals or metal layers may also be reaction solders, soft solders or hard solder.

[0052] It is particularly noteworthy that in the case of punctiform heat sources, the heat must spread very quickly over the entire surface of the cooling box, i.e. distributed. Thus, the cooling

box, with comparatively low thermal conductivity, can thus have the resulting heat get distributed via the metal over its total area. Since the cooling box is electrically insulating, the metal can simultaneously fulfill the function of electrical conductivity and thermal conductivity.

5 **[0053]** In one embodiment, the metals or metal layers on the cooling boxes may have different functions. Thus, they may have the function of electrical conductivity and/or thermal conductivity or the function of a color change of the surface or thermal spreading or a bonding agent to third materials, such as solders, adhesives, as well as any combination of the functions of the same or different metal regions.

10 **[0054]** The advantage lies in the adapted current-carrying capacity of the metal areas. Therefore, for example, they do not necessarily have the same heights or thicknesses.

15 **[0055]** Consequently, the metals or the metallization layers are connected over the entire area or part of the area in the same or different thicknesses (heights) with the material of the cooling box in the same or different metal regions.

20 **[0056]** In another embodiment, identical or different metals as metallization layers are connected in one layer or in multiple layers with the same or different thicknesses (heights) to the material of the cooling box over the entire surface or part of the surface.

25 **[0057]** In a further embodiment, the cooling box carries the intrinsic coloration of the material or materials used over the entire surface or part of the surface or portions of the cooling box are discolored differently from the intrinsic color.

30 **[0058]** The cooling box, based on a technical alumina, for example, may be provided during the manufacturing process of the same with coloring additives, so that as a result of a thermal treatment, the bulk material is completely and mechanically inseparably through-colored.

30 **[0059]** The cooling box, based for example on the basis of a technical zirconia, can be provided with coloring additives, for example superficially after the production process thereof, so that the surface of the bulk material is completely through-colored as a result of a thermal treatment. Depending on the depth of penetration of the resulting discoloration, the bulk material may retain

its inherent color within. The gradient of the discoloration can take on a wide variety of characteristics.

[0060] The cooling box, for example, based on a technical alumina, can be provided with coloring layers, so that as a result, the bulk material of the cooling box is not discolored and the color change is only generated by one or more mechanically separable layers. Coloring layers can be, for example, paints, glazes, adhesive films, metals, etc.

[0061] In another embodiment, the cooling box is connected to at least one other geometrically identical or different cooling box via suitable bonding materials to form a kind of three-dimensional array.

[0062] Bonding materials can be single-layered or multi-layered in nature. Bonding materials may be the same or different, or may be used in combination with a single or multi-layered construction. By way of example, bonding materials such as adhesives, metallizations, metals, metals that have been connected to the cooling box by methods such as DCB (Direct Copper Bonding) or AMB (Active Metal Brazing) could be mentioned. It is also possible, for example, to use solders, reaction solders, double-sided adhesive films, etc.

[0063] In one embodiment, the cooling box is connected to one or more light-emitting substances or one or more light-emitting components and combinations thereof, and is preferably simultaneously provided with standardized or non-standard electrical connectors. It is also possible to use combinations of identical or different electrical connectors. It is preferable to use a mechanical connection to the cooling box that is appropriate for the electrical connector. Electrical connectors may be, for example, lamp bases E27, E14, GU series, G series, U series, R series, plug sockets, bayonet sockets, clamp connectors, screw connectors, plug connectors, etc. Mechanical connections or combinations of mechanical connections may be, for example, gluing, soldering, crimping, riveting, clamping, etc.

[0064] In a further embodiment, at least one cooling box is connected to at least one further geometric body via suitable bonding materials to form a kind of three-dimensional structure. Bonding materials can be single-layered or multi-layered in nature. Bonding materials may be the same or different, or may be used in combination with a single or multi-layered construction. At least one or more identical or dissimilar cooling boxes may be mounted at any location in the

same or different orientations. By way of example, bonding materials such as adhesives, metallizations, metals, metals which have been connected to the cooling box by methods such as DCB (Direct Copper Bonding or AMB (Active Metal Brazing), solders, reaction solders, double-sided adhesive films, etc. could be mentioned. By way of example, geometric bodies can be plates on which at least one or more identical or different cooling boxes are located in different regions.

[0065] The cooling box may for example be part of a plastic housing.

[0066] According to the invention, at least one and/or different or the same cooling cans are embedded in a matrix material in any direction or in the same direction. The embedding can be done for example by injection molding or die casting. The embedding materials themselves are arbitrary and can be selected according to the respective target functions. Plastics are excellent.

[0067] A change in the heat transfer is achieved in a cooling box by modifying the size or coloring or a modification of the geometry of the metallized regions or the metallization layers or combinations of these. If, for example, the design of the cavity in the cooling box is changed, the absolute temperature in the steady state or in the equilibrium state can change with constant heat input, via the release or absorption of heat energy. This can also take place, for example, by deliberately adding or removing or enlarging or reducing the cavity in the cooling box. The change can for example also take place by changing the color. In this way, the radiation characteristic of a black body is different than with a white body.

[0068] The surface of the cavity can also assume the functions of the surface which is not part of the cavity, i.e. be formed, for example, as a circuit board. The metallization layers are applied to the outer or inner surface of the cooling box by sintering.

[0069] High-power semiconductors with or without thermal power dissipation, such as MOS-FET, IG-BT, processor cores, are preferably directly or indirectly connected to the cooling box. As a result, at the same time and by itself, the resulting waste heat passes to the material of the cooling box. The material of the cooling box can then pass the amount of heat to the heating or cooling medium. The process can also run in the opposite direction, so that heat is removed from the heating or cooling medium. A combination of both transport directions can also be used.

[0070] In one embodiment, the metallization regions consist of tungsten and are chemically nickel-plated and/or gold-plated. The metallization regions are circular in design.

[0071] According to the invention, the cooling box is provided with electrical conductor paths, via which electrical voltages can be transported, for example, into the kV range, without there being an electrical voltage drain via the material of the cooling box. Of particular technical interest are electrical voltage ranges from 1 volt to 600 volts, as well as voltages $\gg$ 2 k volts (2,000 volts).

[0072] In a preferred embodiment, the cooling box has no or little shielding effect against electrical or magnetic or electromagnetic fields or combinations of these, whereby these fields can penetrate the cooling box.

[0073] In one embodiment, the cooling box is provided in a targeted manner over the entire surface or part of the surface with materials whose function is to create regions in which a different shielding effect occurs against electrical or magnetic or electromagnetic fields or combinations thereof, compared to the shielding effect of the material of the cooling box.

[0074] Preferably, by targeted application of suitable materials, such as metals, regions are arranged on the cooling box which are, due to their geometry, capable of receiving or sending electrical or magnetic or electromagnetic signals via inductive or capacitive effects or combinations of these. Signals in the broadest sense serve the wireless transmission of energy. The energy can also transmit additional information, for example, by modulation.

[0075] In an embodiment according to the invention, the cooling box is equipped with the functionality of intelligent self-identification. Self-identification may be, for example, a lettering or a mark or a magnetic stripe with corresponding information or an RFID unit (radio-frequency identification) or combinations of these.

[0076] In one embodiment, the cooling box is connected directly or indirectly to at least one laser diode of the same or different wavelength. The laser diode may be a module or the light-emitting semiconductor itself. An indirect connection would be, for example screwing, gluing, jamming. A direct connection would be, for example, soldering on.

[0077] In one embodiment, the cooling box is directly or indirectly connected to at least one power module of the same or different construction, which regulates, for example, the starting current of an electric motor. An indirect connection would be, for example screwing, gluing, jamming. A direct connection would be, for example, soldering on.

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[0078] In one embodiment, only one electrical conductor of a power semiconductor, for example, is soldered to a cooling box and at least one other electrical conductor of the power semiconductor is soldered to another cooling box, for example, to ensure optimal heat transfer with simultaneous electrical isolation. Suitable power semiconductors can thus be soldered, for example, to at least two cooling boxes in order to enhance the desired cooling effect via a type of sandwich construction.

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[0079] In one embodiment, the material of the cooling box is selected so that the cooling box can come into contact with corrosive or ionically conductive heating or cooling media.

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[0080] According to the invention, the cooling box is equipped with connectors for the heating or cooling medium.

[0081] The material of the cooling box or the ceramic material as main component preferably contains 50.1wt.-% to 100wt.-% ZrO₂/HfO₂ or 50.1wt.-% to 100wt.-% Al₂O₃ or 50.1wt.-% to 100wt.-% AlN or 50.1wt.-% to 100wt.-% of Si₃N₄ or 50.1wt.-% to 100wt.-% of BeO, 50.1wt.-% to 100wt.-% of SiC or a combination of at least two of the main components in any combination in the specified range of proportions, and as a minor component the elements Ca, Sr, Si, Mg, B, Y, Sc, Ce, Cu, Zn, Pb in at least one oxidation state and/or compound with a proportion of ≤49.9wt.-% individually or in any combination in the stated range of proportions, and the main components and the minor components, with a deduction of a proportion of impurities of ≤3% by weight, combined in any combination with each other to a total composition of 100wt.-%.

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[0082] In one embodiment, in multi-piece cooling boxes at least one piece of the cooling box is made of a metallic material. As metallic materials, for example, aluminum, copper, nickel, and the technical variants of pure metals or stainless steels are mentioned.

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[0083] In one embodiment, the metallic piece of a cooling box is made of combinations of different metals.

[0084] In one embodiment, full-area or partial area regions of the cooling box are provided with high-current carrying conductor paths and high-current carrying standardized or non-standard conductor connections.

[0085] In one embodiment, at least one thin layer $<1,000\ \mu\text{m}$ of the same or different material is applied to the cooling box by sputtering or lithography processes or combinations thereof over the entire surface or part of the surface.

[0086] In one embodiment, an alternating stack construction of the cooling box and the component to be cooled takes place by partially or completely connecting individual or all levels of the stack. Joining can be performed, for example, by gluing or clamping or soldering or brazing or phase change materials.

[0087] Preference is given to multi-piece cooling boxes having been connected to one another with the DCB (direct copper bonding) or AMB (active metal brazing) methods or metallizations such as tungsten. In this case, the metals can cover the entire or partial area of the sealing surface and/or be larger than the actual sealing surface.

[0088] In one embodiment, metal regions that are larger than the sealing surface also perform other functions, such as that of a seal. Other functions may be, for example, an assembly option, electrical signal transmission, electrical connection, thermal conduction, connection to another cooling box or combinations thereof.

[0089] In one embodiment, the heating or cooling medium connections of at least two cooling boxes are interconnected in series or in parallel.

[0090] In one embodiment, at least one cooling box is supplied an amount of heat and an amount of heat is withdrawn from at least one other cooling box. This state of heat flow direction may be static or reversible or dynamically changing with respect to the single cooling box. The heating or cooling medium circuit may be closed or open or provided with a pressure equalization.

[0091] In one embodiment, the cooling box has at least two separate self-contained cavities. The cavities may be closed or provided with at least one input. The same or different heating or cooling media may be in the same or different states in the cavities.

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[0092] In one embodiment, at least two cavities within the cooling box or outside are interconnected in series or parallel, or combinations thereof, via the heating or cooling medium inputs or combinations thereof.

10 [0093] In one embodiment, the heating or cooling medium flows through the cooling box via convection or is circulated by a pump or by combination thereof.

[0094] In one embodiment, the cooling box is provided with standardized or non-standard optical or optoelectronic connectors or components. Connectors or components may be, for
15 example, ferrules or optoelectric transducers or fiber optic connections.

[0095] In one embodiment, an RFID unit is connected to the cooling box.

[0096] In one embodiment, at least one conductor path of the RFID unit and/or at least one
20 antenna of the RFID unit and/or at least one active and/or passive component of the RFID unit are connected to the cooling box.

[0097] In one embodiment, the cooling box is made of technical alumina with a minimum alumina content of 89%. The metallization regions are suitable, for example, for soldering
25 components and thus producing a close bond. The composite with, for example, a commercially available LED can be produced via a solder connection. The solder connection has at least the functions of the mechanical connection of LED and cooling box. In addition, the metallization regions allow the electrical contacting of the LED and the thermal contact.

30 [0098] Using the example of a construction of a cooling box with printed and sintered metallization regions (also conductor cross-sections) with a soldered point heat source, such as an LED, the technically necessary electrical conductor cross-section can be significantly larger than required, since at the same time for electrical conduction through the metallization and conductor path cross-sections and the heat spreading to a larger surface of the cooling box takes

place. Compared with an electrically reasonable and sufficient smaller metallization region and conductor path cross-section, a larger amount of heat can be distributed over the surface of the cooling box over larger metallization regions and conductor cross-sections in a shorter time.

5 **[0099]** The cooling box, hereinafter also called body, may preferably consist of at least one ceramic component or a composite of different ceramics. For example, technical grade alumina 80-99.9%, alumina, beryllia, zirconia, stabilized zirconia, aluminum nitride, zirconium reinforced alumina, glass ceramic or ceramics formed by blending at least two different ceramics or additives are to be named. Monocrystalline ceramics may be, for example, sapphire.

10 **[0100]** The body can also consist of a composite material. Matrix materials, e.g. resins, polymers or silicones can be used with additives. The additives cause a change in the thermal conductivity of the matrix materials. Multicomponent systems may be preferred, such as polymers with Al_2O_3 , polymers with AlN , silicones with $\text{Al}_2\text{O}_3/\text{AlN}$.

15 **[0101]** The body may be rigid or flexible or a combination of rigid-flexible.

[0102] The body can be a composite metal-ceramic or a composite of body and metal.

20 **[0103]** The body may have a multilayer structure with internal conductor paths and electrical components such as resistors, coils, capacitors, etc., whereby electrically conductive regions between the layers are also possible.

25 **[0104]** The body can also be used as a replacement for an electrically conductive heat sink, in particular, when the environment is corrosive.

[0105] The body can also be an assembly housing at the same time.

30 **[0106]** The use of the cooling box according to the invention has the following advantages:

- > Reduction of component diversity
- > Expansion of the variety of functions
- > Intrinsic safety against thermal overload
- > Long-term reliability
- > Avoiding TCE mismatch by using a variety of materials

- > Performance increase through improved heat dissipation
- > Difficulty to dissipate high heat losses was overcome
- > Basic principle can be transferred to a variety of applications
- > A "self-inherent" thermal balance
- 5 > Circuitous route of assembling heat source in a separate housing, which in turn can be assembled on the body, is eliminated

[0107] Heat sources may be electrical or electronic components, such as heating elements, Peltier elements, resistors, active and passive semiconductors.

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[0108] The heat can be deliberately generated as a function or incurred as a by-product in the exercise of the function.

[0109] The heat sources can also experience changes in the functionality of their own heat produced during operation.

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[0110] The heat sources can be directly connected to the body, e.g. with a solder joint.

IGBT

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[0111] Modules are assigned ever higher performance per area and the permanent functionality of these modules can only be guaranteed by assembling heat sinks.

[0112] Here, the cooling box according to the invention is selected for thermal dissipation.

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LED (light emitting diode) or laser diodes

[0113] With the state of the art, it has hitherto not been possible, or only to a limited extent, to achieve higher required luminances. The reasons are the poor thermal management associated with the prior art. With increasing luminance, the waste heat increases. The waste heat significantly influences the service life and the color constancy. The same applies to applications with laser diodes.

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[0114] The semiconductors can be assembled directly on a circuit board or housed beforehand and then placed as a component on the board. The circuit arranged on the board is cooled in turn according to the invention by the cooling box, or the semiconductor is provided directly with an additional cooling box. Semiconductors may, for example, also be solar cells, since their power output decreases with increasing temperature. In this case, the semiconductor itself would not produce any waste heat that has to be dissipated by the operation, but here the semiconductor is warmed up by the IR component of the sunlight.

Controls

[0115] According to the prior art, e.g. in the automobile, the heat sources are separated from the circuit and electrically connected. Again, the construction with heat-conductive heat sinks is used.

Corrosion of heat sinks

[0116] Under certain conditions of use, electrically conductive heat sinks cause surface corrosion. The surface compounds resulting through chemical conversion change the transition to the cooling medium and can also change the surface, e.g. by pitting. Cooling boxes made of a ceramic solve this problem.

Ceramic heating element

[0117] Use for thermal stabilization of the heat sink itself, or the direct or indirect environment.

Peltier application

[0118] Peltier elements have a cold and warm side. Depending on the application, the structure can always be seen in combination with a separate heat sink. Here, the Peltier element can be applied directly to the electrically insulating heat sink. Also, the reverse effect can be used to generate electrical voltage from a temperature difference (Seebeck effect).

Sensors internal/superficial due to direct feedback in own system

[0119] The heat sink itself may contain sensors introduced or assembled/applied on a surface. Due to the direct connection to the system, self-regulating protective functions of the heat sources are possible.

5 Assembling the heat sink

[0120] Assembly points, pads, cavities, assembly bolts

Active and passive cooling

- Drilling
- 10 - Fan
- Ribs in cooling medium different than air

[0121] The prior art often requires in the assembly of the component and heat sink, a third component, a so-called heat conducting foil, which must also be electrically insulating at the same time. So that the desired effect of heat dissipation can be achieved, heat sink and component must identify even and plane-parallel surfaces, so that a 100% positive engagement is guaranteed. If a heat-conducting foil is added, it must also have a flat and plane-parallel surface. When assembling such a structure, a screw is often chosen. If there is a delay in construction during assembly or during operation, the thermal contact may be partially lost. Thus, the functionality and lifetime of the structure is in question.

[0122] Now for the first time there is the possibility of a solder joint on electrically insulating heat sinks, where the disadvantages of thermal coupling described above during the soldering process do not arise.

25 Multilayer sandwich construction

[0123] Simple mechanical connections of the heat sink for assembling the unit itself and for connection to other heat sinks and/or body-bound functions.

30 Self-cooled circuit board

[0124] The prior art is to provide a board with insufficient thermal management with an electrically conductive heat sink. The thermal connection is limited insofar as it has to be stable

for a long time. Limiting factors are e.g. the temporal and geometric change of the electrically insulating medium.

[0125] The invention will be explained with reference to figures.

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[0126] Figure 1 shows a cooling box 1 according to the invention, which consists of two sections 1'. The two sections 1' are identical in the embodiment shown here and enclose a cavity which is arranged between the two sections 1'. The cavity is not visible in this figure. This cavity is connected to the outside world via two openings 2. Through the two openings, a cooling medium
10 can be passed into the cavity.

[0127] Figure 2 shows two cooling boxes 1, both of which each include a cavity, not visible in the figure. Both cooling boxes 1 are integrally formed and are connected to each other via an assembly option 8, here a bolt soldered to the cooling boxes 1. The cavities are connected to the
15 outside world via openings 2. A cooling box has only a single opening 2. The cooling medium can pass into the cavity by convection in this case. The other cooling box shown has two openings 2. The cooling medium can be pumped here, for example, into the cavity. The two cooling boxes are made of a ceramic and are not electrically conductive or are almost non-conductive. In both cooling boxes, at least one surface area of the cooling box 1 is defined by the functions electrical
20 and/or thermal conductivity. The surface area of the cooling boxes 1, which is defined by the functions of electrical and/or thermal conductivity, is a metallization layer sintered with the material of the cooling boxes 1. In the embodiment shown here, this surface area is a circuit board 5. These surface areas can be arranged on all sides and also in the cavity of the cooling boxes 1.

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[0128] Figure 3 shows a cooling box 1 according to the invention, similar to Figure 1, which consists of two sections. Figure 4 shows a section along the line A-A of Figure 3. The two sections are identical and enclose a cavity 4, which is arranged between the two sections. This cavity 4 is connected to the outside world via two openings 2. Via the two openings, a cooling
30 medium can be conducted into the cavity 4.

[0129] On the top of the cooling box 1, a metallization 3 sintered with the material of the cooling box 1 is applied.

[0130] Figure 5 shows the left-hand cooling box of Figure 2, a one-piece cooling box 1 with an opening 2 for a cavity (not shown here). A metallization layer 5 designed as a printed circuit board is applied on the surface 6 of the cooling box 1. Again, the cooling box 1 consists of a ceramic as a material of the cooling box. The metallization layer 5 is also sintered here with the material of the cooling box 1.

[0131] Figure 6 shows a total of three cooling boxes 1, which are connected to form a kind of three-dimensional array. Each of the cooling boxes 1 has openings 2 for supplying the coolant. It is not shown that surface areas of the cooling boxes 1 are defined by the functions of electrical and/or thermal conductivity, i.e. having metallization layers sintered with the material of the cooling boxes 1.

[0132] Figure 7 shows a cooling box 1 according to the invention, which consists of two identical sections 1'. These sections 1' are connected by a bonding material 7, here an adhesive. Again, the sintered metallization layers are not shown.

Patentkrav

1. Køledåse (1) til elektriske eller elektroniske komponenter eller kredsløb, af et materiale med termisk ledeevne, og dette materiale består af mindst en keramisk komponent, idet køledåsen (1) ikke er elektrisk ledende, er opbygget i flere dele og har et hulrum (4) indkapslet af materialet, og dette hulrum (4) er lukket eller forsynet med mindst en åbning (2), og i det mindste et overfladeområde af køledåsen (1) er defineret af funktionen elektrisk ledeevne, og dette overfladeområde er ledende spor, **kendetegnet ved, at** mindst en og/eller flere forskellige eller ens køledåser (1) er placeret valgfrit eller i samme retning integreret i et matrixmateriale, og køledåsen/køledåserne (1) er forsynet med konnektorer til et varme- eller kølemedium.

2. Køledåse ifølge krav 1, **kendetegnet ved, at** hulrummet (4) i køledåsen (1) indeholder et varme- eller kølemedium.

3. Køledåse ifølge krav 2, **kendetegnet ved, at** varme- eller kølemediet er en gas, som f.eks. luft eller nitrogen eller en væske, som f.eks. vand eller olie.

4. Køledåse ifølge et af kravene 1 til 3, **kendetegnet ved, at** delstykkerne (1, 1') af en køledåse i flere dele (1) foretrukket er forbundet med hinanden ved hjælp af limning, sintring, lodning, reaktionslodning, fastklemning, nitning, tilspænding og foretrukket ved tætning med yderligere tætningsmateriale.

5. Køledåse ifølge et af kravene 1 til 4, **kendetegnet ved, at** køledåsen (1) er fladeformet eller udformet med fordybninger eller forhøjninger, idet disse er udført i ét eller flere stykker med det respektive køledåseelement.

6. Køledåse ifølge et af kravene 1 til 5, **kendetegnet ved, at** køledåsen (1) har mindst to separate lukkede hulrum (4).

7. Køledåse ifølge krav 6, **kendetegnet ved, at** mindst to hulrum (4) i køledåsen (1) eller udenfor er serie- eller parallelkoblet, eller kombinationer heraf, via varme- eller kølemiddelindgange eller kombinationer heraf.

8. Køledåse ifølge et af kravene 1 til 7, **kendetegnet ved, at** varme- eller kølemediet strømmer gennem køledåsen (1) via konvektion eller cirkuleres ved hjælp af en pumpe eller en kombination heraf.

Fig.1

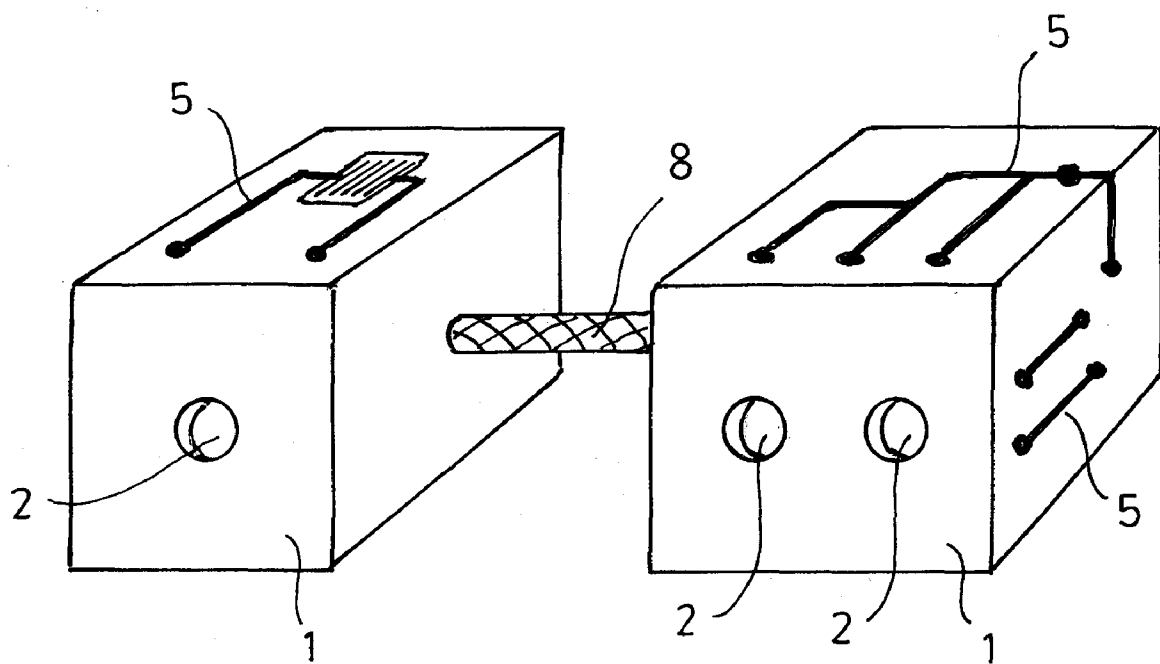
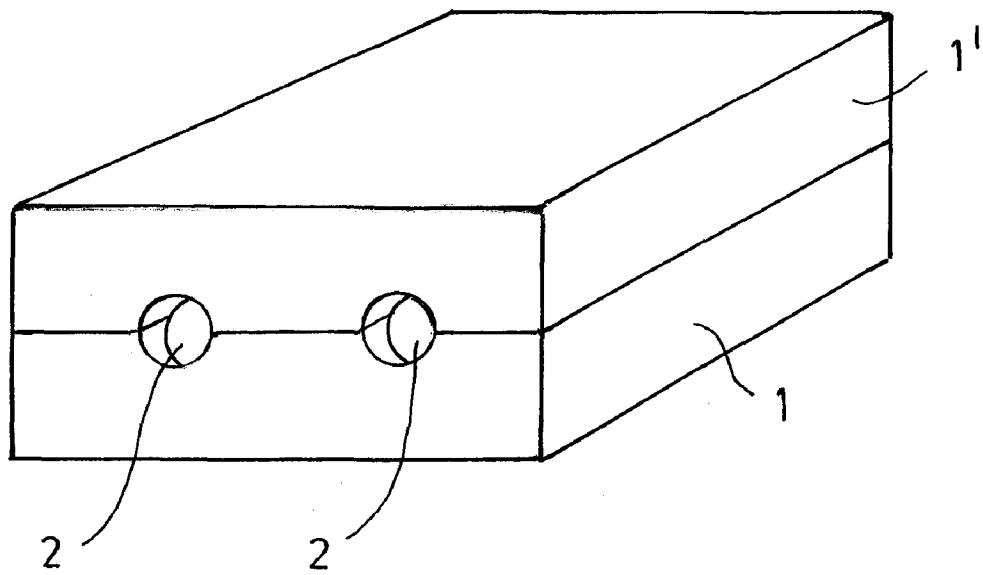


Fig.2

Fig.3

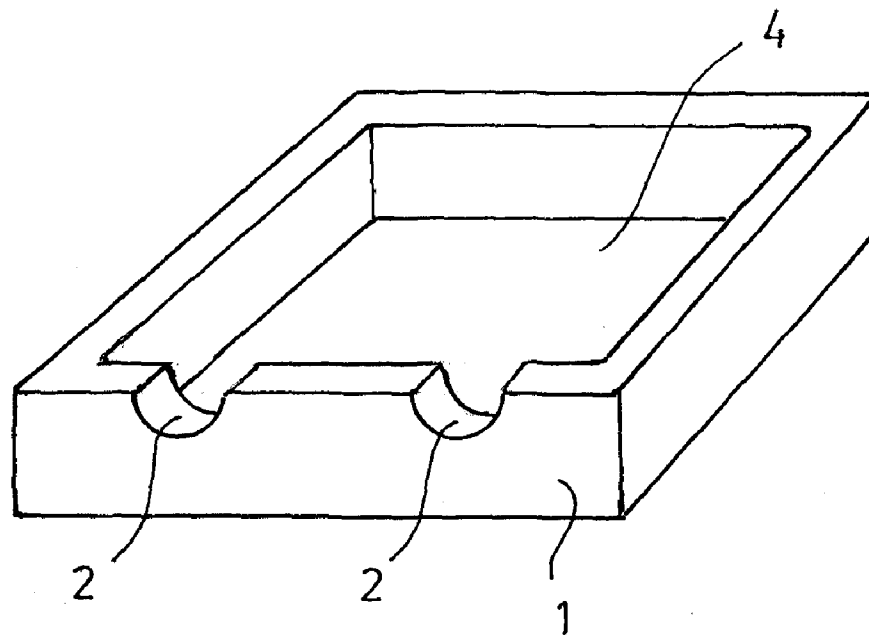
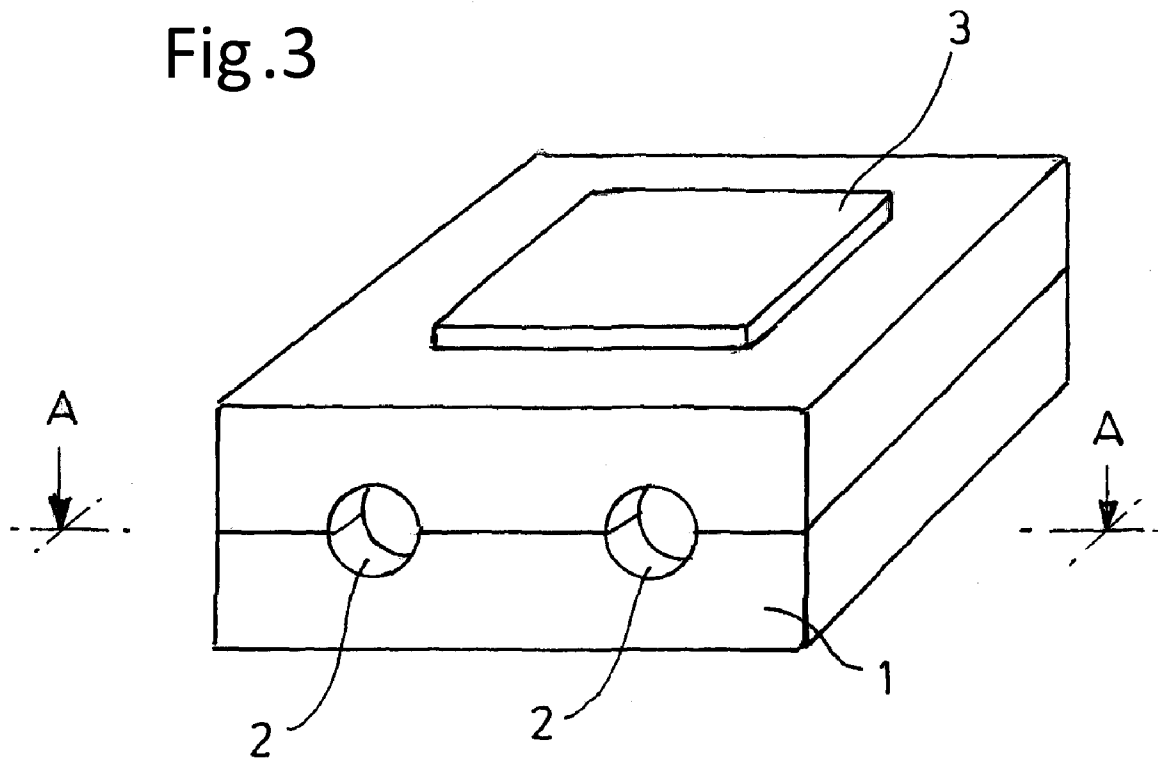


Fig. 4

Fig.5

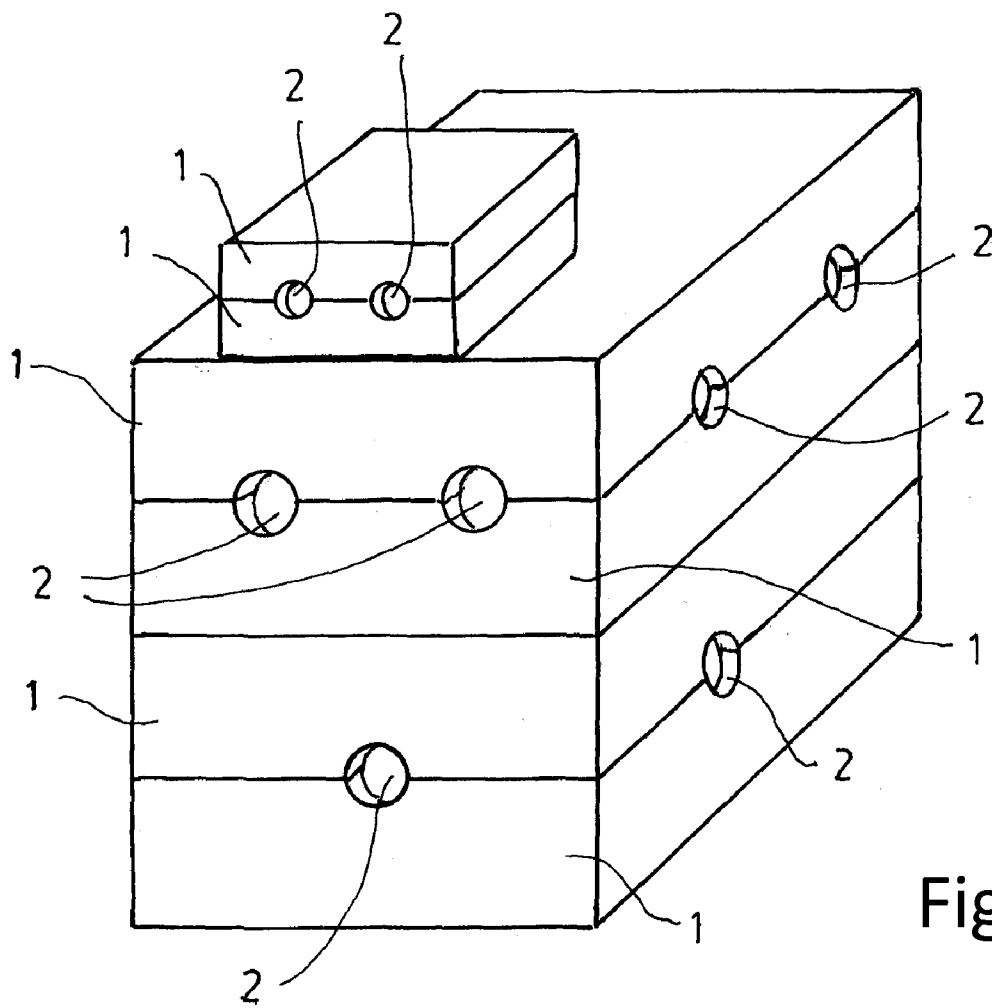
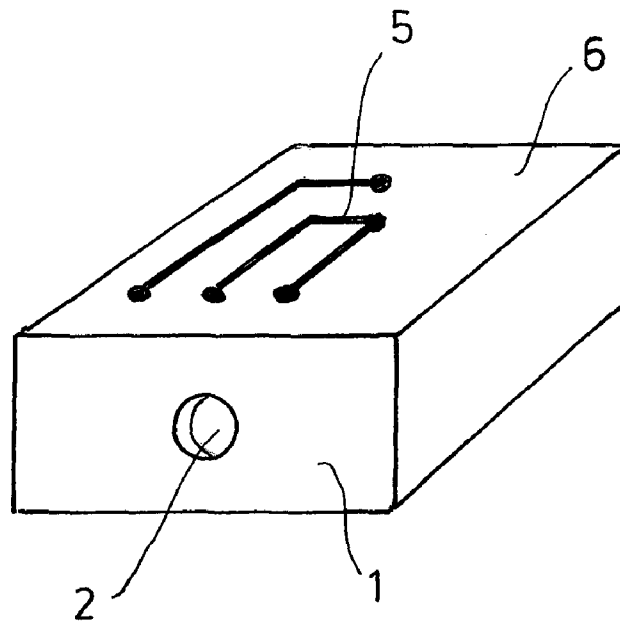


Fig. 6

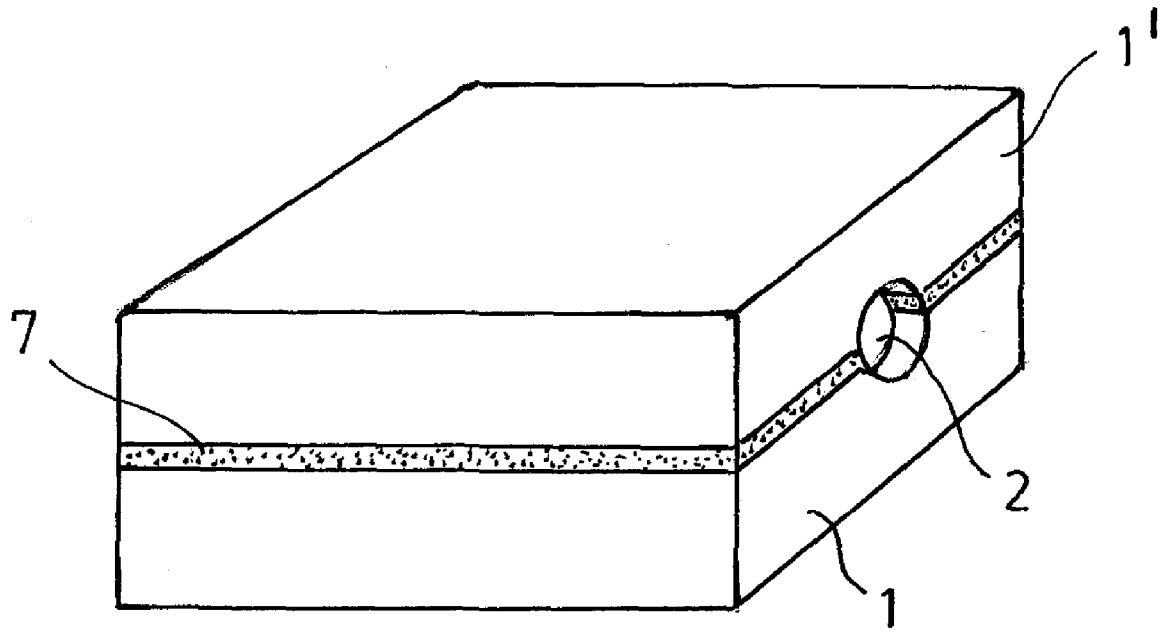


Fig. 7