(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) **World Intellectual Property Organization**
International Bureau

(43) **International Publication Date**
22 October 2015 (22.10.2015)

(10) **International Publication Number**
WO 2015/159126 A1

(51) **International Patent Classification**:
H05K 1/02 (2006.01) ***H05K 1/18*** (2006.01)

(21) **International Application Number**:
PCT/IB2014/060747

(22) **International Filing Date**:
16 April 2014 (16.04.2014)

(25) **Filing Language**: English

(26) **Publication Language**: English

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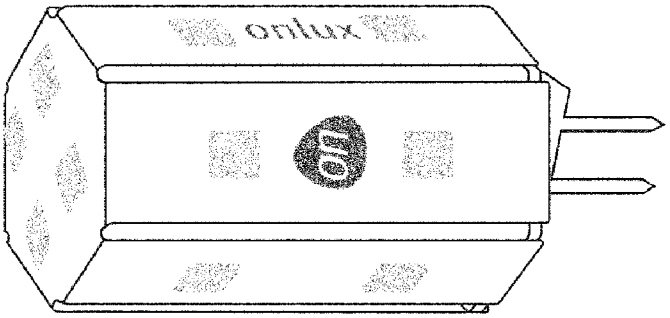
(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) **Title**: FLEXIBLE LED

Figure 2: *Scheme of a G4-LED-Corn-Lamp made of flexible PCB*



(57) **Abstract**: The present invention (Flexible PCB based LED- & COFB-LED Lighting solutions and Bulbs) relates to light emitting device methods and arrangements for LED-Lighting modules or "bulbs" using a number of LED-light-sources placed on a flexible PCB structure. The present invention contemplates the use of flexible PCB, integrating and providing multiple functions. Besides the electric circuit on one, two or more layers, the PCB may provide static function, isolating function, heat sink, heat abduction to heat dissipating elements (heat piping), ease of automated assembly, and mainly the shaping of freely tailored three dimensional shapes for lighting bulbs or other lighting apparatus with or without the necessity of using additional components providing static, heatsink, electric or other function. The COB-Technology will be considered in particular since it may be expected that such technology can lead to a quantum leap to the making and appearance of LED-lighting apparatus. The lighting devices based on this invention may be used for direct lighting or in combination with optical elements. It is the aim of this invention to grant easy to make yet highly effective and efficient methods for the creation of lighting devices. LED-Bulbs, Modules, Light Engines, lighting Elements or any kind of Apparatus with deriving benefit from using three dimensional flexible PCBs are subject of this invention. The invention may be considered for newly designed or modernized lighting apparatus such as for retrofit applications. The present invention is easy for process-integration, automation and mass- production. Quality oriented manufacturing is simple and reliable.

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FLEXIBLE LED

Background of the invention (Description – Part 1):

LED lighting arrangements can be based on many principles. "Corn-Lamps" are normally an assembly of rigid fiberglass or aluminum PCB-Elements each one equipped with several relatively low powered LEDs. Smaller Corn-Lamps are integrating a number of PCBs normally by soldering one to the other while bigger Corn-Lamps may contain structures to keep the PCBs in their position. "LED-Arrays" are somewhat similar to Corn-Lamps but they are typically restricted to flat (two-dimensional) arrangements. "LED-Strips" are a thing in between, they are linear and Flexible. LED-Strips can be used for many things – even to provide three-dimensional shape to a device for decoration or lighting. Yet LED-strips are not really suitable to create devices since they normally imply a lot of labor, additional heatsink and structural parts to avoid the strips wiggling or moving away from their intended position.

Many topics of the LED-technology have been overcome in the recent years but some issues are still causing problems to producers and users of LED light. The following topics shall be considered:

a) *Making of LED-Lighting devices: In many cases LED-Lighting assemblies based on multiple rigid PCBs look like "tinker"-items. Visible and touchable solder-contacts on the surface and the sheer number of solder-joints make such products unreliable and expensive.*
b) *Making use of COB-technology: In order to achieve extraordinary lighting results a new approach shall be introduced – the direct application of LED-lighting-Chips onto a flexible substrate (COFB instead of COB). Highly efficient and surprisingly effective structures for LED-Lighting can result.*
c) *Acceptance, Ease of Use and adaptation to user's purpose: The solutions provided to the market are often rejected by the customers. A professional and well integrated make of LED-Lighting-devices based on flexible PCBs shall disclose a big range of applications.*
d) *Modularity of LED-Lighting devices: Ease of make and ease of use shall also enable solutions for modular and virtually unlimited LED-Lighting applications with light-emission to different emission axes, on large surfaces or even for three dimensional, free form embodiments.*

This present invention will help to overcome these issues in a very effective and efficient manner. By the use of flexible PCB and by applying new arrangements to the design of the circuits and board shapes to enhance and integrate their functions, PCBs will be seen in a "different light". The following topics are in the focus of this invention:

a) *Structure & third dimension: Similar to sheet metal or paper (simple origami) flexible printed circuit material (e.g. Polyimide-PCB) can be used to provide three dimensional structure and shape to an object or lighting device. By choosing adequate design such PCB-Material can be sufficiently strong to integrate static and even dynamic function to such apparatus. Even if produced in two dimensions only by adequate design such material can be confectioned, shaped and tailored by cutting it up, bending and attaching it similar to a stiff textile tissue material. Materials and layer thickness and geometry are selected according to the electric and static requirements. Thanks to the minimal requirement for materials, the solutions provided based on this technology will be of extraordinary light weight.*
b) *Isolation: By absence of conducts or by adding (varnishing or laminating) isolating layers, the PCB-Material can be designed and specified to comply with requirements for isolation. By coating or filling the structure with resin or varnish, the targeted apparatus can additionally be equipped with an "IP-degree of protection" – if required.*

c) Heat sink and heat abduction: By specifying the thickness and material of conductive layers also the heat within the PCB can be managed according to requirements. One common method is to enlarge conducts to increase their surface for heat dissipation. "Wings" or particular dissipation surfaces can be added as required. Also it is possible to abduct heat to a separate dissipation unit by the use of conductive layers as heat-pipes. By adding particular surface characteristics (e.g. by adding micro-scale or nano-technology roughening to the surface) the heat dissipation capacity of the PCBs surface can be increased – on both sides of the PCB. Other than a thermally almost isolating fiberglass PCB a laminated flexible PCB does emit half of the heat to its rear. With other words: When applying proper design the capacity of heatsink in presence of air convection is double in comparison to rigid traditional PCB.

d) Ease of making: By the use of technologies known from the making of PCB-Bases for LED-Strips, materials and shapes to produce three-dimensional lighting devices are broadly available in mass production for small and big surfaces. By the use of Laser-Cutting or punching, free form shapes and cutouts can be provided. In the further process of assembly the use of stencils (for applying solder-paste) and robots are common technology and do not depend on the shape of the PCB in its original flat position. Besides LEDs other / additional electronic components can be added to the circuits – for instance to control a constant current flow through the LEDs.

Besides the much easier logistics by reduction of the number of parts involved the big advantage and saving is to be found in the "assembly" of the flexible PCB. This consists normally of 1 (one single) piece. In comparison to the assembly of several rigid PCBs for a corn lamp, the amount of employed labor and the risk of quality issues are much smaller. By simply folding and fixing the flexible PCB in the predefined locations, the product takes the desired shape and function. Alignment and (manual) soldering are reduced to a minimum or even immanent to the PCBs design.

e) Modularity: By adopting pattern and layouts suitable for parallel or serial multiplication of such structures, big surfaces and big quantities of light can be reached. Further such LED-modules can be equipped with logic or ID-control, so they can perform as pixels or arrays in correspondingly controlled applications.

This invention has a broad scope of application ranging from possible tiny G4 to big E40 LED-Bulb applications, to adaptable replacement-solutions for existing or new types of wall- or ceiling apparatus or any kind of freely shaped surface-lighting of small, modular or substantial dimension (e.g. barrel-shaped bill-boards). The invention may be used also in streetlights or in the automotive field. High, mid or low power LEDs, COB or as defined hereafter COFB, and even remote phosphor may be applied to make use of the principles specified in this invention.

Definitions (Description – Part 2):

<u>Flexible Printed Circuit Board (PCB)</u>: Even if in fact a flexible printed circuit is NOT a "board" the term PCB is used since it is industry standard. Also not necessarily the circuits need to be applied by "printing" technology the invention sticks to the term PCB for it's ease of use. Flexible PCBs may be made of Polyimide but are not limited thereto. These PCBs are normally a composition of carrying material with a layer of conductive material in front and – if required – another one in rear. The conductive layers are normally protected with laminate materials or varnish. This invention clearly differentiates to applications and claims where rigid PCB is used – even if flexible PCB-material may be used to interconnect such rigid PCBs. This invention also differentiates from rigid PCBs that may be bendable to one side if only one side is used for conductive layers. The aim of this invention is to integrate a number (1..n) of potentially three-dimensional PCB-Surfaces that are interlinked on the same unit of PCB. Such "single-free-cutout" pattern shall be bent and fixed to obtain designated two or three dimensional lighting units with virtually no limitation to geometric shape.

Chip on Flexible Board (COFB): Since this COFB-technology is an innovative approach proposed here, it requires some effort to deduct and define the intention of the term. COB (Chip on Board) defines normally a solution where a LED-Chip is attached directly to a PCB-Substrate. Typically such substrates are made of Ceramics, Aluminum or other materials providing a good heatsink and rigid protection along with built-in reflectors or other function. With the increased popularity of filament LEDs some new kinds of substrate have found their way to the markets. For Filament LEDs a number (typically 7..10 pcs) of very low power LED-Chips is placed in series on a very slim glass or aluminum strip-substrate. Then by bonding to each other and to the circuit at the end of the substrate the LED-Chips get connected. Glass-Substrate has the advantage of permitting the light transmission to both sides of the substrate and a little bit of heat-abduction while aluminum "threads" have better heat abduction but may chop some of the light. Both technologies are very subtle and filigree for making and in particular for applying the phosphorus to the LED-Filament. Further the assembly-process to obtain filament-based Lamps (looking like "original" bulbs) is very cumbersome and implies a lot of manual labor.

The positioning of LED-Chips directly to a flexible and transparent substrate (COFB) will bring a risk of damage to the bond-wires in case of rough handling or bending but in the same the flexibility of substrate will resist and protect the wires and LED-Chips from too harsh movements relative to the tiny sizes inside the assembly. By using the other principles of this invention the final assembly of flexible substrate is very easy in comparison to "glassy" substrate – actually no (or very limited) assembly of LED-Modules will be required. In order to assure a proper functioning of the COFB-Principle a number of technical requirements will have to be defined. Next to the COFB-Principle a "sister"-principle of placing LED-Chips directly into (!) the substrates will be discussed (CIFB-Technology – Fig. 10).

Lighting Device: The invention clearly aims for lighting purposes. Applications for arrangements of controller or other electronics are not in the primary focus, even if they may contain some LED lighting units to indicate a control-status.

Heat-Sink: Even if LEDs are very efficient the energy supplied to them will be transferred to structural heat in an extent of around 90%. Sustainable lighting devices must therefore foresee the abduction and dissipation of the heat generated in the LEDs. By using the particular characteristics of flexible PCBs, double sided conducts and possible optimization of the PCBs surface, the heat of the targeted lighting devices shall be fully dissipated by the flexible PCBs. Additional heat-sink capacity (e.g. aluminum cooler) shall be attached only if required. If needed, additional cooling can be provided by abducting heat with "extra-heat-pads" attached as wings to the PCBs structure or by using a PCBs duct as a heat-pipe to lead excessive heat to an "external" dissipation-device.

Modularity: When a lighting module is done in a pattern that can be used in a cluster of double or multiple (1..n) without changing the general setup of the arrangement this is considered being modular. It is foreseen to provide such lighting modules to enable the creation of big surfaces of lighting-modules, arranged in flat or three dimensional manner.

Definition of Elements used in illustrations with their reference-numbers:

1. *Flexible PCB: Composition of bendable materials to enable the operation of electronic components by leading electricity through the conducts of the material. The composition consists of different layers of materials to perform different functions such as isolation, conduction, etc.*
2. *PCB-Carrier-Material: Isolating material (for flexible PCBs e.g. Polyimide – but not limited thereto) to constitute and carry the structures of a printed circuit.*
3. *PCB-Conducting layers (Conductors): Typical flexible PCBs consist of one or two conducting layers. Typically the Front-Layer is used for small "local" circuits while the layer on the PCBs rear is used for the supply with current throughout the PCB.*

4. Via: Conductors / conducting layers on the two sides of the PCB (or on multiple layers) are inter-connected with plated-through holes named "via".
5. PCB-Isolation layer and optical enhancements to the layer(s): Electric isolation is a vital function of PCBs. Such isolation can be composed of Laminate, LED-phosphor (on COB), Varnish, absence of material ("air" or vacuum), liquids or other method if applicable. An interrupt (by void, cut, break, etc.) of optically carrying material can be required for "optical isolation". This may be the case to prevent (blue or red) LED-light from COFB-LED-Chips to escape through its transparent PCB carrying substrate (that would function as an optical duct if not interrupted).
   The isolation layer of a PCB being subject to this invention shall however possibly abduct the heat of a conductive layer to the next layer above or to the ambient of the PCB. Therefore isolating layers may be optimized for their heat sink-function or they may be additionally equipped with particular surface to increase heat dissipation. Transparent or partly opaque flexible isolation layers may be utilized to distribute the emitted light over a desired surface. In order to do so a transparent substrate can be provided with (printed, engraved, etc.) structure in order to capture eventually inducted light for redistribution (principle known from LED-Panels). By the use of the principles in this invention three dimensional illuminating shapes are possible. Consequently the principles of this invention are equally applicable for structures made on the basis of OLED (flexible Organic LED materials).
6. PCB information Layer(s): Text or numeric information can be added to a PCB e.g. by modifying conductive layers by removing "negative text" from the corresponding surface. The same method could be used for "negative information" on the isolating layer. More commonly however is the application of data or marketing-information to the top-surface of the isolating or heat dissipating layer.
7. Connector: A connector is a unit on the PCB foreseen to connect this same to another element of the functioning system. Connectors may be used to attach a standardized Base to the apparatus or to attach a controller, driver or also to attach other PCB-Elements in a modular system. Connector may find embodiments as solder-points (often coinciding with a Via) or as a jack- or plug-module soldered to the surface of the PCB. Wiggle-Line-Contacts leading the PCBs conducts to another system-element may be part of some embodiments.

Description – Part 3:

Listing and brief description of the illustrations & drawings:

Figure 1.	shows a typical example of a G4 LED-Corn-Lamp next to a G4 Halogen-Lamp
Figure 2.	shows a scheme of a G4-LED-Corn-Lamp made of flexible PCB
Figure 3.	shows a possible PCB-pattern for a materialization of the lamp illustrated in fig. 2
Figure 4.	shows options to increase the heatsink surface to flexible PCB-pattern
Figure 5.	shows a methods to stabilize & shape flexible PCB without using additional components
Figure 6.	shows possible enhancements of PCB-Segments to add functionality
Figure 7.	shows possible generic PCB-Pattern for modular application
Figure 8.	shows additional optical elements attached to an embodiment made of flexible PCB
Figure 9.	shows two methods for making COFB assemblies (LED-Chips On Flexible Board)
Figure 10.	shows two methods for making CIFB assemblies (LED-Chips inside Flexible Board)
Figure 11.	shows a possible cutout-pattern for an E27 A55-Replacement Lamp using CIFB
Figure 12.	shows a Mockup of E27 A55-Replacement Lamp using the CIFB-Pattern of Fig. 11

Detailed description of the invention – Part 4:

Figure 1 shows an example of a G4 Halogen Lamp and its LED-Substitute next to it. Actually many substitutes of traditional lamps are made by a pattern of so called "Corn Lamps". Corn Lamps received their name due to their appearance as the single LEDs look like Corn on a Cob (maize). Corn Lamps are typically an assembly of a number of relatively low power LEDs in an arrangement to ensure a desired light distribution. The quantity of LEDs and their power determine the flux of the apparatus. Such arrangement has some advantages in comparison to morphologies based on power LEDs emitting big quantities of light to one direction and requiring structural heatsink in an extent corresponding to their power. The relatively low power in the (big) number of LEDs on a corn makes heat-management easier – it is normally dissipated by the PCB or "absorbed". The distribution of light according to the positioning of the individual LEDs is another advantage.

In spite of these advantages corn lamps are "fighting for acceptance" in the market. Many potential customers perceive them as low quality "tinker-items". This is often due to their lack of engineering and aesthetics. Another issue is the fact of relatively high price, since these lamps employ a high number of LEDs and typically a big share of manual labor. The present invention will help to improve the engineering and make of such typologies of lamps or lighting arrangements by optimizing the following functions:

- *a) Use of flexible-PCB-Pattern to engineer lighting elements from possibly one single unit of PCB containing all LED-light sources. This PCB-Module shall be shaped and fixed to position with innovative ways and methods to reduce soldering and mechanical assembly to a minimum.*
- *b) Improve the heatsink function of PCBs used for such lighting products to ensure high efficiency and life expectancy. Therefore the use of double sided PCBs shall ensure the double-sided abduction and dissipation of heat generated by the electronic components (mainly LEDs).*
- *c) Enhance the functionality of lighting apparatus making use of the flexibility of adequate PCB. Along with the light weight of this material also the possibility of giving strength by controlled shaping the PCB-Material shall be considered.*

Considering the corn lamp shown in fig. 1 it seems obvious that the traditional technology is limited to some extent in its development. The technology of applying flexible PCBs will disclose a wide range of "unexpected" applications while enabling a new level of industrialization of LED-Lighting.

Figure 2 shows a simple product to replace products as shown in fig. 1 based on flexible PCB. All the lighting-part of this G4 LED lamp is placed on a double sided flexible PCB. This flexible PCB is in its final structure strong enough to fulfill the lamps static requirements when installing and in operation. The use of latest technology LEDs also allows the placement of printed information (legal requirement often not considered in small corn lamps of "old style"). Looks and haptics of the new product are much "smoother" and will improve the acceptance. The air convection enabled with this arrangement will – by making use of the rear side of the PCB – significantly increase the heatsink of this product in comparison to a traditional corn lamp.

Figure 3 shows some of the elementary steps for the "making of" a lamp as shown in fig.2. Please note that the invention is clearly targeted also to bigger lamps and apparatus to generate big amounts of light, even for public lighting. This "tiny" arrangement is used here for the ease of understanding and illustration. The principles of this invention are explicitly applicable also to big and powerful lighting apparatus.

Figure 3.1 shows the cutout pattern of the PCB-Module. It shall be mentioned here that the cutout will normally be done when the "raw" PCB is finished in all its layers. However it will be essential for the efficient industrial production and for the assembly of these products that entire sheets of PCB will be produced. Such sheets will be typically containing several (1..n) PCB-Modules and they are equipped *with devices for alignment of the sheet throughout the following process of equipping with electronic components and LEDs. The single Module will remain connected to the sheet by predetermined breaking points until the production will no longer require alignment for automated processing or for ease of workflow. Such predetermined breaking points are illustrated in fig. 7 in relation to the positioning and detachment of "wiggle" connectors.*

Figure 3.1 also shows the "long-hole" cutouts to determine the easy and correct folding of the sections. Besides these cutouts there are through holes to prepare the "vias" of the PCB.

Figure 3.2 shows the rear conductive layer of the flexible PCB. This layers first purpose is to supply the entire PCBs surface with electric potential. The layout of this "supply-layer" is designed to enable individual provision and control of every "branch" and element on the PCB. Voids in the supply-layer are added to make the fold easier and precise in designated locations. The maximization of the conductive layer in relation to the entire surface of the PCB is mainly intended to utilize the ability of heat conduction by the layers material. The heat – normally inducted from the opposite side layer bearing the LEDs – will be absorbed and dissipated by the opposite supply-layer. By applying a surface optimized for heat dissipation, such layer can contribute greatly to increase the heat dissipation capacity of an LED-application.

Figure 3.3 displays the front circuit of the PCB. The arrangement of conductive surfaces and vias enables the individual supply with electric potential to every element of the PCB. Big and multiple Vias can help to maximize the heat transfer from the front to the back-side. However – a big part of heat will be transferred through the PCB-carrier. To maximize this desired effect all surfaces of the circuit layers conducts are extended as much as possible. In "opposite" alignment with the "supply-layer" also the front layer foresees "voids" to enable easy and correct bending of the PCB.

Figures 3.4 to 3.6 depict a number of steps in the process of making LED-Modules. Figures 3.7 and 3.8 show how the flexible PCB assembly is attached to a controller / driver-PCB and finalized with a plastic cover to close the bottom of the product.

Figure 4.1 and 4.2 show two possible embodiments of increasing the heatsink-surface by adding surface to the PCB. The number of variants and arrangements of such "heatsink-pads" is numerous. For the effective abduction of heat an optimum between additional surface and gaps for air convection must be targeted. However: The temperature inside the LED (and other electronic components) is relevant for its lifetime. Additional surface to abduct and distribute heat will be of benefit as long as the system temperature can be lowered. Having high temperature on a dissipation wing is not a problem as long as the temperature in the LEDs is lowered by the use of more surface or abduction.

The selection of two reference-methods to illustrate this inventions potential does not exclude the protection of all other variants that make use of claims of this invention.

Figure 5 depicts a schematic illustration of possible materialization + arrangement of flexible PCB in order to obtain stable or shaped embodiments without using additional structural parts. The fully disclosed 6 degrees of freedom for the design of lighting equipment based on this inventions principles is unlimited. Not only these principles allow the development of embodiments in three dimensions but also they allow directing the surfaces in the direction of required intent.
The present invention integrates a new approach for static and heatsink design for LED-Lighting-Modules. The objectives of this integrated "static heatsink" via the PCBs surface are the following:

- *abduct the heat reliably to maximize endurance of the lighting modules*
- *provide static strength and shape to the lighting modules*
- *save weight to keep the entire apparatus weight within lowest limits*

- *ease of make at low cost*

Figure 5 is limited to the basic principles of shaping. The extension of the heatsinks surface has been shown in fig. 4. In many embodiments of lighting devices several shapes according to figures 4 and 5 will be integrated to "complex" cutout pattern to produce a desired surface. Dimensioning is therewith closely linked to a calculation of the required surfaces for heat dissipation in relation to the required luminous power and LED-Efficiency. The shape of the PCBs folds and bends will – along with the LEDs characteristics – determine the light distribution of the apparatus.

In case some optical enhancement is required such optical enhancement can be applied to the LEDs directly (Lenses or reflectors) or it can be attached to the apparatus as a kind of "reflector-collar" typically made of flexible and highly reflexive material. If required several such optical elements can be attached or even combined (Fig. 8).

Figure 6 shows possible functional enhancements to the flexible PCB. Thanks to the particular design (if required like this) it is possible to add functionality to the entire PCB (e.g. driver can be on board, inside or outside of the visual arrangement) or such enhancement can be done to single modules or to each of them. Figure 6 shows one example where it is possible to either switch off or to dim each branch of the apparatus. This is done by adding corresponding circuit to the front (or rear) conduct. In this example a double SMD switch will allow to completely switch off or to regulate the intensity (e.g. according to resistor) of a branch/segment on the PCB.

The variety of options to enhance functionality is almost endless. Thanks to the ease of making and controlling, this option may be an important factor for the success of such structure. This may be the case e.g. when such LED-apparatus will be used for pathway lighting in a "fungus luminaire". The direction of light can be directly influenced. Disturbing light illuminating houses or private yards can be dimmed or switched off with no effort – right at location and with increasing energy efficiency (unlike shading).

The following is a list of possible functions to add to the circuit(s) if required. The listing is by nature not complete and can not mention every nuance of alternative:

- *Switching / dimming / enhancing*
- *Current control e.g. in relation to light or temperature*
- *Motion or presence sensor control directly on the single module*
- *Midnight reduction control (autonomous timer function)*
- *Digital control by LED-Module ID*
- *System failure display*
- *Aging compensation*
- *Alert or flash-mode*

Many of these functions are meaningful for the sector of public lighting. It is also main aim of this invention to propose solutions for the effective and efficient replacement of sodium or mercury vapor lamps. The proposed solutions will provide equivalent amounts of light but of much better quality. Powerful lighting solutions for indoor or outdoor applications are targeted for such project. Light weight, a relatively low glare factor – thanks to typically relatively low power on every single LED – and ease of use in combination to attractive cost will promote such system.

Figure 7 shows two modular elements of flexible PCB attached to each other by the "wiggle" attached as comprehensive part to the second module. Such modular Elements with connectors can be equipped with SMD plugs and jacks. If configured accordingly, such Modules can be connected in parallel (to increase extension capacity) and / or in series.

Figure 8 is illustrating a simple "Vietnamese Hat" reflector made from highly reflective vacuum plated plastic foil, cut and shaped with the same methods as applied for the shaping of the lighting equipment from flexible PCB. Such a simple and very low cost reflector will direct the light to the designated place. Using a number of reflectors or providing them with (similar to) parabolic shape, a bigger portion of light can be directed. It is a part of this invention to supply such "simple" enhancement-set with lighting solutions made for public lighting. By the use of such minimalist approach the effect of lighting can be improved to an impressive extent. This achievement convinces in particular when it comes to energy efficiency and in combination with the switchable elements to distributing the light exactly where it is needed – and only there.

Figure 9 depicts schematically the making of COFB-Assemblies (Chip on flexible board). Making COB on flexible board is totally new in its kind for LED-Lighting. Since the bonding of LEDs is not particularly demanding this technology is available for the making of LED-Lighting. When using transparent carrier-material to ensure the light emitting on both sides of the material the leads to be printed on the PCB will be designed very narrow – to keep the transparency in the appearance. This is however a trade-off with heat-sink. Since for the making of COFB-elements the use of very low power LED-Chips is proposed (below 100mW) the heatsink may be kept at a minimum. When aiming for opaque carrier the use of large conducts as illustrated above allows more power per LED. One additional option is to use highly reflective conductive layers (e.g. silver) to ensure a maximum emission of the LED-light eventually reflected from within the assembly. The phosphor can be applied to the LEDs and eventually to the opposite side of the (transparent) carrier by different methods. Figure 9.1 shows an image with the phosphor applied through a stencil – similar to a stencil for applying solder paste. For such transparent application it is possible / required to add Phosphor also on the "back" of the LED-chip respectively on the opposite side of the substrate. The advantage will be that the substrate emits light to all directions. Further methods and variants to apply the phosphor are not listed in detail or combination here since there are many (injection molding, remote phosphor pads, tubes or domes, etc.). All methods are applicable on one side or on both sides depending on the targeted effect and arrangement for lighting.

When placing the LED-Chips directly on transparent board or when using very small underlying conduct surface the emission of light through the material of the substrate is possible (similar to fiberglass transmission). Since this effect might cause blue or red "edged" or "glowing" PCBs it shall be avoided by adding "optical isolation" to the affected carrier material. This can be done by simply cutting it in the direction where the light shall not distribute. Another method is by applying a pattern of small perforations that could even be filled with phosphor to enhance the lights characteristics as required. As shown below (for CIFB) such diffusion effect can be highly wanted and effective. In such case methods as specified further down can be applied.

One popular method to increase the CRI is to add red LEDs to the blue ones. By blending in red LED-light Phosphor with less red-part can be used. This is normally more efficient. Concerning the phosphor also the difference between silicon-Based (flexible) phosphor shall be considered in comparison to phosphor integrated to rigid plastic. While rigid phosphor will provide some robustness to the assembly in the same this may be dangerous in relation to the moving parts. The use of soft silicone-based phosphor shall therefore be considered. It is expected that the bonding is showing better reliability when the ambient structure allows some marginal movements according to thermal or mechanical stress.

Summarizing the COFB-Technology in combination with all other developments of this invention will allow the making of light transparent, three dimensional, robust and jet flexible lighting units to perfectly replace incandescent light or halogen light. Since Flexibility is part of the name, versatile applications can be expected by making use of the principles underlying this invention.

Figure 10 depicts schematically two principles for the making of CIFB-Assemblies (Chip in (inserted to) flexible board). The novelty of this development is of a kind that it is applicable not only to flexible but also the rigid substrates such as Glass, Polycarbonate (PC), PMMA or any other adequate material. The abbreviated name for such application is CIB – Chip IN Board. Making CIB/CIFB for lighting applications is totally new in its kind. Other than based on COB-technology the substrate gets perforated in the locations where an LED-Chip shall be inserted. Such perforations can be big enough for one single LED-Chip or for a "cluster" of LED-Chips (1..n). The LED-Chips can be bonded directly to each other or by using conducts "printed" to the surface of the substrate or to an underlying carrier (becoming the conductive substrate). Such perforated "Array" can extend considerably according to the requirements and targets of the lighting apparatus.

The targets of inserting the LED-Chips to the substrate are the following:

- *Lateral emission of light to a desired extent*
- *Reduction of the "thickness" of the Assembly to a minimum*
- *Beautiful and "light" aesthetics of such embodiment*
- *Protection of the components encapsulated in the substrate or assemblies*
- *Optical enhancement in comparison to COB/COFB assemblies*

The light being emitted laterally is available for distribution throughout the surface of the substrate being used as optical duct. By adding texture to the substrate or to its surface the light carried by it can be extracted and distributed as required.

Instead of placing the LEDs directly inside the substrate a "sandwich-assembly" of two (or more 1..n) substrates and/or layers can be another method to obtain the desired results (Figure 10.2). Substrates and layers may be equipped with desired particular function (electric, optical, thermal, etc.) to optimize the results.

By using and combining different principles claimed in this invention the use of flexible and / or rigid, transparent and / or opaque substrate are disclosing totally new approaches for making LED-lighting bulbs and luminaires. However – the field of invention is not limited to flexible substrate – some principles are equally new and applicable for rigid and / or opaque substrates. Technologies may be easily combined with other technologies and materials. On top most required technologies for the making of such apparatus are available in the industry for mass production. Reliable and low cost manufacturing of effective apparatus is going to be lifted to the next level.

Since the principles of bending and folding the substrates can be applied to the OLED-technology in a similar way, the proposed methods are likely to accompany the development of lighting devices and luminaires also in the extended future for OLED-Lighting but also for displays (eventually used for lighting function as well) and for further applications to come.

Figure 11 shows a possible layout pattern for the making of a CIFB-Based replacement "bulb". This CIFB-Module is done in one single piece for the demonstration of this possibility. Since the assembly in this case may require some skills it may be considered to do such product in two or more pieces of PCB. Also it may be considered – in case the flexibility is not an essential factor for the assembly of such lamp – to use "rigid" or relatively "stiff" material for this assembly. The haptic perception may require some "mass". Such type of "Bulb-Embodiment" may create competition to "filament LEDs" but it has some advantages. The manufacturing is much easier and can be fully industrialized and automated. The surface to apply LED-Chips is much bigger than in filament lamps where for the sake of its assembly the number of filament "wires" may be restricted. With this method a very high number of LEDs and "virtual LED-Wires" can be placed inside or on top of the transparent substrate. The visual result can be very similar to filaments while the robustness of the flexible PCB is promising.

A "simulative" calculation of the possibilities of such CIFB replacement lamps shows the following figures:

- *Number of LED-Chips per "virtual Filament" (in series) = 17 (ca. 51 Volts @ 21.5mA)*
- *Wattage per LED-Chip = 0.064W => Wattage per "Filament" = 1.1W*
- *Maximum Number of proposed "Filaments" = 12 units (3 per "Quarter")*
- *Maximum Power of the Lamp = 13W*
- *Expected Efficiency = 120-150lm/W (@ 2700°K and CRI>85)*
- *Total Luminous output = 1600lm (equivalent to a 100W incandescent bulb)*

As an additional factor it can be mentioned that the provided surface on the PCB is offering sufficient space to place driver electronics too. Therefore also wanted enhancements like dimming or "double-click" control can be provided.

Figure 12 shows a Mockup based on the layout pattern of Figure 11. The proposed solution offers as an enhancement the possibility to "flip" the front-parts of the lamps wings. This is to redirect the light emitted from this part to desired direction (e.g. more to the front). All 4 elements may be flipped individually to one or the other direction. If the market will require it for better acceptance a "housing" (outer Bulb) can be added to such apparatus as it is done to protect filament LEDs. For the sake of heatsink it will be better however to assure sufficient cooling to the lighting devices.

Flexible PCB based LED-, COFB-LED and OLED-Lighting solutions and Bulbs

Claims of the invention:

1. *New typologies for effective and efficient making of well shaped and structured LED-Lighting devices from flexible PCB-Material (Figures 2-9).*

2. *New typologies for enhanced functionality of LED-Lighting devices based on flexible PCB-Material (Figures 4-9).*

3. *New principles for shaping and structuring of LED-Lighting devices based on flexible PCB-Material (Figures 3-5 and 7-9).*

4. *New principles for shaping and structuring the light output of LED-Lighting devices based on flexible reflective Material (Figure 8).*

The following Claims are referring to one or more claims above. For the ease of reading and understanding not all logical references are explicitly formulated and repeated in each single claim.

5. *Three dimensional and flexible illuminating arrangements of Claim 1, 2 + 3 typically make use of single or double sided flexible PCB.*

6. *Illuminating arrangements of Claim 1, 2 + 3 may make use of an undefined number of layers on a flexible PCB.*

7. *Illuminating arrangements of Claim 1, 2 + 3 may make use of additional wires or "bridges" to the flexible PCB.*

8. *Illuminating arrangements of Claim 1, 2 + 3 can make use of additional rigid PCB to connect to further electronic, optical or mechanical structures (Figure 3.7).*

9. *Illuminating arrangements of Claim 1, 2 + 3 are suitable to be produced in mass in a reliable and quality assured predefined process and with a high degree of process-integration and automation.*

10. *Referring to Claim 1 such three dimensional and flexible Illuminating arrangements are typically made of one single piece/unit of flexible PCB.*

11. *Referring to Claim 3 such arrangements shall be shaped and fixed to position with innovative ways and methods (Claims 23 and 24) to reduce manual soldering and mechanical assembly to a minimum.*

12. *With reference to claims 1, 2 + 3 double sided PCB ensures the double sided abduction and dissipation of heat.*

13. *Referring to Claim 12 enhancements such as micro- or nano-structural roughness or simple matte-black paint or laminate can be added to the surface of the PCB on one or on both sides to increase its heat dissipation capability.*

14. With reference to Claim 12 the thermally conductive layers of a PCB may be used to abduct heat to further surface or thermal dissipation elements added to the flexible PCB (Fig. 3.2 and 3.3).

15. Referring to Claim 14 additional heat dissipation elements can be attached to the PCBs surface by soldering, welding, gluing, screwing or by any other method considered to be suitable for attaching.

16. With reference to Claim 1 a number (1..n) of designated flexible PCB lighting devices are attached by predetermined breaking points to a Sheet of PCB throughout their manufacturing process.

17. With reference to Claim 1, 2 and 3 one or more connecting "wiggle"-elements may be incorporated to a PCBs body. Such devices are attached by predetermined breaking points on one side to the PCB.

18. With reference to claim 17 "wiggle"-connectors may be equipped with (SMD) jacks and plugs (Figure 7).

19. Referring to Claims 1, 2 + 3 the predefined PCB-Pattern shall be equipped with holes / long holes (in a row or bend) to predefine the folding locations (Figure 3.1 and Figure 5).

20. Referring to Claims 1, 2 + 3 the predefined PCB-Pattern shall be optimized in its design of the conductive layers in order to predefine the folding locations (Figures 3.2, 3.3 and 5) and therewith the shape of the apparatus. Conductive layers shall not be double sided (only in exceptional cases) in places that are intended for folding or sharp bending. For optimized bending voids shall be applied to the conducts – possibly without compromising the minimal requirements for the electric conduct capacity.

21. Referring to Claim 14 additional heat dissipation elements can be attached to the PCBs surface by extending its surface with additional heat-dissipation surfaces such as Wings or "umbrella"-shapes (Fig. 4.1 and Fig. 4.2). The folding-Lines are specified by holes or long-holes as for the main body of the lighting apparatus.

22. Referring to Claim 21 additional surfaces may be equipped with single-sided or double-sided conducts while the rule "one conduct per bending joint" (Claim 20) shall be considered for better flexibility.

23. With reference to Claim 3 additional "cross-bendings" or "attach-latches" (and further methods) can be applied to the surface (Fig. 5.1). As the other elements of the flexible PCB such element can contain conductive material for increased heatsink.

24. With reference to Claim 3 angular or curved predefined bending-lines may be added to the PCB by applying perforation or long-holes (Reference to claim 20 applies). Convex, Concave and many other shapes may be generated according to predefined folding-line-pattern (Fig. 5.2).

25. Referring to Claim 24 typically no additional structural parts need to be added to a LED-Lighting-device following the principles of this invention.

26. With Reference to Claims 23 and 24 and by combining different elements in a systematic manner this invention enables the construction of bodies with 6 degrees of freedom (Fig 5.1. and 5.2).

27. With reference to Claims 23 and 24 the qualified application of bending and folding equips the flexible PCB-structure with static strength typically not requiring any additional structural part for *the assembly and operation of such lighting apparatus.*

28. *Referring to Claims 1, 2 + 3 (and following) the use of these principles enables the construction of extremely lightweight lighting structures in comparison to apparatus made in traditional manner requiring additional heatsink or structural parts.*

29. *With reference to Claims 1, 2 + 3 (and following) one or both sides of the electric conduct on the PCB may be enhanced by adding functionality by adding, jumpers, (dip-) switches, resistors, processors or other elements required to obtain a desired behavior of the apparatus.*

30. *Such enhancements with reference to Claim 29 can be done "centrally" or on every single element of the intended apparatus. Integrated individual control or logic can enhance the purpose of such luminaire.*

31. *With reference to Claim 17 Modular systems may be set up in a way not requiring any additional material for their interconnection. All required connectors and "wires" are integral to the standard of the assembly. Modules are connected and inter-connected by breaking the predetermined breaking points of the wiggle-wires and by attaching the predefined connectors (Fig. 7).*

32. *Referring to Claims 1 to 4 low cost and low weight reflectors shall be attached to the lighting apparatus. Such reflector collar or "Vietnamese hats" are guiding the light to designated location while avoiding light spill to places where it is not desired (Fig. 8).*

33. *The materialization of reflectors corresponding to Claim 32 can be done by applying the same methods as used for the making of shaped PCB. The material in use can be the same as PCB carrier equipped with highly reflective (vapor coated) surface.*

34. *In reference to Claim 32 light emitting bodies and reflectors shall be equipped with easily fitting Jacks and plugs to attach the reflector(s) fast and securely in the desired position(s).*

35. *When applying reflectors according to Claim 32 the use of multiple reflectors can enable the total cut-off of the light beam and the perfectly targeted distribution of the light. An unlimited number of reflectors may be attached to the lighting body (1...n) and such reflectors may be of the same or of variable shapes to obtain desired results. "Do-it-yourself"-Reflector-Kits shall be offered for local adaptation if desired.*

Separate Section for the claims concerning COFB:

36. *Referring to Claim 1 of this invention the application of LED-Chips shall be attached to flexible substrate material (COFB, Fig. 9.1 and 9.2).*

37. *Like on a glass substrate of a filament LED in relation to Claim 36 the LEDs emit their light also to all sides when applied to transparent flexible substrate.*

38. *When using transparent material according to Claim 37, the conductive leads shall be designed in small extension to allow the unhindered diffusion of light to all directions.*

39. *When using electric and thermal conducts of small dimension with reference to Claim 38, the LEDs shall be operating at very low power to avoid overheating. Instead a big number of LEDs shall be set in series to allow low current and relatively high voltage for their operation.*

40. In reference to Claim 36 for the use of opaque substrate, the use of large conductive layers is recommended.

41. Referring to Claim 40 the use of conducts with high degree of reflection (e.g. silver) is recommended to allow the maximum of light being emitted away from the substrate.

42. In relation to Claim 36 (and ff.) the phosphor can be applied directly to the LED-Chips.

43. Referring to Claims 37 ff. for the use of transparent substrate the application of phosphor to the rear side of the substrate is required (fig. 9.1).

44. In relation to Claims 36ff the required phosphor can be applied by stencil-printing similar to the application of solder paste for the assembly of SMT components (fig. 9.1).

45. In relation to Claims 36ff the required phosphor can be applied by casting it over the LEDs (fig. 9.2).

46. In relation to Claims 36ff the required phosphor can be applied by injection molding over the LEDs.

47. Referring to Claim 1 and 36ff a mix of blue and red LED-Chips can be applied to increase the CRI and to lower the color temperature of the assembly if required.

48. With reference to Claim 36ff the use of silicone-based phosphor is possible.

49. With reference to Claim 36ff the use of rigid or remote phosphor is possible.

50. Referring to Claims 36ff the use of 2 or more bonding-wires (1..n) (Fig. 9.1 and 9.2) may be considered to ensure the reliability of the connections throughout the lifetime of the apparatus.

51. With reference to Claim 36ff the number of LED-Chips or other electronic components added to the COFB circuit is not limited (1..n) (Fig. 9.1).

52. With reference to Claim 51 it is a target to increase the voltage in order to reduce the current of the solution. This for better efficiency.

53. With reference to Claim 36ff and when using transparent PCB carrier material the quantity of "blue" or "red" LED-light emitted to the side of the PCB material (similar to the effect of fiberglass transmission) depends on the making and quality of the LED-Chip to PCB assembly and the "quality" of the PCB carrier. In order to minimize such effect the PCB-Material can be interrupted (cut) with optical gaps (optical isolation) in parallel to the axes of the conduct or elsewhere if required. (Fig. 9.1)

54. Related to claim 53 also a method of adding a pattern of small holes (perforation) can be added to the optical conduct.

55. Related to claim 53 another method to hinder the non-desired emission of light on the side of the optical conduct is by adding a reflective layer to its edge (e.g. silver coating).

56. Referring to Claims 52 and 44-46 the "optical gaps" can or shall be filled with phosphor if this is helpful to obtain better results of lighting or light quality.

57. With reference to Claims 1 and 2 such as 36ff the use of the light emitted inside the substrate can be highly desired (Figures 10.1. & 10.2). Due to the importance of this factor a number of Claims will follow related to Claim 57.

58. With reference to Claims 1 and 2 such as 36ff, 57 and others LED-Chips can be located inside the substrate. This is particularly meaningful in case of transparent substrate. Nomenclature of the Technology = CIB or CIFB (Chip in flexible Board).

59. Referring to Claim 58 such technology is applicable for rigid substrates too (CIB). This is particularly meaningful in case of transparent substrate (examples Glass, Polycarbonate, PMMA, stiff Polyimide, etc.)

60. Referring to Claim 57 the substrate gets perforated in the locations where LED-Chips (1..n) shall be inserted (Fig. 10).

61. With reference to Claim 60 the perforation size and shape can be arranged to "host" 1 or more LED-Chips.

62. Referring to Claim 61 the cutout (perforation) shall consider the static requirements of the apparatus.

63. Referring to Claim 57 the LED-Chips can be bonded directly to each other (Fig. 9 & 10).

64. Referring to Claim 57 the LED-Chips can be bonded to conducts embedded, underlying or on the surface of the substrate (Fig. 10.1. and Fig. 10.2).

65. With reference to Claim 57 the Substrate or other layers of the assembly are used as optical duct for the distribution of light throughout the substrate (Fig. 10).

66. Referring to Claim 65 texture can be added to the substrate or to its surface to extract the light carried within (Fig. 10.1).

67. Referring to Claim 57 the substrate may be assembled to a "sandwich"-construction with 2 or more layers (2..n) providing desired particular function such as electric, optical, thermal, protective, isolation, etc. (Fig. 10.2)

68. With reference to Claims 1, 2, 36ff and 57ff the field of application can be extended to OLED – technology (organic LED) in an equivalent way and in particular for all shaping and folding-principles.

69. With reference to Claim 68 and many others, the use of OLED, COFB, CIFB and COB is suitable to manufacture light sources to replace incandescent or other type of lighting bulbs (Fig. 11 & 12).

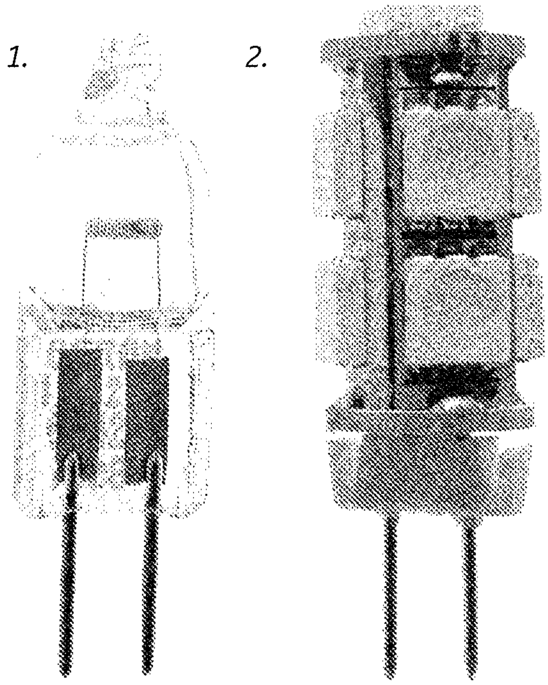
70. Referring to Claim 10 and 69 the quantification of number of Modules to the assembly is subject to an optimization of total cost of manufacture and feasibility of concept.

71. With reference to all Claims of this patent the individual or combined use of CIFB, COFB, OLED (etc.) and mechanical such as optical and electrical principles listed, is suitable to engineer a new generation of highly performing LED-lighting products.

Flexible PCB based LED-, COFB-LED and OLED-Lighting solutions and Bulbs

Drawings and illustrations

Figure 1: *Typical example of a G4 LED-Corn-Lamp (2.) next to a G4 Halogen-Lamp (1.)*



Picture source indication: Halogen Lamp & LED-Corn photographs by inventor

Figure 2: *Scheme of a G4-LED-Corn-Lamp made of flexible PCB*

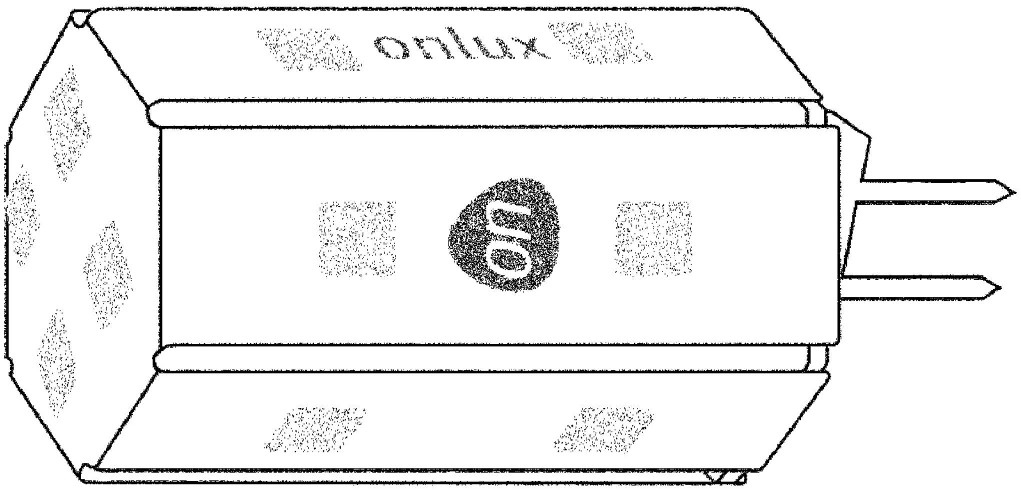
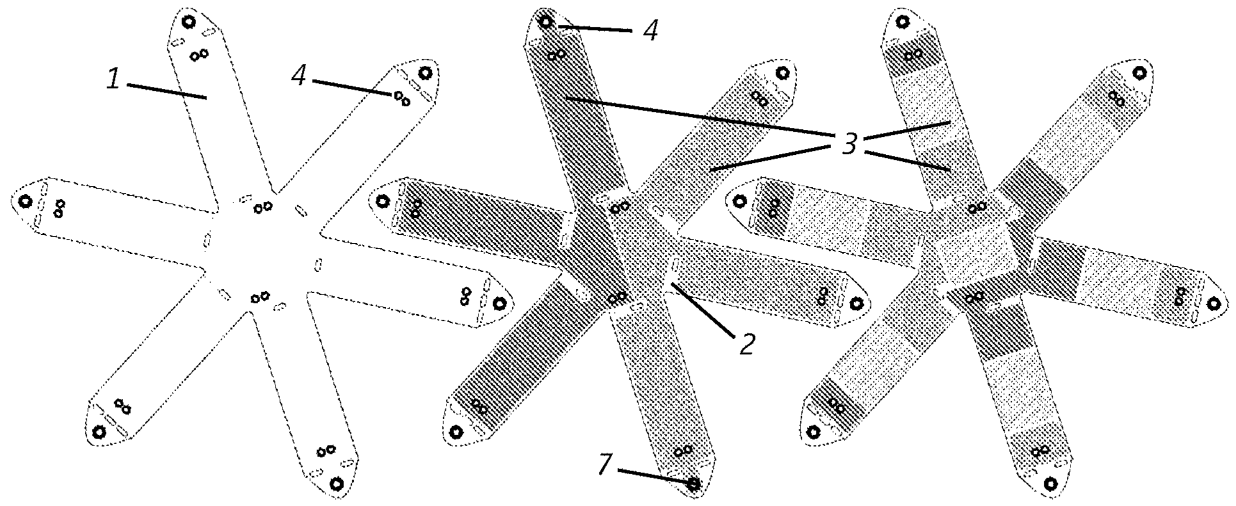


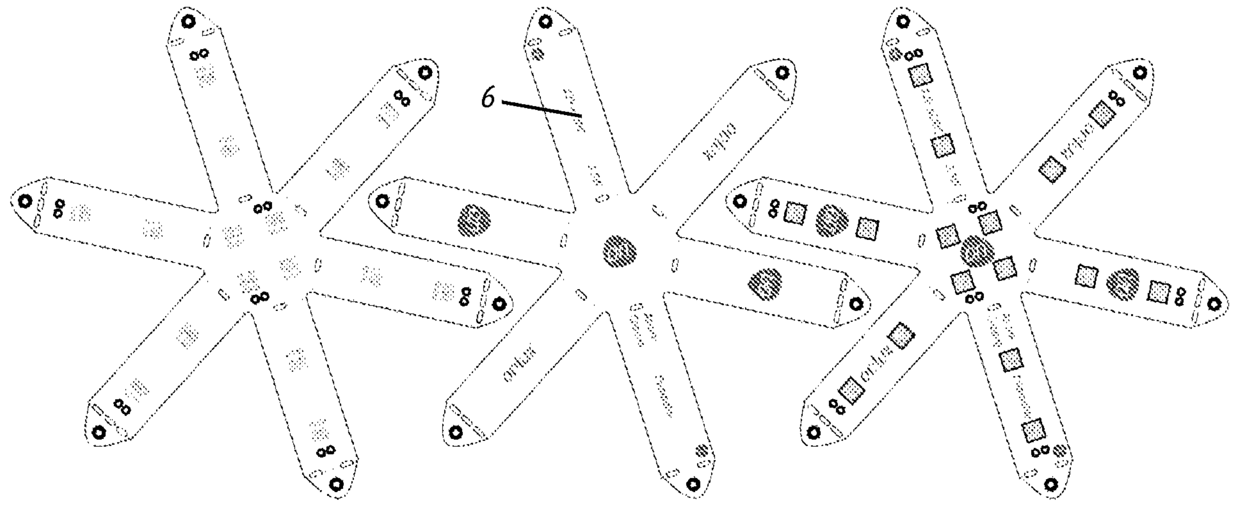
Figure 3: *Possible PCB-pattern for a materialization of the lamp illustrated in fig. 2*



3.1 PCB Cutout Pattern

3.2 PCB Rear Printed Circuit

3.3 PCB Front Printed Circuit

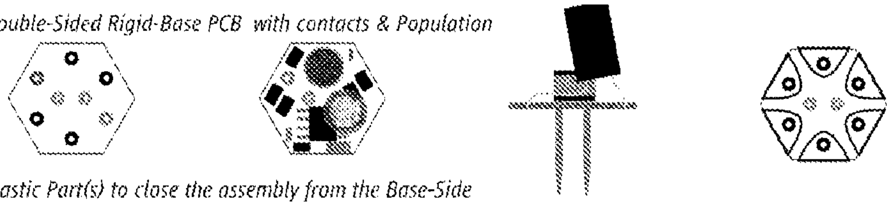


3.4 PCB Front Contacts

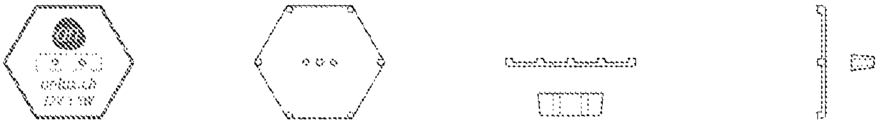
3.5 PCB Markings & Branding

3.6 Populated PCB assembly

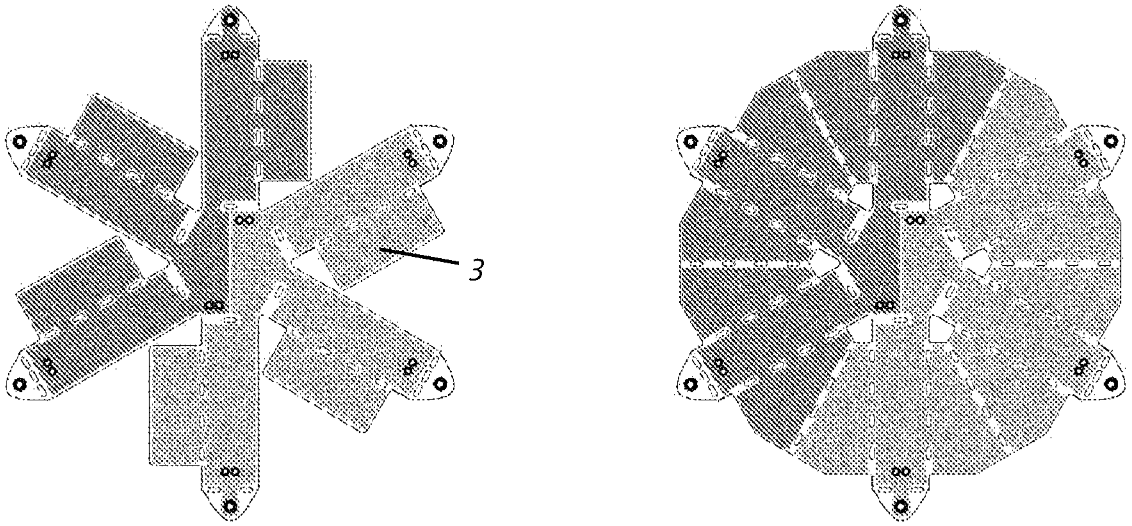
3.7 Double-Sided Rigid-Base PCB with contacts & Population



3.8 Plastic Part(s) to close the assembly from the Base-Side



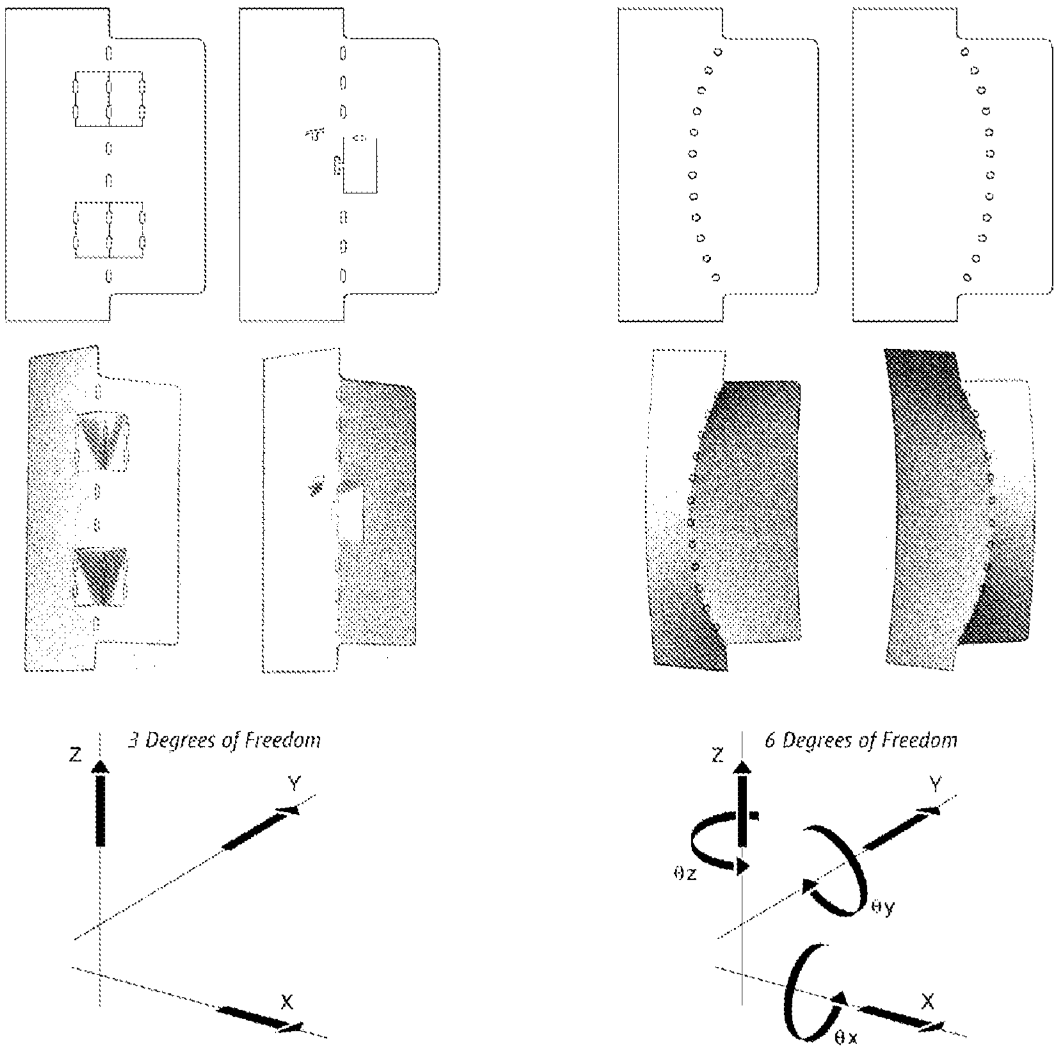
Figures 4: *Options to increase the heatsink surface to flexible PCB-pattern*



4.1 PCB with Heat Dissipation Wing

4.2 PCB with Heat-Dissipation Umbrella

Figure 5: *Methods to stabilize & shape flexible PCB without using additional components*



5.1 Stabilize PCB by cross-folding or Latching

5.2 PCB Convex and concave shape

Figure 6: E*nhancements of PCB-Segments to add functionality*

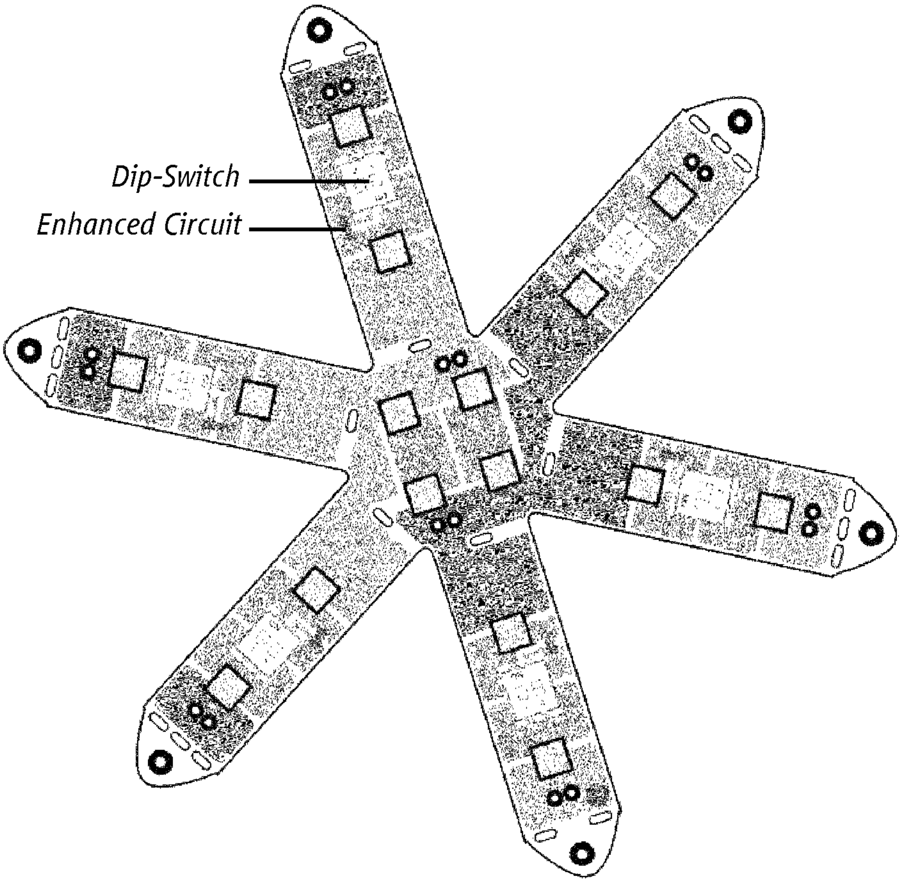


Figure 7: *PCB-Pattern for modular application*

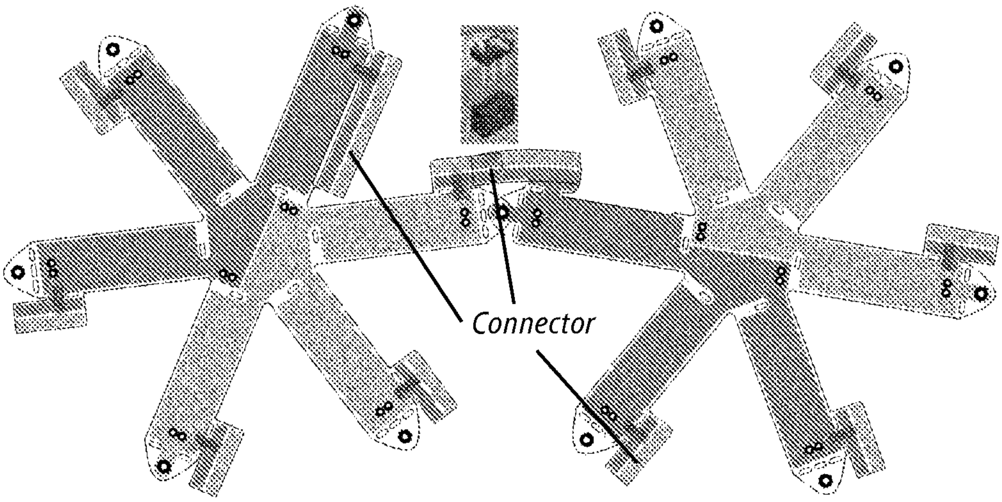


Figure 8: *Optical elements attached to an embodiment made of flexible PCB*

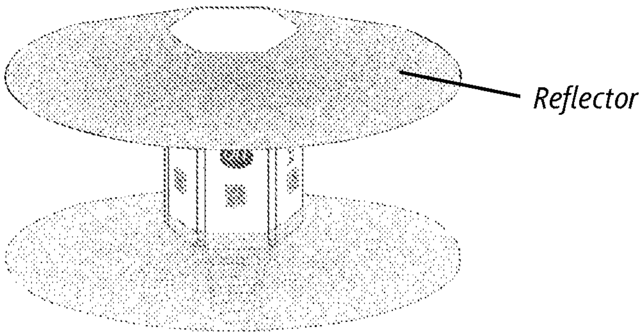
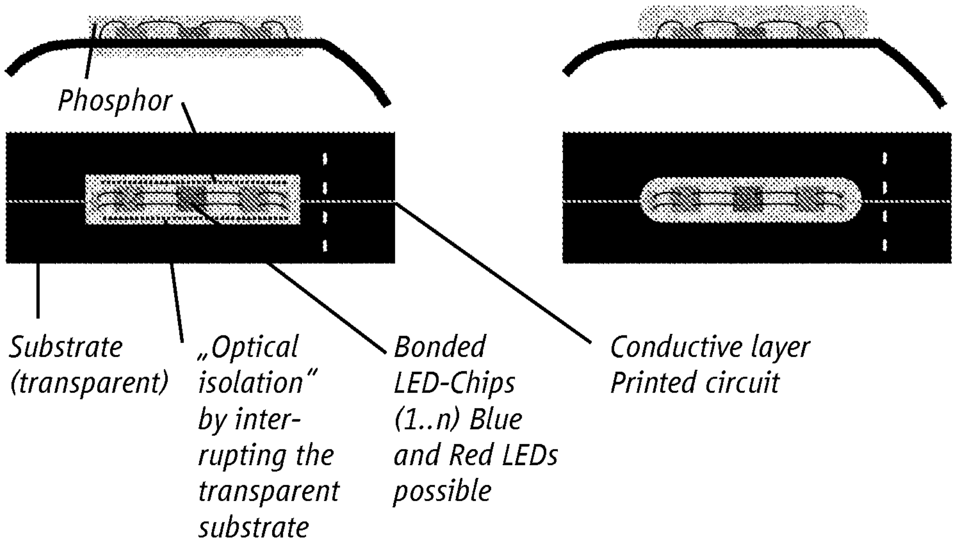
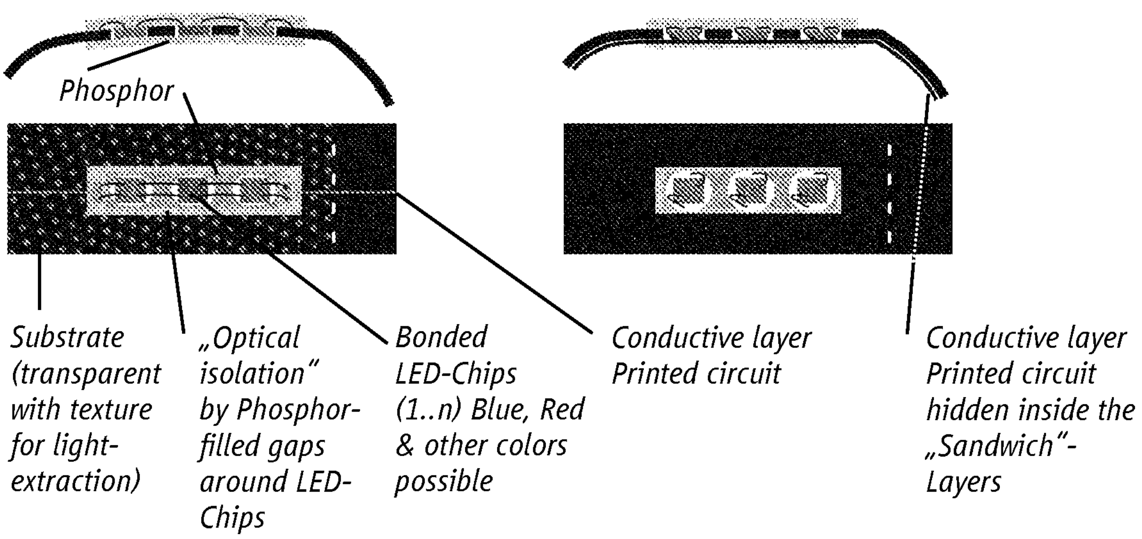


Figure 9: *Two methods for making COFB assemblies*


9.1 COFB with Stencil-Printed Phosphor on both sides

9.2 COFB with Cast Phosphor on Mirror-Back

Figure 10: *Method for making CIFB assemblies*


10.1 CIFB with Stencil-Printed Phosphor on both sides

10.2 CIFB LED-Chips inserted to PCB-Layers

Figure 11: *Method for making an E27 A55-Replacement Lamp using CIFB assemblies*

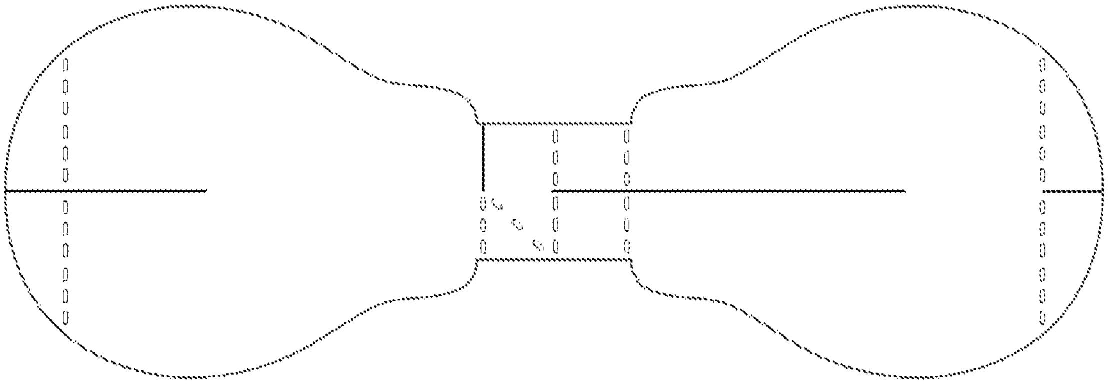
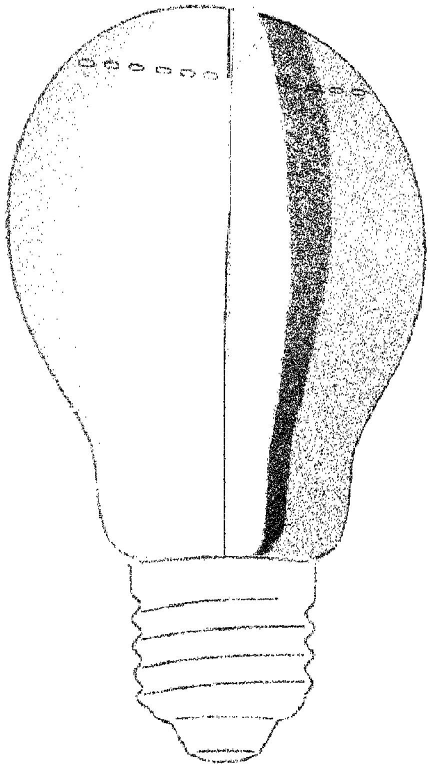


Figure 12: *Mockup of E27 A55-Replacement Lamp using the CIFB-Pattern of Fig. 11*



INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2014/060747

A. CLASSIFICATION OF SUBJECT MATTER
INV. H05K1/02 H05K1/18
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)
H05K

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	WO 2010/002156 A2 (PARK CHANG SOO [KR]; KONG BAE [KR]) 7 January 2010 (2010-01-07) abstract; figures 1-8 -----	1-4
X	GB 2 484 152 A (ZETA CONTROLS LTD [GB]) 4 April 2012 (2012-04-04) the whole document -----	1-4
X	US 2009/261368 A1 (WANG BILY [TW] ET AL) 22 October 2009 (2009-10-22) the whole document -----	1-4
X	WO 2010/034873 A1 (KONE CORP [FI]; JAHKONEN PEKKA [FI]) 1 April 2010 (2010-04-01) the whole document -----	1-4

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"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 2 February 2015	Date of mailing of the international search report 10/02/2015
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Zimmer, René

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2014/060747

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 5-71(completely); 1-4(partially)
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.2

Claims Nos.: 5-71(completely); 1-4(partially)

The present application contains 71 claims, of which 4 are independent. There is no clear distinction between the independent claims because of overlapping scope. There are so many claims, and they are drafted in such a way that the claims as a whole are not in compliance with the provisions of clarity and conciseness of Article 6 PCT, as it is particularly burdensome for a skilled person to establish the subject-matter for which protection is sought. The non-compliance with the substantive provisions is to such an extent, that the search was performed taking into consideration the non-compliance in determining the extent of the search (PCT Guidelines 9.19 and 9.25).
Claims 1-4 refer
back to the figures and contain no technical features that define an invention contrary to Rule 6.2(a) PCT and Rule 6.3(a) PCT. It is therefore not possible to understand the limitations of the dependent claims. Claims 5-71 have not been searched. The search has been limited to what can be understood from the description and the figures.

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guidelines C-IV, 7.2), should the problems which led to the Article 17(2) declaration be overcome.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2014/060747

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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