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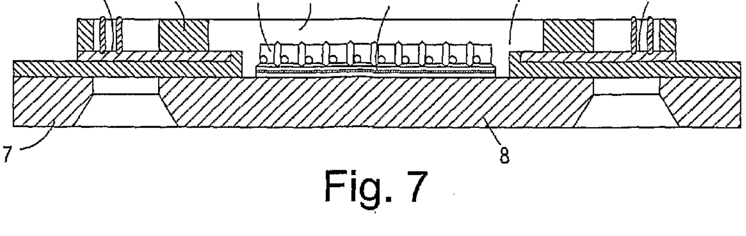

Fig. 7

(57) **Abstract:** An LED device comprising at least one LED chip (3); and a heatsink (7), wherein the LED chip (3) is thermally coupled to the heat sink (7) using a silver based thermally conductive substrate (5).

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Improved LED Device

Field of the Invention

The present invention relates to the field of light emitting diode (LED) devices, and more particularly to packaging light emitting diodes (LEDs) and other semi-conductor substrates

Background to the Invention

Light emitting diodes (LEDs) are an important class of solid state devices that convert electric energy to light and generally comprise an active layer of semiconductor material sandwiched between two oppositely doped layers. When a bias is applied across the doped layers, holes and electrons are injected into the active layer where they recombine to generate light. Light is emitted omni-directionally from the active layer and from all surfaces of the LED.

Artificial lighting for illumination purposes is incorporated in a wide variety of environments. Major categories include office lighting, home lighting, outdoor lighting for various purposes, signage, indicators, and many others, in the age of modern electricity, the common forms of artificial lighting include (but are not limited to) incandescent, halogen vapour, and fluorescent. All of these have particular advantages and disadvantages, but in certain aspects and they all use relatively large amounts of electricity compared to their light output, and all tend to have obviously finite lifetimes. In particular, the incandescent lamp has been in use in its present form for almost a century, making it one of the longest lived of modern inventions to remain in an early form, in comparison most other early electronic technologies have been replaced by digital electronic counterparts.

The semiconductor era has witnessed the replacement of many types of electrical devices with solid state counterparts. The most obvious is perhaps the replacement of the vacuum tube (almost unknown to present younger generations) with the transistor. Solid state devices, because of their nature and operation, are inherently much more reliable than earlier generations of electronic devices and can have significantly longer lifetimes, typically by a factor of at least 100.

Furthermore, some solid-state devices emit light in operation. The most common is the light emitting diode (LED) in which current is injected across a p-n junction to drive the recombination of electrons and holes with the concurrent production of photons. Depending upon the semiconductor materials from which the diode is formed, and particularly depending upon the bandgap of those materials, different frequencies of light are emitted and are characteristic of the material. For example, gallium arsenide phosphide (GaAsP) represents a well-established material system for light emitting diodes. Depending on the mole fraction of Ga and As, these materials have a bandgap of between about 1.42 and 1.98 electron volts (eV), and will emit light in the infrared, red and orange portions of the electromagnetic spectrum. In comparison, materials such as silicon carbide (SiC), gallium nitride (GaN), or the related Group III nitride compounds, have wider bandgaps of about 3.0 and about 3.5 eV respectively, and thus generate photons of higher frequency in the blue, violet, and ultraviolet portions of the spectrum.

Because of their reliability, efficiency and relatively low power demands, solid- state light-emitting devices have gained wide acceptance for a number of applications. Because the devices are relatively small, however, and comparatively less bright than more conventional alternatives (incandescent, florescent) their greatest use has been as indicators and other low brightness applications rather than for illumination.

Additionally, some of the LED properties that are favourable in many circumstances (e.g., emission along a narrow band of wavelengths), tend to make LEDs initially less attractive for illumination purposes. For example, LEDs cast only a narrow range of wavelengths. In many circumstances - often because much of colour perception depends upon the illumination frequencies - this compares unfavourably with natural light, or even incandescent or florescent light which, because of some of their inherent limitations, actually cast light across a wider range of frequencies than do LEDs.

Two types of technology are used to produce white light from light emitting diodes, in the first technology, blue light emitting diodes are combined with both red and green light emitting diodes to produce the desired full colours of the visible spectrum, including white light. In the second technology, higher frequency emitting diodes (e.g., in the ultraviolet, violet and blue range) are used in conjunction with phosphors (typically yellow- emitting) to emit a combination of direct blue light from the diode and yellow light from the phosphor that in combination give white light from the lamp.

The efficiency of a light emitting diode can be characterized in numerous manners, but in general is dependent upon several factors which in practice become cumulative in their positive or negative aspects. For example, for any given amount of current injected into a light emitting diode, some fraction less than 100% of the injected carriers (electrons or holes) will actually recombine. Of those that recombine, another fraction less than 100% will generate photons. Of the photons created, yet another fraction less than 100% will actually be extracted; i.e., leave the diode as visible light. When a phosphor is incorporated, the efficiency is moderated yet again by the conversion efficiency of the phosphor.

Based upon these and other factors, full spectrum light emitting diode devices have the potential to completely replace both incandescent and fluorescent lighting, and inexpensive, readily-manufactured solid-state lamps that emit white light remain a major goal of both researchers and manufacturers.

Accordingly, increasing the desired output of a white light emitting diode for illumination purposes requires increasing one or more of the injection efficiency, the percentage of radiative recombinations, and the amount of photons extracted. Thus, producing brighter total output at relative power levels and across a wider range of the visible spectrum to produce more pleasing effects when in use remains another continuing goal.

Typical LEDs are designed to operate with no more than 30-60 milli Watts of electrical power. In around 1999, however, Philips Lumileds introduced high power LEDs capable of continuous use at one Watt. These LEDs used much larger semi-conductor die sizes to handle the large power input, the semi-conductor dies were also mounted to metal slugs to allow for heat removal from the LED die. In order to manufacturer LEDs into lighting apparatus for standard lighting in for example homes or street lighting as a replacement for incandescent light bulbs and fluorescent lamps the LEDs have generally bee packaged as a cluster of white LEDs grouped together to form a light source. A traditional LED can be thought of as comprising an LED chip component (the power source) and an LED bulb component (the bit that the light is emitted from) typically in high power LEDs in order to achieve greater brightness than the continuous 1 Watt two approaches have been taken. These are namely the multiple LED lamp cluster type and the multiple LED chip cluster type

The LED lamp cluster type involves putting a number of individual LED chip and lamp combinations into a housing to act together as a single bulb as seen in Figures 1 and 2. Each LED chip and lamp combinations includes a standard 1 Watt high power chip and a bulb portion covering the chip to direct the light emitted from the chip. The LED chip and lamp combinations have a predetermined space which they take up and due to their size can only be packed so closely together. They have another problem in that as there are multiple individual light sources each individual light source gives off it's own circle of lighting. Each circle of light interferes with the neighbouring circles as seen in Figure 3 to give un-uniform lighting through constructive interference.

The multiple LED chip cluster type has a number of 1 Watt LED chips coupled together all directing the light emitted through a single LED bulb. The chips can be spaced closer together and a single light source is generated which has the light of the number of chips put into the single LED bulb. The problem with this is that that the chips overheat and the maximum number of chips which can be placed together without over heating is nine 1 Watt chips or combinations thereof up to a maximum of 9 Watts. If more LED chips are used then the system overheats and the bulb effectively blows.

Consequently, there remains a need for an improved LED package that overcomes or alleviates one or more of the shortcomings of the prior art packages.

Summary of the Invention

According to an aspect of the present invention there is provided an LED device comprising

a) at least one LED chip; and
b) a heat sink

wherein the LED chip is thermally coupled to the heat sink using a silver based thermally conductive substrate. This advantageous as the silver based thermally conductive substrate allows for greater thermal conduction of heat generated by the LED chip away from the LED chip to the heat sink. This allows for the LED chip to function more efficiently and produce more light energy as the thermal energy is being drawn away from the chip. Each LED chip can only function at a certain temperature, an increase above this temperature and the LED chip is effectively destroyed. As more LED chips are placed together in close proximity in a small area footprint the thermal energy produced by the surrounding LED chips will interfere with each other causing the maximum temperature to be reached more quickly, effectively limiting the input energy and therefore the light and thermal energy released. The present invention allows for more efficient removal of the thermal energy away from the LED chips which allows for more chips to be used together in close proximity in a small area footprint with increased input energy and therefore increased light energy released along with increased thermal energy which is quickly conducted away from the LED chips. The LED chips may be directly mounted onto the heat sink, rather than being mounted first to a PCB. This allows for the increased conduction of heat away from the chips and into the heat sink. The silver based thermally conductive substrate allows for the LED chips to be directly mounted onto the heat sink without the need for a PCB board. This allows for the LED chips to be placed in close proximity to each other and for the heat to be drawn away more efficiently, leading to more efficient light production.

In an embodiment there may additionally be a layer of copper placed between the heat sink and the LED chip. The heat sink is provided with a layer or coating of copper or gold and the LED chip is mounted onto the surface of the copper of the heat sink using the silver based thermally conductive substrate. The copper or gold may be directly applied to the heat sink as a coating or in the alternative may be a thin layer of copper or gold which is mounted to the heat sink, this mounting may employ the silver based thermally conductive substrate described. This advantageously provides for the first time, the direct mounting of LED chips to a heat sink without the need for a PCB board, allowing for heat to be efficiently and quickly drawn away from the LED chips. This allows for multiple chips to be placed in very close proximity, each generating light in an efficient manner.

In an alternative embodiment the heat sink is a heat pipe system located directly below the LED module. This would work to conduct the heat from the LED module.

Preferably the silver based thermally conductive substrate comprises silver and Beryllium Oxide.

Preferably the silver based thermally conductive substrate comprises silver in the range of about 75% to about 95% and Beryllium Oxide in the range of about 0.1% to about 3%.

Preferably the silver based thermally conductive substrate further comprises a halogen acyl polymer of the aromatic series.

Preferably the silver based thermally conductive substrate further comprises a halogen acyl polymer of the aromatic series in the range of about 3% to about 10%.

Preferably the silver based thermally conductive substrate further comprises epoxy resin, a thixotropic agent, a dispersant, a collodion and an organosilyl gum.

Preferably the silver based thermally conductive substrate further comprises epoxy resin in the range of about 2% to about 20%, a thixotropic agent in the range of about 0.5% to about 7%, a dispersant in the range of about 0.5% to about 6%, a collodion in the range of about 0.1% to about 5% and an organosilyl gum in the range of about 0.1% to about 10%.

Preferably the silver based thermally conductive substrate comprises;

Silver	about 75-95%
Epoxy resin	about 2-20%
Thixotropic agent	about 0.5-7%
Dispersant	about 0.5-6%
Collodion	about 0.1-5%
Beryllium Oxide	about 0.1-3%
Halogen acyl polymer of the aromatic series	about 3-10%
Organosilyl gum	about 0.1-10%

Preferably the silver based thermally conductive substrate comprises a glue.

Preferably the silver is nanometer grade silver powder.

Preferably the thixotropic agent is a polyvinyl alcohol.

Preferably the thixotropic agent is polyvinylpyrrolidone.

Preferably the dispersant is sodium lauryl sulphate, or alternatively the dispersant is sodium dodecyl benzene.

Preferably the organosilyl gum is silicon resin.

Preferably the LED device comprises a plurality of LED chips, more preferably the combined power of the LED chip(s) is greater than 10 watts, even more preferably the device comprises 10 or more 1 watt or greater LED chips.

Preferably the LED chips are first coupled together in at least 2 groups of at least 2 LED chips in series and each group is coupled in parallel.

Preferably the heat sink is provided with a layer of gold between the heat sink and the silver based thermally conductive glue, more preferably the heat sink comprises nickel plated copper or a nickel plated copper alloy.

According to a further aspect of the present invention there is provided an LED device comprising a plurality of LED chips, wherein the plurality of LED chips are first coupled together in at least 2 groups of at least 2 LED chips in series and each group is coupled in parallel.

Preferably the device further comprises a heat sink wherein the plurality of LED chips are coupled to the heat sink using a silver based thermally conductive substrate.

Preferably the silver based thermally conductive substrate comprises silver and Beryllium Oxide.

Preferably the silver based thermally conductive substrate comprises silver in the range of about 75% to about 95% and Beryllium Oxide in the range of about 0.1% to about 3%.

Preferably the silver based thermally conductive substrate further comprises a halogen acyl polymer of the aromatic series.

Preferably the silver based thermally conductive substrate further comprises a halogen acyl polymer of the aromatic series in the range of about 3% to about 10%.

Preferably the silver based thermally conductive substrate further comprises epoxy resin, a thixotropic agent, a dispersant, a collodion and an organosilyl gum.

Preferably the silver based thermally conductive substrate further comprises epoxy resin in the range of about 2% to about 20%, a thixotropic agent in the range of about 0.5% to about 7%, a dispersant in the range of about 0.5% to about 6%, a collodion in the range of about 0.1% to about 5% and an organosilyl gum in the range of about 0.1% to about 10%.

Preferably the silver based thermally conductive substrate comprises;

Silver	about 75-95%
Epoxy resin	about 2-20%
Thixotropic agent	about 0.5-7%
Dispersant	about 0.5-6%
Collodion	about 0.1-5%
Beryllium Oxide	about 0.1-3%
Halogen acyl polymer of the aromatic series	about 3-10%
Organosilyl gum	about 0.1-10%

Preferably the silver based thermally conductive substrate comprises a glue.

Preferably the silver is nanometer grade silver powder

Preferably the thixotropic agent is a polyvinyl alcohol

Preferably the thixotropic agent is polyvinylpyrrolidone.

Preferably the dispersant is sodium lauryl sulphate, or alternatively the dispersant is sodium dodecyl benzene

Preferably the organosilyl gum is silicon resin.

Preferably the combined power of the LED chip(s) is greater than 10 watts, more preferably the device comprises 10 or more 1 watt or greater LED chips.

Preferably the heat sink is provided with a layer of gold between the heat sink and the silver based thermally conductive glue.

Preferably the heat sink comprises nickel plated copper or a nickel plated copper alloy.

According to yet another aspect of the present invention there is provided a silver based thermally conductive substrate for use in thermally connecting semi-conductor substrates to a heat sink.

Preferably the silver based thermally conductive substrate comprises silver and Beryllium Oxide.

Preferably the silver based thermally conductive substrate comprises silver in the range of about 75% to about 95% and Beryllium Oxide in the range of about 0.1% to about 3%.

Preferably the silver based thermally conductive substrate further comprises a halogen acyl polymer of the aromatic series.

Preferably the silver based thermally conductive substrate further comprises a halogen acyl polymer of the aromatic series in the range of about 3% to about 10%.

Preferably the silver based thermally conductive substrate further comprises epoxy resin, a thixotropic agent, a dispersant, a collodion and an organosilyl gum.

Preferably the silver based thermally conductive substrate further comprises epoxy resin in the range of about 2% to about 20%, a thixotropic agent in the range of about 0.5% to about 7%, a dispersant in the range of about 0.5% to about 6%, a collodion in the range of about 0.1% to about 5% and an organosilyl gum in the range of about 0.1% to about 10%.

Preferably the silver based thermally conductive substrate comprises;

Silver	about 75-95%
Epoxy resin	about 2-20%
Thixotropic agent	about 0.5-7%
Dispersant	about 0.5-6%
Collodion	about 0.1-5%
Beryllium Oxide	about 0.1-3%
Halogen acyl polymer of the aromatic series	about 3-10%
Organosilyl gum	about 0.1-10%

Preferably the silver based thermally conductive substrate comprises a glue.

Preferably the silver is nanometer grade silver powder

Preferably the thixotropic agent is a polyvinyl alcohol

Preferably the thixotropic agent is polyvinylpyrrolidone.

Preferably the dispersant is sodium lauryl sulphate, or alternatively the dispersant is sodium dodecyl benzene

Preferably the organosilyl gum is silicon resin.

According to another aspect of the present invention there is provided an improved packaging of semiconductor devices which allows for increased power to be inputted into a semiconductor device.

According to still another aspect of the present invention there is provided an LED device comprising

a) at least one LED chip;

b) a heat sink;

c) a layer of gold provided on the upper surface of the heat sink between the heat sink and the LED chip;

d) a plastic surround surrounding the LED chip on the upper surface of the LED chip; and

e) a silicon resin set inside the plastic surround to cover the upper surface of the LED chip,

wherein the LED chip is thermally coupled to the heat sink via the layer of gold using a silver based thermally conductive substrate.

Brief Description of the Drawings

The present invention will now be described by way of example only with reference to the accompanying drawings, wherein:-

Figure 1 is a standard multiple LED light of the prior art showing individual LED devices mounted in a housing.

Figure 2 is a standard multiple LED light of the prior art showing individual LED devices mounted in a housing.

Figure 3 is a shadow pattern cast on the ground showing areas of interference when individual LED devices are mounted in a housing to create a lighting device.

Figure 4 is a schematic of an LED device according to the present invention.

Figure 5 is a simple circuit diagram of an LED device according to the present invention.

Figure 6 is a schematic of an LED device according to the present invention.

Figure 7 is a schematic of an LED device according to the present invention.

Figure 8 is a schematic of an LED device according to the present invention.

Figure 9 is a schematic of an LED device according to the present invention.

Figure 10 is a schematic of an LED device according to the present invention.

Figure 11 is a schematic of an LED device according to the present invention.

Figure 12 is a schematic of an LED device according to the present invention.

Figure 13 is a schematic of an LED device according to the present invention with dimensions.

Description of the Preferred Embodiments

The present embodiments represent currently the best ways known to the applicant of putting the invention into practice. But they are not the only ways in which this can be achieved. They are illustrated and they will now be described, by way of example only.

Referring to Figure 4, this illustrates a schematic diagram of a new packaging for a super high-power LED. The packaging arrangement comprises a plurality of LED chips 3, preferably 1 Watt chips although these can be 3 Watt or 5 Watt or higher as dictated by the LED chips commercially available and determined suitable for use by the LED chip specialist. The plurality of LED chips 3 are coupled to each other in serial or in multiple serial in parallel as illustrated in Figure 5. Power in the form of electricity is then fed into the plurality of LED chips 3 by means of gold leads 4 connecting the LED chips 3 to a positive plate 1 and a negative plate 2 to complete the circuit. The packaging arrangement further comprises a bottom layer comprising nickel plated copper or copper alloy such as brass or red brass 7 this acts as the lowest heat sink layer and as the radiator for heat drawn down into this layer from the LED chips 3. On top of the nickel plated copper or copper alloy such as brass or red brass, 7 is provided either a layer of gold or copper 8 which acts as a secondary heat conducting layer to draw the excess heat produced by the LED chips 3 away from the LED chips 3. On top of the copper or gold layer 8 is provided a layer of a super thermal conducting silver glue 5, which acts to thermally connect the LED chips 3 to the heat sink unit and acts as the first heat conducting layer to draw the excess heat produced by the LED chips 3 away from the LED chips 3. On top of the LED chips 3 to seal the unit and to enable a uniform light source to be created a bulb or reflector 9 is formed from a silica gel packed layer housed within a plastic framework 6 which acts to direct the light produced by the LED chips 3 to the desired target location. Alternative arrangements or the same components are found in figures 6 to 10 wherein the same numerals represent the same components.

Figures 11 and 12 illustrate top and side schematic views of an improved packaging for semiconductor devices of the present invention.

Figure 13 illustrates, with measurements, an improved packaging for semiconductor devices of the present invention.

The super thermal conducting silver glue 5 is made up of a number of components in a range of percentages as detailed below:

1. Nanometer grade Silver Powder 75-95%
2. Epoxy resin 2-20%
3. Thixotropic agent and/or protective agent (Polyvinyl alcohols such as vinol, ` Povidone or AEO-7 i.e. Polyvinylpyrrolidone) 0.5-7%
4. Dispersant (Sodium Lauryl Sulphate or sodium dodecyl benzene) 0.5-6%
5. Collodion 0.1-5%
6. Beryllium Oxide 0.1-3%
7. Halogen acyl polymer of the aromatic series such as an aromatic halide polymer 3-10%
8. Organosilyl gum such as Silicone resin 0.1-10%

Table I below shows typical amounts of the components for use in an LED device with an LED chip with a power less than 30 Watts.

Table II below shows typical amounts of the components for use in an LED device with an LED chip with a power between 30 and 70 Watts.

Table III below shows typical amounts of the components for use in an LED device with an LED chip with a power above 70 Watts or less.

Wattage of LED Lighting	**Components and Percentage of Heat Conductive Glue Applied**	
TABLE I	Silver	79%
	Epoxy resin	11%

	Thixotropic agent	1.3%
Below 30 Watts	Dispersant	0.9%
	Collodion	0.8%
	Beryllium Oxide	2.5%
	Halogen acyl polymer of the aromatic series	3.0%
	Organosilyl gum	1.5
	Silver	83%
	Epoxy resin	7.2%
TABLE II	Thixotropic agent	1.5%
	Dispersant	1.2%
30 – 70 Watts	Collodion	1.1%
	Beryllium Oxide	2.8%
	Halogen acyl polymer of the aromatic series	1.8%
	Organosilyl gum	1.4%
TABLE III	Silver	90%
	Epoxy resin	4.0%
Above 70 Watts	Thixotropic agent	1.0%
	Dispersant	1.0%
	Collodion	0.3%
	Beryllium Oxide	2.0%
	Halogen acyl polymer of the aromatic series	1.0%
	Organosilyl gum	0.7%

The super thermal conducting silver glue 5 is formulated so as to have a higher heat conductivity coefficient compared with present glues.

The super thermal conducting silver glue 5 is formed by

a) pre-treating the powder forms of the raw materials
b) dosing a certain proportion of solution
c) dosing epoxy resin
d) dosing thixotropic agent
e) dosing nanometer silver powder
f) supply remaining solution.

Figure 6 shows a type of packing structure for a super high-power LED, the bottom of the plane-type super thermal conductor piece 5 has a surface mount technology (SMT) level installation plane 8 with a position-limit grid. The LED chip 3 is installed on the installation plane 8 through connection 5. The plane-type super thermal conductance piece 5 is coupled with the radiator 8 or heat sink. The radiator or heat sink 8 is fused with the 2-stage super thermal conductance piece 7 as one with a chemical plating method, so as to connect an LED chip on the installation surface of the plane-type super thermal conductance piece 5. According to the position-limit grid and usage requirements, there is a serial-parallel connection to achieve high integration requirements.

Gold wire 4 connects the positive and negative poles between the middle LED and the LED. Gold wire 4 connects the positive and negative poles of the LED at the 2 ends with the positive pole wire terminal 1 or negative pole wire terminal 2 separately. And then through the positive pole wire terminal 1 or negative pole wire terminal 2, it is coupled with the control driving PCB.

White plastic 6, silica gel packed layer 9 and nickel plated copper or copper alloy such as brass or red brass, 7 form the packing structure of the LED.

In order to realize LED civil lighting, the improved LED device provides a new type of super high power LED-packing structure, which improves the heat radiation performance of the LED light bulb, lamps and lanterns, and extends the LED bulb lifetime and increases LED lamp power.

Therefore, the improved LED device adopts the following technical scheme: a new type of super high power LED packing structure, including the applied new model, an LED chip and radiator. The characteristic being: a super thermal conductor designed between the mentioned radiator or heat sink 7 and each LED chip 3. An installation plane is designed on the super thermal conductance piece. And the LED chip 3 group is designed on the installation plane. In this packing structure, the LED chip 3 can be directly coupled on the super thermal conductance piece (the super thermal conductance silver glue 5) through the installation plane. The heat, which is generated when the LED chip 3 is working, is transferred to the 2-stage super thermal conductance coating (the super thermal conductance silver glue 5) on the radiator or heat sink 8. The 2-stage super thermal conductance coating transfers the heat to the radiator for radiation. The radiator and the super thermal conductor inside are designed to have a 2-stage plating coat of super thermal conductors with a position-limit grid. The mentioned radiator is designed to have an interface of thermal conductance. The 2-stage plating coat of super thermal conductance material applies a chemical turmeric method to deposit the thermal conductance interface. The LED chip 3 is used to connect the super thermal conductance piece directly, with the installation plane set on the super thermal conductance piece, so as to optimize its structure, to increase the rate of thermal conductance, to improve the heat radiation performance after the LED is on and the luminescence ratio of the chip, to extend the LED lifetime, and to make it easier to make high-power LED lamps and lanterns.

The mentioned super thermal conductance piece is a type of thermo-curing super thermal conductance material, to form a function plane on the levelling surface of the radiator. The level forms an installation surface for the LED chip. The LED chip array is installed on the surface. Meanwhile, it has a primary positioning function for the SMT chip. The material is formed at will, so it is easy for processing and favourable for the chip array design.

The 2-stage super conductance thermal coating is a gold plating layer. In fact, both the super thermal conductance piece and the radiator or heat sink are integrated as one, favourable to radiate the heat, which is generated during work, as quickly as possible through the super thermal conductance silver glue and gold plating layer. The heat transfer is quicker, and thermal conductance rate is accelerated with a geometric progression.

Both the mentioned chip array design and adopting serial-parallel connection provide a possibility to pack the high power LED lamp. The applicable range of the LED bulb can determine the array and serial-parallel connection mode.

The mentioned nickel-plating red brass is a radiator or heat sink for the LED lamp. On its surface, LED positive and negative pole lead-out terminals are led out with a PCB method. Meanwhile, a hardware plastic mode is used to form a cavity structure of a white plastic ring on the upper side of the structure, which is formed with an injection moulding method.

The silica gel packed layer fills the LED chip fully, to make the whole packing structure more stable, and to resist high temperatures and ageing.

The applied new model involves an external form of nickel-plating, an external form of white plastic, series-parallel connection of the chip array, and with or without a position-limit grid, but not limited to the above mentioned.

In summary the present invention provides a new type of packing structure for a super high-power LEDs, i.e. greater than 1 Watt, in the field of lighting equipment. The existing technology of lighting equipment has disadvantages, such as poor heat radiation capability, low working efficiency, short lifetime and it is difficult to make high-power LED lamps and lanterns. The present invention provides for an LED chip and a primary radiator. Its primary characteristic is that a super thermal conductor is located between the primary radiator and each LED chip. An installation plane is designed on the surface super thermal conductance piece for installation of the LED chips. The primary radiator and the super thermal conductor have a 2-stage plating coat of super thermal conductors with a position-limit grid. The primary radiator is provided with an interface of thermal conductance. The 2-stage plating coat of super thermal conductance material applies a chemical turmeric method to deposit the thermal conductance interface. The LED chip is used to connect the super thermal conductor piece directly, with the installation plane set on the super thermal conductance piece, so as to optimize its structure, to increase the rate of thermal conductance, to improve the heat radiation performance after the LED is on and the luminescence ratio of the chip, to extend the LED lifetime, and to make it easier to make high-power LED lamps and lanterns.

A street light made to the above specifications using 70 individual 1 Watt LED chips integrated as described above in series and in parallel would give a brightness of 50 lumens per Watt i.e. 3500 lumens. If chips are used which generated 100 lumens per Watt then this could be increased to 7000 lumens. The overall colour temperature of the light produced is in the range of 4500 to 600K with a lighting range of 300 metres and an overall working temperature below 55°C with a bulb size of only 1cm square.

Referring to Figure 15 this shows an LED module with an aluminium or copper packing base 21, the thermally conductive substrate adhesive 22 and the inner side of an aluminium outer casing 23, when the module is being used within a street light for example.

Referring to Figure 14 this shows an alternative arrangement of the present invention wherein there is provided an LED module with an aluminium or copper packing base 11 and the thermally conductive substrate adhesive 12. There is also provided an aluminium plate 13 and heat pipe 14 with heat sink thin plates 15, another layer of thermally conductive substrate adhesive 16 and the inner side of an aluminium outer casing 17, where the module is being used within a street light, for example. The aluminium plate 13, heat pipe 14 and heat sink thin plates 15 all act together as one big heat sink to efficiently draw the heat away from the LED module.

<u>Key to Figures 11, 12 and 13</u>

50	Red-coloured frame is the packing interfact of LED chips
51	The Au lead used to solder the LED chips
52	Frames to position the LED chips
53	"-" of Chip Cluster
54	"+" of Chip Cluster

55	super conducting Ag thermal glue below the LED chips
56	Silicon layer acting as the refractor for LED
57	White Plastic

58	"-" pole
59	Cu with Ni coating (second grade thermal conducting also functions as heat sinking) 3 ~ 6 μ
60	Au coating functions as buffer for second grade thermal conducting
61	"+" pole
62	Plastic
63	Cu with Ni coating
64	Cu with Ni coating

Claims

1. An LED device comprising
    c) at least one LED chip; and
    d) a heat sink

wherein the LED chip is thermally coupled to the heat sink using a silver based thermally conductive substrate.

2. An LED device as claimed in Claim 1 wherein the silver based thermally conductive substrate comprises silver and Beryllium Oxide.

3. An LED device as claimed in Claim 1 or Claim 2 wherein the silver based thermally conductive substrate comprises silver in the range of about 75% to about 95% and Beryllium Oxide in the range of about 0.1% to about 3%.

4. An LED device as claimed in any of the preceding claims wherein the silver based thermally conductive substrate further comprises a halogen acyl polymer of the aromatic series.

5. An LED device as claimed in Claim 4 wherein the silver based thermally conductive substrate further comprises a halogen acyl polymer of the aromatic series in the range of about 3% to about 10%.

6. An LED device as claimed in any of the preceding claims wherein the silver based thermally conductive substrate further comprises epoxy resin, a thixotropic agent, a dispersant, a collodion and an organosilyl gum.

7. An LED device as claimed in claim 6 wherein the silver based thermally conductive substrate further comprises epoxy resin in the range of about 2% to about 20%, a thixotropic agent in the range of about 0.5% to about 7%, a dispersant in the range of about 0.5% to about 6%, a collodion in the range of about 0.1% to about 5% and an organosilyl gum in the range of about 0.1% to about 10%.

8. An LED device as claimed in claim 1 wherein the silver based thermally conductive substrate comprises;

Silver	about 75-95%

Epoxy resin	about 2-20%
Thixotropic agent	about 0.5-7%
Dispersant	about 0.5-6%
Collodion	about 0.1-5%
Beryllium Oxide	about 0.1-3%
Halogen acyl polymer of the aromatic series	about 3-10%
Organosilyl gum	about 0.1-10%

9. An LED device as claimed in any of the preceding claims wherein the silver based thermally conductive substrate comprises a glue.

10. An LED device as claimed in any of claims 2 to 9 wherein the silver is nanometer grade silver powder.

11. An LED device as claimed in any of claims 6 to 10 wherein the thixotropic agent is a polyvinyl alcohol.

12. An LED device as claimed in any of claims 6 to 10 wherein the thixotropic agent is polyvinylpyrrolidone.

13. An LED device as claimed in any of claims 6 to 12 wherein the dispersant is sodium lauryl sulphate.

14. An LED device as claimed in any of claims 6 to 12 wherein the dispersant is sodium dodecyl benzene.

15. An LED device as claimed in any of claims 6 to 14 wherein the organosilyl gum is silicon resin.

16. An LED device as claimed in any of the preceding claims comprising a plurality of LED chips.

17. An LED device as claimed in any of the preceding claims wherein the combined power of the LED chip(s) is greater than 10 watts.

18. An LED device as claimed in any of the preceding claims comprising 10 or more 1 watt or greater LED chips.

19. An LED device as claimed in Claim 16, Claim 17 when dependant on Claim 16 or Claim 18 inclusive wherein the LED chips are first coupled together in at least 2 groups of at least 2 LED chips in series and each group is coupled in parallel.

20. An LED device as claimed in any preceding claim wherein the heat sink is provided with a layer of gold between the heat sink and the silver based thermally conductive glue.

21. An LED device as claimed in any preceding claim wherein the heat sink comprises nickel plated copper or a nickel plated copper alloy.

22. An LED device comprising a plurality of LED chips, wherein the plurality of LED chips are first coupled together in at least 2 groups of at least 2 LED chips in series and each group is coupled in parallel.

23. An LED device as claimed in Claim 22 further comprising a heat sink wherein the plurality of LED chips are coupled to the heat sink using a silver based thermally conductive substrate.

24. An LED device as claimed in Claim 23 wherein the silver based thermally conductive substrate comprises silver and Beryllium Oxide.

25. An LED device as claimed in Claim 23 or Claim 24 wherein the silver based thermally conductive substrate comprises silver in the range of about 75% to about 95% and Beryllium Oxide in the range of about 0.1% to about 3%.

26. An LED device as claimed in any of claims 23 to 25 wherein the silver based thermally conductive substrate further comprises a halogen acyl polymer of the aromatic series.

27. An LED device as claimed in Claim 26 wherein the silver based thermally conductive substrate further comprises a halogen acyl polymer of the aromatic series in the range of about 3% to about 10%.

28. An LED device as claimed in any claims 23 to 27 wherein the silver based thermally conductive substrate further comprises epoxy resin, a thixotropic agent, a dispersant, a collodion and an organosilyl gum.

29. An LED device as claimed in claim 28 wherein the silver based thermally conductive substrate further comprises epoxy resin in the range of about 2% to about 20%, a thixotropic agent in the range of about 0.5% to about 7%, a dispersant in the range of about 0.5% to about 6%, a collodion in the range of about 0.1% to about 5% and an organosilyl gum in the range of about 0.1% to about 10%.

30. An LED device as claimed in claim 23 wherein the silver based thermally conductive substrate comprises;

Silver	75-95%
Epoxy resin	2-20%
Thixotropic agent	0.5-7%
Dispersant	0.5-6%
Collodion	0.1-5%
Beryllium Oxide	0.1-3%
Halogen acyl polymer of the aromatic series	3-10%
Organosilyl gum	0.1-10%

31. An LED device as claimed in any of claims 23 to 30 wherein the silver based thermally conductive substrate comprises a glue.

32. An LED device as claimed in any of claims 23 to 31 wherein the silver is nanometer grade silver powder.

33. An LED device as claimed in any of claims 28 to 32 wherein the thixotropic agent is a polyvinyl alcohol.

34. An LED device as claimed in any of claims 28 to 32 wherein the thixotropic agent is polyvinylpyrrolidone.

35. An LED device as claimed in any of claims 28 to 34 wherein the dispersant is sodium lauryl sulphate.

36. An LED device as claimed in any of claims 28 to 34 wherein the dispersant is sodium dodecyl benzene.

37. An LED device as claimed in any of claims 28 to 36 wherein the organosilyl gum is silicon resin.

38. An LED device as claimed in any of claims 22 to 37 inclusive wherein the combined power of the LED chip(s) is greater than 10 watts.

39. An LED device as claimed in any of claims 22 to 38 inclusive comprising 10 or more 1 watt or greater LED chips.

40. An LED device as claimed in any of claims 23 to 39 inclusive wherein the heat sink is provided with a layer of gold between the heat sink and the silver based thermally conductive substrate.

41. An LED device as claimed in any of claims 23 to 40 inclusive wherein the heat sink comprises nickel plated copper or a nickel plated copper alloy.

42. A silver based thermally conductive substrate for use in thermally connecting semi-conductor substrates to a heat sink.

43. An LED device as claimed in Claim 42 wherein the silver based thermally conductive substrate comprises silver and Beryllium Oxide.

44. An LED device as claimed in Claim 42 or Claim 43 wherein the silver based thermally conductive substrate comprises silver in the range of about 75% to about 95% and Beryllium Oxide in the range of about 0.1% to about 3%.

45. An LED device as claimed in any of claims 43 to 44 wherein the silver based thermally conductive substrate further comprises a halogen acyl polymer of the aromatic series.

46. An LED device as claimed in Claim 45 wherein the silver based thermally conductive substrate further comprises a halogen acyl polymer of the aromatic series in the range of about 3% to about 10%.

47. An LED device as claimed in any claims 43 to 46 wherein the silver based thermally conductive substrate further comprises epoxy resin, a thixotropic agent, a dispersant, a collodion and an organosilyl gum.

48. An LED device as claimed in claim 47 wherein the silver based thermally conductive substrate further comprises epoxy resin in the range of about 2% to about 20%, a thixotropic agent in the range of about 0.5% to about 7%, a dispersant in the range of about 0.5% to about 6%, a collodion in the range of about 0.1% to about 5%and an organosilyl gum in the range of about 0.1% to about 10%.

49. An LED device as claimed in claim 42 wherein the silver based thermally conductive substrate comprises;

Silver	about 75-95%
Epoxy resin	about 2-20%
Thixotropic agent	about 0.5-7%
Dispersant	about 0.5-6%
Collodion	about 0.1-5%
Beryllium Oxide	about 0.1-3%
Halogen acyl polymer of the aromatic series	about 3-10%
Organosilyl gum	about 0.1-10%

50. An LED device as claimed in any of the claims 42 to 49 wherein the silver based thermally conductive substrate comprises a glue.

51. An LED device as claimed in any of claims 42 to 50 wherein the silver is nanometre grade silver powder.

52. An LED device as claimed in any of claims 47 to 51 wherein the thixotropic agent is a polyvinyl alcohol.

53. An LED device as claimed in any of claims 47 to 51 wherein the thixotropic agent is polyvinylpyrrolidone.

54. An LED device as claimed in any of claims 47 to 52 wherein the dispersant is sodium lauryl sulphate.

55. An LED device as claimed in any of claims 47 to 52 wherein the dispersant is sodium dodecyl benzene.

56. An LED device as claimed in any of claims 47 to 55 wherein the organosilyl gum is silicon resin.

57. An LED device as substantially hereinbefore described with reference to Figures 4 to 13.

58. A silver based thermally conductive substrate as substantially hereinbefore described.

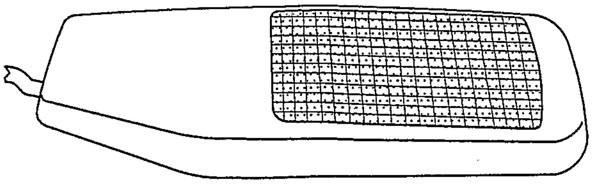

Fig. 1

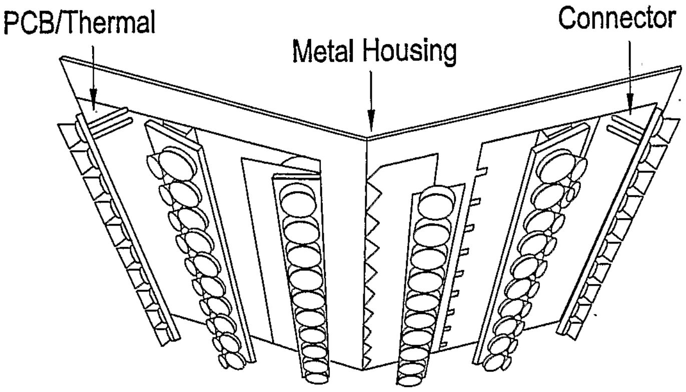

Fig. 2

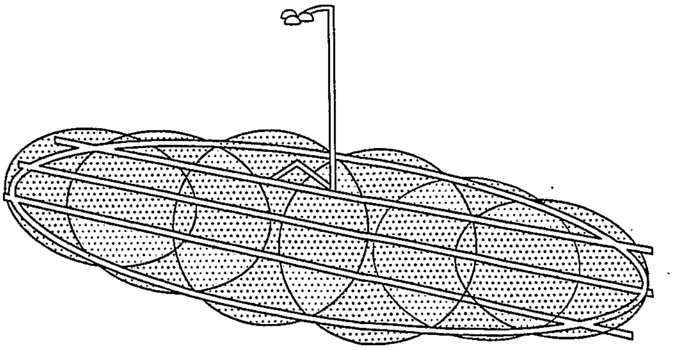

Fig. 3

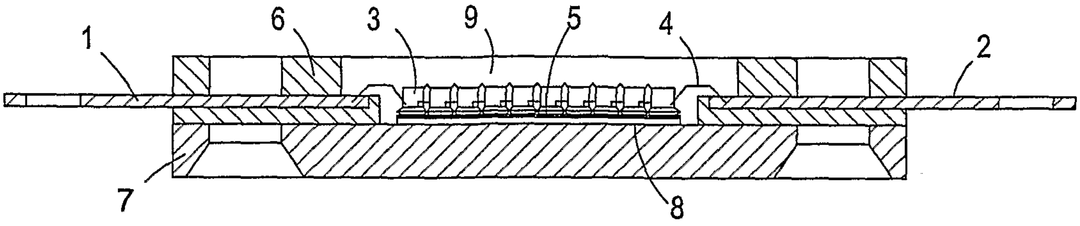

Fig. 4

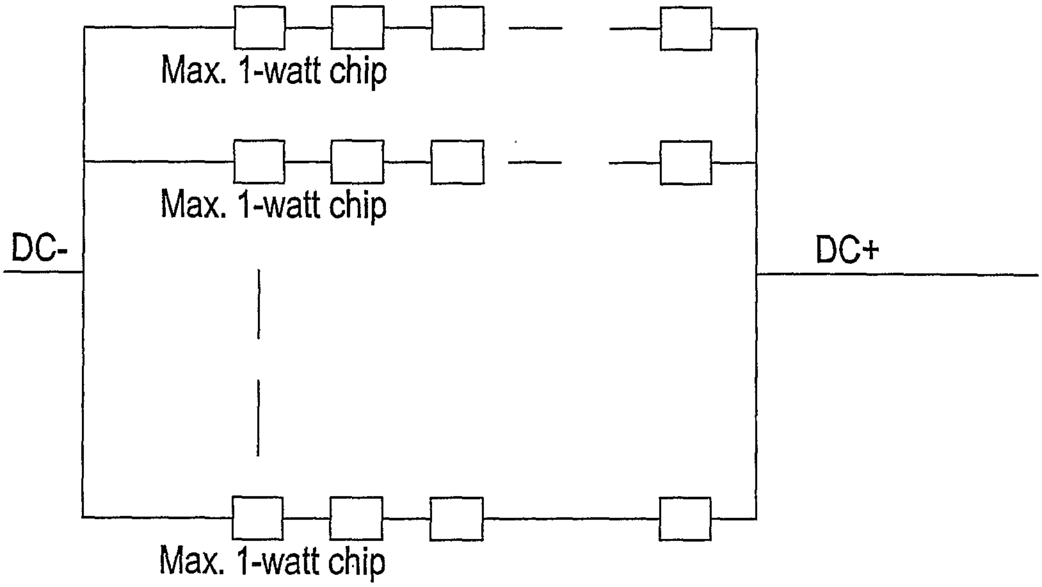

Fig. 5

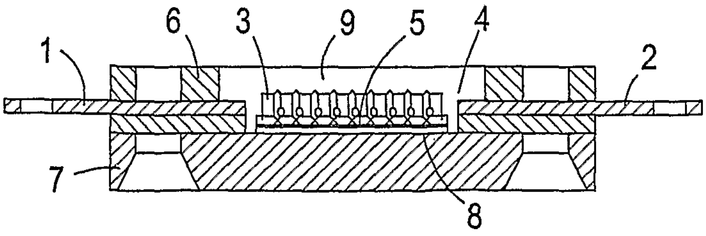

Fig. 6

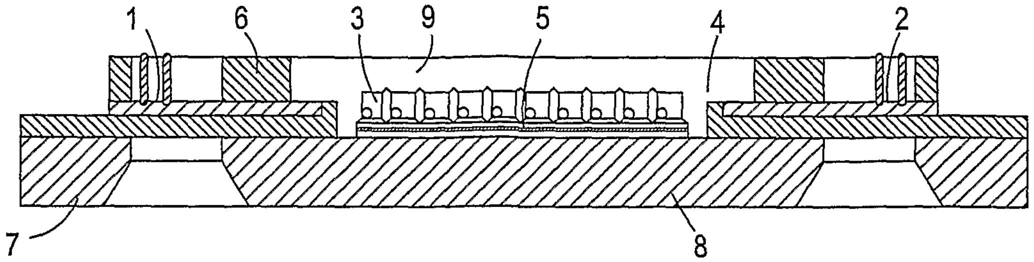

Fig. 7

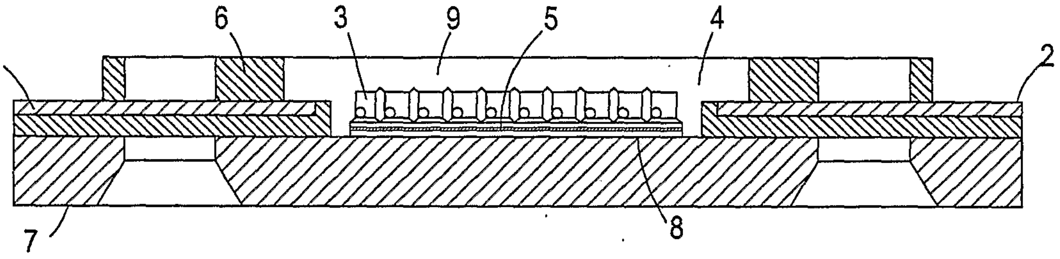

Fig. 8

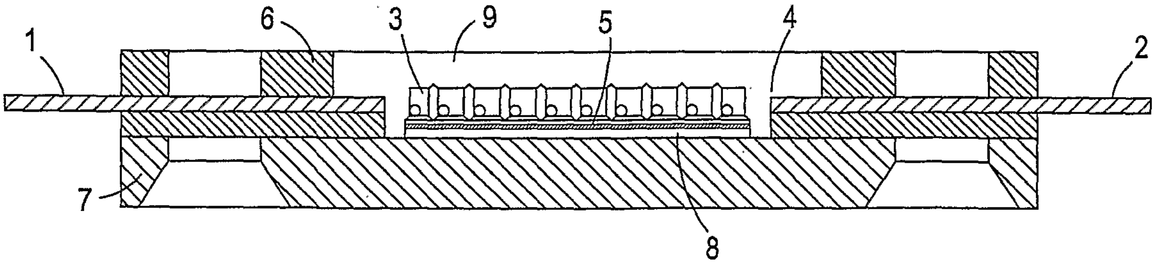

Fig. 9

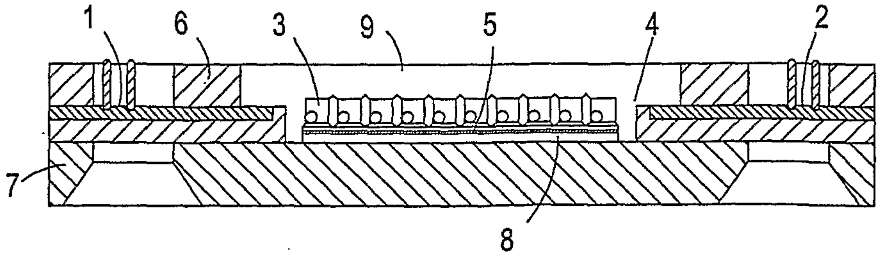

Fig. 10

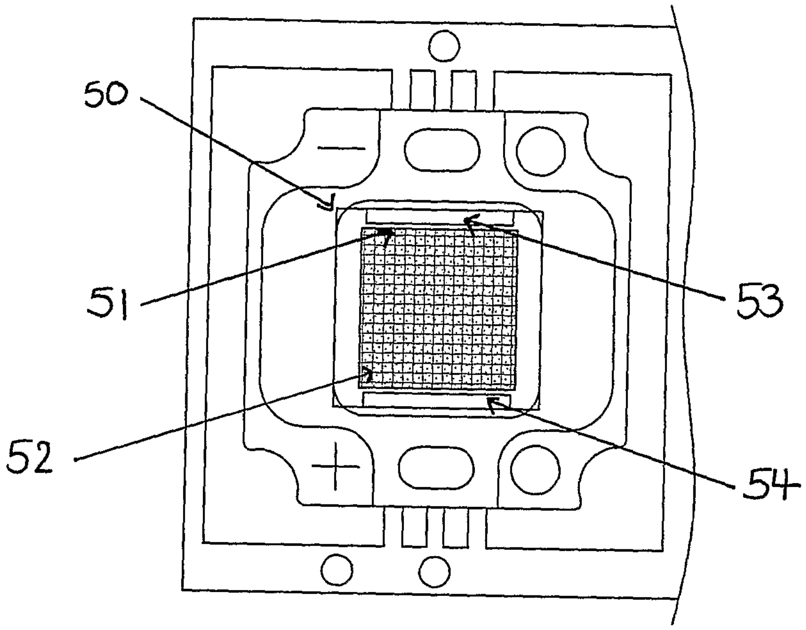

Fig. 11

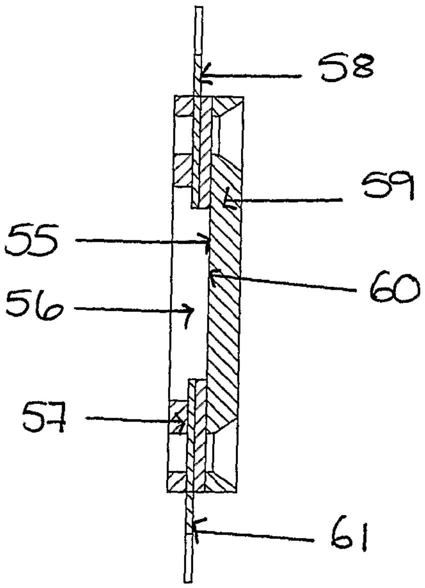

Fig. 12

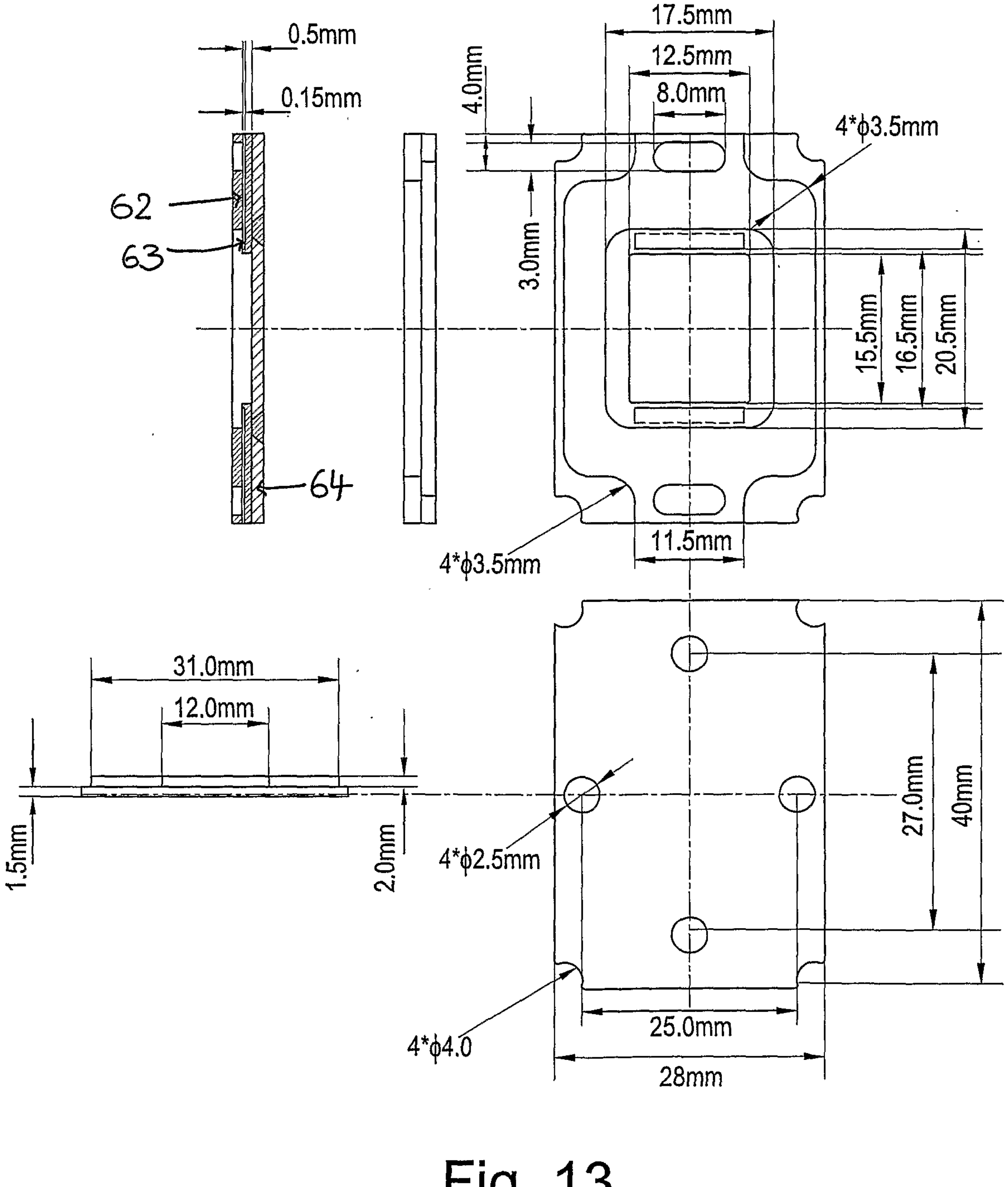
0.5mm
0.15mm
62
63
64
4.0mm
3.0mm
17.5mm
12.5mm
8.0mm
4*ϕ3.5mm
15.5mm
16.5mm
20.5mm
11.5mm
4*ϕ3.5mm
31.0mm
12.0mm
1.5mm
2.0mm
4*ϕ2.5mm
27.0mm
40mm
4*ϕ4.0
25.0mm
28mm

Fig. 13

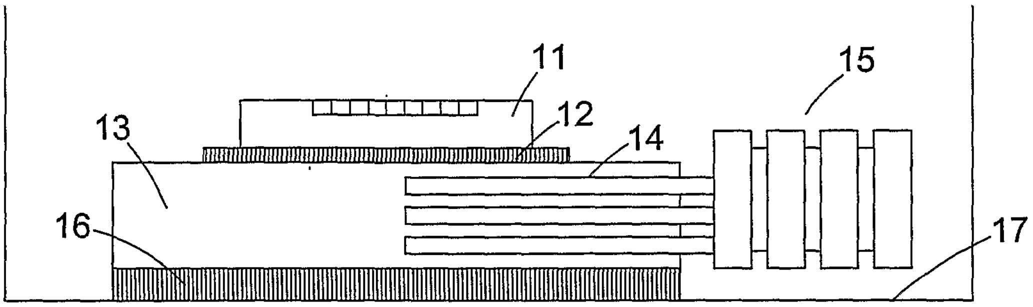

Fig. 14

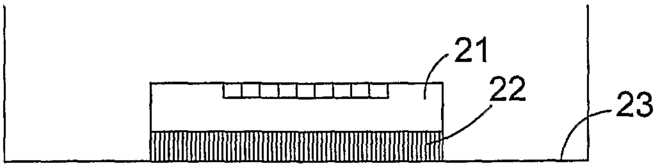

Fig. 15

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2008/051078

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01L33/00 C09J11/04
ADD. H01L25/075 C09J9/00

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)
H01L C09J C08K

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 practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2003/234074 A1 (BHAGWAGAR DORAB EDUL [US]) 25 December 2003 (2003-12-25)	1,2,4,6, 9,11-15, 20,21, 42,43, 45,47, 50-58
	the whole document	
Y		16-19, 23,24, 26,28, 31,33-41

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☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents :

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"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 24 March 2009	Date of mailing of the international search report 31/03/2009
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 Rodríguez-Gironés, M

International application No
PCT/GB2008/051078

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2005/237747 A1 (SHIMIZU MASANORI [JP] ET AL) 27 October 2005 (2005-10-27) abstract figure 6(a)	22 16-19, 23,24, 26,28, 31,33-41
X	US 2006/092639 A1 (LIVESAY WILLIAM R [US] ET AL LIVESAY WILLIAM R [US] ET AL) 4 May 2006 (2006-05-04) paragraph [0048]; figure 2D	1
X	EP 0 539 095 A (FUJITSU LTD [JP] FUJITSU LTD [GR]) 28 April 1993 (1993-04-28) column 4, lines 16,17; figure 2	1
X	US 2003/189830 A1 (SUGIMOTO MASARU [JP] ET AL) 9 October 2003 (2003-10-09) page 6, left-column, paragraph [0077], last sentence	1
X	EP 1 526 585 A (SEIKO EPSON CORP [JP]) 27 April 2005 (2005-04-27) paragraph [0194]	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2008/051078

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2003234074 A1	25-12-2003	AU 2003221683 A1	06-01-2004
		EP 1579501 A2	28-09-2005
		JP 2005530887 T	13-10-2005
		TW 265180 B	01-11-2006
		WO 2004001844 A2	31-12-2003
US 2005237747 A1	27-10-2005	US 2005242362 A1	03-11-2005
US 2006092639 A1	04-05-2006	WO 2006049844 A2	11-05-2006
EP 0539095 A	28-04-1993	DE 69224343 D1	12-03-1998
		DE 69224343 T2	10-06-1998
		JP 2602380 B2	23-04-1997
		JP 5114669 A	07-05-1993
US 2003189830 A1	09-10-2003	AT 425556 T	15-03-2009
		CN 1436374 A	13-08-2003
		EP 1387412 A1	04-02-2004
		WO 02084750 A1	24-10-2002
		TW 517402 B	11-01-2003
EP 1526585 A	27-04-2005	CN 1609701 A	27-04-2005
		KR 20050039610 A	29-04-2005
		US 2005110395 A1	26-05-2005