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(54) **HETEROSTRUCTURE CONTAINING IC AND LED AND METHOD FOR FABRICATING THE SAME**

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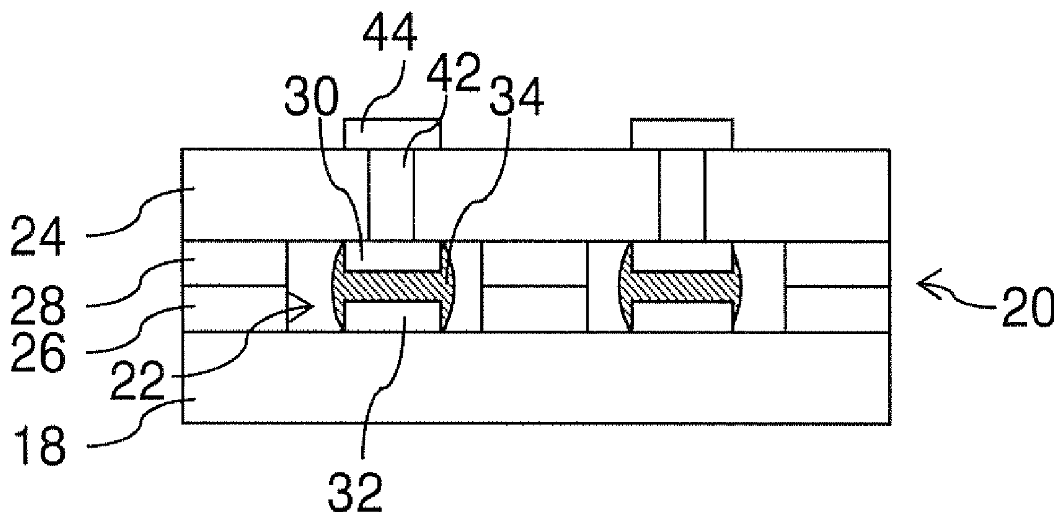
(57) **ABSTRACT**

A heterostructure containing IC and LED and a method of fabricating. An IC and an LED are established with the IC having a first electric-conduction block and a first connection block. The IC electrically connects to the first electric-conduction block. A first face of the LED has a second electric-conduction block and a second connection block. The LED is electrically connected to the second electric-conduction block. The first electric-conduction block and the first connection block are respectively joined to the second electric-conduction block and the second connection block, and the first electric-conduction block are electrically connected with the second electric-conduction block to form a heterostructure. The heterostructure provides functions of heat radiation and electric communication for IC and LED.



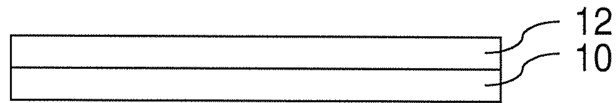


Fig.1(a) (prior art)

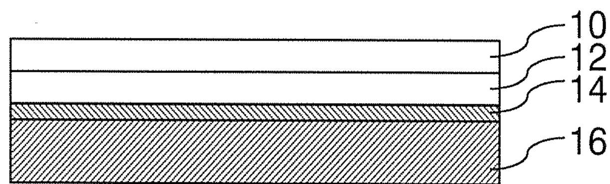


Fig.1(b) (prior art)

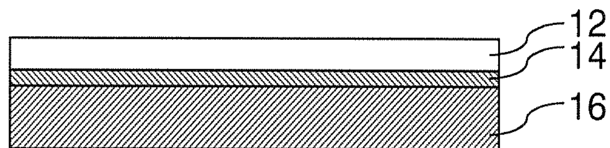


Fig.1(c) (prior art)

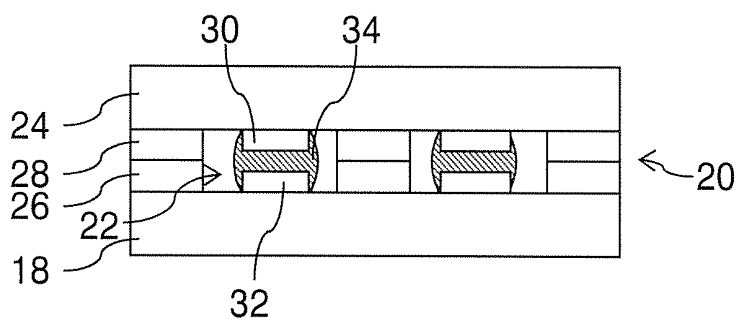


Fig.2

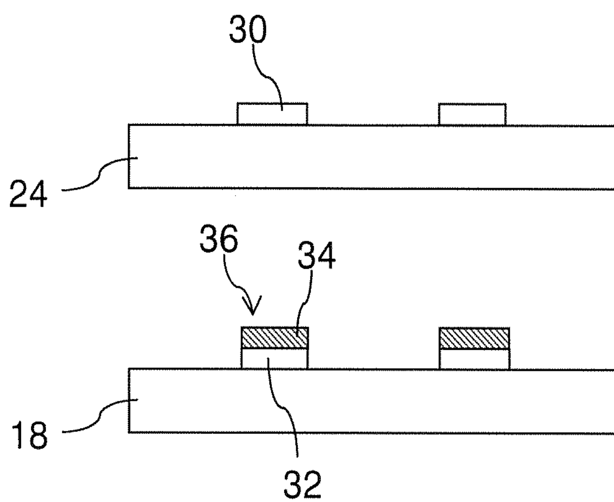


Fig.3(a)

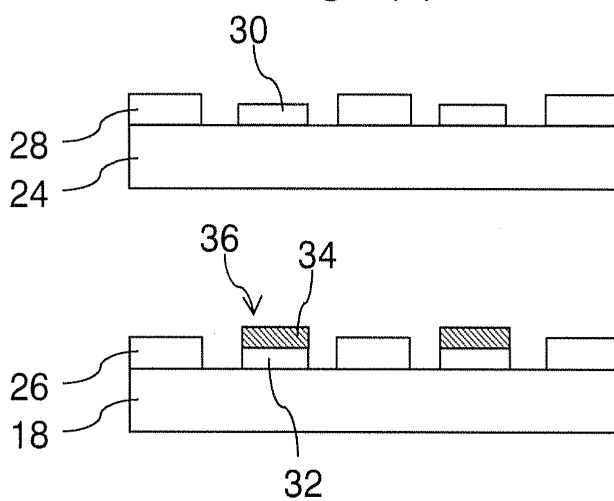


Fig.3(b)

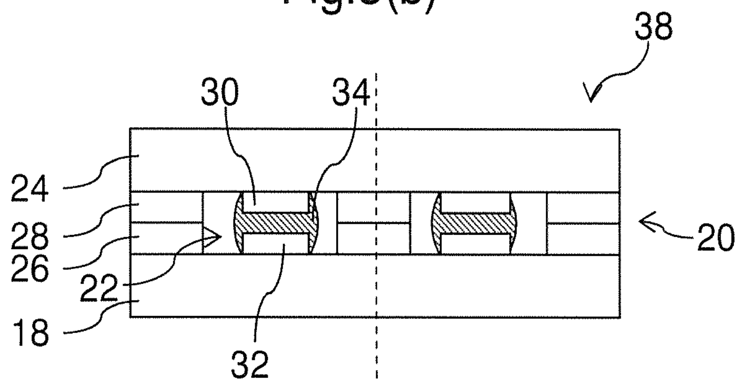


Fig.3(c)

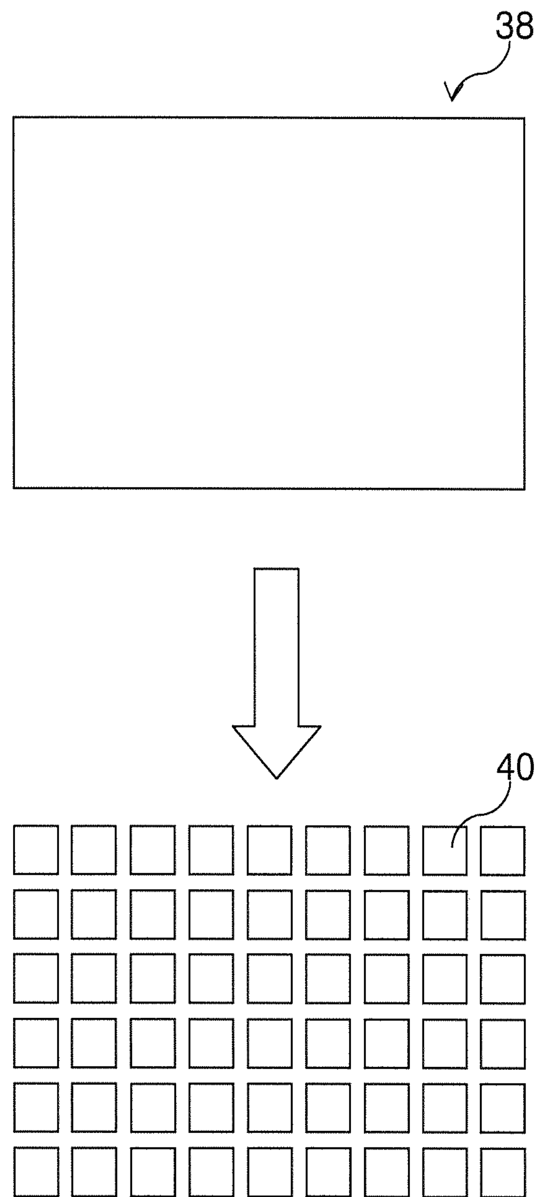


Fig.3(d)

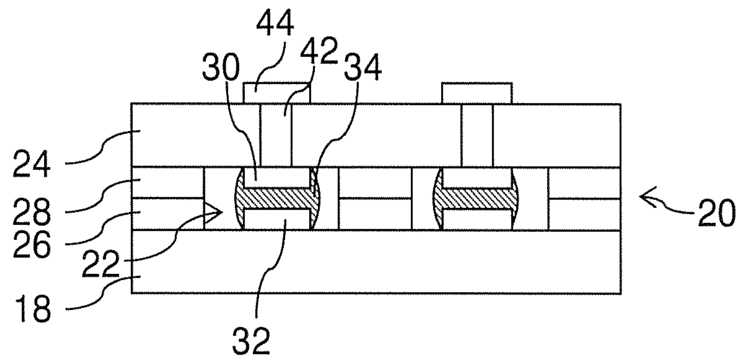


Fig.4

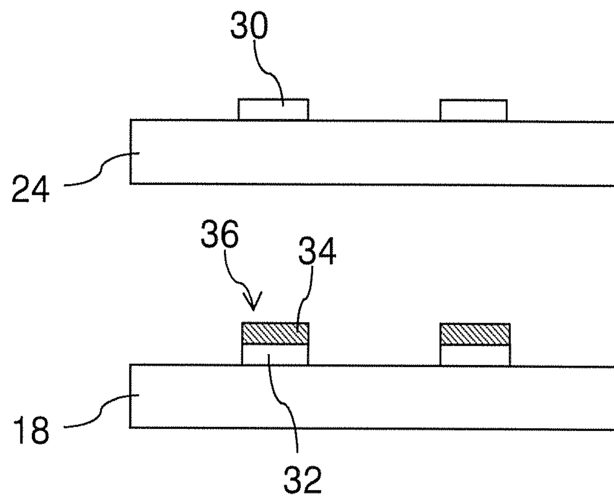


Fig.5(a)

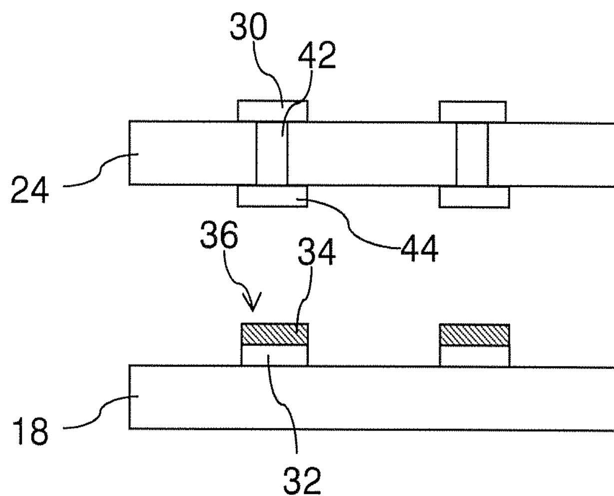


Fig.5(b)

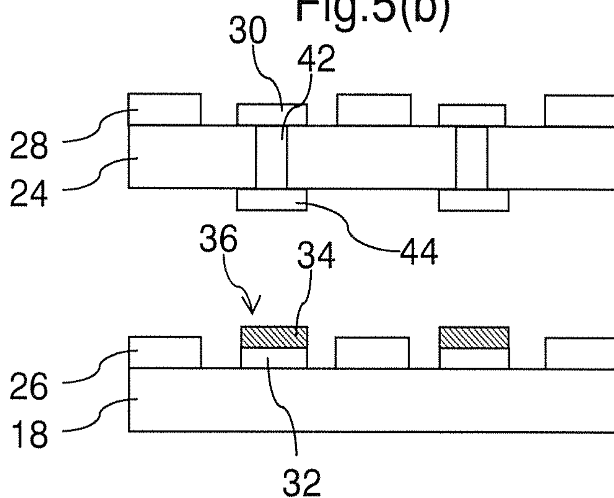


Fig.5(c)

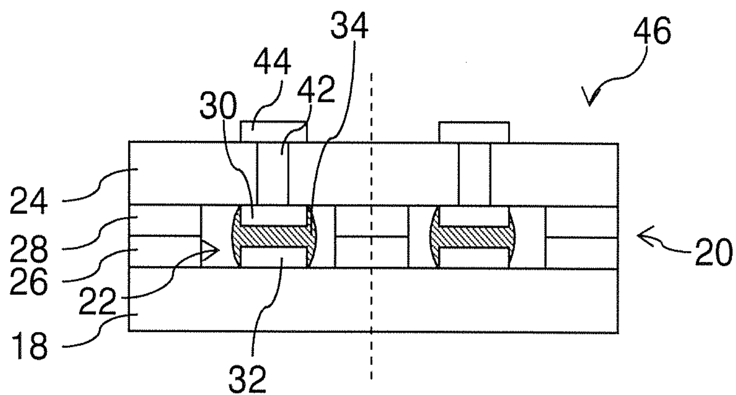
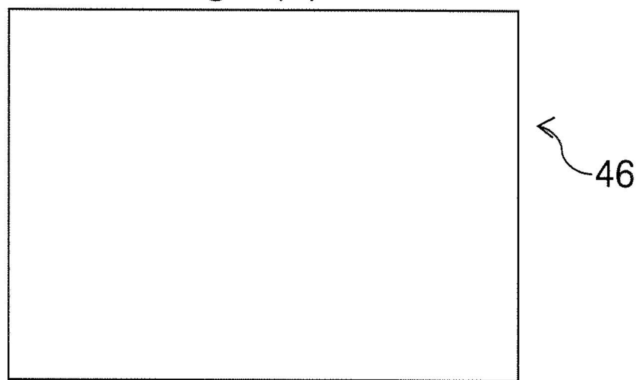
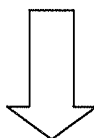


Fig.5(d)





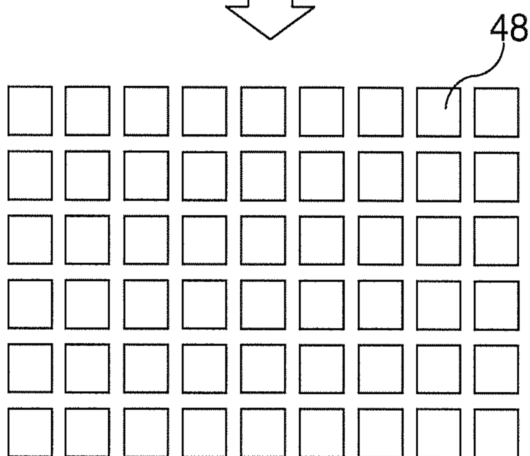


Fig.5(e)

HETEROSTRUCTURE CONTAINING IC AND LED AND METHOD FOR FABRICATING THE SAME

RELATED APPLICATIONS

[0001] This application is a Divisional patent application of co-pending application Ser. No. 13/224,607, filed on 2 Sep. 2011, now pending. The entire disclosure of the prior application, Ser. No. 13/224,607, from which an oath or declaration is supplied, is considered a part of the disclosure of the accompanying Divisional application and is hereby incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a heterostructure technology, particularly to a heterostructure containing IC and LED and a method for fabricating the same.

[0004] 2. Description of the Related Art

[0005] LED (Light Emitting Diode) is a luminescent element, wherein electrons and holes recombine to release light. LEDs made of different materials emit monochromatic lights having different wavelength, which may be categorized into the visible lights and the invisible lights. Compared with the conventional bulb, LED has advantages of high power efficiency, high impact resistance and high blink speed. Therefore, LED has been an indispensable element for daily living.

[0006] Refer to FIGS. **1**(*a*) to **1**(*c*) sectional views showing conventional steps of fabricating LED with heat-radiating function. In FIG. **1**(*a*), fabricate a LED **12** on a sapphire substrate **10** with a deposition method. Next, in FIG. **1**(*b*), use a metal adhesive layer **14** to join the LED **12** with a high thermal conductivity silicon substrate **16**. Next, in FIG. **1**(*c*), remove the sapphire substrate **10**. The objective of joining the LED **12** with the silicon substrate **16** is to use the high thermal conductivity of the silicon substrate **16** to assist in heat radiation. None electric connection exists between the LED **12** and the silicon substrate **16**. The whole metal adhesive layer **14** is only to mechanically join the LED **12** and the silicon substrate **16**. Thereby, heat generated by the LED **12** is transmitted downward to the silicon substrate **16** and effectively dissipated. The conventional technologies for fabricating LED are mainly high-temperature processes, which have high thermal budget and result in high thermal stress in LED. Besides, the conventional technologies cannot integrate LED with functional IC.

[0007] Accordingly, the present invention proposes a heterostructure containing IC and LED to overcome the abovementioned problems.

SUMMARY OF THE INVENTION

[0008] The primary objective of the present invention is to provide a heterostructure containing IC and LED and a method for fabricating the same, wherein IC and LED are stacked and joined with a metal and a joining block in a hybrid bonding method, whereby is achieved the heat-radiating function of IC and LED and the electric communication between IC and LED, and whereby is accomplished the development and application of a high-density and multi-functional heterostructure.

[0009] To achieve the abovementioned objective, the present invention proposes a heterostructure containing IC and LED, which comprises an IC and an LED. The IC has at least one connection structure and at least one electric-conduction structure on the surface thereof, and the IC is electrically connected with the electric-conduction structure. The LED has a first face and a second face opposite to the first face. The first face of the LED is joined to and electrically connected with the electric-conduction structure, whereby the LED is integrated with the IC. Further, the LED may have an electric-conduction through-hole electrically connected with the electric-conduction structure. Besides, the second face of the LED may have an electric-conduction block electrically connected with the electric-conduction through-hole, whereby other structures can be easily stacked on the LED.

[0010] The present invention also proposes a method for fabricating a heterostructure containing IC and LED, which comprises steps: providing an IC and an LED, wherein the IC has at least one first electric-conduction block and at least one first connection block on the surface thereof, and wherein the IC is electrically connected with the first electric-conduction block, and wherein the LED has a first face and a second face opposite to the first face, and wherein the first face has at least one second electric-conduction block and at least one second connection block, and wherein the LED is electrically connected with the second electric-conduction block; respectively joining the first electric-conduction block and the first connection block to the second electric-conduction block and the second connection block so as to join the IC to the LED, and electrically connecting the first electric-conduction block with the second electric-conduction block, whereby is formed a heterostructure where other structures are easily stacked on the LED. Besides, the LED may further have an electric-conduction through-hole electrically connected with the electric-conduction structure, and the second face has a third electric-conduction block electrically connected with the electric-conduction through-hole.

[0011] Below, the embodiments are described in detail in cooperation with the drawings to make easily understood the technical contents, characteristic and accomplishments of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIGS. **1**(*a*) to **1**(*c*) are sectional views showing conventional steps for fabricating LED with heat-radiating function;

[0013] FIG. **2** is a sectional view schematically a heterostructure containing IC and LED according to a first embodiment of the present invention;

[0014] FIGS. **3**(*a*) to **3**(*c*) are sectional views schematically showing steps of fabricating a heterostructure containing IC and LED according to the first embodiment of the present invention;

[0015] FIG. **3**(*d*) is a diagram schematically showing a cutting step according to the first embodiment of the present invention;

[0016] FIG. **4** is a sectional view schematically a heterostructure containing IC and LED according to a second embodiment of the present invention;

[0017] FIGS. **5**(*a*) to **5**(*d*) are sectional views schematically showing steps of fabricating a heterostructure containing IC and LED according to the second embodiment of the present invention; and

[0018] FIG. **5**(*e*) is a diagram schematically showing a cutting step according to the second embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0019] Refer to FIG. **2** for a heterostructure containing IC and LED according to a first embodiment of the present invention. The present invention comprises an IC (Integrated Circuit) **18** and an LED **24**. The IC **18** has at least one connection structure **20** and at least one electric-conduction structure **22** on the surface thereof. The IC **18** is electrically connected with the electric-conduction structure **22**. The LED **24** has a first face and a second face opposite to the first face. The first face of the LED **24** is on the connection structure **20** and the electric-conduction structure **22** so as to join to the IC **18** and electrically connect with the electric-conduction structure **22**. The IC **18** is a multifunctional one and may function as a power source of the LED **24**, a logic/control processor, a memory, a CMOS (Complementary Metal Oxide Semiconductor) image sensor, an RF (Radio Frequency) IC, etc. Distinct from the conventional technology, the present invention replaces the silicon substrate with an IC. Thereby, the present invention realizes the heat radiation of the IC **18** and the LED **24** and the electric communication between the IC **18** and the LED **24**. Thus is accomplished the development and application of a high-density and multifunctional heterostructure.

[0020] The connection structure **20** further comprises a first connection block **26** and a second connection block **28**, which may comprise a polymeric material stable below a temperature of 250° C., such as an epoxy-based photoresist SU-8. The first connection block **26** is arranged on the surface of the IC **18**. The second connection block **28** is arranged on the first face of the LED **24** and joined to the first connection block **26**. The electric-conduction structure **22** further comprises a first electric-conduction block and a second electric-conduction block **30**, which comprise a metallic material. The first electric-conduction block is arranged on the surface of the IC **18** and electrically connected with the IC **18**. The second electric-conduction block **30** is arranged on the first face of the LED **24** and electrically connected with the LED **24**. The second electric-conduction block **30** is joined to and electrically connected with the first electric-conduction block. The first electric-conduction block includes a high-temperature metallic connection block **32** disposed on the surface of the IC and a low-temperature metallic connection block **34** joined to and electrically connected with the high-temperature metallic connection block **32** and the second electric-conduction block **30**. The low-temperature metallic connection block **34** may comprise a metallic material stable below a temperature of 250° C., such as tin or indium. In other words, the IC **18** and the LED **24** are joined by a metallic material and a polymeric material in a hybrid bonding way, wherein the metallic material and the polymeric material both function as the joint material but respectively implement electric communication and structural strengthening. Thereby, the present invention not only realizes the electric communication between the IC **18** and the LED **24** but also polymerically fills the micro-gap between the IC **18** and the LED **24**. Thus is improved the bonding strength of the IC **18** and the LED **24** and the reliability of the stacked element.

[0021] Below is described the method for fabricating the heterostructure containing IC and LED according to the first embodiment of the present invention. Refer to FIGS. **3**(*a*) to **3**(*d*) sectional views schematically showing steps of fabricating the heterostructure containing IC and LED according to the first embodiment of the present invention. Firstly, as shown in FIG. **3**(*a*), form the high-temperature metallic connection block **32** on the surface of the IC **18** and electrically connect the high-temperature metallic connection block **32** with the IC **18**; form the low-temperature metallic connection block **34** on the high-temperature metallic connection block **32** and electrically connect the low-temperature metallic connection block **34** with the high-temperature metallic connection block **32**, whereby the high-temperature metallic connection block **32** and the low-temperature metallic connection block **34** form the first electric-conduction block **36**. At the same time, form the second electric-conduction block **30** on the first face of the LED **24** and electrically connect the second electric-conduction block **30** with the LED **24**. The high-temperature metallic connection block **32**, the low-temperature metallic connection block **34** and the second electric-conduction block **30** are fabricated with a photolithographic technology, an electroplating technology and an etching technology. Next, as shown in FIG. **3**(*b*), respectively form the first connection block **26** and the second connection block **28** on the surface of the IC **18** and the first face of the LED **24** with a photolithographic technology. A low-temperature process is more suitable to the LED **24**, and the connection material and the electric-conduction material also allow a low-temperature process. Therefore, as shown in FIG. **3**(*c*), process the first and second connection blocks **26** and **28** and the first and second electric-conduction blocks **30** and **36** at a temperature of as low as 25-250° C. to make the first connection block **26** and the low-temperature metallic connection block **34** of the first electric-conduction block **36** respectively join with the second connection block **28** and the second electric-conduction block **30**, whereby is completed the joint of the IC **18** and the LED **24**, and whereby is completed the electric connection of the low-temperature metallic connection block **34** and the second electric-conduction block **30**. Thus is completed a low-temperature joined heterostructure **38**. Next, as shown in FIG. **3**(*d*), perform a cutting process along the dotted line shown in FIG. **3**(*c*) to dice the heterostructure **38** containing the ICs **18** and the LEDs **24** into a plurality of heterostructure units **40**.

[0022] In the abovementioned steps, the step shown in FIG. **3**(*d*) can be omitted. In FIG. **3**(*a*), the step to form the high-temperature metallic connection block **32** and the low-temperature metallic connection block **34** on the IC **18** can be replaced by a step of directly forming the first electric-conduction block **36** containing the high-temperature and low-temperature metallic connection blocks **32** and **34** on the IC **18**, wherein the high-temperature metallic connection block **32** must be interposed between the low-temperature metallic connection block **34** and the IC **18**. Further, the steps shown in FIG. **3**(*a*) and FIG. **3**(*b*) can be replaced by a single step, wherein is directly provided an IC **18** having at least one first electric-conduction block **36** and at least one first connection block **26** on the surface thereof and electrically connected with the first electric-conduction block **36**, and wherein is directly provided an LED **24** having at least one second electric-conduction block **30** and at least one second connection block **28** on the first face thereof and electrically connected with the second electric-conduction block **30**. The alternative step is also illustrated by FIG. **3**(*b*). Then, undertake the step shown in FIG. **3**(*c*).

[0023] Below is described a second embodiment of the present invention. Refer to FIG. **4**. The second embodiment is basically similar to the first embodiment. However, the second embodiment is different from the first embodiment in that the LED **24** has an electric-conduction through-hole **42** elec-

trically connected with the second electric-conduction block **30** of the electric-conduction structure **22** and that at least one third electric-conduction block **44** comprising a metallic material is formed on the second face of the LED **24** and electrically connected with the electric-conduction through-hole **42**.

[0024] Below is described the method for fabricating the heterostructure containing IC and LED according to the second embodiment of the present invention. Refer to FIGS. **5**(*a*) to **5**(*e*). Firstly, as shown in FIG. **5**(*a*), form the high-temperature metallic connection block **32** on the surface of the IC **18** and electrically connect the high-temperature metallic connection block **32** with the IC **18**; form the low-temperature metallic connection block **34** on the high-temperature metallic connection block **32** and electrically connect the low-temperature metallic connection block **34** with the high-temperature metallic connection block **32**, whereby the high-temperature metallic connection block **32** and the low-temperature metallic connection block **34** form the first electric-conduction block **36**. At the same time, form the second electric-conduction block **30** on the first face of the LED **24** and electrically connect the second electric-conduction block **30** with the LED **24**. The high-temperature metallic connection block **32**, the low-temperature metallic connection block **34** and the second electric-conduction block **30** are fabricated with a photolithographic technology, an electroplating technology and an etching technology. Next, as shown in FIG. **5**(*b*), firstly form the electric-conduction through-hole **42** in the LED **24** and electrically connect the electric-conduction through-hole **42** with the second electric-conduction block **30**. Next, use a photolithographic technology, an electroplating technology and an etching technology to form the third electric-conduction block **44** on the second face of the LED **24** and electrically connect the third electric-conduction block **44** with the electric-conduction through-hole **42**. Thereby, the LED **24** can be easily installed, and other elements can be easily stacked up. Next, as shown in FIG. **5**(*c*), respectively form the first and second connection blocks **26** and **28** on the surface of the IC **18** and the first face of the LED **24** with a photolithographic technology. Next, similarly to the first embodiment, process the first and second connection blocks **26** and **28** and the first and second electric-conduction blocks **30** and **36** at a temperature of as low as 25-250° C. to make the first connection block **26** and the low-temperature metallic connection block **34** of the first electric-conduction block **36** respectively join with the second connection block **28** and the second electric-conduction block **30**, whereby is completed the joint of the IC **18** and the LED **24**, and whereby is completed the electric connection of the low-temperature metallic connection block **34** and the second electric-conduction block **30**, as shown in FIG. **5**(*d*). Thus is completed a low-temperature joined heterostructure **46**. Next, as shown in FIG. **5**(*e*), perform a cutting process along the dotted line shown in FIG. **5**(*d*) to dice the heterostructure **46** containing the ICs **18** and the LEDs **24** into a plurality of heterostructure units **48**.

[0025] In the abovementioned steps, the step shown in FIG. **5**(*e*) can be omitted. In FIG. **5**(*a*), the step to form the high-temperature metallic connection block **32** and the low-temperature metallic connection block **34** on the IC **18** can be replaced by a step of directly forming the first electric-conduction block **36** containing the high-temperature and low-temperature metallic connection blocks **32** and **34** on the IC **18**, wherein the high-temperature metallic connection block **32** must be interposed between the low-temperature metallic connection block **34** and the IC **18**. Further, the steps shown in FIGS. **5**(*a*)-**5**(*c*) can be replaced by a single step, wherein is directly provided an IC **18** having at least one first electric-conduction block **36** and at least one first connection block **26** on the surface thereof and electrically connected with the first electric-conduction block **36**, and wherein is directly provided an LED **24** having at least one second electric-conduction block **30** and at least one second connection block **28** on the first face thereof and electrically connected with the second electric-conduction block **30**. The alternative step is also illustrated by FIG. **5**(*c*). Then, undertake the step shown in FIG. **5**(*d*).

[0026] In conclusion, the heterostructure technology of the present invention not only provides a heat-radiation function for IC and LED but also provides an electric-communication function between IC and LED and thus can be used to realize a high-density and multifunctional heterostructure.

[0027] The embodiments described above are only to exemplify the present invention but not to limit the scope of the present invention. Any equivalent modification or variation according to the structure, characteristic or spirit disclosed in the present invention is to be also included within the scope of the present invention.

What is claimed is:

1. A method for fabricating a heterostructure containing an integrated circuit (IC) and a light emitting diode (LED), comprising steps:

providing an IC and an LED, wherein at least one first electric-connection block and at least one first connection block are arranged on one surface of said IC, and wherein said first electric-connection block is electrically connected with said IC, and wherein said LED has a first face and a second face opposite to said first face, and wherein said first face has at least one second electric-conduction block and at least one second connection block, and wherein said second electric-conduction block is electrically connected with said LED; and

respectively joining said first electric-conduction block and said first connection block to said second electric-conduction block and said second connection block so as to bond said IC to said LED and realize electric connection of said first electric-conduction block and said second electric-conduction block.

2. The method for fabricating a heterostructure containing IC and LED according to claim **1**, wherein said step of providing said IC having said first electric-connection block and said first connection block further comprises steps:

forming said first electric-conduction block on said surface and electrically connecting said first electric-conduction block with said IC; and

forming said first connection block on said surface.

3. The method for fabricating a heterostructure containing IC and LED according to claim **2**, wherein said first electric-connection block is fabricated with a photolithographic process, an electroplating process and an etching process, and wherein said first connection block is fabricated with a photolithographic process.

4. The method for fabricating a heterostructure containing IC and LED according to claim **2**, wherein said step of forming said first electric-conduction block on said surface further comprises steps:

forming a high-temperature metallic connection block on said surface and electrically connecting said high-temperature metallic connection block with said IC; and

forming a low-temperature metallic connection block on said high-temperature metallic connection block and electrically connecting said low-temperature metallic connection block with said high-temperature metallic connection block.

5. The method for fabricating a heterostructure containing IC and LED according to claim **1**, wherein said step of providing said LED having said second electric-conduction block and said second connection block further comprises steps:

forming said second electric-conduction block on said first face and electrically connecting said second electric-conduction block with said LED; and

forming said second connection block on said first face.

6. The method for fabricating a heterostructure containing IC and LED according to claim **5**, wherein said second electric-connection block is fabricated with a photolithographic process, an electroplating process and an etching process, and wherein said second connection block is fabricated with a photolithographic process.

7. The method for fabricating a heterostructure containing IC and LED according to claim **1**, wherein said step of bonding said IC to said LED is to process said first connection block, said second connection block, said first electric-conduction block and said second electric-conduction block at a temperature of 25-250° C. to realize a low-temperature joining.

8. The method for fabricating a heterostructure containing IC and LED according to claim **1**, wherein in said step of providing said LED having said second electric-conduction block and said second connection block, at least one electric-conduction through-hole is formed in said LED and electrically connected with said second electric-conduction block, and wherein at least one third electric-conduction block is formed on said second face and electrically connected with said electric-conduction through-hole.

9. The method for fabricating a heterostructure containing IC and LED according to claim **8**, wherein said step of providing said LED having said second electric-conduction block, said second connection block, said electric-conduction through-hole and said third electric-conduction block further comprises steps:

forming said second electric-conduction block on said first face and electrically connecting said second electric-conduction block with said LED;

forming said electric-conduction through-hole in said LED and electrically connecting said electric-conduction through-hole with said second electric-conduction block;

forming said third electric-conduction block on said second face and electrically connecting said third electric-conduction block with said electric-conduction through-hole; and

forming said second connection block on said first face.

10. The method for fabricating a heterostructure containing IC and LED according to claim **9**, wherein said second electric-conduction block and said third electric-conduction block are fabricated with a photolithographic process, an electroplating process and an etching process, and wherein said second connection block is fabricated with a photolithographic process.

11. The method for fabricating a heterostructure containing IC and LED according to claim **1** further comprising a cutting step, wherein said ICs and said LEDs are diced into a plurality of heterostructure units.

* * * * *