US Patent & Trademark Office
Patent Public Search | Text View

United States Patent	12387998
Kind Code	B2
Date of Patent	August 12, 2025
Inventor(s)	Lee; Chiu-Feng et al.

QFN package and fabricating method of the same

Abstract

A QFN package includes a copper lead frame. The copper lead frame includes a die paddle. A die is fixed on the die pad. A coolant passage is disposed within the die paddle. An inlet passage connects to one end of the coolant passage. An outlet passage connects to another end of the coolant passage. A mold compound encapsulates the copper lead frame and the die.

Inventors: **Lee; Chiu-Feng (Taoyuan, TW), Wang; Chen-Hsiao (Hsinchu, TW), Ho; Kai-Kuang (Hsinchu, TW)**

Applicant: **UNITED MICROELECTRONICS CORP.** (Hsin-Chu, TW)

Family ID: **1000008751328**

Assignee: **UNITED MICROELECTRONICS CORP. (Hsin-Chu, TW)**

Appl. No.: **17/985912**

Filed: **November 14, 2022**

Prior Publication Data

Document Identifier	Publication Date
US 20240128168 A1	Apr. 18, 2024

Foreign Application Priority Data

CN	202211246071.0	Oct. 12, 2022

Publication Classification

Int. Cl.: **H01L23/495** (20060101); **H01L21/48** (20060101); **H01L23/00** (20060101)

U.S. Cl.:

CPC **H01L23/49568** (20130101); **H01L21/4821** (20130101); **H01L23/49503** (20130101); **H01L23/4952** (20130101); **H01L23/49534** (20130101); **H01L23/49548** (20130101); **H01L23/49579** (20130101); **H01L24/48** (20130101); **H01L24/49** (20130101); H01L2224/48011 (20130101); H01L2224/48091 (20130101); H01L2224/48249 (20130101); H01L2224/48257 (20130101); H01L2224/4903 (20130101); H01L2224/49052 (20130101); H01L2224/49175 (20130101); H01L2924/182 (20130101)

Field of Classification Search

CPC: H01L (23/49568)

USPC: 257/675

References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
5780928	12/1997	Rostoker	257/713	H01L 23/427
6429513	12/2001	Shermer, IV	257/E23.092	H01L 23/427
7834448	12/2009	Gerbsch	361/689	H01L 23/473
7990711	12/2010	Andry	N/A	N/A
2005/0083652	12/2004	Jairazbhoy	361/689	H01L 23/473
2023/0019930	12/2022	Yoo	N/A	H01L 23/44
2023/0284421	12/2022	Malouin	N/A	G06F 1/20

Primary Examiner: Arora; Ajay

Background/Summary

BACKGROUND OF THE INVENTION

1. Field of the Invention

(1) The present invention relates to a quad flat no leads (QFN) package and a fabricating method of the same, and more particularly to a QFN package with a coolant passage and a fabricating method of the same.

2. Description of the Prior Art

(2) Semiconductor packaging processes have been widely used to electrically connect a semiconductor chip to an external component with a better reliability and also to protect the semiconductor chip from damages caused by external conditions. Among several package technologies, quad flat no lead (QFN) packaging technology is used to produce packaged die which are not significantly bigger than the actual die. An ongoing challenge in QFN package includes the removal of thermal heat generated by active components of the integrated circuit. Because the operating temperature of the QFN may be as high as 125° C., it is no longer sufficient to dissipate heat only through the circuit board or heat sink.

SUMMARY OF THE INVENTION

(3) In view of this, a QFN package using coolant for heat dissipation is provided to solve the above mentioned problem.

(4) According to a preferred embodiment of the present invention, a QFN package includes a copper lead frame. The copper lead frame includes a die paddle, a pad, a first extend portion and a second extend portion, wherein the first extend portion and the second extend portion are respectively extend from the die paddle. A die is fixed on the die paddle, wherein the die includes a conductive bond disposed at a surface of the die. A coolant passage is disposed within the die paddle. An inlet passage is disposed within the first extend portion, wherein the inlet passage connects to one end of the coolant passage. An outlet passage is disposed within the second extend portion, wherein the outlet passage connects to another end of the coolant passage. A wire electrically connects to the pad and the conductive bond. A mold compound encapsulates the copper lead frame, the die and the wire.
(5) A fabricating method of a QFN package includes providing a upper copper lead frame and a lower copper lead frame, wherein the upper copper lead frame includes a first pattern, the lower copper lead frame includes a second pattern, and the first pattern is the same as the second pattern. Next, the upper copper lead frame is adhered to the lower copper lead frame to form a copper lead frame, wherein the first pattern completely overlaps the second pattern, the copper lead frame includes a die paddle and a pad, and a coolant passage is disposed within the die paddle. Next, a die is provided and the die is fixed on the die paddle. A wire is provided to electrically connect the pad and the die. Finally, a mold compound is formed to encapsulate the copper lead frame, the die and the wire.
(6) These and other objectives of the present invention will no doubt become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiment that is illustrated in the various figures and drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** to FIG. **2** depict a fabricating method of a QFN package according to a preferred embodiment of the present invention, wherein:
(2) FIG. **2** is a fabricating step following FIG. **1**.
(3) FIG. **3** depicts a coolant passage within a QFN package and pads outside of the QFN package.
(4) FIG. **4** depicts a QFN package according to another preferred embodiment of the present invention.
(5) FIG. **5** depicts a QFN package according to another preferred embodiment of the present invention.
(6) FIG. **6** depicts a QFN package according to another preferred embodiment of the present invention.
(7) FIG. **7** depicts a QFN package according to another preferred embodiment of the present invention.
(8) FIG. **8** depicts a QFN package according to another preferred embodiment of the present invention.
DETAILED DESCRIPTION
(9) FIG. **1** to FIG. **2** depict a fabricating method of a quad flat no leads (QFN) package according to a preferred embodiment of the present invention. FIG. **3** depicts a coolant passage within a QFN package and pads outside of the QFN package. Although the coolant passage can't be seen from outside of the QFN package, in order to show the position of the coolant passage, a perspective view is used.
(10) As shown in FIG. **1**, a upper copper lead frame F1 and a lower copper lead frame F2 are provided. The upper copper lead frame F1 includes a first pattern **10**. The lower copper lead frame F2 includes a second pattern **20**. The first pattern **10** is entirely the same as the second pattern **20**.

The first pattern **10** and the second pattern **20** can be formed by a stamping process or an etching process. The first pattern **10** includes a die paddle pattern **10***a*, a first extend pattern **10***b*, a second extend pattern **10***c* and numerous pad patterns **10***d*. The die paddle pattern **10***a* is in a shape of a rectangle or a square. The first extend pattern **10***b* and the second extend pattern **10***c* connect to the die paddle pattern **10***a*. The first extend pattern **10***b* and the second extend pattern **10***c* respectively extend from two opposing corners of the die paddle pattern **10***a*. Numerous pad patterns **10***d* surround four sides of the die paddle pattern **10***a*, and all of the pad patterns **10***d* do not contact the die paddle pattern **10***a*, the first extend pattern **10***b* and the second extend pattern **10***c*.

(11) Moreover, the die paddle pattern **10***a* includes an interdigitated pattern **10***g* formed by the upper copper lead frame F1. A passage pattern **12** is between the interdigitated pattern **10***g*. The passage pattern **12** is in a shape of a square wave when viewing from the top of the upper copper lead frame F1. The passage pattern **12** is a trench which can be formed by removing part of the upper copper lead frame F1 without penetrating the upper copper lead frame F1. That is, a bottom of the passage pattern **12** is still upper copper lead frame F1. The lower copper lead frame F2 includes a second pattern **20** which is entirely the same as the first pattern **10**. The description of the second pattern **20** is therefore omitted.

(12) As shown in FIG. **2** and FIG. **3**, the upper copper lead frame F1 is adhered to the lower copper lead frame F2 to form a copper lead frame F. The first pattern **10** completely overlaps the second pattern **20**. The copper lead frame F includes a die paddle **30***a* and numerous pads **30***d*. A coolant passage **32** is disposed within the die paddle **30***a*. After that, a die **40** is provided. The die **40** is fixed onto the die paddle **30***a*. The die **40** can be a high power semiconductor die such a gallium nitride die, but not limited to it. The die **40** can also be a silicon-based die. Subsequently, numerous wires **42** are provided. Each of the wires **42** electrically connects one of the pads **30***d* to a conductive bond **44** on the die **40**. Finally, a mold compound **46** is formed to encapsulate the copper lead frame F, the die **40** and the wires **42**. In details, the die paddle pattern **10***a* of the first pattern **10** entirely overlaps the die paddle pattern **20***a* of the second pattern **20** and the die paddle pattern **10***a* is adhered to the die paddle pattern **20***a* to form a die paddle **30***a*. The first extend pattern **10***b* and the second extend pattern **10***c* of the first pattern **10** entirely overlap the first extend pattern **20***b* and the second extend pattern **20***c* of the second pattern **20** and the first extend pattern **10***b* and the second extend pattern **10***c* are adhered to the first extend pattern **20***b* and the second extend pattern **20***c* to form a first extend portion **30***b* and a second extend portion **30***c*. The pad pattern **10***d* of the first pattern **10** entirely overlaps the pad pattern **20***d* of the second pattern **20** and the pad pattern **10***d* is adhered to the pad pattern **20***d* to form pads **30***d*. The passage pattern **12** of the first pattern **10** entirely overlaps the passage pattern **22** of the second pattern **20** to become a coolant passage **32**. The interdigitated pattern **10***g* of the first pattern **10** overlaps the interdigitated pattern **20***g* of the second pattern **20**, and the interdigitated pattern **10***g* is adhered to the interdigitated pattern **20***g* to form an interdigitated pattern **30***g*. The die **40** is directly on the coolant passage **32**. Now, a QFN package of the present invention is completed. Moreover, a bottom of the die paddle **30***a* and bottoms of the pads **30***d* are exposed from the mold compound **46**. The bottom of the die paddle **30***a* and the bottoms of the pads **30***d* are aligned. The pads **30***d* can be connected to a PCB afterwards. The exposed die paddle **30***a* can also help for heat dissipation.

(13) FIG. **2** and FIG. **3** depict a QFN package according to a preferred embodiment of the present invention.

(14) As shown in FIG. **2** and FIG. **3**, a QFN package **100** includes a copper lead frame F. The copper lead frame F includes die paddle **30***a*, numerous pads **30***d*, a first extend portion **30***b* and a second extend portion **30***c*. The first extend portion **30***b* and the second extend portion **30***c* extend from the die paddle **30***a*. A die **40** includes numerous conductive bonds **44** disposed on a surface of the die **40**. The die **40** is fixed on the die paddle **30***a*. A coolant passage **32** is disposed within the die paddle **30***a*. An inlet passage **32***b* is disposed within the first extend portion **30***b*, wherein the inlet passage **32***b* connects to one end of the coolant passage **32**. An outlet passage **32***c* is disposed

within the second extend portion **30***c*, wherein the outlet passage **32***c* connects to another end of the coolant passage **32**. A wire **42** electrically connects to one of the pads **30***d* and one of the conductive bonds **44**. A mold compound **46** encapsulates the copper lead frame F, the die **40** and the wire **42**.

(15) An interdigitated pattern **30***g* is disposed within the die paddle **30***a*, and the coolant passage **32** is between the interdigitated pattern **30***g*. The coolant passage **32** is in a shape of a square wave when viewing from a top view. Besides, the mold compound **46** includes a first sidewall E1, a second sidewall E2, a third sidewall E3 and a fourth sidewall E4. The first sidewall E1 is opposed to the third sidewall E3. The second sidewall E2 is opposed to the fourth sidewall E4. A first corner A1 is a region where the first sidewall E1 connecting to the second sidewall E2. A second corner A2 is a region where the third sidewall E3 connecting to the fourth sidewall E4. The first extend portion **30***b* connects to the first corner A1, and the second extend portion **30***c* connects to the second corner A2. Numerous pads **30***d* are respectively disposed on the first sidewall E1, the second sidewall E2, the third sidewall E3 and the fourth sidewall E4. A bottom of the die paddle **30***a* and a bottom of each of the pads **30***d* are exposed from the mold compound **46**. The bottom of the die paddle **30***a* and the bottom of each of the pad **30***d* are aligned.

(16) When cooling the die **40**, coolant can be input from the inlet passage **32***b* to enter the coolant passage **32**. After heat exchange, coolant flows out from the outlet passage **32***c*. In this way, the heat of the die **40** can be dissipated. Coolant can be water, oil, liquid nitrogen, fluorocarbon liquid or other liquid with thermal conductivity.

(17) FIG. **4** depicts a QFN package according to another preferred embodiment of the present invention. FIG. **4** shows a coolant passage within the QFN package and pads outside of the QFN package. Elements which are substantially the same as those in the embodiment of FIG. **3** are denoted by the same reference numerals; an accompanying explanation is therefore omitted.

(18) As shown in FIG. **4**, the first extend portion **30***b* of the QFN package **200** connects to the first sidewall E1, and the second extend portion **30***c* connects to the third sidewall E3. The pads **30***d* are only disposed at the second sidewall E2 and the fourth sidewall E4. That is, there is no pad **30***d* on the first sidewall E1 and the third sidewall E3. Other elements in the QFN package **200** are the same as those in the QFN package **100**, and detailed description is therefore omitted.

(19) FIG. **5** depicts a QFN package according to another preferred embodiment of the present invention. FIG. **5** shows a coolant passage within the QFN package and pads outside of the QFN package. Elements which are substantially the same as those in the embodiment of FIG. **3** are denoted by the same reference numerals; an accompanying explanation is therefore omitted.

(20) The shape of the coolant passage **32** of the QFN package **300** is different from the coolant passage **32** of the QFN package **100**. As shown in FIG. **5**, numerous support walls **30***e* are disposed within the die paddle **30***a*, the support walls **30***e* are parallel to each other, and the coolant passage **32** is between the support walls **30***e*. Other elements in the QFN package **300** are the same as those in the QFN package **100**, and detailed description is therefore omitted.

(21) FIG. **6** depicts a QFN package according to another preferred embodiment of the present invention. FIG. **6** shows a coolant passage within the QFN package and pads outside of the QFN package. Elements which are substantially the same as those in the embodiment of FIG. **4** are denoted by the same reference numerals; an accompanying explanation is therefore omitted.

(22) The shape of the coolant passage **32** of the QFN package **400** in FIG. **6** is different from the coolant passage **32** of the QFN package **200** in FIG. **4**. As shown in FIG. **6**, numerous support walls **30***e* are disposed within the die paddle **30***a*, the support walls **30***e* are parallel to each other, and the coolant passage **32** is between the support walls **30***e*. Other elements in the QFN package **400** are the same as those in the QFN package **200**, and detailed description is therefore omitted.

(23) FIG. **7** depicts a QFN package according to another preferred embodiment of the present invention. FIG. **7** shows a coolant passage within the QFN package and pads outside of the QFN package. Elements which are substantially the same as those in the embodiment of FIG. **3** are

denoted by the same reference numerals; an accompanying explanation is therefore omitted.
(24) The shape of the coolant passage **32** of the QFN package **500** in FIG. **7** is different from the coolant passage **32** of the QFN package **100** in FIG. **3**. As shown in FIG. **7**, numerous columns **30***f* are disposed within the die paddle **30***a*, and the coolant passage **32** is between the support columns **30***f*. Other elements in the QFN package **500** are the same as those in the QFN package **100**, and detailed description is therefore omitted.
(25) FIG. **8** depicts a QFN package according to another preferred embodiment of the present invention. FIG. **8** shows a coolant passage within the QFN package and pads outside of the QFN package. Elements which are substantially the same as those in the embodiment of FIG. **4** are denoted by the same reference numerals; an accompanying explanation is therefore omitted.
(26) The shape of the coolant passage **32** of the QFN package **600** in FIG. **8** is different from the coolant passage **32** of the QFN package **200** in FIG. **4**. As shown in FIG. **8**, numerous columns **30***f* are disposed within the die paddle **30***a*, and the coolant passage **32** is between the support columns **30***f*. Other elements in the QFN package **600** are the same as those in the QFN package **200**, and detailed description is therefore omitted.
(27) In the present invention, passage patterns are defined on the upper lead frame and the lower lead frame, and then the upper lead frame and the lower lead frame are adhered to each other to form a copper lead frame, so that a coolant passage can be formed in the die paddle. That is, the coolant passage is sandwiched inside the die paddle. In this way, coolant can be input into the coolant passage to dissipate heat of the die. The present invention specially suitable for dies of 5G high frequency communication formed by gallium nitride because of their higher requirements for heat dissipation under high voltage conditions.
(28) Those skilled in the art will readily observe that numerous modifications and alterations of the device and method may be made while retaining the teachings of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.

Claims

1. A quad flat no leads (QFN) package, comprising: a copper lead frame comprising a die paddle, a pad, a first extend portion and a second extend portion, wherein the first extend portion and the second extend portion are respectively extend from the die paddle; a die fixed on the die paddle, wherein the die comprises a conductive bond disposed at a surface of the die; a coolant passage disposed within the die paddle; an inlet passage disposed within the first extend portion, wherein the inlet passage connects to one end of the coolant passage; an outlet passage disposed within the second extend portion, wherein the outlet passage connects to another end of the coolant passage; a wire electrically connects to the pad and the conductive bond; and a mold compound encapsulating the copper lead frame, the die and the wire.
2. The QFN package of claim 1, wherein the copper lead frame is formed by adhering a upper copper lead frame to a lower copper lead frame, the upper copper lead frame comprises a first pattern, the lower copper lead frame comprises a second pattern, and the first pattern is the same as the second pattern.
3. The QFN package of claim 2, wherein the first pattern completely overlaps the second pattern.
4. The QFN package of claim 1, wherein the mold compound comprises a first sidewall, a second sidewall, a third sidewall and a fourth sidewall, the first sidewall is opposed to the third sidewall, and the second sidewall is opposed to the fourth sidewall.
5. The QFN package of claim 4, wherein the copper lead frame further comprises a plurality of the pads.
6. The QFN package of claim 5, wherein the plurality of the pads are only disposed at the second sidewall and the fourth sidewall, and the first extend portion connects to the first sidewall and the

second extend portion connects to the third sidewall.
7. The QFN package of claim 5, wherein a first corner is a region where the first sidewall connecting to the second sidewall, a second corner is a region where the third sidewall connecting to the fourth sidewall, and the plurality of the pads are disposed at the first sidewall, the second sidewall, the third sidewall and the fourth sidewall.
8. The QFN package of claim 7, wherein the first extend portion connects to the first corner, and the second extend portion connects to the second corner.
9. The QFN package of claim 1, wherein a plurality of support columns are disposed within the die paddle, and the coolant passage is between the plurality of support columns.
10. The QFN package of claim 1, wherein a plurality of support walls are disposed within the die paddle, the plurality of support walls are parallel to each other, and the coolant passage is between the plurality of support walls.
11. The QFN package of claim 1, wherein an interdigitated pattern is disposed within the die paddle, and the coolant passage is between the interdigitated pattern.
12. The QFN package of claim 1, wherein a bottom of the pad is exposed through the mold compound, and the bottom of the pad is aligned with a bottom of the die paddle.
13. A fabricating method of a quad flat no leads (QFN) package, comprising: providing a upper copper lead frame and a lower copper lead frame, wherein the upper copper lead frame comprises a first pattern, the lower copper lead frame comprises a second pattern, and the first pattern is the same as the second pattern; adhering the upper copper lead frame to the lower copper lead frame to form a copper lead frame, wherein the first pattern completely overlaps the second pattern, the copper lead frame comprises a die paddle and a pad, and a coolant passage is disposed within the die paddle; providing a die and the die fixed on the die paddle; providing a wire to electrically connecting the pad and the die; and forming a mold compound encapsulating the copper lead frame, the die and the wire.
14. The fabricating method of a QFN package of claim 13, wherein the copper lead frame further comprises a first extend portion and a second extend portion, the first extend portion and the second extend portion are respectively extend from the die paddle, an inlet passage is disposed within the first extend portion, the inlet passage connects to one end of the coolant passage, an outlet passage is disposed within the second extend portion, and the outlet passage connects to another end of the coolant passage.
15. The fabricating method of a QFN package of claim 13, wherein mold compound comprises a first sidewall, a second sidewall, a third sidewall and a fourth sidewall, the first sidewall is opposed to the third sidewall, and the second sidewall is opposed to the fourth sidewall.
16. The fabricating method of a QFN package of claim 15, wherein the copper lead frame further comprises a plurality of the pads, the plurality of the pads are only disposed at the second sidewall and the fourth sidewall, and the first extend portion connects to the first sidewall and the second extend portion connects to the third sidewall.
17. The fabricating method of a QFN package of claim 15, wherein the copper lead frame further comprises a plurality of the pads, the plurality of the pads are disposed on the first sidewall, the second sidewall, the third sidewall and the fourth sidewall, a first corner is a region where the first sidewall connecting to the second sidewall, a second corner is a region where the third sidewall connecting to the fourth sidewall, the first extend portion connects to the first corner, and the second extend portion connects to the second corner.
18. The fabricating method of a QFN package of claim 13, wherein a plurality of support columns are disposed within the die paddle, and the coolant passage is between the plurality of support columns.
19. The fabricating method of a QFN package of claim 13, wherein a plurality of support walls are disposed within the die paddle, the plurality of support walls are parallel to each other, and the coolant passage is between the plurality of support walls.

20. The fabricating method of a QFN package of claim 13, wherein an interdigitated pattern is disposed within the die paddle, and the coolant passage is between the interdigitated pattern.