# DESCRIPTION

## Title of Invention

# COLD PLATE

## Technical Field

[0001]

The present disclosure relates to a cold plate.

The present application claims priority based on Japanese Patent Application No. 2024-025576 filed in Japan on February 22, 2024, the content of which is incorporated herein by reference.

## Background Art

[0002]

Electronic devices such as a central processing unit (CPU) and a graphics processing unit (GPU) mounted on a server or the like generate heat during operation. In order to cool these heat generating bodies, a cold plate is used. A refrigerant flows inside the cold plate. The heat generating element is cooled by the refrigerant inside the cold plate removing heat from the heat generating element. Cold plates include, for example, a boiling cooling type cold plate that boils a refrigerant to remove the heat from a heat generating element by latent heat of vaporization.

[0003]

In addition, PTL 1 discloses a technique of providing a fin in a flow path through which a refrigerant flows to increase a heat transfer area. By forming such a fin in the cold plate, the heat transfer area is increased, and an improvement in cooling capacity is expected.

Citation List

Patent Literature

[0004]

[PTL 1] Japanese Unexamined Patent Application Publication No. 2000-35295

Summary of Invention

Technical Problem

[0005]

However, in a case where fins are provided in the cold plate, a backflow or an unstable flow may occur in a flow between the fins. These flow phenomena may hinder heat transfer from the heat generating element to the refrigerant, and the cooling performance may decrease.

[0006]

In addition, in a case where a flow path width between the fins is narrow, in a region where a bubble volume on the upstream side is small, bubbles are flattened, and a thin liquid film region expands. In this liquid film region, heat transfer from the heat generating element to the refrigerant is promoted. On the other hand, in a region where the bubble volume on the downstream side is large, the flattening of the bubbles progresses, and a dryout region having poor heat transfer performance expands. Therefore, there is a concern that the heat transfer performance deteriorates and the cooling performance decreases from the upstream side toward the downstream side.

[0007]

In addition, in order to prevent the unstable flow, for example, there is a method of changing a shape of a casing in which the refrigerant is sealed, gradually expanding a space above the fins toward the downstream side, and making it easy for

the bubbles to escape to the space above the fins in accordance with an increase in an amount of vapor due to boiling. However, in this method, the cold plate may be enlarged, and it may be difficult to install the cold plate in the server.

[0008]

The present disclosure has been made to solve the above-described problems, and an object of the present disclosure is to provide a cold plate capable of improving cooling capacity without increasing the size of the server.

Solution to Problem

[0009]

In order to solve the above-described problems, a cold plate according to the present disclosure includes a casing that is disposed to be adjacent to a heat generating element in a first direction, is attached to an outer surface of the heat generating element, and boils a refrigerant flowing through the casing to remove heat from the heat generating element, and a plurality of fins that are disposed in the casing at intervals in a second direction intersecting the first direction, in which the fins protrude from a bottom surface of an inner surface of the casing, the bottom surface extending along the outer surface, toward the first direction and extend in a direction intersecting both the first direction and the second direction, the plurality of fins form a flow path through which the refrigerant is capable of flowing between adjacent fins, the plurality of fins include a plurality of first fins extending from an upstream end to a downstream end of the flow path, and a plurality of second fins disposed between adjacent first fins, and a height of the second fins in the first direction on an upstream side in a flow direction of the flow path is higher than a height of the second fins in the first direction on a downstream side in the flow direction.

[0010]

A cold plate according to the present disclosure includes a casing that is disposed to be adjacent to a heat generating element in a first direction, is attached to an outer surface of the heat generating element, and boils a refrigerant flowing through the casing to remove heat from the heat generating element, and a plurality of fins that are disposed in the casing at intervals in a second direction intersecting the first direction, in which the fins protrude from a bottom surface of an inner surface of the casing, the bottom surface extending along the outer surface, toward the first direction and extend in a direction intersecting both the first direction and the second direction, the plurality of fins form a flow path through which the refrigerant is capable of flowing between adjacent fins, and a height of the fins in the first direction on an upstream side in a flow direction of the flow path is higher than a height of the fins in the first direction on a downstream side in the flow direction.

Advantageous Effects of Invention

[0011]

According to the cold plate of the present disclosure, cooling performance can be improved.

Brief Description of Drawings

[0012]

FIG. 1 is a plan view of a cold plate according to a first embodiment of the present disclosure.

FIG. 2 is a cross-sectional view taken along line II-II of FIG. 1.

FIG. 3 is a plan view of a fin according to the first embodiment of the present disclosure.

FIG. 4 is a front view of the fin according to the first embodiment of the present disclosure.

FIG. 5 is a side view of the fin according to the first embodiment of the present disclosure.

FIG. 6 is a diagram illustrating a function of the fin according to the first embodiment of the present disclosure.

FIG. 7 is a diagram illustrating a function of the fin according to the first embodiment of the present disclosure.

FIG. 8 is a plan view of a fin according to a second embodiment of the present disclosure.

FIG. 9 is a front view of the fin according to the second embodiment of the present disclosure.

FIG. 10 is a side view of the fin according to the second embodiment of the present disclosure.

FIG. 11 is a plan view of a fin according to a third embodiment of the present disclosure.

FIG. 12 is a front view of the fin according to the third embodiment of the present disclosure.

FIG. 13 is a side view of the fin according to the third embodiment of the present disclosure.

FIG. 14 is a plan view of a fin according to a fourth embodiment of the present disclosure.

FIG. 15 is a front view of the fin according to the fourth embodiment of the present disclosure.

FIG. 16 is a side view of the fin according to the fourth embodiment of the present disclosure.

FIG. 17 is a side view of a fin according to a modification example of the

fourth embodiment of the present disclosure.

Description of Embodiments

[0013]

<First Embodiment>

Hereinafter, a cold plate 1 according to a first embodiment of the present disclosure will be described with reference to FIGS. 1 to 7.

A server includes a plurality of chips such as CPUs and GPUs on a substrate 2. These chips generate heat during operation. The cold plate 1 of the present disclosure is used to cool these chips. Hereinafter, these chips are referred to as a heat generating element 3. These chips are examples of the heat generating element 3.

[0014]

The heat generating element 3 is disposed to extend in a horizontal direction. Hereinafter, the vertical direction may be referred to as a first direction D1. In addition, one direction in the horizontal direction may be referred to as a "second direction D2", and a direction orthogonal to the second direction D2 in the horizontal direction may be referred to as a "third direction D3". The first direction D1, the second direction D2, and the third direction D3 are orthogonal to each other.

[0015]

As shown in FIGS. 1 and 2, the cold plate 1 is placed on the heat generating element 3 from above and is disposed to extend in the horizontal direction in the same manner as the heat generating element 3. The cold plate 1 includes a casing 10, flow path walls 20, and fins 30.

[0016]

(Casing)

The casing 10 is disposed to be adjacent to the heat generating element 3 in

the first direction D1. The casing 10 is capable of sealing a refrigerant R that cools the heat generating element 3. The refrigerant R flows inside the casing 10. The casing 10 boils the refrigerant R to remove heat from the heat generating element 3. The casing 10 extends in the second direction D2 and the third direction D3. The casing 10 is formed in a rectangular plate shape having the second direction D2 as a longitudinal direction.

Hereinafter, a virtual plane passing through a center of the casing 10 in the third direction D3 and extending in the first direction D1 and the second direction D2 will be referred to as a center plane C. The casing 10 is formed of, for example, a material having heat transfer properties, such as a metal material.

The casing 10 includes a base plate 11 and a cover 12.

[0017]

The base plate 11 is attached to an outer surface 3a of the heat generating element 3 on a side opposite to the substrate 2 in the first direction D1. The base plate 11 extends in the second direction D2 and the third direction D3. The base plate 11 is formed in a rectangular plate shape having the second direction D2 as a longitudinal direction.

[0018]

The cover 12 is overlapped with the base plate 11 from a side opposite to the heat generating element 3 in the first direction D1. The cover 12 is open to the base plate 11 side in the first direction D1. The cover 12 covers the flow path walls 20 and the fins 30, which will be described later. The cover 12 has side walls 13 and an upper wall 14. A total of four side walls 13 are provided along each edge of the base plate 11. The side walls 13 rise from the base plate 11 in the first direction D1. Hereinafter, among the side walls 13, a pair of side walls 13 facing each other in the

second direction D2 will be referred to as first side walls 13a, and a pair of side walls 13 facing each other in the third direction D3 will be referred to as second side walls 13b.

[0019]

A supply hole 15 is formed in one first side wall 13a of the two first side walls 13a. The supply hole 15 penetrates the first side wall 13a in the second direction D2. A supply port 4 is connected to the supply hole 15. The supply port 4 supplies the refrigerant R into the casing 10. The refrigerant R is supplied into the casing 10 through the supply hole 15. In the present embodiment, the supply hole 15 is formed in a circular shape. A center of the supply hole 15 is located on the center plane C.

[0020]

The upper wall 14 is provided at end portions of the side walls 13 on a side opposite to the base plate 11 in the first direction D1. The upper wall 14 closes a space surrounded by the four side walls 13. The upper wall 14 extends in the second direction D2 and the third direction D3. The upper wall 14 is formed in a rectangular plate shape having the second direction D2 as a longitudinal direction.

[0021]

A discharge hole 16 is formed in the upper wall 14. The discharge hole 16 penetrates the upper wall 14 in the first direction D1. A discharge hole 16 extends in the second direction D2. A discharge port 5 is connected to the discharge hole 16. The discharge port 5 discharges the refrigerant R from the inside of the casing 10. The refrigerant R is discharged to the outside of the casing 10 through the discharge hole 16. A center line passing through the center of the discharge hole 16 in the third direction D3 and extending in the second direction D2 is located on the center plane C.

[0022]

(Flow Path Wall)

The flow path walls 20 are disposed in a pair on both outer sides of the discharge hole 16 in the second direction D2 as viewed from the first direction D1. The flow path walls 20 extend in the third direction D3. In addition, the flow path walls 20 protrude from the base plate 11 in the first direction D1 and connect the base plate 11 and the upper wall 14. In addition, the flow path walls 20 are disposed at positions facing the first side wall 13a in the second direction D2. The flow of the refrigerant R supplied into the casing 10 is changed from the second direction D2 to the third direction D3 by the flow path walls 20.

[0023]

(Fin)

A plurality of fins 30 are disposed in the casing 10 at intervals in the second direction D2. In the present embodiment, the plurality of fins 30 are disposed at equal intervals in the second direction D2. The fins 30 extend in the third direction D3. The fins 30 protrude from a bottom surface 17a on the base plate 11 of the inner surface 17 of the casing 10 and connect the base plate 11 and the upper wall 14. The bottom surface 17a is along the outer surface 3a of the heat generating element 3. The plurality of fins 30 form a flow path 6 through which the refrigerant R is capable of flowing between the adjacent fins 30 in the casing 10. The refrigerant R flows in the third direction D3 from the second side walls 13b toward the discharge hole 16 in the flow path 6. Hereinafter, the flow direction Df of the flow path 6 will be simply referred to as the flow direction Df. In the present embodiment, the flow direction Df coincides with the third direction D3. In addition, the upstream side Dfu in the flow direction Df will be simply referred to as the upstream side Dfu, and the downstream side Dfd in the flow direction Df will be simply referred to as the downstream side Dfd.

A width W1 of the flow path 6 in the second direction D2 is constant at all positions in the flow direction Df.

[0024]

In addition, the plurality of fins 30 are formed of, for example, the same material as the casing 10. That is, the plurality of fins 30 are formed of, for example, a material having heat transfer properties, such as a metal material. A width W2 of the fins 30 in the second direction D2 is constant at all positions in the flow direction Df. The width W2 of the fins 30 is smaller than the interval between the fins 30 (the width W1 of the flow path 6). In addition, a height H of each fin 30 in the first direction D1 is designed to be larger than the width W2 of the fin 30 and the interval between the fins 30 (the width W1 of the flow path 6) at least at an end portion of each fin 30 on the most upstream side Dfu.

[0025]

In the present embodiment, one set of the plurality of fins 30 is provided on each of both sides of the center plane C in the third direction D3. The sets of the plurality of fins 30 are formed symmetrically with respect to the center plane C. Each set of the plurality of fins 30 includes a plurality of first fins 31 and a plurality of second fins 32. In the present embodiment, both the first fins 31 and the second fins 32 extend from the upstream end 6a to the downstream end 6b of the flow path 6 in the flow direction Df. That is, a length L1 of the first fin 31 in the second direction D2 and a length L2 of the second fin 32 in the second direction D2 are equal to each other.

[0026]

(First Fin)

The first fins 31 extend from the upstream end 6a to the downstream end 6b of the flow path 6. The first fins 31 adjacent to each other in the third direction D3 with

the center plane C interposed therebetween (the first fins 31 formed at the same position in the second direction D2) are connected to each other at the center plane C and are integrated with each other. The first fins 31 adjacent to each other in the third direction D3 (the first fins 31 formed at the same position in the second direction D2) may be formed as separate bodies or may be spaced apart from each other in the third direction D3.

[0027]

As shown in FIGS. 3 to 5, the first fins 31 extend in the flow direction Df with a uniform height H in the first direction D1. That is, the height H of the first fin 31 in the first direction D1 is constant at all positions in the flow direction Df.

[0028]

A plurality of slits 33 are formed in the first fins 31 at intervals in the flow direction Df. The plurality of slits 33 are formed at equal intervals in the flow direction Df. The slits 33 are formed in a triangular shape that tapers toward the base plate 11 side in the first direction D1 when viewed from the second direction D2. That is, a length L3 of the slit 33 in the flow direction Df gradually decreases toward the base plate 11 side in the first direction D1. The slits 33 are formed from an edge of the first fins 31 on a side opposite to the bottom surface 17a in the first direction D1 to the bottom surface 17a over the entire region in the first direction D1. The slits 33 need not be formed up to the bottom surface 17a. In addition, the slits 33 may be formed at once when the fins 30 are formed by casting, or may be formed by cutting out the fins 30 after the fins 30 are formed. In addition, the slits 33 need not be formed at equal intervals in the flow direction Df. In addition, the shape of the slit 33 can be changed as appropriate. The slits 33 may be formed in a rectangular shape extending in the first direction D1 when viewed from the second direction D2.

[0029]

The first fins 31 are divided into a plurality of segments 31a in the flow direction Df by the plurality of slits 33. The segments 31a are formed in a trapezoidal shape. A length of the segment 31a in the flow direction Df decreases as the segments 31a are separated from the bottom surface 17a in the first direction D1. A length L4 of an edge of the segment 31a on the bottom surface 17a side in the flow direction Df is equal in all the segments 31a. In addition, the length L4 of the segment 31a in the flow direction Df is larger than the length L3 of the slit 33 in the flow direction Df.

[0030]

(Second Fin)

The second fins 32 are disposed between the adjacent first fins 31. One second fin 32 is disposed in each gap between the adjacent first fins 31. The second fins 32 adjacent to each other in the third direction D3 with the center plane C interposed therebetween (the second fins 32 formed at the same position in the second direction D2) are in contact with each other at the center plane C. The second fins 32 adjacent to each other in the third direction D3 (the second fins 32 formed at the same position in the second direction D2) may be spaced apart from each other in the third direction D3 or may be formed integrally with each other.

[0031]

The height H of the second fins 32 in the first direction D1 on the upstream side Dfu is higher than the height H of the second fins 32 in the first direction D1 on the downstream side Dfd. In other words, the height H of the second fins 32 in the first direction D1 on the downstream side Dfd is lower than the height H of the second fins 32 in the first direction D1 on the upstream side Dfu. In the present embodiment,

the second fins 32 are formed in a tapered shape in which the height H in the first direction D1 gradually decreases from the upstream side Dfu toward the downstream side Dfd when viewed from the second direction D2. In the illustrated example, the second fins 32 are formed in a triangular shape in which the height H in the first direction D1 decreases when viewed from the second direction D2. Therefore, only ends of the second fins 32 on the upstream side Dfu are connected to the upper wall 14 of the casing 10.

[0032]

In other words, the second fin 32 has a tip edge 34 formed on a side opposite to the bottom surface 17a in the first direction D1 of the second fin 32, and the tip edge 34 is formed in a linear shape that extends in the flow direction Df and is inclined to approach the bottom surface 17a side in the first direction D1 from the upstream side Dfu toward the downstream side Dfd. An end of the second fin 32 on the downstream side Dfd is located on the bottom surface 17a.

[0033]

(Operation and Effect)

Hereinafter, effects and advantages of the cold plate 1 according to the present embodiment will be described.

The refrigerant R supplied into the casing 10 from the supply hole 15 collides with the flow path walls 20 and is divided into two directions. Thereafter, the refrigerant R flows along the second side walls 13b and flows into each flow path 6 between the fins 30. The refrigerant R flows from the second side walls 13b toward the center plane C side. Heat is transferred to the refrigerant R from the heat generating element 3 in the process of flowing in the flow path 6. Since the heat transfer area of the cold plate 1 is increased by the fins 30, the heat is favorably

transferred from the heat generating element 3 to the refrigerant R, and the refrigerant R boils by receiving the heat of the heat generating element 3. In this case, the latent heat of vaporization is taken away from the heat generating element 3 by the refrigerant R, and the heat generating element 3 is cooled. The vaporized refrigerant R is discharged from the discharge port 5 to the outside of the casing 10. Thereafter, the refrigerant R circulates through a pipe (not shown) and is supplied into the casing 10 from the supply hole 15 again through the condenser.

The refrigerant R may flow only by natural convection caused by the heat of the heat generating element 3, or a pump or the like may be provided to pump the refrigerant R.

[0034]

In the present embodiment, the cold plate 1 includes the casing 10 and a plurality of fins 30. The casing 10 is disposed adjacent to the heat generating element 3 in the first direction D1 and is attached to the outer surface 3a of the heat generating element 3. The refrigerant R flows inside the casing 10. The casing 10 boils the refrigerant R flowing inside to remove heat from the heat generating element 3. The plurality of fins 30 are disposed in the casing 10 at intervals in the second direction D2 intersecting the first direction D1. The fins 30 protrude from the bottom surface 17a of the inner surface 17 of the casing 10, the bottom surface 17a extending along the outer surface 3a, toward the first direction D1 and extend in the third direction D3 intersecting both the first direction D1 and the second direction D2. The plurality of fins 30 form the flow path 6 through which the refrigerant R is capable of flowing between the adjacent fins 30. The plurality of fins 30 include a plurality of first fins 31 extending from the upstream end 6a to the downstream end 6b of the flow path 6 and a plurality of second fins 32 disposed between the adjacent first fins 31. A height

H of the second fins 32 in the first direction D1 on the upstream side Dfu in the flow direction Df of the flow path 6 is higher than a height H of the second fins 32 in the first direction D1 on the downstream side Dfd in the flow direction Df.

[0035]

As shown in FIGS. 6 and 7, the bubbles 50 are generated in the cold plate 1 by boiling of the refrigerant R. The bubbles 50 are crushed by the fins 30 to have a flattened shape. The bubbles 50 having a flattened shape have a liquid film region 51 having good heat transfer performance and a dryout region 52 having poor heat transfer performance. A volume of the bubbles 50 is smaller on the upstream side Dfu and is larger on the downstream side Dfd. In addition, the volume of the bubbles 50 is smaller on a root side (lower side) of the fins 30 closer to the heat generating element 3 in the first direction D1 (up-down direction) and is larger on a tip side (upper side) of the fins 30 farther from the heat generating element 3 in the first direction D1 (up-down direction). In a case where the volume of the bubbles 50 increases in the narrow flow path 6, the bubbles 50 hinder the flow of the refrigerant R. In addition, the dryout region 52 may increase, the heat transfer performance may deteriorate, and the cooling performance may decrease.

[0036]

In the present embodiment, the first fins 31 and the second fins 32 are alternately disposed, and the height H of the second fins 32 on the upstream side Dfu in the flow direction Df of the flow path 6 is higher than the height H of the second fins 32 on the downstream side Dfd in the flow direction Df. Accordingly, the gap (flow path 6) between the fins 30 in the upper portion in the casing 10 can be expanded more toward the downstream side Dfd and away from the heat generating element 3. Therefore, as the volume of the bubbles 50 increases, the bubbles 50 are

likely to flow out to the downstream side Dfd and upward, and the backflow or the unstable flow of the refrigerant R is suppressed.

In addition, in the narrow gap between the adjacent fins 30, the dryout region 52 having poor heat transfer performance in the bubbles 50 gradually increases toward the downstream side Dfd. According to the present embodiment, as the bubbles 50 move toward the downstream side Dfd, the bubbles 50 are more likely to flow out from the narrow gap between the adjacent fins 30 to a wide space above the second fins 32. In a case where the bubbles 50 flow out to the wide space, the dryout region 52 is reduced.

In this way, since the backflow or the unstable flow of the refrigerant R can be suppressed and the dryout region 52 of the bubbles 50 on the downstream side Dfd can be reduced, the deterioration of the heat transfer performance can be suppressed, and the cooling performance can be improved. In addition, since the cooling performance is improved, the energy required for cooling the heat generating element is reduced.

In addition, since it is not necessary to change the volume of the casing 10, the enlargement of the cold plate 1 can be suppressed.

[0037]

In the present embodiment, the second fin 32 has the tip edge 34 that is formed on a side opposite to the bottom surface 17a in the first direction D1 and that extends in the flow direction Df. The tip edge 34 is inclined to approach the bottom surface 17a side in the first direction D1 from the upstream side Dfu toward the downstream side Dfd.

[0038]

According to the present embodiment, the flow path area between the fins 30 is gradually expanded from the upstream side Dfu toward the downstream side Dfd.

Accordingly, an increase in pressure loss due to the volume flow rate of the refrigerant R generated from the upstream side Dfu toward the downstream side Dfd can be reduced, so that the occurrence of unstable flow accompanied by a sudden change in the flow rate of the refrigerant R or an increase in pressure loss is suppressed.

In the present embodiment, a case where the tip edge 34 is formed in a linear shape has been described, but the present disclosure is not limited thereto. The tip edge 34 may be formed in a curved shape in which the height H of the second fins 32 in the first direction D1 is reduced. Even in this case, the cold plate 1 can exhibit the same effects and advantages.

[0039]

<Second Embodiment>

Hereinafter, a cold plate 201 according to a second embodiment of the present disclosure will be described with reference to FIGS. 8 to 10. In the configuration of the second embodiment, configurations common to the above-described embodiment are denoted by the same names and the same reference numerals or the like, and the description thereof will be appropriately omitted.

[0040]

As shown in FIGS. 8 to 10, in the present embodiment, the plurality of fins 230 include a plurality of first fins 31 and a plurality of second fins 232. The second fin 232 extends from the upstream end 6a of the flow path 6 in the flow direction Df, but a length L2 of the second fin 232 in the flow direction Df is shorter than a length L1 of the first fin 31 in the flow direction Df. The second fin 232 has a tip edge 234 that is formed on a side opposite to the bottom surface 17a in the first direction D1 and extends in the flow direction Df. The tip edge 234 is formed in a stepped shape in which the tip edge 234 approaches the bottom surface 17a side in the first direction D1

from the upstream side Dfu toward the downstream side Dfd in a stepwise manner. That is, the tip edge 234 has a plurality of stepped surfaces 235 arranged in the flow direction Df. Each stepped surface 235 extends in the flow direction Df in parallel with the bottom surface 17a. The plurality of stepped surfaces 235 are located on the bottom surface 17a side in the first direction D1 from the upstream side Dfu toward the downstream side Dfd. Distances in the first direction D1 between the stepped surfaces 235 adjacent to each other in the flow direction Df are all equal. In addition, only the stepped surface 235 on the most upstream side Dfu among the plurality of stepped surfaces 235 is connected to the upper wall 14 of the casing 10.

[0041]

(Operation and Effect)

Hereinafter, effects and advantages of the cold plate 201 of the present embodiment will be described. The cold plate 201 of the present embodiment exhibits the same fluid and thermal effects and advantages as those of the first embodiment described above, and exhibits the following effects and advantages.

In the present embodiment, the tip edge 234 is formed in a stepped shape in which the tip edge 234 approaches the bottom surface 17a side in the first direction D1 from the upstream side Dfu toward the downstream side Dfd in a stepwise manner.

[0042]

As a result, it is easy to change the design of the height H of the second fins 232, and it is possible to design the second fin 232 in accordance with the specification of the cold plate 201, such as the heat generation amount and the type of the refrigerant R.

[0043]

<Third Embodiment>

Hereinafter, a cold plate 301 according to a third embodiment of the present disclosure will be described with reference to FIGS. 11 to 13. In the configuration of the third embodiment, configurations common to the above-described embodiment are denoted by the same names and the same reference numerals or the like, and the description thereof will be appropriately omitted.

[0044]

As shown in FIGS. 11 to 13, in the present embodiment, the plurality of fins 330 include the plurality of first fins 31 and the plurality of second fins 332. A center 332a of the second fin 332 in the flow direction Df is located on the upstream side Dfu, and a length L2 of the second fin 332 in the flow direction Df is shorter than a length L1 of the first fin 31 in the flow direction Df. In the present embodiment, an end of the second fin 332 on the upstream side Dfu is located at the upstream end 6a of the flow path 6, and an end of the second fin 332 on the downstream side Dfd is located at an intermediate position of the flow path 6 in the flow direction Df. The length L2 of the second fin 332 in the flow direction Df is half the length L1 of the first fin 31. The position of the end of the second fin 332 on the upstream side Dfu can be changed as appropriate. The end of the second fin 332 on the upstream side Dfu may be located on the downstream side Dfd with respect to the upstream end 6a of the flow path 6.

[0045]

In the present embodiment, the second fins 332 extend in the flow direction Df with a uniform height H in the first direction D1, similarly to the first fins 31. That is, the height H of the second fins 332 in the first direction D1 is constant at all positions in the flow direction Df. The entire region of the second fin 332 in the flow direction Df is connected to the upper wall 14 of the casing 10. In addition, similarly to the

first fin 31, a plurality of slits 33 are formed in the second fin 332 at intervals in the flow direction Df. The slits 33 of the second fin 332 are formed at the same positions in the flow direction Df as the slits 33 of the first fin 31. That is, the slits 33 of the second fin 332 overlap the slits 33 of the first fin 31 in the second direction D2.

[0046]

(Operation and Effect)

Hereinafter, the effects and advantages of the cold plate 301 of the present embodiment will be described. The cold plate 301 of the present embodiment exhibits the same fluid and thermal effects and advantages as those of the first embodiment described above, and exhibits the following effects and advantages.

In the present embodiment, the center 332a of the second fin 332 in the flow direction Df is located on the upstream side Dfu, and the length of the second fin 332 in the flow direction Df is shorter than the length of the first fin 31 in the flow direction Df.

[0047]

As a result, the second fins 332 and the first fins 31 can be designed to have the same shape while exhibiting the above-described improvement in cooling performance only by shortening the length of the second fins 332, and thus the manufacturing efficiency of the fins 330 can be improved.

[0048]

<Fourth Embodiment>

Hereinafter, a cold plate 401 according to a fourth embodiment of the present disclosure will be described with reference to FIGS. 14 to 16. In the configuration of the fourth embodiment, configurations common to the above-described embodiment are denoted by the same names and the same reference numerals or the like, and the

description thereof will be appropriately omitted.

[0049]

As shown in FIGS. 14 to 16, the cold plate 401 includes a plurality of fins 430. In the present embodiment, the casing 10 and the plurality of fins 430 are provided. The plurality of fins 430 are all formed in the same shape. The plurality of fins 430 form the flow path 6 through which the refrigerant R is capable of flowing between the adjacent fins 430. A height H of the fin 430 in the first direction D1 on an upstream side Dfu in the flow direction Df of the flow path 6 is higher than a height H of the fin 430 in the first direction D1 on a downstream side Dfd in the flow direction Df. In other words, the height H of the fin 430 in the first direction D1 on the downstream side Dfd is lower than the height H of the fin 430 in the first direction D1 on the upstream side Dfu.

[0050]

In the present embodiment, the tip edge 434 of the fin 430 has a parallel portion 434a on the upstream side Dfu and an inclined portion 434b on the downstream side Dfd. The parallel portion 434a extends in parallel with the bottom surface 17a. The inclined portion 434b extends further toward the downstream side Dfd from a downstream end 434c of the parallel portion 434a. The inclined portion 434b is inclined toward the bottom surface 17a side toward the downstream side Dfd. An end of the inclined portion 434b on the downstream side Dfd is located on the bottom surface 17a. Only the parallel portion 434a of the fins 430 is connected to the upper wall 14 of the casing 10.

[0051]

(Operation and Effect)

Hereinafter, effects and advantages of the cold plate 401 of the present

embodiment will be described.

In the present embodiment, the cold plate 401 includes the casing 10 and the plurality of fins 430. The plurality of fins 430 are disposed in the casing 10 at intervals in the second direction D2 intersecting the first direction D1. The fins 430 protrude from the bottom surface 17a of the inner surface 17 of the casing 10, the bottom surface 17a extending along the outer surface 3a, toward the first direction D1 and extend in the third direction D3 intersecting both the first direction D1 and the second direction D2. The plurality of fins 430 form the flow path 6 through which the refrigerant R is capable of flowing between the adjacent fins 430. A height H of the fin 430 in the first direction D1 on an upstream side Dfu in the flow direction Df of the flow path 6 is higher than a height of the fin 430 in the first direction D1 on a downstream side Dfd in the flow direction Df.

[0052]

In the present embodiment, the height H of the fin 430 on the upstream side Dfu in the flow direction Df of the flow path 6 is higher than the height H of the fin 430 on the downstream side Dfd in the flow direction Df. Accordingly, the gap (flow path 6) between the fins 430 in the upper portion in the casing 10 can be expanded more toward the downstream side Dfd. Therefore, as the volume of the bubbles 50 increases, the bubbles 50 are likely to flow out to the downstream side Dfd and upward, and the backflow or the unstable flow of the refrigerant R is suppressed.

In addition, in the narrow gap between the adjacent fins 430, the dryout region 52 having poor heat transfer performance in the bubbles 50 gradually increases toward the downstream side Dfd. According to the present embodiment, as the bubbles 50 move toward the downstream side Dfd, the bubbles 50 are more likely to flow out from the narrow gap between the adjacent fins 430 to a wide space above the fins 430.

In a case where the bubbles 50 flow out to the wide space, the dryout region 52 is reduced.

In this way, since the backflow or the unstable flow of the refrigerant R can be suppressed and the dryout region 52 of the bubbles 50 on the downstream side Dfd can be reduced, the deterioration of the heat transfer performance can be suppressed, and the cooling performance can be improved. In addition, since the cooling performance is improved, the energy required for cooling the heat generating element is reduced.

In addition, since it is not necessary to change the volume of the casing 10, the enlargement of the cold plate 401 can be suppressed.

[0053]

In the present embodiment, the end of the inclined portion 434b of the tip edge 434 on the downstream side is located on the bottom surface 17a, but the present disclosure is not limited thereto. The shape of the fin 430 can be changed as appropriate. For example, as shown in FIG. 17, the end of the inclined portion 434b of the tip edge 434 on the downstream side may be spaced apart from the bottom surface 17a in the first direction D1. (The end of the inclined portion 434b on the downstream side may be located above the bottom surface 17a.) In addition, the position of the boundary between the parallel portion 434a and the inclined portion 434b can be changed as appropriate.

[0054]

In addition, in the present embodiment, all of the plurality of fins 430 are formed in the same shape, but the present disclosure is not limited thereto. Some of the fins 430 may be formed in different shapes.

[0055]

(Other Embodiments)

Although the embodiments of the present disclosure have been described in detail with reference to the drawings, the specific configuration is not limited to the embodiments and includes design changes and the like within a scope not departing from the gist of the present disclosure.

[0056]

In the above-described embodiments, the cold plates 1, 201, 301, and 401 are disposed to extend in the horizontal direction, but the present disclosure is not limited thereto. The orientation of the cold plates 1, 201, 301, and 401 can be appropriately changed according to the shape and orientation of the heat generating element 3. For example, the cold plates 1, 201, 301, and 401 may be disposed to be inclined with respect to the horizontal direction.

[0057]

In addition, in the first to third embodiments, a case where the first fins 31 and the second fins 32, 232, and 332 are alternately provided one by one in the second direction D2 has been described, but the present disclosure is not limited thereto. For example, the plurality of second fins 32, 232, and 332 may be provided between the first fins 31, or the plurality of first fins 31 may be provided between the second fins 32, 232, and 332.

[0058]

In addition, in the first to third embodiments, the slits 33 are formed in the first fins 31 and the second fins 32, 232, and 332, but the present disclosure is not limited thereto. The slits 33 need not be formed in the first fins 31 and the second fins 32, 232, and 332.

In addition, in the fourth embodiment, the slits 33 are not formed in the fin 430, but the present disclosure is not limited thereto. In the fourth embodiment, the

slits 33 may be formed in the fin 430 as in the first to third embodiments.

[0059]

<Supplementary Notes>

The cold plates 1, 201, 301, and 401 described in each embodiment are understood as follows, for example.

[0060]

(1) Cold plates 1, 201, and 301 according to a first aspect include a casing 10 that is disposed to be adjacent to a heat generating element 3 in a first direction D1, is attached to an outer surface 3a of the heat generating element 3, and boils a refrigerant R flowing through the casing 10 to remove heat from the heat generating element 3, and a plurality of fins 30, 230, and 330 that are disposed in the casing 10 at intervals in a second direction D2 intersecting the first direction D1, in which the fins 30, 230, and 330 protrude from a bottom surface 17a of an inner surface 17 of the casing 10, the bottom surface 17a extending along the outer surface 3a, toward the first direction D1 and extend in a direction intersecting both the first direction D1 and the second direction D2, the plurality of fins 30, 230, and 330 form a flow path 6 through which the refrigerant R is capable of flowing between adjacent fins 30, 230, and 330, the plurality of fins 30, 230, and 330 include a plurality of first fins 31 extending from an upstream end 6a to a downstream end 6b of the flow path 6, and a plurality of second fins 32, 232, and 332 disposed between adjacent first fins 31, and a height H of the second fins 32, 232, and 332 in the first direction D1 on an upstream side Dfu in a flow direction Df of the flow path 6 is higher than a height H of the second fins 32, 232, and 332 in the first direction D1 on a downstream side Dfd in the flow direction Df.

[0061]

In the present aspect, the first fins 31 and the second fins 32, 232, and 332 are alternately disposed, and the height H of the second fins 32, 232, and 332 on the upstream side Dfu in the flow direction Df of the flow path 6 is higher than the height H of the second fins 32, 232, and 332 on the downstream side Dfd in the flow direction Df. Accordingly, the gap (flow path 6) between the fins 30, 230, and 330 can be expanded more toward the downstream side Dfd. Therefore, as the volume of the bubbles 50 increases, the bubbles 50 are likely to flow out to the downstream side Dfd, and the backflow or the unstable flow of the refrigerant R is suppressed.

In addition, in the narrow gap between the adjacent fins 30, 230, and 330, the dryout region 52 having poor heat transfer performance in the bubbles 50 gradually increases toward the downstream side Dfd. According to the present aspect, as the bubbles 50 move toward the downstream side Dfd, the bubbles 50 are more likely to flow out from the narrow gap between the adjacent fins 30, 230, and 330 to a wide space. In a case where the bubbles 50 flow out to the wide space, the dryout region 52 is reduced.

In this way, since the backflow or the unstable flow of the refrigerant R can be suppressed and the dryout region 52 of the bubbles 50 on the downstream side Dfd can be reduced, the deterioration of the heat transfer performance can be suppressed, and the cooling performance can be improved.

In addition, since it is not necessary to change the volume of the casing 10, it is possible to suppress the increase in size of the cold plates 1, 201, and 301.

[0062]

(2) The cold plate 1 according to a second aspect is the cold plate 1 according to (1), in which each of the second fins 32 may have a tip edge 34 that is formed on a side opposite to the bottom surface 17a in the first direction D1 and extends in the flow

direction Df, and the tip edge 34 may be inclined to approach a bottom surface 17a side in the first direction D1 from the upstream side Dfu toward the downstream side Dfd.

[0063]

According to the present aspect, the flow path area between the fins 30 is gradually expanded from the upstream side Dfu toward the downstream side Dfd. Accordingly, an increase in pressure loss due to the volume flow rate of the refrigerant R generated from the upstream side Dfu toward the downstream side Dfd can be reduced, so that the occurrence of unstable flow accompanied by a sudden change in the flow rate of the refrigerant R or an increase in pressure loss is suppressed.

[0064]

(3) The cold plate 201 according to a third aspect is the cold plate 201 according to (1), in which each of the second fins 232 may have a tip edge 234 that is formed on a side opposite to the bottom surface 17a in the first direction D1 and extends in the flow direction Df, and the tip edge 234 may be formed in a stepped shape in which the tip edge 234 approaches a bottom surface 17a side in the first direction D1 from the upstream side Dfu toward the downstream side Dfd in a stepwise manner.

[0065]

As a result, it is easy to change the design of the height H of the second fins 232, and it is possible to design the second fins 232 in accordance with the specification of the cold plate 201, such as the heat generation amount and the type of the refrigerant R.

[0066]

(4) The cold plate 301 according to a fourth aspect is the cold plate 301

according to (1), in which a center 332a of each of the second fins 332 in the flow direction Df may be located on the upstream side Dfu, and a length of the second fins 332 in the flow direction Df may be shorter than a length of the first fins 31 in the flow direction Df.

[0067]

As a result, the second fins 332 and the first fins 31 can be designed to have the same shape while exhibiting the above-described improvement in cooling performance only by shortening the length of the second fins 332, and thus the manufacturing efficiency of the fins 330 can be improved.

[0068]

(5) The cold plate 401 according to a fifth aspect includes a casing 10 that is disposed to be adjacent to a heat generating element 3 in a first direction D1, is attached to an outer surface 3a of the heat generating element 3, and boils a refrigerant R flowing through the casing 10 to remove heat from the heat generating element 3, and a plurality of fins 430 that are disposed in the casing 10 at intervals in a second direction D2 intersecting the first direction D1, in which the fins 430 protrude from a bottom surface 17a of an inner surface 17 of the casing 10, the bottom surface 17a extending along the outer surface 3a, toward the first direction D1 and extend in a direction intersecting both the first direction D1 and the second direction D2, the plurality of fins 430 form a flow path 6 through which the refrigerant R is capable of flowing between adjacent fins 430, and a height H of the fins 430 in the first direction D1 on an upstream side Dfu in a flow direction Df of the flow path 6 is higher than a height H of the fins 430 in the first direction D1 on a downstream side Dfd in the flow direction Df.

[0069]

In the present aspect, the height H of the fins 430 on the upstream side Dfu in the flow direction Df of the flow path 6 is higher than the height H of the fins 430 on the downstream side Dfd in the flow direction Df. Accordingly, the gap (flow path 6) between the fins 430 can be expanded more toward the downstream side Dfd. Therefore, as the volume of the bubbles 50 increases, the bubbles 50 are likely to flow out to the downstream side Dfd, and the backflow or the unstable flow of the refrigerant R is suppressed.

In addition, in the narrow gap between the adjacent fins 430, the dryout region 52 having poor heat transfer performance in the bubbles 50 gradually increases toward the downstream side Dfd. According to the present aspect, as the bubbles 50 move toward the downstream side Dfd, the bubbles 50 are more likely to flow out from the narrow gap between the adjacent fins 430 to a wide space. In a case where the bubbles 50 flow out to the wide space, the dryout region 52 is reduced.

In this way, since the backflow or the unstable flow of the refrigerant R can be suppressed and the dryout region 52 of the bubbles 50 on the downstream side Dfd can be reduced, the deterioration of the heat transfer performance can be suppressed, and the cooling performance can be improved.

In addition, since it is not necessary to change the volume of the casing 10, the enlargement of the cold plate 401 can be suppressed.

Industrial Applicability

[0070]

According to the cold plate of the present disclosure, cooling performance can be improved.

Reference Signs List

[0071]

1: cold plate

2: substrate

3: heat generating element

3a: outer surface

4: supply port

5: discharge port

6: flow path

6a: upstream end

6b: downstream end

10: casing

11: base plate

12: cover

13: side wall

13a: first side wall

13b: second side wall

14: upper wall

15: supply hole

16: discharge hole

17: inner surface

17a: bottom surface

20: flow path wall

30: fin

31: first fin

31a: segment

32: second fin

33: slit

34: tip edge

50: bubble

51: liquid film region

52: dryout region

201: cold plate

230: fin

232: second fin

234: tip edge

235: stepped surface

301: cold plate

330: fin

332: second fin

332a: center

401: cold plate

430: fin

434: tip edge

434a: parallel portion

434b: inclined portion

434c: downstream end

C: center plane

D1: first direction

D2: second direction

D3: third direction

Df: flow direction

Dfu: upstream side

Dfd: downstream side

H: height

L1: length

L2: length

L3: length

L4: length

R: refrigerant

W1: width

W2: width