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(54) **HEAT SINK**

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(63) Continuation-in-part of application No. 11/007,192, filed on Dec. 9, 2004.

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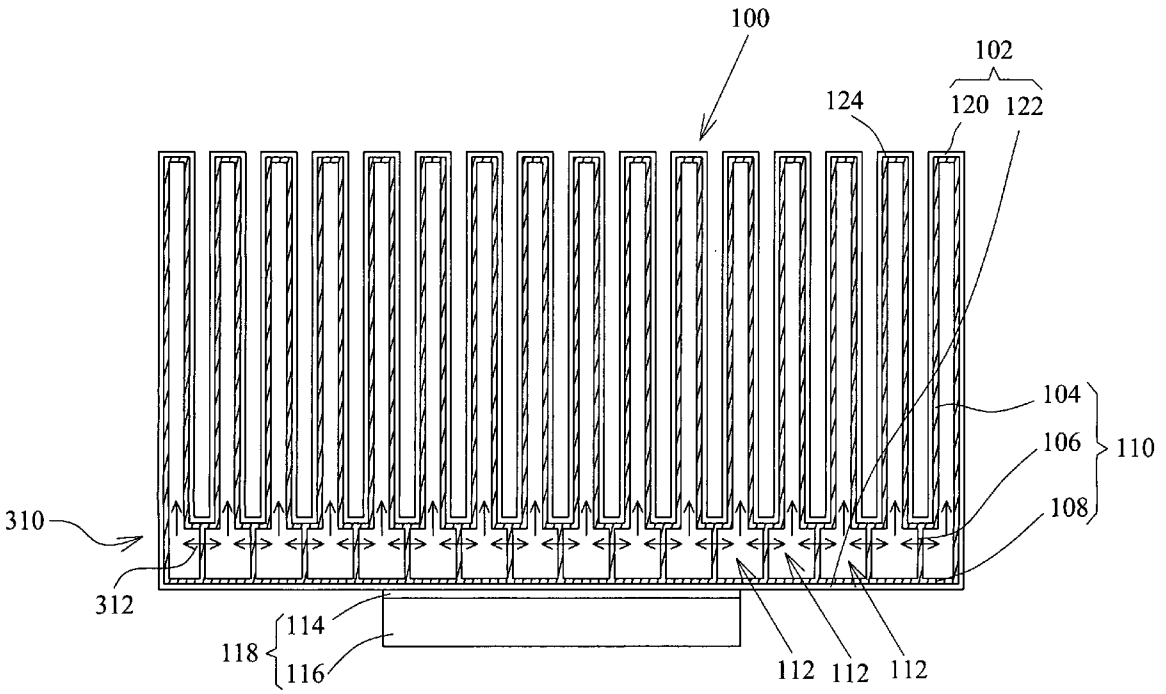
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(57) **ABSTRACT**

A heat sink including a main body and a plurality of porous structures is disclosed. The main body has a plurality of hollow fins and a base. The fins and the base form a closed room. The porous structures are set on the interior surfaces of different fins, and are connected to the base. Each porous structure defines a vapor chamber.



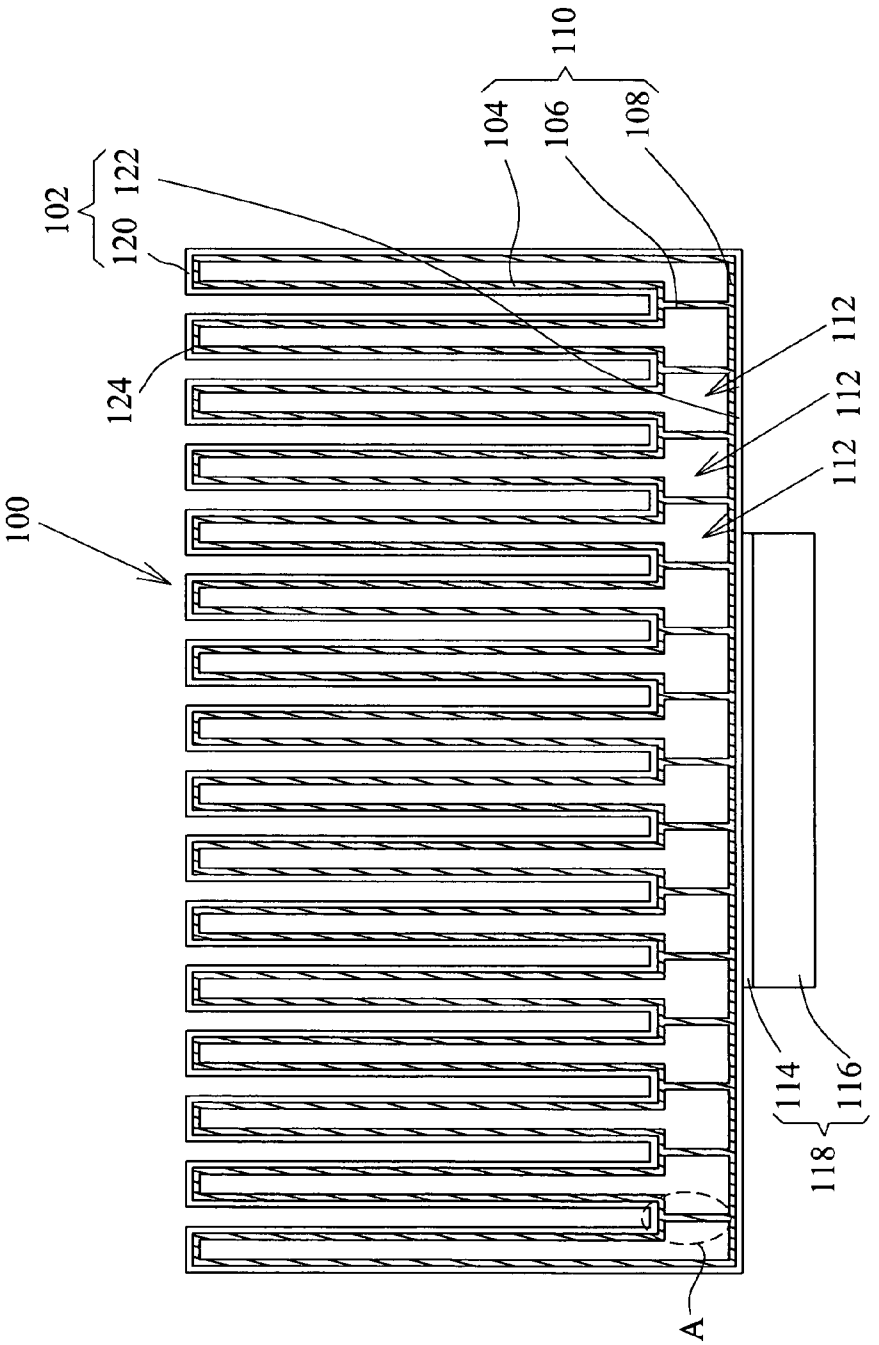



Fig. 1

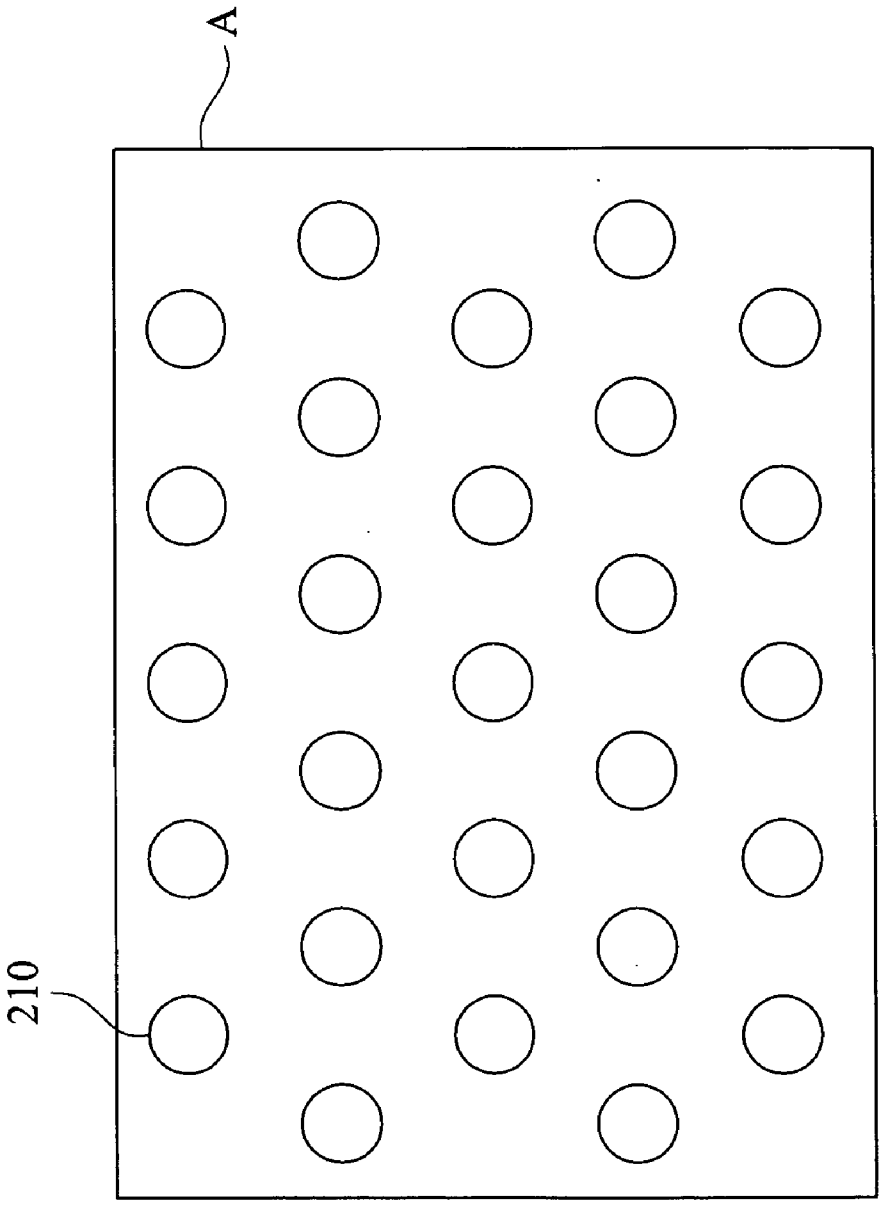



Fig. 2

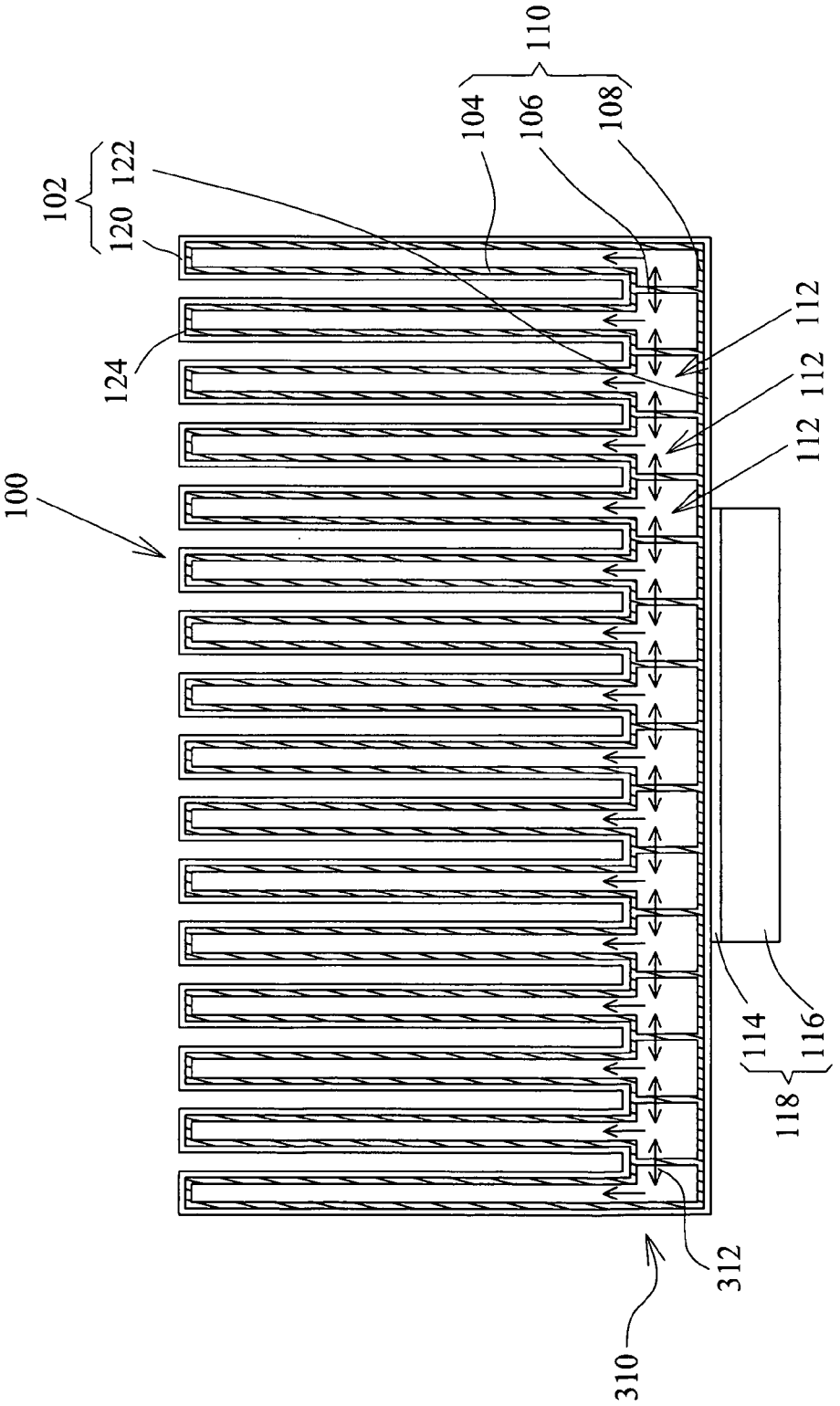

110
104
106
108
102
122
120
124
112
112
112
100
114
116
118
312
310

Fig. 3

# HEAT SINK

## RELATED APPLICATIONS

[0001] This application is a continuation-in-part of U.S. application Ser. No. 11/007,192, filed Dec. 09, 2004, which claims priority to Taiwan Application Serial Number 93106818, filed Mar. 15, 2004, the disclosure of which is hereby incorporated by reference herein in its entirety.

## BACKGROUND OF THE INVETION

[0002] a) Field of the Invention

[0003] The invention relates to a heat sink and, more particularly, to a heat sink that is able to dissipate heat quickly and efficiently.

[0004] b) Description of the Prior Art

[0005] With the advancement of electronic technology, the electronic components are miniaturized and densely packaged. However, this correspondingly produces more heat, and therefore relying on natural or forced convection is insufficient to remove heat.

[0006] The conventional method of removing heat generated from electronic components is to conduct the heat from a heat source to a heat sink and then to dissipate the heat to the surroundings through natural or forced convection to the fins of the heat sink. However, the conventional heat sinks with fins have some problems that do affect the efficiency of heat removal. For instance, a deficiency in temperature gradient due to the temperature difference between the fin surfaces and the heat sink airflow being only 5-10 degrees Celsius; the heat resistance problems due to the material and structure of the heat sink and low fin efficiency that is less than 70%. These problems are the root causes for the conventional heat sinks not able to increase its' heat dissipation efficiency and further unable to remove the heat produced by electronic components sufficiently.

[0007] Thus, U.S. Pat. No. 6,490,160 has disclosed a heat sink composed of a vapor chamber in view of the aforementioned problems. The concept of this patent is to form a single vapor chamber in a heat sink, wherein the top of the vapor chamber is composed of an array of sheet tapered hallow pins deeply mounted in the heat sink fins, and the bottom of the vapor chamber is a single chamber connected to the bottom of all sheet tapered hollow pins. The heat sink according to this patent dissipates heat by having a working fluid to absorb heat and to be vaporized to the hollow pins and then to be liquefied again after exchanging heat with the outer surroundings. After the condensation, the working fluid (liquid) flows along the groove wick structure on the surface of the hollow pins and returns to the chamber from the outer wall.

[0008] Nonetheless, the path for the working fluid to return to the chamber is long. Therefore, under a large heat-loading situation, there may be no condensed liquid (working fluid) in the vapor chamber and cause the chamber to dry out. In addition, the single phase state (only vapor) in the heat conductive mechanism and the long return path can make the fins except the outmost fins ineffective. Under this condition, the effective dissipating surface is greatly reduced and hence lowers the effectiveness of the heat sink.

[0009] Moreover, another heat sink with vapor chamber has been disclosed in US patent application serial number 2002/0118511. This patent application also forms a single vapor chamber in the heat sink, the chamber bottom is still a single chamber connected to all hollow pin except that a matrix arrangement of the columnar hollow pins is applied. This patent application utilizes a working fluid to absorb heat in the chamber and to be vaporized to the hollow pins. The vaporized working fluid then exchange heat with the surroundings and condenses, and then trickles down along the sidewall and back into the chamber due to gravity force. Since gravity is the return-flow mechanism used in this application, direction problems do exist. That is, when the installation direction of the heat sink changes, the return-flow mechanism becomes inoperable.

[0010] In regards to the foregoing statements, US patent application 2002/0118511 also disclosed a method combining the two technologies by forming a porous structure inside the hollow fins, so that the working fluid can return to the chamber through the porous structure by capillary force. However, this technology did not solve the problem that exists in the U.S. Pat. No. 6,490,160, where the dry out occurs and all but the outmost hollow fins are inoperable under a high heat-loading condition, which lowers the dissipation efficiency.

## SUMMARY OF THE INVENTION

[0011] To solve the abovementioned problems, the present invention discloses a heat sink with high heat dissipation efficiency under any heat loading.

[0012] An object of the invention is to provide a heat sink with high heat dissipation efficiency under high heat loadings.

[0013] Another object of the invention is to provide a heat sink with high heat dissipation efficiency when installed in any direction.

[0014] Yet another object of the invention is to provide a heat sink which prevents dry outs and hot spots from occurring.

[0015] The invention discloses a heat sink including a main body and a plurality of porous structures. The main body has a plurality of hollow fins and a base, the fins and the base form a closed room. The porous structures are set on the interior surfaces of a different fin and are connected to the base, and each porous structure defines a vapor chamber.

[0016] The invention also discloses a heat sink including a main body and a plurality of porous structures with the main body having a plurality of hollow protrusions and a base. The protrusions and the base form a closed room. The porous structures are set on the interior surfaces of a different protrusion and are connected to the base, and each porous structure defines a vapor chamber.

[0017] The porous structures are wick structures; common wick structures include mesh, fiber, sintered, groove wicks, or combinations thereof. The porous structures and the main body are assembled by methods such as sintering, adhering, filling, or depositing. The material of the porous structures includes plastics, alloys or metals such as copper, aluminum, iron, porous non-metallic materials and mixtures thereof.

The porous structures contain a working fluid; the working fluid can be inorganic compounds, water, alcohols, liquid metals such as mercury, ketones, refrigerants such as HFC-134a, other organic compounds or mixtures thereof.

[0018] The main body can be one-piece molded or composed of several components. The components are bind together by soldering, engaging, embedding, adhering, or combinations thereof. Neighboring vapor chambers are communicated with each other directly, or indirectly in fluid communication through the porous structures.

[0019] The vapor chambers are arranged in the closed room either in an array arrangement, a longitudinal arrangement, a parallel arrangement, or a transverse arrangement.

[0020] Since the heat sink according to the invention utilizes wick structures (porous structures) to form several small vapor chambers and/or small sectors, the wick structure of every protrusion forms an independent heat-removal cycle. So, under high heat-loading situation, the dry outs will not occur and the high heat dissipation efficiency is maintained.

[0021] Moreover, since the bottom of the small vapor chambers and/or small sectors are composed of connecting wicks (heat-absorptive portion), the working fluid in each small vapor chamber are in fluid communication, and thus the possibility of hot spots occurring is lowered, and the heat is evenly distributed to each small vapor chamber and/or small sector.

[0022] Furthermore, since the return-flow mechanism of the heat sink according to the invention uses capillary force but not simply relies on gravity, the return-flow speed of the working fluid in the heat sink will not be affected by the direction for installation.

[0023] The vapor chamber in the heat sink according to the invention is composed of a plurality of small vapor chambers and/or small sectors, and therefore the return-flow path of the working fluid is short, and the return-flow speed and heat dissipation efficiency are enhanced.

[0024] The foregoing and other objectives, features, and advantages of the invention will be more readily understood upon consideration of the following detailed description of the invention, taken in conjunction with the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0025] **FIG. 1** is a schematic diagram of a preferred embodiment of a heat sink in accordance with the invention;

[0026] **FIG. 2** is an enlarged partial view of the preferred embodiment of **FIG. 1**; and

[0027] **FIG. 3** illustrates the vapor flow in the preferred embodiment of **FIG. 1**.

## DETAILED DESCRIPTION OF THE INVENTION

[0028] Referring to **FIG. 1**, a heat sink **100** includes a main body **102** and a plurality of porous structures **110** inside the main body **102**, wherein the main body **102** has a closed room **124** formed therein.

[0029] The main body **102** has a plurality of hollow protrusions **120** and a base **122** connecting to a heat source **118**. The shape and/or size of the base **122** varies in accordance with the placement of the protrusions **120** and the shape of the heat source **118**. Each protrusion **120** is hollow and has two ends; the end proximate the base **122** has an opening and the other end is closed. The protrusions **120** are in a shape of fin, column, lamella, cone, or lump; and in a form of curve, arch, slant, vertical, or any other form. The protrusions **120** and the base **122** of the main body **102** can be one-piece molded or jointed by soldering, engaging, embedding, adhering, or a combination of any of the methods listed thereof. Moreover, the closed room **124** can be divided into a plurality of vapor chambers **112** by the porous structures **110**.

[0030] The porous structures **110** are embedded on the interior surfaces of the main body **102**, and are sealed therein. The porous structures **110** form a plurality of vapor chambers **112** in the main body **102**. Each porous structure **110** is sectioned into a conductive portion **104** and a connective portion **106**, and a heat-absorptive portion **108**. The porous structures **110** are for absorbing working fluid; the condensed working fluid flows through the conductive portion **104**, the connective portion **106**, and into the heat-absorptive portion **108**. The working fluid is of inorganic compounds, water, alcohols, liquid metals such as mercury, ketones, refrigerants such as HFC-134a, other organic compounds, or a mixture of any of the fluids listed thereof. Using the pressure in the vapor chambers **112** can control the boiling temperature of the working fluid. The heat-absorptive portion **108** set on the interior surfaces of the base **122** is for absorbing the working fluid. The conductive portion **104** set on the interior surfaces of the protrusion **120** is for conducting the condensed working fluid to the heat-absorptive portion **108**. The other connective portion **106** is set between the heat-absorptive portion **108** and the conductive portion **104**, and connected to both portions.

[0031] The conductive portion **104**, the connective portion **106** and the heat-absorptive portion **108** can be made of material such as copper, aluminum, iron, other metals and/or alloys, plastics, other porous non-metallic materials, or a mixture of any of the materials listed thereof. The conductive portion **104**, the connective portion **106** and the heat-absorptive portion **108** are required to have a porous formation such as wicking structures. Common wicking structures include mesh wicks, fiber wicks, sintered wicks, groove wicks, or other structures including a combination of any of the wicking structures listed thereof. The porous structures **110** and the main body **102** are assembled by sintering, adhering, filling, or depositing.

[0032] The connective portion **106106** is set between neighboring protrusions **120** so that the working fluid in the conductive portion **104** can flow quickly to the heat-absorptive section **108** along the connective portion **106**. The connective portion **106** divides the closed room **124** into a plurality of vapor chambers **112**; each vapor chamber **112** corresponds to at least one of the protrusions **120**. The connective portion **106** can also divide the closed room **124** into a plurality of sectors; the sectors each corresponds to a protrusion **120** and the neighboring sectors are communicated with each other. The vapor chambers **112** or the small sectors can be disposed in array, parallel, longitudinal, transverse, diagonal or irregular arrangements.

[0033] Although the closed room **124** has been divided into a plurality of vapor chambers **112** and/or small sectors by the connective portions **106**, the working fluid in the heat-absorptive portion **108** on the bottom of each vapor chamber is in fluid communication with other vapor chambers. Thus the occurred probability of the partial hot spots on the heat sink **100** is reduced, and the heat is distributed evenly on the bottom of the heat sink **100**.

[0034] The heat sink **100** described above is used to illustrate the heat-removal mechanism used in the invention. In this embodiment, the base **122** of the heat sink **100** is installed on the heat source **118**, wherein the heat source **118** is composed of a heat-generating element **116** and a conducting structure **114** connected to the heat-generating element **116**. The conducting structure **114** can be a heat-dissipating paste, or a phase-changing metal sheet; the heat-generating element **116** can be a computer-processing unit (CPU), or a semi-conductor chip. For illustration purpose, the protrusions **120** exemplify a fin shape in this embodiment.

[0035] When the bottom of the vapor chambers **112** is heated and the temperature of the working fluid raises to the boiling point, the working fluid in the heat-absorptive portions **108** boils and evaporates, causing the pressure in the vapor chambers **112** to rise and the vapors move towards the fins quickly. The heat in the fins is then dissipated by natural or forced convection; the vapors condensate into liquid on the interior surfaces of the fins and the working fluid (liquid) penetrates into the conductive portions **104** (wick structure) in the fins. Since the heat-absorptive portions **108** (wick structure) are drier than the conductive portions **104**, the capillary force drives the working fluid (liquid) to flow back to the bottom of the vapor chambers **112** and hence a heat-removal cycle is completed.

[0036] Since the bottom edges of the fins are connected to the base **122** with the connective portions **106** (wick structure), the return-flow speed of the working fluid is enhanced and dry out is prevented from occurring.

[0037] Referring to **FIG. 2**, the section "A" of the partial view of the connective portion **106** is enlarged to show the detailed structure thereof. The connective portion **106** further includes a plurality of holes **210** thereon for evenly distributing the vaporized fluid in the vapor chambers **112**. Therefore, the vaporized fluid in the vapor chambers **112** can quickly and uniformly distribute in the vapor chambers **112**.

[0038] Referring to **FIG. 3**, the vapor can easily flow to the adjacent vapor chambers **112** along the arrow signs **312** and to the protrusion **120** along the arrow signs **310**.

[0039] Concluding from the description above, the heat sink according to the invention utilizes wick structures (porous structures) to form a plurality of small vapor chambers and/or small sectors, so that the wick structure in each protrusion forms an independent heat-removal cycle. Thus even under high heat-loading situations, dry outs caused by the lack of working fluid will not occur and the heat-dissipating effect can be maintained. In addition, the connective portions include a plurality of holes so that the vapor in the vapor chambers is uniformly distributed. Hence, the heat can be more smoothly distributing in the heat sink.

[0040] Moreover, the bottom of the small vapor chambers and/or small sectors are made of connecting wick structures (heat-absorptive portions), thereby the working fluid in each small vapor chamber and/or small sector is in fluid communication via the wick structures on the bottom. This in turn lowers the occurred probability of hot spots and the heat is evenly distributed to each small vapor chamber and/or small sector.

[0041] Furthermore, since the heat sink according to the invention utilizes capillary force in the return-flow mechanism instead of simply relying on gravity, thus the installation direction of the heat sink will not affect the return-flow speed.

[0042] In addition, since the vapor chamber of the heat sink according to the invention includes a plurality of small vapor chambers and/or small sectors, each small vapor chamber and/or small sector has shorter return-flow path than that of the conventional technology. Therefore, the return-flow speed of the working fluid is increased and the heat-dissipating effect is enhanced.

[0043] While the invention has been described by way of example and in terms of the preferred embodiment, it is to be understood that the invention is not limited to the disclosed embodiments. To the contrary, it is intended to cover various modifications and similar arrangements as would be apparent to those skilled in the art. Therefore, the scope of the appended claims should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements.

What is claimed is:

**1**. A heat sink, comprising:

a main body having a plurality of hollow fins and a base, each fin having a close end and an open end facing the base, and the fins and the base forming a closed room; and

a plurality of porous structures comprising a plurality of conductive portions, connective portions and heat-absorptive portions, wherein the conductive portions are continuously formed on the interior surfaces of the hollow fins, the heat-absorptive portions are formed on the base, and each connective portion is set between the neighboring conductive portions and connected to the heat-absorptive portions on the base to divide the closed room into a plurality of vapor chambers, and each connective portion comprises a plurality of holes for allowing vaporized fluid to pass therethrough.

**2**. The heat sink as described in claim 1, wherein the porous structures are wicks selected from the group consisting of a combination of one or more of mesh wicks, fiber wicks, sintered wicks, and groove wicks.

**3**. The heat sink as described in claim 1, wherein the porous structures contain a fluid selected from the group consisting of a mixture of one or more of inorganic compounds, water, alcohols, liquid metals, ketones, refrigerants, and organic compounds.

**4**. The heat sink as described in claim 1, wherein the material of the porous structures is selected from the group consisting of a mixture of one or more of plastics, metals, alloys, and porous non-metal materials.

**5**. The heat sink as described in claim 1, wherein the fins and the base are formed by a method selected from the group

consisting of a combination of one or more of soldering, engaging, embedding and adhering, or the main body is one-piece molded.

**6**. The heat sink as described in claim 1, wherein the fins are arranged in a longitudinal, parallel, transverse, diagonal, or irregular array.

**7**. The heat sink as described in claim 1, wherein neighboring vapor chambers are communicated with each other or in fluid communication through the porous structures.

**8**. A heat dissipating device, comprising:

a main body having a plurality of hollow protrusions and a base, each protrusion having a close end and an open end facing the base, and the protrusions and the base forming a closed room; and

a plurality of porous structures comprising a plurality of conductive portions, connective portions and heat-absorptive portions, wherein the conductive portions are continuously formed on the interior surfaces of the hollow protrusions, the heat-absorptive portions are formed on the base, and each connective portion is set between the neighboring conductive portions and connected to the heat-absorptive portions on the base to divide the closed room into a plurality of vapor chambers, and each connective portion comprises a plurality of holes for allowing vaporized fluid to pass therethrough.

**9**. The heat dissipating device as described in claim 8, wherein one of the protrusions has a fin shape, columnar shape, lamellar shape, conical shape, or lump shape.

**10**. The heat dissipating device as described in claim 8, wherein the porous structures are wicks.

**11**. The heat dissipating device as described in claim 10, wherein the wicks are selected from the group consisting of a combination of one or more of mesh wicks, fiber wicks, sintered wicks, and groove wicks.

**12**. The heat dissipating device as described in claim 8, wherein the porous structures and the main body are assembled by sintering, adhering, filling, or depositing.

**13**. The heat dissipating device as described in claim 8, wherein the porous structures contain a fluid selected from the group consisting of a mixture of one or more of inorganic compounds, water, alcohols, liquid metals, ketones, refrigerants, and organic compounds.

**14**. The heat dissipating device as described in claim 8, wherein the material of the porous structures is selected from the group consisting of a mixture of one or more of plastics, metals, alloys, and porous non-metal materials.

**15**. The heat dissipating device as described in claim 8, wherein the protrusions and the base are formed by soldering, engaging, embedding or adhering, or the main body is one-piece molded.

**16**. The heat dissipating device as described in claim 8, wherein neighboring vapor chambers are communicated with each other, or in fluid communication through the porous structures.

**17**. The heat dissipating device as described in claim 8, wherein the vapor chambers of the porous structures are arranged in the closed room in a longitudinal, parallel, transverse, diagonal, or irregular array.

**18**. A heat sink, comprising:

a main body having a plurality of hollow fins and a base, the fins and the base forming a closed room; and

a plurality of porous structures continuously formed on the interior surfaces of the hollow fins and connected to the base, wherein the porous structures further comprise a plurality of connective portions, each connective portion is set between the porous structures on neighboring hollow fins and connected to the porous structures on the base to divide the closed room into a plurality of vapor chambers, and each connective portion comprises a plurality of holes for allowing vaporized fluid to pass therethrough.

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