An exemplary heat pipe includes a tube, an evaporation section and a condenser section located at two opposite ends of the tube, a wick structure received in the tube and abutting an inner wall of the tube, and a working fluid sealed in the tube. The grid wick structure includes a plurality of rhombuses. Each rhombus includes two opposite first included angles, one of the first included angles is at a point of the rhombus nearest one of the ends of the tube, the other first included angle is at a point of the rhombus nearest the other end of the tube. Each first included angle is smaller than 90 degrees.
FIG. 8
HEAT PIPE WITH GRID WICK STRUCTURE HAVING RHOMBUSES

BACKGROUND

[0001] 1. Technical Field

[0002] The disclosure relates to heat pipes, and more particularly to a heat pipe having a grid wick structure made up of rhombuses.

[0003] 2. Description of the Related Art

[0004] With the continuing development of electronics technology, many electronic components are nowadays made in a small size but with a high operating frequency capability. When such electronic components operate inside a device, a lot of heat is generated and is required to be dissipated. In order to cool the electronic components, one or more heat dissipation devices are provided in the device. Generally, the heat dissipation devices include heat pipes as heat transferring components.

[0005] A typical heat pipe includes a tube, a mesh wick structure received in the tube, and a working fluid sealed in the tube. The wick structure is generally attached on an entire inner wall of the tube, and thus has the shape of an elongated cylinder. The mesh of the wick structure is usually comprised of perpendicularly interlocked strands, with one group of the strands having each strand aligned along a horizontal direction and another group of the strands having each strand aligned along a vertical direction. A wicking efficiency of the wick structure for conducting the working fluid along the vertical direction is prone to be low. In some applications, the heat pipe with such a wick structure can not properly satisfy the requirement of transferring a high amount of heat from the electronic component(s).

[0006] Therefore, it is desirable to provide a heat pipe with a wick structure which can solve or at least mitigate the above-described problems.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Many aspects of the disclosure can be better understood with reference to the drawings. The components in the drawings are not necessarily drawn to scale, the emphasis instead being placed upon clearly illustrating the principles of the present heat pipe. Moreover, in the drawings, all the views are schematic, and like reference numerals designate corresponding parts throughout the views.

[0008] FIG. 1 is an abbreviated, plan view of a heat pipe in accordance with an exemplary embodiment of the disclosure.

[0009] FIG. 2 is an enlarged, cross sectional view of the heat pipe of FIG. 1, taken along line II-II thereof.

[0010] FIG. 3 is a cross sectional view of part of the heat pipe of FIG. 2, taken along line III-III thereof, and showing a grid wick structure having rhombuses.

[0011] FIG. 4 is essentially an enlarged view of two rhombuses of the grid wick structure of FIG. 3, indicating flow paths of a working fluid flowing along the grid wick structure.

[0012] FIG. 5 is a cross sectional view of a heat pipe in accordance with another exemplary embodiment of the disclosure.

[0013] FIG. 6 is an enlarged view of a cored portion VI of the heat pipe of FIG. 5.

[0014] FIG. 7 is an abbreviated, plan view of a grid wick structure having a grid with squares, used in the heat pipe of FIG. 5.

[0015] FIG. 8 is essentially an enlarged view of one rhombus of a grid wick structure having a grid with rhombuses, also used in the heat pipe of FIG. 5, indicating flow paths of a working fluid flowing along the grid wick structure.

DETAILED DESCRIPTION

[0016] Referring to FIG. 1 through FIG. 3, a heat pipe 100 in accordance with an exemplary embodiment is shown. The heat pipe 100 includes a tube 10, a grid wick structure 20 received in the tube 10, and a working fluid 30 (see FIG. 4) sealed in tube 10. The heat pipe 100 includes an evaporation section 11 and a condenser section 12 located at two opposite ends of the tube 10. In this embodiment, the heat pipe 100 is a flat heat pipe.

[0017] The tube 10 is made of material with good heat conductivity, such as copper. The tube 10 is hollow and flat, and the tube 10 is formed by deforming (i.e. flattening) a circular tube. The tube 10 includes a top plate 13, a bottom plate 14, and two side plates 15. The top plate 13 is parallel with the bottom plate 14. The two side plates 15 are arc-shaped, and respectively interconnect the top plate 13 and the bottom plate 14. A thickness of the tube 10, i.e., a distance between a topmost extremity of the top plate 13 and a bottommost extremity of the bottom plate 14, is smaller than 1.5 millimeters (mm).

[0018] The grid wick structure 20 abuts an inner wall of the tube 10. In the illustrated embodiment, the grid wick structure 20 is in contact with the inner wall of the tube 10. The grid wick structure 20 extends from the evaporation section 11 to the condenser section 12. The grid wick structure 20 is formed by weaving (or meshing) linear material (e.g., strands or yarn) such as copper wire, stainless steel wire, fiber, and so on. Preferably, the grid wick structure 20 in this embodiment is formed by weaving wires, with each wire having a diameter in the range of from about 0.03 mm to about 0.05 mm.

[0019] Referring to FIGS. 1-4, the grid wick structure 20 includes a multiplicity of rhombuses 21. The rhombuses 21 provide capillary force to drive the working fluid 30 to flow from the condenser section 12 back to the evaporation section 11. The rhombuses 21 are all identical to each other. Each rhombus 21 includes four equilateral sides 213, and the rhombuses 21 are arranged uniformly from the evaporation section 11 to the condenser section 12. The sides 213 of the rhombuses 21 correspond to the linear material (e.g. wires) that make up the grid wick structure 20.

[0020] Specifically, a length of the sideline 213 of each rhombus 21 is in the range of from about 0.10 mm to about 0.25 mm. Each rhombus 21 includes two first angles 211 opposite to each other and two second angles 212 opposite to each other. Each first angle 211 is smaller than 90 degrees, and a diagonal line (not shown) interconnecting vertexes of the two first angles 211 is substantially parallel to a longitudinal direction of the tube 10 from the evaporation section 11 to the condenser section 12. Correspondingly, each second angle 212 is larger than 90 degrees and smaller than 180 degrees. A length of the line interconnecting the vertexes of the two first angles 211 is larger than that of a diagonal line (see FIG. 8) interconnecting vertexes of the two second angles 212.

[0021] In this embodiment, the two first angles 211 are smaller than 45 degrees, and the two second angles 212 are larger than 135 degrees. Correspondingly, a flow path of the working fluid 30 travelling from the condenser section 12 back to the evaporation section 11 is restricted to be in an
optimal range. In particular, a flow resistance of the working fluid 30 moving along directions parallel to the line interconnecting the vertexes of the two second angles 212 is restricted to be in a lowest range. This helps prevent backflow from occurring.

[0022] When the heat pipe 100 works, the evaporation section 11 of the tube 10 contacts a heat source. The working fluid 30 absorbs heat from the evaporation section 11, becomes vaporized, flows to the condenser section 12 and thereby conveys the heat to the condenser section 12, and releases the heat at the condenser section 12 and thereby becomes liquefied. The grid wick structure 20 provides capillary force to drive the liquefied working fluid 30 at the condenser section 12 to flow back to the evaporation section 11 along the sidelines 213 of the rhombuses 21. In this way, the working fluid 30 moves in the tube 10 in a circulatory manner to transfer heat generated by operation of one or more electronic components from the evaporation section 11 to the condenser section 12 of the heat pipe 100. In this embodiment, the working fluid 30 is material with a low boiling point, such as water, methanol, alcohol, and so on.

[0023] Referring to FIG. 4, this illustrates how the rhombuses 21 of the grid wick structure 20 are arranged. When the working fluid 30 flows along two consecutive sidelines 213 of any of the rhombuses 21, the total length of the path traversed is shorter than that of two consecutive sidelines of a corresponding square (shown in dashed lines in FIG. 4 for illustration). That is, the liquefied working fluid 30 flows along a relatively short path. Furthermore, because the second angle 212 is larger than 90 degrees, when the working fluid 30 travels from one trailing sideline 213 to the adjacent leading sideline 213 of any of the rhombuses 21, the working fluid 30 need only negotiate a gentler bend compared to that of two consecutive sidelines of a corresponding square (shown in dashed lines in FIG. 4). In particular, in the grid wick structure 20, the bend requiring negotiation corresponds to the obtuse second angle 212, which represents a gentler angle compared with the right-angle bend of the corresponding square. For these reasons, the working fluid 30 sealed in the tube 10 can circulate quickly with low resistance and minimal or no backflow.

[0024] Referring to FIG. 5 through FIG. 8, a heat pipe 200 in accordance with another exemplary embodiment is shown. The difference between the heat pipe 200 and the heat pipe 100 is that the heat pipe 200 includes a grid wick structure 201 with squares 22 and another grid wick structure 202 with rhombuses 23. The two grid wick structures 201, 202 are stacked one on the other. The squares 22 partly coincide with the rhombuses 23, such that the squares and rhombuses 22, 23 support each other. Each square 22 comprises four equal sidelines 223. Preferably, in this embodiment, each rhombus 23 corresponds in size to two squares 22. One of the sidelines 223 of each square 22 overlaps with the line interconnecting the two second angles 212 of a corresponding one of the rhombuses 23. The intersection point of the two sidelines 213 at each second angle 212 of each rhombus 23 coincides with the intersection point of two corresponding sidelines 223 of each of four corresponding squares 22. The intersection point of the two sidelines 213 at each first angle 211 of each rhombus 23 coincides with the center point of a sideline 223 of each of two corresponding squares 22.

[0025] Referring to FIG. 8, the working fluid 30 travelling from position A to position B is taken as an example to show the difference between the functioning of the grid wick structure 201 and the grid wick structure 202, and the benefit of providing both the grid wick structures 201, 202 stacked together. FIG. 8 and the following description also serve to illustrate differences between the functioning of both heat pipes 100, 200 and the above-described traditional heat pipe.

[0026] In the traditional square 22 alone, when the working fluid 30 travels from position A to position B, the working fluid 30 must traverse two 90-degree bends along three corresponding sidelines 223 of the square 22. The total length of the path traveled is the length of two sidelines 223. In contrast, with the heat pipe 200 having the squares 22 stacked with the rhombuses 23, part of the flow path of the working fluid 30 can be along one of the sidelines 213 of the rhombus 21 to reach position B. Thus the total length of the path traveled from position A to position B is shorter. In this way, for the heat pipe 200, the flow path of the working fluid 30 from the condenser section 12 to the evaporation section 11 is shortened.

[0027] In addition, because the rhombuses 23 and the squares 22 are stacked together in the manner described above such that the squares 22 partly coincide with the rhombuses 23 and the squares and rhombuses 22, 23 support each other, the working fluid 30 conduct heats evenly along the tube 10. As a result, a heat transfer evenness of the heat pipe 200 is stable, and a heat transfer efficiency of the heat pipe 200 is improved.

[0028] All in all, one grid wick structure 20, 202 with rhombuses 21, 23 is received in the heat pipe 100, 200, respectively. When the working fluid 30 flows along two consecutive sidelines 213 of any of the rhombuses 21, 23, the total length of the path traversed is shorter than that of two consecutive sidelines of a corresponding square (shown in dashed lines in FIG. 4). The liquefied working fluid 30 flows from the condenser section 12 to the evaporation section 11 along a path that is as much as, or even more than, 19% shorter than that of a conventional heat pipe.

[0029] Because the first angle 211 is smaller than 90 degrees and the second angle 212 is greater than 90 degrees, when the working fluid 30 flows between the two consecutive sidelines 213 of any of the rhombuses 21, 23, the working fluid 30 only needs to negotiate the gentle angle between the two consecutive sidelines 213. Thus the working fluid 30 can travel easily and evenly from the condenser section 12 to the evaporation section 11. In addition, the flow resistance of the working fluid 30 moving along directions parallel to the line interconnecting the vertexes of the two second angles 212 of each rhombus 21, 23 is restricted to be in a lowest range. This helps prevent backflow from occurring.

[0030] It is to be understood that the above-described embodiments are intended to be illustrative rather than limiting. Variations may be made to the embodiments without departing from the spirit of the disclosure. The above-described embodiments illustrate the scope of the disclosure but do not restrict the scope of the disclosure.

What is claimed is:
1. A heat pipe, comprising:
a tube, the tube having an evaporation section and a condenser section located at two opposite ends thereof;
a grid wick structure received in the tube and abutting an inner wall of the tube, the grid wick structure comprising a plurality of rhombuses, each rhombus comprising two first included angles opposite to each other, one of the first included angles being at a point of the rhombus nearest one of the ends of the tube, the other first
included angle being at a point of the rhombus nearest the other end of the tube, each first included angle being smaller than 90 degrees; and a working fluid sealed in the tube.

2. The heat pipe of claim 1, wherein each rhombus further comprises two second included angles opposite to each other, a length of an imaginary line interconnecting vertices of the two first included angles being larger than that of an imaginary line interconnecting vertices of the two second included angles.

3. The heat pipe of claim 2, further comprising another grid wick structure with squares, wherein the another grid wick structure with squares and the grid wick structure with rhombuses are stacked one on the other.

4. The heat pipe of claim 3, wherein one of the sidelines of the each square overlaps the imaginary line interconnecting the two second included angles of a corresponding one of the rhombuses.

5. The heat pipe of claim 1, wherein an imaginary line interconnecting the two first included angles of each rhombus is substantially parallel to a longitudinal direction of the tube from the evaporation section to the condenser section.

6. The heat pipe of claim 1, wherein the wick structure is formed by weaving wires, and a diameter of each of the wires is in a range of from 0.03 millimeters to 0.05 millimeters.

7. The heat pipe of claim 1, wherein the first angle is smaller than 45 degrees.

8. The heat pipe of claim 1, wherein the heat pipe is a flat heat pipe, and a thickness of the tube from one flat side of the heat pipe to the other flat side of the heat pipe is smaller than 1.5 millimeters.

9. The heat pipe of claim 1, wherein a length of the sideline of each rhombus is in the range of from 0.10 millimeters to 0.25 millimeters.

10. A heat pipe, comprising: a tube, the tube having an evaporation section and a condenser section located at two opposite ends thereof, the tube defining a longitudinal direction thereof from the evaporation section to the condenser section; a grid wick structure received in the tube and abutting an inner wall of the tube, the grid wick structure being in the form of woven yarn comprising a first group of lines of yarn each oriented along a first direction and a second group of lines of yarn each oriented along a second direction different from the first direction, each two adjacent lines of the yarn oriented along the first direction and two corresponding adjacent lines of the yarn oriented along the second direction cooperatively defining a rhombus, the rhombus comprising two first included angles opposite to each other, an imaginary diagonal line interconnecting vertices of the rhombus having the two first included angles being substantially parallel to the longitudinal direction of the tube, each first included angle being smaller than 90 degrees; and a working fluid sealed in the tube.

11. The heat pipe of claim 10, wherein each rhombus further comprises two second included angles opposite to each other, a length of an imaginary line interconnecting the vertices of the two first included angles being larger than that of an imaginary diagonal line interconnecting vertices of the two second included angles.

12. The heat pipe of claim 11, further comprising another grid wick structure with squares, wherein the another grid wick structure with squares and the grid wick structure with rhombuses are stacked one on the other.

13. The heat pipe of claim 12, wherein one of the sidelines of each square overlaps the imaginary line interconnecting the two second included angles of a corresponding one of the rhombuses.

14. The heat pipe of claim 10, wherein an imaginary line interconnecting the two first included angles of each rhombus is substantially parallel to a longitudinal direction of the tube from the evaporation section to the condenser section.

15. The heat pipe of claim 10, wherein the wick structure is formed by weaving wires, and a diameter of each of the wires is in a range of from 0.03 millimeters to 0.05 millimeters.

16. The heat pipe of claim 10, wherein the first included angle is smaller than 45 degrees.

17. The heat pipe of claim 10, wherein the heat pipe is a flat heat pipe, and a thickness of the tube from one flat side of the heat pipe to the other flat side of the heat pipe is smaller than 1.5 millimeters.

18. The heat pipe of claim 10, wherein a length of the sideline of each rhombus is in the range of from 0.10 millimeters to 0.25 millimeters.

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