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(54) A VAPOR CHAMBER

(57) The invention relates to a vapor chamber (1), comprising walls sealing off an interior space of the vapor chamber from surroundings, said walls including at least an evaporator wall (3) and a condenser wall (4). In order to obtain a reliable and efficient vapor chamber, the vapor chamber comprises porous pillars (6) with different porosity in different parts of the pillars extend into the vapor chamber from the evaporator wall for evaporating fluid (5) by a heat load (7) received via the evaporator wall (3), and a condenser section (8) at the condenser wall (4) for condensing the evaporated fluid by dissipating heat (9) to surroundings via the condenser wall (4).

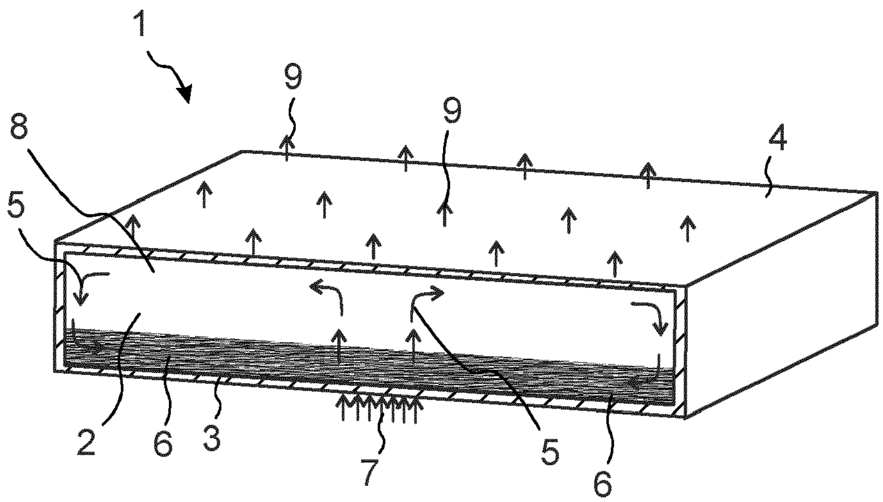

FIG. 1

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Description

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0001] This invention relates to a vapor chamber which may be utilized as a cooling element.

DESCRIPTION OF PRIOR ART

[0002] Previously there is known a vapor chamber having walls which seal off an interior space of the chamber. In this known solution a wick implemented as porous areas is arranged in proximity of an evaporator wall of the chamber. Fluid entering the wick is vaporized by a heat load received via the evaporator wall. Driven by the vapor pressure the fluid flows towards the condenser wall, condensation occurs, and the fluid is returned towards the wick.

[0003] A challenge with this known vapor chamber is the implementation of the porosity. A high level of porosity ensures that an efficient fluid flow is achieved in the vapor chamber.

[0004] However, it has turned out that due to this high level of porosity, the wick is not sufficiently rigid to remain intact in the vapor chamber during the entire lifetime of the vapor chamber. Due to this the wick creates a weak point in terms of reliability.

SUMMARY OF THE INVENTION

[0005] An object of the present invention is to solve the above-mentioned drawback and to provide an improved vapor chamber. This object is achieved with a vapor chamber according to independent claim 1.

[0006] When the vapor chamber comprises porous pillars with different porosity in different parts of the porous pillars, sufficient rigidity and efficient flow can be ensured by providing a suitably dimensioned porosity in different parts of the pillars.

[0007] Preferred embodiments of the invention are disclosed in the dependent claims.

BRIEF DESCRIPTION OF DRAWINGS

[0008] In the following the present invention will be described in closer detail by way of example and with reference to the attached drawings, in which

Figure 1 illustrates a vapor chamber,
Figure 2 illustrates porous pillars of the vapor chamber in Figure 1,
Figure 3 illustrates a second embodiment of porous pillars, and
Figures 4 and 5 illustrate a third embodiment of porous pillars.

DESCRIPTION OF AT LEAST ONE EMBODIMENT

[0009] Figure 1 illustrates a vapor chamber 1 with walls sealing off an interior space of the vapor chamber 1 from surroundings. These walls include at et least an evaporator wall 3 and a condenser wall 4. A fluid 5 is arranged to circulate within the vapor chamber 1, as will be explained in the following.

[0010] A wick implemented with porous pillars 6 is provided into the vapor chamber at the evaporator wall 3. A heat load 7 received by the evaporator wall 3 increases the temperature of the porous pillars 6 and evaporates the fluid 5 at the porous pillars 6.

[0011] The evaporated fluid 5 is in a vapor state passed on from the porous pillars 6 towards a condenser section 8 located in proximity of the condenser wall 4. The condenser wall 4 dissipates to the surrounding heat 9 released from the fluid 5 which condensates in the condenser section 8. The condensed fluid is returned to the porous pillars 6 in a liquid state.

[0012] An advantage with a vapor chamber 1 as described is that a heat load 7 directed towards a relatively small area of the evaporator wall 3 can be dissipated to surroundings via a much bigger area of the condenser wall 4. This facilitates efficient cooling for devices which may be attached to the evaporator wall, for instance. One practical implementation is cooling of electric components, in which case one or more electric components may be attached to different locations of the evaporator wall 3 in order to provide efficient cooling for them with the vapor chamber 1.

[0013] The fluid circulation in the vapor chamber 1 may be implemented without a need for a separate pump The heat load 7 vaporizes the fluid 5 at the porous pillars 6 forming a wick at the evaporator wall 3. Driven by the vapor pressure, the fluid flows as vapor through smooth channels of the wick towards the condenser section 8. Once condensed into liquid, the fluid 5 returns to the porous pillars 6 where capillary pressure generated by the porosity of the pillars and channels between the pillars 6 of the wick provides a pumping force that ensures circulation of the fluid within the vapor chamber 1 irrespectively of the position (gravity does not affect) in which the vapor chamber 1 is utilized. Consequently, the vapor chamber may work 1 as an orientation free cooling element, for instance.

[0014] Figure 2 illustrates porous pillars of the vapor chamber in Figure 1. The porous pillars 6 are arranged to extend into the vapor chamber 1 from the evaporator wall 3. In the illustrated example, the porous pillars 6 have been implemented as rectangular pillars with different porosity in different parts of the pillars. This makes it possible to ensure sufficient rigidity to the pillars at those locations where it is most needed by providing a lower porosity. Simultaneously, other parts of the same pillars where rigidity is not a problem, may be provided with a higher porosity, which ensures that an efficient fluid flow can be obtained in the vapor chamber 1. Though the porosity is different in different parts of the pillars, the pore size of the pores may be the same in the different parts of the pillars. Though Figure 2 illustrates rectangular pillars, it should be observed that instead of rectangular, the pillars may be polygonal, circular or elliptical, for instance.

[0015] In Figure 2 some of the layers of the illustrated porous pillars 6 are common for the porous pillars, but in other implementations each pillar may be an entirely separate part from the other pillars. In Figure 2 the lowermost section is a base layer 10 having a lowest porosity. This relatively dense lowest section may be common to all the porous pillars 6, and it may work as the evaporator wall 3. Alternatively, the base layer 10 may be a separate layer arranged closest to the evaporator wall 3. The porosity of the base layer 10 may be 5% or less. The purpose of the base layer 10 is to mechanically fix heating elements, to conduct heat and provide a leak tightness for the fluid 5.

[0016] From the first porous section, in other words the base layer 10, the porous pillars 6 continue as a second porous section 11 with a low porosity, such as 20-50%. The purpose of the second porous section 11 is to mechanically and thermally connect the dense base layer 10 with a following third porous section 12. It also provides a part of the structure of the porous pillars. The pillars may be dimensioned to have a width of 0.4-1 mm and a height of 0.5-3 mm, for instance.

[0017] The third porous section 12 may have a high porosity of about 40-70%. It covers the pillar structure including the second porous section 11. The purpose of the third porous section 12 is to provide a capillary force pumping the fluid 5, a large evaporation heat transfer area and easy liquid penetration.

[0018] Figure 2 also illustrates a space between neighboring porous pillars 6 working as channels 13 which are empty, except for fluid 5 contained in them. Consequently, the porosity is 100%. The purpose of the channels 13 is to provide a low pressure drop liquid circulation and a vapor escape. The channels may be bout 0.05 - 0.3 mm wide, for instance. They also participate in generating a fluid flow by providing a capillary force moving the fluid.

[0019] One alternative to manufacture the porous pillars 6 is additive manufacturing, such as 3D printing. The manufacturing can be implemented by Selective Laser Sintering/Melting (SLS/SLM), Laser Metal Deposition/Direct Metal Deposition (LMD/DMD) and Binder-Jetting (BJ), for instance.

[0020] The pillars may be manufactured of any sufficiently heat conducting material, such as of aluminum alloys. Preferably the selected aluminum alloy or alloys used in a pillar is selected to be suitable for additive manufacturing.

[0021] The porous pillars may be manufactured to have a polygonal, circular, elliptical or rectangular cross-sectional shape, for instance. One alternative is to manufacture such pillars to have a largest cross-sectional area closer to the evaporator wall, and a smallest cross-sectional area closer to the condenser wall. In this way more vapor escape space can be obtained at locations where more vapor is produced, as the distance between the neighboring pillars is in that case larger closer to the condenser wall. Such pillars may also be manufactured to have a truncated shape, such as the shape of a truncated cone or a truncated pyramid, for instance.

[0022] Figure 3 illustrates a second embodiment of porous pillars which may be utilized in the vapor chamber 1 of Figure1. The embodiment of Figure 3 is very similar to the one explained in connection with Figure 2. Therefore, the embodiment of Figure 3 will in the following be explained mainly by pointing out the differences between these embodiments.

[0023] In Figure 2 it has by way of example been assumed that the pillars 6 of the vapor chamber are of similar size and shape. However, in Figure 3 the size and shape of the pillars may vary.

[0024] In practical implementations the evaporator wall 3 of the vapor chamber 1 may receive a heat load 7 which is unevenly distributed over the area of the evaporator wall 3. One alternative is that several components, such as electrical components, are cooled by the vapor chamber, in which case the head load may be largest at the locations of the components, while areas of the evaporator wall where no components are located, may receive a smaller head load. Also the amount of heat generated by the different components may vary.

[0025] In Figure 3 the side dimensions S1 and S2 and the density of the pillars 6 and 16 is proportional to the heat load received via the evaporator wall 3 at the location of the respective pillars 6 and 16. In this connection the term "density" refers to the number of pillars per on an area of a specific size, in other words a high density refers to an area with many pillars as compared to a low density where an area of the same size has a smaller number of pillars.

[0026] A solution as illustrated in Figure 3 makes it possible to provide high heat flux pillars 16 at locations 14 where the porous pillars need to handle a higher heat load than the other porous pillars 6 at other locations 15. Such high heat flus pillars 16 may have a smaller side dimensions S1 and possibly the largest cross-sectional area of the high heat flux pillars 16 may be smaller than for other pillars 6. In this example "smaller side dimension" of a pillar refers to the dimension of a side of an area facing away from the evaporator wall 3. In this way transfer of the heat load from the porous pillars to the fluid may be as efficient as possible at locations where it is most needed.

[0027] Figures 4 and 5 illustrate a third embodiment of porous pillars which may be utilized in the vapor chamber 1 of Figure1. The embodiment of Figures 4 and 5 is very similar to the one explained in connection with Figure 3. Therefore, the embodiment of Figures 4 and 5 will in the following be explained mainly by pointing out the differences between these embodiments.

[0028] As illustrated in Figure 4 the height h and density of the pillars 6 and 26 is proportional to the heat load received via the evaporator wall 3 at the location of the respective pillars 6 and 26. Also the side length S of the pillars may wary, at least for some of the pillars, with the height and the heat flux to provide pillars with a truncated shape, such as a shape of a truncated pyramid. For such pillars, irrespectively if they are rectangular or have another shape, the surface area of the surface facing away from the evaporator wall is smaller for higher pillars than for lower pillars.

[0029] A solution as illustrated in Figure 4 makes it possible to provide high heat flux pillars 26 at locations 24 where the porous pillars need to handle a higher heat load such that these pillars are higher than at locations where a smaller heat load is received. The pillars may also be shaped to have a side length which varies with the height h of the pillars 26 to provide a truncated shape, such a s a shape of a truncated pyramid.

[0030] An advantage in having pillars with a largest cross-sectional area at the evaporator wall 3 and a cross-sectional area which decreases as the distance to the evaporator wall increases, is that more vapor escape space can be obtained at locations where more vapor is produced.

[0031] Figure 5 illustrates a side view of a part of the porous pillars of Figure 4. From Figure 5 the height difference between the high flux pillars 26 as compared to other pillars 6 is clearly visible. Additionally, it can be seen that there may be pillars of many different heights, as the height of the pillars is selected based on the heat load at the location of the respective pillar.

[0032] It is to be understood that the above description and the accompanying figures are only intended to illustrate the present invention. It will be obvious to a person skilled in the art that the invention can be varied and modified without departing from the scope of the invention.

Claims

1. A vapor chamber (1), comprising

walls sealing off an interior space of the vapor chamber from surroundings, said walls including at least an evaporator wall (3) and a condenser wall (4), **characterized in that** the vapor chamber comprises

porous pillars (6) with different porosity in different parts of the pillars which extend into the vapor chamber from the evaporator wall for evaporating fluid (5) by a heat load (7) received via the evaporator wall (3), and

a condenser section (8) at the condenser wall (4) for condensing the evaporated fluid by dissipating heat (9) to surroundings via the condenser wall (4).

2. The vapor chamber of claim 1, wherein at least some of the porous pillars (6) have a section with a lower porosity (11) closer to the evaporator (3) wall than in a section (12) located further away from the evaporator wall (3).

3. The vapor chamber according to one of claims 1 to 2, wherein the evaporator wall, or a base layer (10) connecting the pillars to the evaporator wall, forms a first porous section with a porosity of 5% or less.

4. The vapor chamber according to claim 3, wherein the porous pillars (6) continue from the first porous section as a second porous section (11) with a porosity of 20-50%.

5. The vapor chamber according to claim 4, wherein the pillars continue from the second porous section as a third porous (12) section with a porosity of 40-70%.

6. The vapor chamber according to one of claims 1 to 5, wherein at least one of side dimensions (S1, S2) and density of the pillars is proportional to the heat load received via the evaporator wall (3) at the location of the respective pillars (6, 16).

7. The vapor chamber according to one of claims 1 to 5, wherein a height (h) of the pillars (6, 26) is proportional to the heat load received via the evaporator wall (3) at the location (15, 24) of the respective pillars.

8. The vapor chamber according to claims 7, wherein a surface area of a surface facing away from the evaporator wall (3) of the pillars vary with the height (h) of the pillars (26) to provide a shape of a truncated pyramid or cone.

9. The vapor chamber according to one of claims 1 to 5, wherein

at least some of the pillars are high heat flux pillars (16) configured to handle a higher heat load than the other pillars (6).

10. The vapor chamber according to claim 9, wherein a largest cross-sectional area of the high heat flux pillars (16) is smaller than for other pillars (6).

11. The vapor chamber according to claim 9 or 10, wherein the high heat flux pillars (26) are arranged with a higher density than other pillars (6).

12. The vapor chamber according to claim one of claims 9 - 11, wherein the high heat flux pillars (26) are higher than other pillars (6).

13. The vapor chamber according to one of claims 9 -

12, wherein the high heat flux pillars (26) have a largest cross-sectional area at the evaporator wall (3) and the cross-sectional area of the pillars decreases as the distance to the evaporator wall (3) increases.

14. The vapor chamber according to one of claims 9 - 13, wherein

the evaporator wall (3) comprises one or more high heat flux areas (14, 24) receiving a higher heat load than other parts (15) of the evaporator wall (3), and
the high heat flux pillars (16, 26) are arranged to extend into the vapor chamber from one or more of the high heat flux areas (14, 24).

15. The vapor chamber according to one of claims 1 to 14, wherein at least one of the porous pillars (6, 16, 26) has a different porosity but a constant pore size in different sections (10, 11, 12) of at least one pillar.

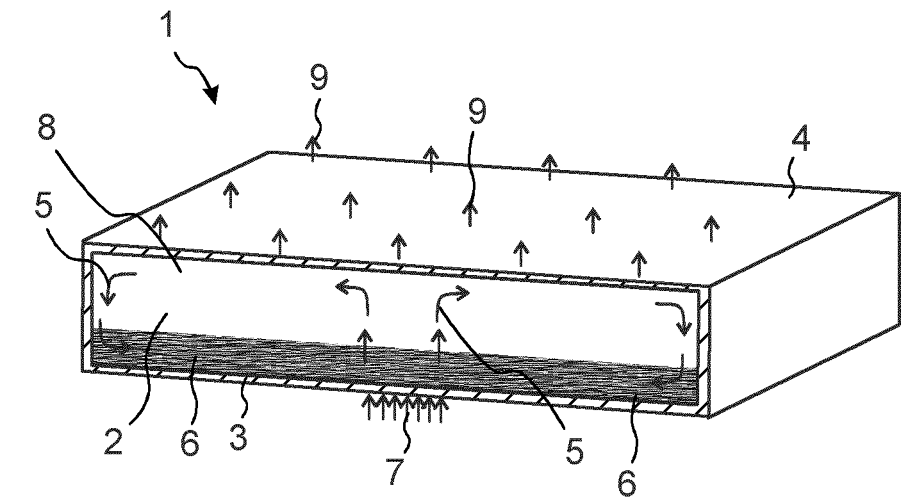

FIG. 1

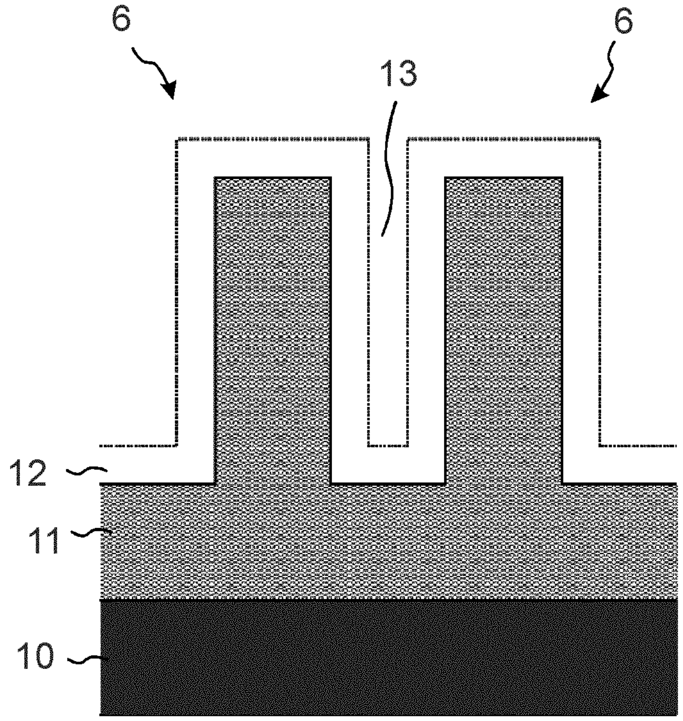

FIG. 2

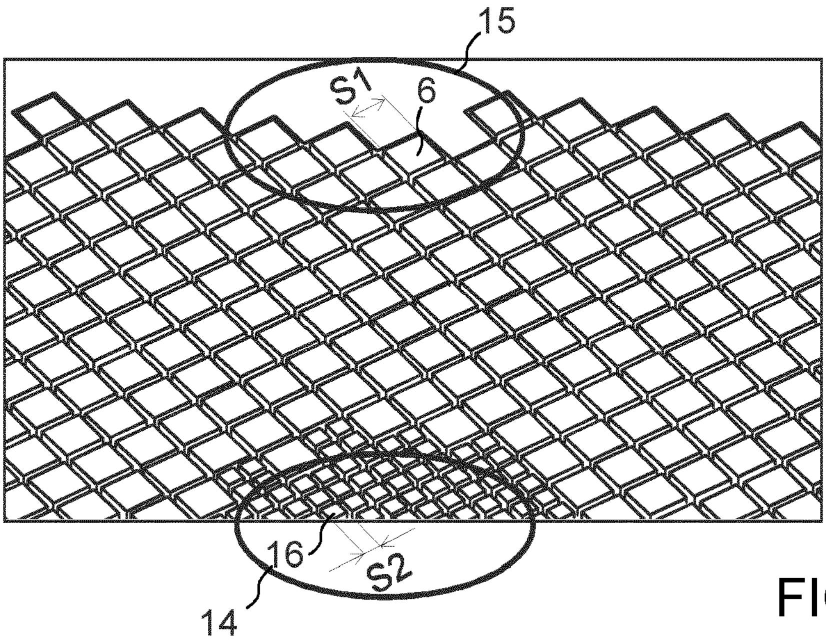

FIG. 3

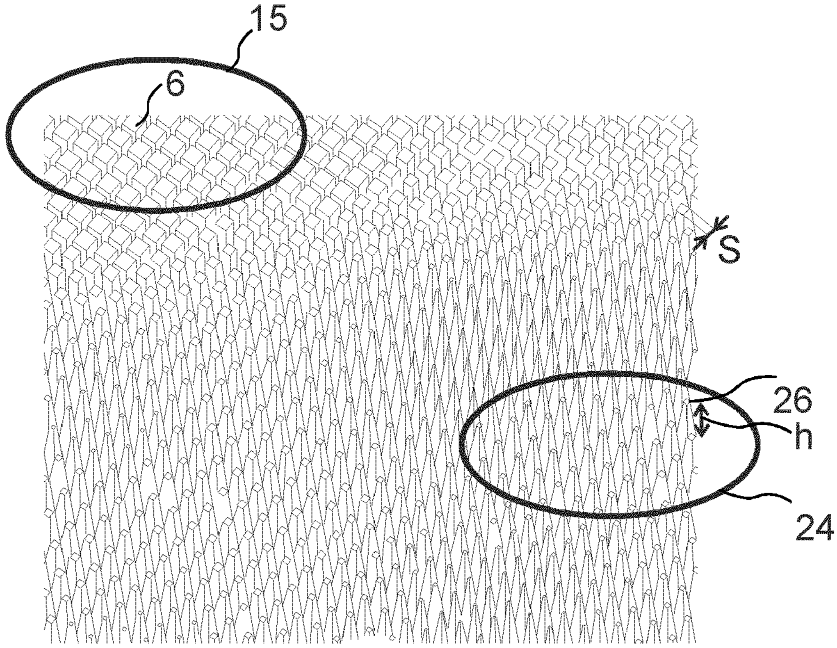

FIG. 4

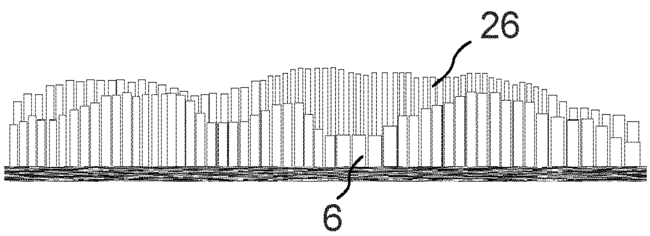

FIG. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 22 16 1773

DOCUMENTS CONSIDERED TO BE RELEVANT

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	18 August 2022	Jessen, Flemming

CATEGORY OF CITED DOCUMENTS

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