US 20110186267A1

(19) United States
(12) Patent Application Publication
Chou
(10) Pub. No.: US 2011/0186267 A1
(43) Pub. Date: Aug. 4, 2011

(54) HEAT TRANSFER DEVICE WITH ANISOTROPIC THERMAL CONDUCTING MICRO STRUCTURES

(75) Inventor: **Chen-Jean Chou**, New City, NY (US)

(73) Assignee: **SUNA DISPLAY CO.**, Suzhou City (CN)

(21) Appl. No.: **12/699,986**

(22) Filed: **Feb. 4, 2010**

Related U.S. Application Data

(60) Provisional application No. 61/300,442, filed on Feb. 1, 2010.

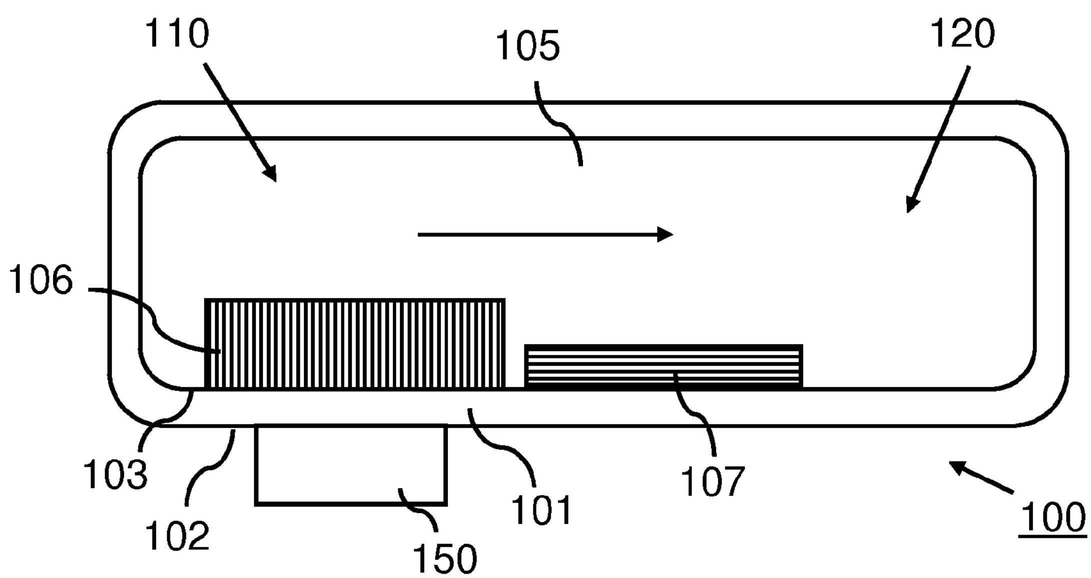
Publication Classification

(51) **Int. Cl.**
F28F 21/00 (2006.01)
F28D 15/00 (2006.01)
F28F 21/02 (2006.01)

(52) **U.S. Cl.** **165/104.19**; 165/104.33; 165/104.34; 165/185

(57) **ABSTRACT**

An isotropic thermal conducting material are arranged in a heat dissipating device to create directional adiabatic heat transfer. In one embodiment, a preferential heat conduction is provided between a heat source and an absorption layer, an absorption layer and a cooling substance, and a cooling substance and a dissipation layer. Structures are further provided to create adiabatic channeling between an absorption and a dissipation.



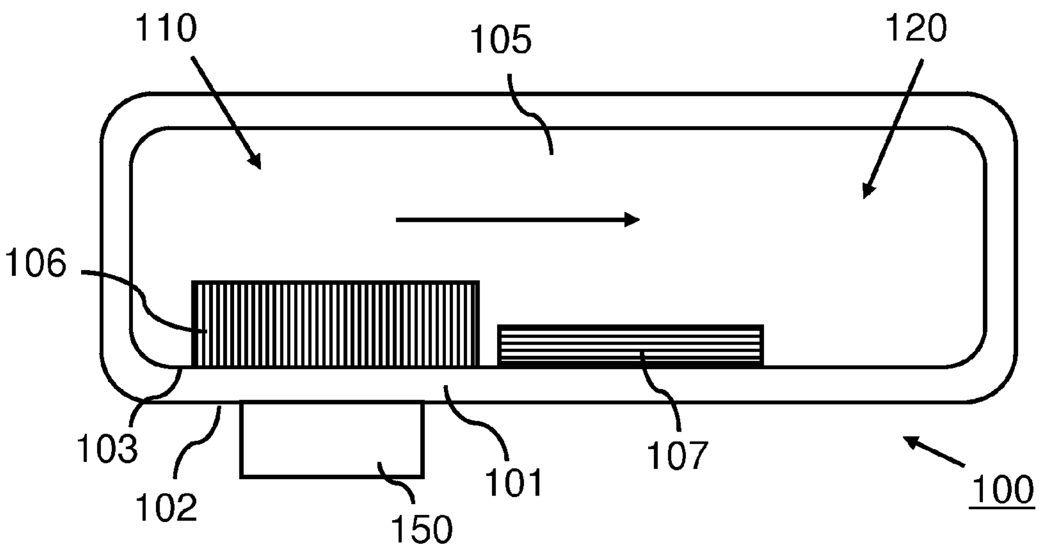


Figure 1a

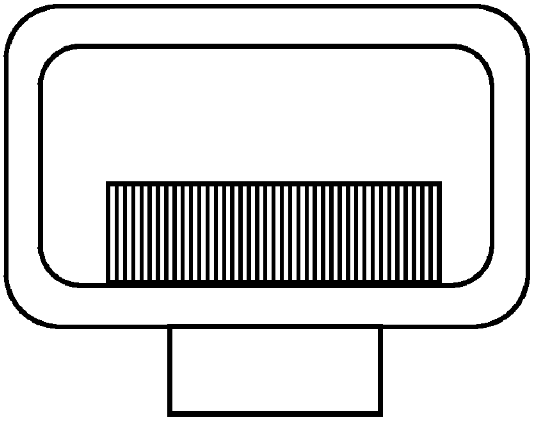


Figure 1b

Figure 1c

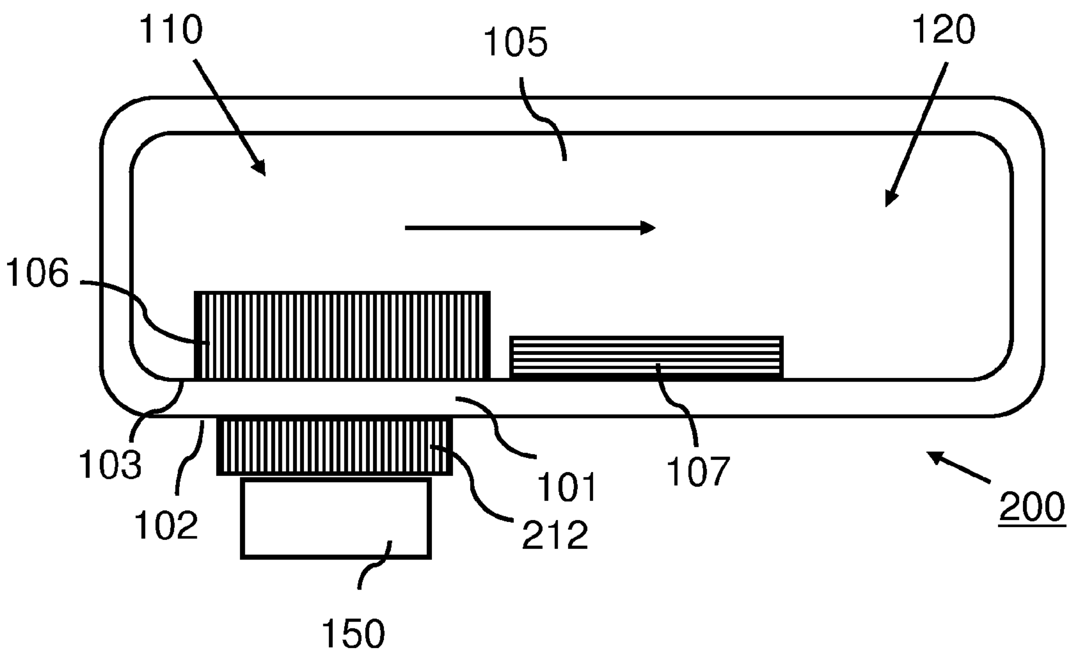


Figure 2

HEAT TRANSFER DEVICE WITH ANISOTROPIC THERMAL CONDUCTING MICRO STRUCTURES

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority of U.S. Provisional Patent Application No. 61/300,442 filed on Feb. 1, 2010, which is hereby incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a heat transfer device useful for removing the heat generated from a heat source. The present invention provides structures comprising anisotropic thermal conducting substance in a heat transfer device, thereby directing the heat away from the heat source at high efficiency.

[0004] 2. Description of the Prior Art

[0005] A typical heat transfer devices such as the heat sink for the cooling of an electronic device comprise metal structure for directing the heat from a heat source to a larger distributed area for dissipation. The heat conducting materials are typically isotropic that direct heat in all directions according to the temperature gradient. In such devices and structures, the heat transfer is limited by the temperature gradient according to the thermal distribution of the isotropic thermal material. In a heat transfer device comprising a heat pipe, a cooling substance and an associated structure for directing the cooling substance are provided. Multiple phases with phase transitions of the cooling substance combined with capillary action provide a directed heat transfer, thereby improving the heat removal and the efficiency to direct the heat to a longer distance away from the heat source. In such devices, the coexistence of two phases and the channeling of the cooling substance creates a temperature distribution that does not follow the isotropic temperature gradient, and the heat transfer efficiency may exceed the isotropic thermal conduction. However, various boundaries and interfaces, the interaction between the container and the cooling substance are still limited by the isotropic thermal conduction. Such limitation is a major obstacle in improving the heat transfer efficiency.

[0006] As the technology drives to continue scaling down in size and scaling up in capacity, the advanced CPU, high speed mobile transmitters, CPV, high power or high density LEDs, are operating at a power density exceeding 100 W/cm2. In some applications, a thermal management to handle a power density exceeding 300 W/cm2 is in critical need. The temperature is becoming a critical limiting factor for the electronic device to continue to scale down in size or scale up in capacity. The present invention provides structures and methods to improve the efficiency and rate of heat transfer applicable for the cooling of a heat source.

SUMMARY OF THE INVENTION

[0007] The present invention provides a thermal transfer device having anisotropic thermal conducting substance disposed at various face to enhance the directional heat transfer and provide a high heat exchange efficiency.

[0008] An object of the present invention is a thermal transfer device having anisotropic thermal conducting substance along the surfaces of both sides of a heat absorption layer. On one side, the surface is in contact with a cooling substance. On the other side, the surface is made to contact a heat source.

[0009] The present invention further provides structures comprising anisotropic heat conducting substance on both sides of the heat absorption layer.

BRIEF DESCRIPTION OF THE DRAWING

[0010] FIG. **1***a* is schematic diagram of a preferred embodiment of the present invention.

[0011] FIG. **1***b* is schematic diagram of a preferred embodiment of the present invention.

[0012] FIG. **1***c* is schematic diagram of a preferred embodiment of the present invention.

[0013] FIG. **2** is a schematic diagram of a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0014] A micro structure in this description refers to a structure having features on the order of a micrometer or smaller. Similarly, a nano structure comprises features on the order of a nano meter or smaller. An example of a micro structure is micro pores. A nano tube is an example for a nano structure, and is also a micro structure.

[0015] An anisotropic heat (or thermal) conducting substance provides a higher thermal conductance in one direction, hereinafter referred to as the longitudinal direction, than in at least a direction perpendicular to such direction. The direction of higher thermal conductance of an anisotropic thermal substance is herein referred to as the longitudinal direction, and the directions perpendicular to a longitudinal direction is hereinafter referred to as transversal directions. An anisotropic thermal conducting substance may possess a single longitudinal direction, such as in carbon nanotubes where the longitudinal direction is along the tube, or multiple longitudinal directions, such as in graphite where the direction of higher thermal conductance may be any direction along the graphite plane.

[0016] The present invention is herein described in detail in reference to the drawings.

[0017] FIGS. **1***a* to **1***c* illustrate a preferred embodiment of the present invention, wherein **100** is a heat transfer device comprising an absorption section **110** and a dissipation section **120**, wherein the absorption section comprises an absorption layer **101** having a first face **102** and a second face **103** on opposite sides of said absorption layer **101**; wherein said first face is made for contacting a heat source **150**. The dissipation section **120** is to be maintained in contact with a temperature lower than the heat source so that the heat is removed from the dissipation section. The first face **102** is so prepared that a heat source **150** of which the heat is to be removed by the device **100** may be attached to the surface of **102**, either directly or with an intermediate structure or layer between 150 and 102.

[0018] The heat transfer device **100** provides a means **105** for directing a cooling substance to or away from said absorption layer, and to directed said cooling substance to or away from the dissipation **120**; as illustrated in FIG. **1**, the open space **105** provides a path for the cooling substance to move from the absorption section **110** to the dissipation section **120**. Since the absorption section **110** continues to absorb heat from the heat source **150**, a distribution and pressure difference is maintained between the absorption section **110** and the dissipation section **120**, providing a driving force to move the cooling substance away from the absorption section **110**.

[0019] In FIG. **1**, **106** is a structure comprising an anisotropic thermal conducting substance. The anisotropic thermal conducting substance provides a substantially higher thermal conductance in one direction (the longitudinal direction) than at least a transversal direction. Structure **106** is placed along the surface of second face **103** of the heat absorption layer **101**, and is in contact with the second face **103**. A preferred embodiment of the anisotropic thermal conducting substance comprises microstructures such as graphite and carbon nano structures, or a combination of the micro and nano structures. A preferred embodiment for the structure **106** comprises a layer of the anisotropic thermal conducting substance. The layer may be fabricated by directly depositing onto the surface of the face **103**, or by attaching a preformed film or slab onto the surface of **103**. Another preferred embodiment of structure **106** comprises a plurality of leaves or blades, wherein each leave or blade comprises a composite of the anisotropic thermal substance.

[0020] The anisotropic thermal conducting substance provides a substantially higher thermal conductance in one direction (the longitudinal direction) than at least one of the transversal directions. In carbon nano tubes, the thermal conductance alone the tube is substantially higher than all the transversal directions. In graphite, the thermal conductance is substantially higher along the graphite plane. In such embodiment comprising graphite, the longitudinal direction may be a selected direction parallel to the graphite plane, and the thermal conduction is lower in the direction perpendicular to the graphite plane.

[0021] In a preferred embodiment, the micro or nano structures, such as graphite or carbon nano tubes, are preferentially arranged to be substantially perpendicular to the surface of the second face **103**.

[0022] A preferred embodiment of the anisotropic thermal conducting substance comprises one of the group of graphite, carbon nano tube, graphene, charcoal layer, charcoal sheet, similar tubular or layered, or sheet of carbon structures, or aforementioned substance containing partial substitutes for carbon.

[0023] The anisotropic thermal conducting substance may have one direction of higher thermal conductance as in carbon nanotubes. In such case, a structure arranged to having the longitudinal direction substantially perpendicular to the surface of contact is represented by **106** in both FIGS. **1***a* and **1***b*. Where the anisotropic thermal substance has more than one direction of higher thermal conductance, such as in graphite where the thermal conductance is higher along the graphite plane, FIGS. **1***b* and **1***c* represent a preferred embodiment of the structure **106**, wherein the graphite plane is arranged parallel to the direction of the path connecting the absorption section and the dissipation section.

[0024] The directional thermal conduction resulted from the design of the anisotropic thermal conduction structure at the internal wall of the heat transfer device enhances the adiabatic transfer of the cooling substance back to the heat absorption region and toward the dissipation region, thereby enhancing the cooling and dissipation efficiency.

[0025] FIG. **2** illustrates another preferred embodiment of the present invention wherein a structure **212** comprising an anisotropic thermal conducting substance is placed along the first face **102** of the heat absorption layer **101**. The anisotropic thermal substance provides a thermal conductance substantially higher in one direction (longitudinal) than in at least a transversal direction. In a preferred embodiment, the anisotropic thermal conducting substance in the structure **212** is arranged in a manner that the longitudinal direction with substantially higher thermal conductance is substantially perpendicular to the surface of said first face **102**.

[0026] Another embodiment of the present invention provides structure or layer in contact with at least one of the two faces **102** and **103** of the absorption layer, wherein the structure or layer contains carbon nano-structures or graphite.

[0027] The structure or layer comprising anisotropic thermal conducting substance may be formed directly onto the surface of the faces **102** and **103**. The method of formation includes gas or liquid phase chemical deposition, such as CVD, electrolytic coating, and MOCVD. In one embodiment of the direct formation embodiments, the section of the layer forming the absorption or dissipation section, or the entire absorption or dissipation section is placed in a chemical ambient for direct deposition to the designated surfaces. Examples of direct deposition to the designated surface include the deposition of carbon nano tubes in MOCVD.

[0028] In another embodiment, the anisotropic thermal substance is provided in a layer of pre-form, wherein the pre-form is attached to the surface where needed to provide a highly directional thermal conduction or insulation whichever is preferred.

[0029] In one preferred embodiment, the structure comprising an anisotropic thermal conduction substance is a layer of high carbon-containing substance such as graphite and carbon nanotubes. It is conceivable that the present invention applies to similar structures and substance wherein some of the carbon atoms are replaced by other elements such as metals.

[0030] Another embodiment of the present invention provides a heat transfer device comprising a heat absorption layer wherein both sides of such layers comprise a plurality of micro or nano-structure attached thereto; said micro or nano structure having a dimension substantially greater in one direction (longitudinal) than in a transversal direction, and wherein the thermal conductance is substantially higher along the longitudinal direction than a transversal direction.

[0031] A preferred embodiment of the heat transfer device according to the previous paragraph provides an arrangement wherein the longitudinal direction is substantially perpendicular to the surface of the absorption layer or dissipation layer.

[0032] Another preferred embodiment provides a heat transfer device according to above description wherein the micro or nano-structure comprises a composite containing more than fifty percent of carbon. The carbon-containing substance may have part of the carbons replaced by substitutes such as metallic atoms.

[0033] Although various embodiments utilizing the principles of the present invention have been shown and described in detail, it is perceivable those skilled in the art can readily devise many other variances, modifications, and extensions that still incorporate the principles disclosed in the present invention. The scope of the present invention embraces all such variances, and shall not be construed as limited by the number of elements, specific arrangement of groups as to rows and column, and specific circuit embodiment to achieve the architecture and functional definition of the present invention.

What is claimed is:

1. A heat transfer device comprising

an absorption section comprising an absorption layer having a first face and a second face on opposite sides of said absorption layer; wherein said first face is made for contacting a heat source;

a dissipation section for removing heat from said device;

a means for directing a cooling substance to or away from said absorption layer; and a means to move said cooling substance to or away from said dissipation section;

wherein for both said first face and second face, a layer or a structure comprising an anisotropic thermal conducting substance is placed on or in close contact to the surfaces thereof;

wherein said anisotropic thermal conducting substance has a thermal conductance substantially higher in one direction (the longitudinal direction) than in a direction perpendicular to said longitudinal direction.

2. The device according to claim **1** wherein said structure comprising an anisotropic heat conducting substance comprises a plurality of micro or nano structures.

3. The device according to claim **1** wherein said anisotropic thermal conducting substance is arranged preferentially to have the longitudinal direction of higher thermal conductance substantially perpendicular to the surface of said second face.

4. The device according to claim **1** wherein said anisotropic heat conducting substance provides a thermal conductance substantially higher in one direction (longitudinal) than the transversal directions.

5. The device according to claim **1** wherein said anisotropic thermal conducting substance comprises one of the group of graphite, carbon nano tube, graphene, charcoal layer, charcoal sheet, similar tubular or layered structures, or sheet of carbon structures, or similar structures containing metal substitutes for carbon.

6. The device according to claim **1** wherein said anisotropic thermal conducting substance is arranged in a manner that the longitudinal direction of the second anisotropic substance is substantially perpendicular to the surface of said first face.

7. A heat transfer device comprising:

an absorption section comprising an absorption layer having a first face and a second face on opposite sides of said absorption layer; wherein said first face is made for contacting a heat source, and said second face is made for contacting a cooling substance;

a dissipation section for removing heat from said device;

a means for directing a cooling substance between said absorption section and said dissipation section;

wherein a structure or a layer, comprising an anisotropic heat conducting substance, is placed on or in close contact with said first face;

wherein said anisotropic thermal conducting substance has a thermal conductance substantially higher in one direction (the longitudinal direction) than in a direction perpendicular to said longitudinal direction.

8. The device according to claim **7** wherein said structure or layer, comprising an anisotropic heat conducting substance, comprises a plurality of micro or nano structures.

9. The device according to claim **7** wherein said anisotropic thermal conducting substance is arranged preferentially to have the longitudinal direction of higher thermal conductance substantially perpendicular to the surface of said first face.

10. A heat transfer device comprising:

a heat absorption layer having a first face and a second face on opposite sides of the layer; wherein said first face is made for contacting a heat source;

a means for directing a cooling substance to or away from said second face;

wherein for both said first face and second face, a layer or a structure comprising an anisotropic thermal conducting substance is placed on or in close contact to the surfaces thereof.

11. The heat transfer device according to claim **10** wherein said first face comprises a structure comprising carbon-containing substance having more than 50% carbon content.

12. The device according to claim **10** wherein said carbon nanostructures are formed directly on the surface of said first and second faces in a gas-phase or liquid-phase chemical deposition.

13. A heat transfer device comprising:

a heat absorption layer having a first face and a second face on opposite sides of the layer; wherein said first face is made for contacting a heat source;

a means for directing a cooling substance to or away from said second face;

wherein for both said first face and second face, a layer or a structure comprising an anisotropic thermal conducting substance is placed on or in close contact to the surfaces thereof.

14. The device according to claim **13** wherein both said first and second faces comprise anisotropic thermal conducting substance formed directly onto the surface of the faces in a gas-phase or liquid-phase chemical deposition process.

15. The device according to claim **13** wherein said anisotropic thermal conducting substance comprises a plurality of micro or nano structures having substantially greater dimension in one direction (the longitudinal direction) than one of the transversal directions.

* * * * *