A heat dissipation device, having a base plate for making contact with a heat producing integrated circuit; several fins disposed on and partially covering the base plate, the fins forming flow channels and the fins and the flow channels having proximal ends and distal ends. The device also includes a fan mounted on the base plate for delivering air flow to the fins, the fan being configured to deliver air to the proximal ends of the fins. The device also includes a shroud disposed over the fins and the fan. The shroud has an aperture that has a shape generally matching the overall shape of the fan, where the aperture acts as an air inlet for the fan. The device also includes members for fastening the heat dissipation device against the heat producing integrated circuit. The fastening members hold in alignment the shroud and the base plate against a printed circuit board having the heat producing integrated circuit.
FIG. 1
FAN SINK HEAT DISSIPATION DEVICE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to U.S. Patent Application No. 60/506,055, filed Sep. 24, 2003, the disclosure of which is hereby incorporated by reference herein in its entirety for all purposes.

BACKGROUND OF THE INVENTION

[0002] The present invention relates to heat sinks, and in particular, to heat sinks including fans that are coupled to graphic cards so that the heat generated by the card can be effectively managed.

[0003] Semiconductors, including microprocessors and other integrated circuits (ICs), generate heat during use. Current microprocessors, for example, can emit 50 watts of power or more. The temperature of the microprocessor or the IC has a direct impact upon its performance. Unless microprocessors and other ICs are thermally managed during use, they will not operate reliably. Failures include phenomena such as junction fatigue, electromigration diffusion, thermal runaway, and electrical parameter shifts. For most uses of a semiconductor device, a proper mechanism for heat dissipation is needed.

[0004] Heat may be transferred from a device by convection, radiation, or conduction. Convection is the transfer of heat by moving air. Radiation is the transfer of heat from one surface to another via electromagnetic waves. Conduction is the transfer of heat from the more energetic particles of a substance to the less energetic particles of a substance, and it does not involve convection. Conduction is typically considered as transfer of heat within materials (e.g., solids, liquids, or gases), from a higher temperature region to a lower temperature one. Each of these principles may have a part in the operation of heat sinks.

[0005] Heat sinks are devices that attach directly or indirectly to a semiconductor or other hot surface to enhance heat dissipation from the surface. Heat flows from the hot surface to cooler air through the heat sink. A heat sink is generally designed with a first surface, for engaging with the semiconductor, and a second surface, for contact with the cooler air. The second surface, often formed of a plurality of projections or fins, is designed for maximum surface area, and thus maximum contact with the air, to allow heat to dissipate more quickly.

[0006] To further facilitate air flow from the hot surface, many heat sinks include small fans mounted thereon. Heat pipes may also form part of the heat sink, allowing heat transfer to the liquid or gas within the pipes. Heat sinks may be painted or anodized to enhance the effect of radiation heat transfer.

[0007] Recently, advances in computer graphics simulation have created thermal design challenges for graphics cards. These challenges are partly driven by the increased power dissipation of the graphic processing unit ("GPU") and associated memory and other devices of the graphic cards. In addition to the increased heat dissipation, such graphics cards need to operate in the ever-decreasing available real estate of typical graphics workstations. For example, it is desirable to have a graphics card not take up more space than one expansion slot (e.g., a Personal Computer Interface [PCI] slot).

[0008] FIG. 1 shows a typical graphics card 100 that may be cooled using embodiments of the present invention. FIG. 1 shows that the graphics card 100, includes one larger GPU 102 and several BGA-type packages 104, all of which generate heat that needs to be managed. It is normal for such a graphics card to dissipate at least 50 Watts of heat.

[0009] FIG. 2 shows a typical graphics card 100 with a prior art heat dissipation device 10. FIG. 2 shows that a common cooling scheme used to thermally manage such a graphics card includes a fan heat sink 10 mounted over the GPU, where heat from the GPU is transferred to an ambient by the air movement provided by the fan 112. This fan heat sink arrangement is commonly referred to as an impingement cooling scheme, where the fan delivers air that impinges on the heat sink. In addition to the limits inherent to impingement-type cooling, this cooling scheme neglects to address the fact the air is being delivered by the fan may be preheated and hence of little relief. In addition, such a cooling scheme neglects to provide for the thermal management of heat sources (e.g., IC's and memory devices) other than the GPU. In addition to neglecting the other heat sources, such a scheme may actually worsen their thermal management by delivering the heat being dissipated by the GPU to the other heat sources.

[0010] Thus, there is a continuing need to support heat producing integrated circuits, such as those of a graphics card, with an improved heat dissipating device.

BRIEF SUMMARY OF THE INVENTION

[0011] The present invention provides a heat dissipation device, having a base plate for making contact with a heat producing integrated circuit; several fins disposed on and partially covering the base plate, the fins forming flow channels and the fins and the flow channels having proximal ends and distal ends. The device also includes a fan mounted on the base plate for delivering air flow to the fins, the fan being configured to deliver air to the proximal ends of the fins. The device also includes a shroud disposed over the fins and the fan. The shroud has an aperture that has a shape generally matching the overall shape of the fan, where the aperture acts as an air inlet for the fan. The device also includes members for fastening the heat dissipation device against the heat producing integrated circuit. The fastening members hold in alignment the shroud and the base plate against a printed circuit board having the heat producing integrated circuit.

[0012] In one aspect, the flow channels extend radially outward in a fanned-out manner from the proximal ends to the distal ends. The proximal ends are arranged along an arc which is complimentarily shaped with a portion of the aperture of the shroud.

[0013] In another aspect, a first flow channel of the fins is generally parallel with a longitudinal axis of the printed circuit board and a last flow channel of the fins is nonparallel and angled with respect to the first flow channel, and the remaining flow channels between the first and the last flow channel are incrementally angled away from the first channel and incrementally aligned with the last flow channel, so
as to form a radially extending fan-shaped series of flow channels that are formed by the fins.

[0014] For a further understanding of the nature and advantages of the invention, reference should be made to the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. 1 shows a typical graphics card that may be cooled using embodiments of the present invention.

[0016] FIG. 2 shows a typical graphics card having a prior art heat dissipation device.

[0017] FIGS. 3A-C show exemplary views of a first embodiment of the heat dissipation device in accordance with the present invention.

[0018] FIGS. 4A-B show exemplary views of the backside of the heat dissipation device of FIG. 3.

[0019] FIGS. 5A-B show exemplary views of an alternate embodiment of the backside of the heat dissipation device of FIG. 3.

[0020] FIG. 6 shows an exemplary view of an operational graphics card using the heat dissipation device of FIG. 3.

[0021] FIG. 7 shows alternative views of FIG. 6.

[0022] FIG. 8 shows an exemplary view of an alternate embodiment of the heat dissipation device in accordance with the present invention, having an alternately shaped shroud.

[0023] FIGS. 9A-B show exemplary views of alternate embodiments of the heat dissipation device having an intake air duct in accordance with the present invention.

[0024] FIG. 10 shows an exemplary view of an alternate embodiment of the heat dissipation device having a blower in accordance with the present invention.

[0025] FIG. 11 shows an exemplary view of an alternate embodiment of the heat dissipation device in accordance with the present invention having heat pipes to cool backside packages by front side cooling.

[0026] FIG. 12 shows a backside view corresponding to the device of FIG. 11.

[0027] FIG. 13 shows an exemplary view of an alternate embodiment of the heat dissipation device in accordance with the present invention having heat pipes to cool backside packages by front side cooling using a blower.

[0028] FIGS. 14A-D show exemplary views of a second embodiment of the heat dissipation device in accordance with the present invention.

[0029] FIGS. 15A-H show exemplary views of a third embodiment of the heat dissipation device in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0030] FIGS. 3A-C show exemplary views of a first embodiment of the heat dissipation device in accordance with the present invention. FIG. 3A shows the heat dissipation device to include a base plate 302, which is configured to be mounted to a printed circuit board (“PCB”), such as a graphic card 305. The graphic card 305 includes various heat sources, including a GPU and various memory devices (e.g., SRAMS). The base plate 302 has disposed thereon a fin section 304. While as shown, the fin section is a soldered-on folded fin section 304 soldered to the base plate 302, other fin types and bonding techniques may be used. FIG. 3B shows a top view of the graphics card assembled with the heat dissipation device of FIG. 3A. As shown in FIG. 3C, the fin section 304 initiates at one end of the base plate 302, a base plate along an arc of a circle 305. The fin section 304 extends outward from this arc 305 radially toward (e.g., fans out) to cover the base plate, such that the fin section extends to a horizontal edge 307 of the base plate along the top portion of the base plate, and to a vertical edge 309 of the base plate along a side portion of the base plate located distal to the arc 305. As can be seen on FIGS. 3A-C, the finned section's fins are arranged such that the entry to the flow channels is tangent to the arc 305, to facilitate the flow of air from the fan into the flow channels of the finned section. The air inlets of the fin section which is adjacent to the fan are aligned geometrically with the major component of the airflow delivered by the fan 308. The heat dissipation device also includes a shroud 306 (e.g., plastic or other) that holds a fan 308.

[0031] The shroud 306 covers the finned section and ensures that the airflow provided by the fan 308 does not bypass the finned section 304 thus ensuring that the airflow gets delivered to the flow channels of the finned section. The shroud surrounds the fan around the fan's perimeter and encloses the region around the finned section and the fan. The shroud has openings in the regions of the fan air inlet and the inlet to the finned section which is adjacent to the fan. In this manner, the shroud ensures that preheated air is drawn into the fan at the fan's inlet and then delivered to the inlet of the flow channels of the finned section, which are adjacent to and aligned with the air exit of the fan. The cooling airflow provided by the fan is not wasted or lost to any region and is directed to the flow channels that are formed by the finned section or region. The shroud also has openings along the exits of the flow channels.

[0032] Also shown in FIG. 3A-C, the finned section 304, which extends to cover the base plate, in one embodiment may include more than one finned section, that are not connected to a common base plate. When a multi-part finned section is used, the primary finned section is a larger section where the fins are connected with the base plate. The other portions 324 and 334 also include smaller base plates and finned sections. These additional finned sections 324 and 334 are not in direct contact with the finned section 304. This lack of contact between these additional finned sections (which are used to manage the heat dissipated by non-GPU devices) ensures that heat being dissipated by the devices does not get transferred to the other devices at the base of the finned section, by conduction through the base plates of the finned section. However, the flow channels of the finned sections 324, 334 are aligned to ensure that the airflow delivered by the fan is delivered to the outermost edges of the finned sections, which include the non-connected finned portions.

[0033] The shroud 306 includes members that are used to hold the larger 304 and smaller finned portions (e.g., 324, 334, shown in FIG. 3) in proper alignment to ensure that the
air flow delivered by the fan gets delivered to the outermost edges of the finned sections, which include the non-connected finned portions. Fasteners 351, 352 hold the shroud 306, the finned portions, 304, 324, and 334 in alignment on the board 304.

[0034] FIGS. 4A-B show exemplary views of the backside of the heat dissipation device of FIG. 3. The fasteners 351, 352 (shown in FIG. 3), extend from the front side of the board 304 to hold the heat dissipation device aligned and in place over the board 304 by engaging a back plate 330. A clip 332 is used to securely hold the back plate 330 against the base plate 302, with the board 304 sandwiched in-between. The back plate 330 includes apertures for receiving the fasteners 351, 352 as well as apertures for guiding and for mounting purposes. The back plate 330 also includes recesses for ensuring an adequate thermal contact between the board 304 and the back plate 330. The back plate, the base plate and the finned sections may be manufactured using any high thermal conductivity material, such as copper or aluminum or related alloys thereof. The finned section may be connected with the base plate by way of any suitable method, such as for example soldering. In addition, the base plate, and the finned sections as well as the back plate may be made of the same or different materials. For example, copper may be used for all the pieces, or alternately, the base plate may be made of copper and the fins of aluminum or any other possible combination of these and other high thermal conductivity materials.

[0035] FIGS. 5A-B show exemplary views of an alternate embodiment of the backside of the heat dissipation device of FIG. 3. Similar to the back plate of FIGS. 4A-B, the fasteners 351, 352, extend from the front side of the board 304 to hold the heat dissipation device aligned and in place over the board 304 by engaging a back plate 330. A clip 332 is used to securely hold the back plate 330 against the base plate 302, with the board 304 sandwiched in-between. The back plate 330 includes apertures for receiving the fasteners 351, 352 as well as apertures for guiding and for mounting purposes. The back plate 330 also includes recesses for ensuring an adequate thermal contact between the board 304 and the back plate 330.

[0036] FIG. 6 shows an exemplary view of an operational graphics card using the heat dissipation device of FIG. 3. Such a board may dissipate approximately 50 Watts at the GPU and approximately 2.5 Watts each for several (e.g., 8) SRAMs. This figure shows the graphic card using an embodiment of the heat dissipation device of the present invention being installed in a single slot in the motherboard of a graphic workstation. The additional space required by the heat dissipation device is still small enough to be able to fit the graphic card and its heat dissipating device within the space of a single PCI slot. FIG. 7 shows alternative views of FIG. 6. As shown by FIGS. 6-7, the heat dissipation device in accordance with one embodiment of the present invention requires no more than 1 slot’s (e.g., PCI slot) worth of space and thus is able to effectively manage the thermal loading of the board while only occupying one slot’s worth of workstation real estate.

[0037] FIG. 8 shows an exemplary view of an alternate embodiment of the heat dissipation device in accordance with the present invention, having an alternately shaped shroud. Similar to the device described in conjunction with FIG. 3C the shroud 306 covers the finned section and ensures that the air flow provided by the fan 308 does not bypass the finned section 304, thus ensuring that the airflow gets delivered to the flow channels of the finned section. Likewise, the shroud 306 includes members that are used to hold the larger 304 and smaller finned portions (e.g., 324, 334) in proper alignment to ensure that the airflow delivered by the fan gets delivered to the outermost edges of the finned sections, which include the non-connected finned portions. Fasteners hold the shroud 306, the finned portions, 304, 324, and 334 in alignment on the board 304. In addition, the shroud by extending beyond the finned area ensures that cooling air flow is also delivered to additional heat dissipating devices (e.g., capacitors in the upper right hand corner of the board).

[0038] FIGS. 9A-B show exemplary views of alternate embodiments of the heat dissipation device having an intake air duct in accordance with the present invention. FIG. 9A shows a first embodiment of the shroud 306 and a first embodiment of an intake air duct 406. FIG. 9B shows a second embodiment of the shroud 306 and a second embodiment of an intake air duct 408. Either of the intake air duct embodiments 406, 408 may be used with either shroud embodiment. The additional intake air duct is used to bring fresh unheated air from outside of the chassis into the finned areas. In cases where the optional intake shroud is used, two adjacent expansion slots may need to be used to accommodate the additional space occupied by the intake air duct. As is shown in FIGS. 9A-B, the additional intake air shroud may be secured by being attached to a PCI bracket, adjacent to the PCI bracket of the graphics card, by a fastener (e.g., a rivet, or a screw). The intake air duct 406 or 408 ensures that fresh air from outside the chassis of the workstation is brought in to provide cooling air to the heat dissipation device. The use of the intake air duct may be preferred for the cooling of higher powered devices, or where the coolest possible available air is required.

[0039] FIG. 10 shows an exemplary view of an alternate embodiment of the heat dissipation device having a blower 410 in accordance with the present invention. The use of a blower instead of a fan ensures an improved and increased flow rate of the cooling air. In addition, the blower’s blade angles may be chosen to ensure a maximum delivery of the blower’s air flow into the flow channels of the finned sections.

[0040] FIG. 11 shows an exemplary view of an alternate embodiment of the heat dissipation device in accordance with the present invention having heat pipes 510 to cool backside packages by front side cooling. FIG. 12 shows a backside view corresponding to FIG. 11. As is shown in FIGS. 11-12, heat pipes imbedded in or in good thermal contact with a heat spreader plate(s) 512 placed on a back side of a board, may be used to deliver heat from a location not in good thermal contact with the forced convection cooled finned section (e.g., board’s backside) to the front of the board where the heat is dissipated by the forced convection cooled finned section.

[0041] FIG. 13 shows an exemplary view of an alternate embodiment of the heat dissipation device of FIGS. 11-12 using a blower. The embodiment shown in FIG. 13 uses a blower instead of a fan (as is shown in FIGS. 11-12). The use of a blower instead of a fan ensures an improved and
increased flow rate of the cooling air. In addition, the blower’s blade angles may be chosen to ensure a maximum delivery of the blower’s air flow into the flow channels of the finned sections.

[0042] FIGS. 14A-D show exemplary views of a second embodiment of the heat dissipation device 600 in accordance with the present invention. This second embodiment of the heat dissipation device 600 uses arrays of folded fins 602 to form the finned section that is disposed above the base plate. As shown in FIGS. 14A-B, the heat dissipation device is configured to cool a card 604 having one GPU and several (e.g., 8-16) memory or SRAM modules 606, using arrays of folded fins. The folded fin is designed to form a sufficient convective surface for the heat dissipation device. Furthermore, the embodiment shown in FIGS. 14A-B relies on an improved air delivery system supplied by a blower 608. SRAMs on the front side are cooled by the cooling air provided through the finned section. Heat from SRAMs on the back side (shown in FIG. 14D) are conducted to the back plate 610 via the raised surfaces 612 of the back plate that contact the back side SRAMs. The back plate 610 also acts as a stiffener for the board. Also shown are two spring cantilevered ears 614 on the back plate 610 that act as springs and which eliminate the need for the use of a backside clip (as shown in FIGS. 4-5). Similar to the features of the first embodiment (e.g., FIGS. 3-5), the finned section is aligned in a manner such that the cooling flow channels originate along a curved line that is aligned with the air flow leaving the blower. The finned section is arranged in a radial manner and fans out away from the curved line to deliver cooling air in the fanned-out manner across the heat producing devices of the board. Also similar to the features of the first embodiment (e.g., FIGS. 3-5), the shroud 614 compliments, guides and improves the airflow from the blower into and through the finned section. Fastening means 616 (e.g., screws, etc.) that fit through apertures in the board, and the shroud connect the heat dissipation device with the board and the back plate.

[0043] The folded fins that are arranged in the arrayed manner next to one another, can be arranged so that they butt up against one another in the direction of the flow or be placed as shown in FIG. 14B where there is a gap in between each row of the folded fins. The gapped array is preferred in this case, since it enables a repeated break up and rebuilding of the thermal boundary layer, which enhances the overall heat dissipation capability of the device. Such folded fins are chosen to be about 0.5 to 0.7 mm thick. This thickness allows for the folding of the strip of metal to form the folded fin. Fins spacing is then chosen to ensure that an adequate air flow rate is provided by the blower. The folded fins may be solid or may have an open slot at their top surface, as is shown in FIG. 14B. The open-topped folded fin is preferred since at the thickness of 0.5 to 0.7 mm, the open top reduces the flow back pressure and allows a smoother and improved flow through the fins, as the flowing air sees more relief. Also the open-topped folded fin arrangement reduces the overall weight of the heat dissipation device by eliminating the additional weight due to the non-open-topped folded fins. Furthermore, the removal of the metal portion from the metal strip before its folding creates a stress concentration that makes it easier to form the folded fin profile. In an alternate embodiment, the folded fins are replaced with air foil-shaped fins that are arranged on the base plate in a similar manner as the folded fins.

[0044] FIGS. 15A-H show exemplary views of a third embodiment of the heat dissipation device in accordance with the present invention. This third embodiment of the heat dissipation device 702 uses arrays of stacked fins 708 to form the finned section that is disposed above the base plate. Shown in FIG. 15A is the heat dissipation device 702, having a base plate 706, on which is placed a fan (or alternately a blower) 710. Also disposed on the base plate 706 is an array of stacked fins 708. The entire heat dissipation device 702 is placed on the graphics card 704 to help remove heat from the GPU (716 shown in FIG. 15C) and the other heat generating devices (e.g., memory or SRAMs). The array of stacked fins are formed by joining (e.g., soldering) C-shaped individual fins with the base plate 706. The C-shaped fins are formed by a bending process into the C-shape. As is shown in FIG. 15A, the C-shaped fins have expanding top and bottom portions, so that when they are placed adjacent to one-another a radially outward expanding shape, in a fanned-out manner is formed. Also, by placing the C-shaped fans next to one-another, closed air flow channels are formed between adjacent fins, that will deliver the air flow provided by the fan 710 from the fanned sections proximal end towards its exist at its distal end that is near the card end away from the fan. The closed flow channel provides a flow channel that ensure the air entering each flow channel travels the entire length of the flow channel and does not leak out of the flow channel, as would happen with open-top flow channels. Adequate air flow is provided to the finned section by the fan (or blower) 710 and this is aided by using thin fins. Furthermore, since the C-shaped fins are wider at their distal end than they are at their proximal end, the flow channels formed by the C-shaped fins are wider towards their distal end than at their proximal end, thus forming flow channels that have continually widening cross sectional area. This continually widening cross sectional area flow channel is advantageous from a pressure drop and hence flow rate perspective, since as the length of the flow channel is increased, its width is also increased to help keep the flow channel’s pressure drop reduced, as compared to a fixed-cross-section flow channel.

[0045] Each of the several C-shaped stacked fins is thin-walled. As used herein, thin-walled refers to a thickness on the order of 0.2-0.3 mm. The thin-walled fins ensure that an adequate flow channel is formed that does not produce a large back pressure that would impede an adequate air flow rate. An adequate flow channel is formed in the finned section by providing a fin-to-fin spacing that is on the order of 2-3 times the fin’s thickness. So, for example, with fins having a wall thickness of 0.2 mm, a 0.6 mm fin spacing is used. This combination of fin thickness and spacing is not achievable with conventional heat sinks that are manufactured using either extrusion or die cast techniques. Furthermore, the use of the stacked fin arrangement also enables the formation of fins as tall as desired (as compared to their thickness); to have aspect ratios (e.g., height to thickness ratio) much higher than those available in conventional heat sinks that are manufactured using either extrusion or die cast techniques. In addition, the use of the thin-walled stacked fin arrangement also enables the production of an effective heat dissipation device having a low weight.
Also shown in FIG. 15A is that the finned section 708 begins at a proximal end 707 that is near the fan (or blower) exit and ends at a distal end 709 near the card's end at the base plates end opposite the fan. The fins 708 extend radially outward from their proximal end 707 towards the distal end 709 in a fanned-out manner, such that a first fin 708i is nearly parallel with the longitudinal axis of the card 704, and a last fin 708ii is non-parallel and at angle with respect the first fin 708i. Also shown in FIG. 15A is that the fins have differing lengths, such that for example, the first fin 708i is much longer than the last fin 708ii, and fins in between the first and the last fin are generally incrementally shorter. In addition, as shown in FIGS. 15A and 15D, the finned section 708 can be made of various fin subsections (i.e., 708A-E). To ease the manufacturing of the fin subsections, the fins in each subsection have generally the same length, however since their proximal ends are offset from one-another (to make the fanned out arrangement), their distal ends are also offset from one-another. The lengths of the fins in the finned section 708 and the fin subsection are chosen to provide a maximum extended surface length and also to maneuver around the various larger components on the card 704. The proximal end of the fin section is aligned along an arc. The arc shape is chosen to be complimentary shaped with the curvature of the fan or blower. Along the arc-shaped proximal end, the openings into and the flow channels formed by the stacked C-shaped fins are oriented so that the major component of the air flow delivered by the fan or blower is aligned with the flow channel inlet. In this manner, the flow channels are arranged to take maximum advantage of the air flow delivered by the fan or the blower.

Shroud 712 is also designed to enhance the overall performance of the heat dissipation device. As is shown in FIGS. 15B, C and E, the shroud 712 fits over the fan 710, the base plate 706 and the finned section 708. The shroud 712 is closed on its periphery except for regions that are aligned with the distal ends of the flow channels, where the air flow delivered from the fan exits the flow channels formed by the fins. On its external surface, the shroud 712 has an aperture that is complimentary-shaped with the overall shape of the fan or blower 710 to provide for an air inlet to the fan or the blower 710. On its internal surface, the shroud has an open passage to allow the air being delivered by the fan or the blower to enter the inlet end (proximal end) of the fin flow channels. This way, the majority of the air being delivered by the fan or the blower is forced to go nowhere but into the finned section's flow channels. In addition, the shroud's height is chosen such that there is a small gap between 0.5 to 1 mm between the top of the fins and the shroud, to allow some of the fan's delivered air to also go above the finned section's flow channels, so that the top of the fins are also cooled. The shroud also includes members 713A-H (e.g., stiffeners) that add rigidity to the shroud. The members 713A-H are also aligned with the fins of the fin section to help direct the air flow exiting the finned section. The members by extending the flow field also reduce the adverse pressure gradient that normally exists at a flow area expansion (e.g., exit from the finned section), and prevents or minimizes the resulting recirculation of air flow and thus help improve the air flow rate and thus the overall performance of the device.

In addition, as shown in FIGS. 15C, E and F, the shroud 712, has apertures and fasteners 714 that are configured to mate through the board 704 to hold the device 702 and the shroud 712 in proper alignment over the card 704. Also shown in FIG. 15D are standoffs 718 and studs 720 that help with the connection of the device 702 with the card 704. FIG. 15E shows an exploded assembly view drawing of the shroud 712, fan or blower 710, the base plate 706 with the attached fin section and an insulating layer 722. The insulating layer 722 prevents the potential for a short circuit being formed by the electrically conductive components of the graphics card that may come into direct contact with the back side of the base plate 706. The insulating layer 722 is typically a thin (0.004 to 0.008 inches) die cut piece of polyester or other insulating film (e.g., Mylar) that includes an adhesive layer that attaches with the back side of the base plate 706. FIG. 15F shows one possible way of providing power to the fan through the fan plug 724A being connected with connector 724B on the PCB or the graphics card.

A comparison of FIGS. 15G and 15H shows that the overall design of the heat dissipation device is very easily scalable to handle larger heat dissipation loads. FIG. 15G shows a shorter fin height for a smaller heat load, where the heat dissipation device when assembled with the PCB occupies no more a single slot (e.g., PCI slot) in a workstation. On the other hand, FIG. 15H shows a taller fin height for a larger heat load, where the heat dissipation device when assembled with the PCB occupies two slots (e.g., PCI slots) in a workstation. In addition to using taller fins, a higher flow rate fan or blower may also be used to increase the heat dissipation capability of the device. So, the same overall design is easily scaled up by increasing the fin height and/or fan flow rate, while keeping all other parameters the same. In addition, the design can be further enhanced by using the intake air ducts to form a two-part shroud to bring in fresh air from outside the workstation chassis as described above.

The heat dissipation device in accordance with the embodiments of the present invention in general, and the device 702 (i.e., the third embodiment) provide the following performance results. The single slot or shorter fin height device (e.g., FIG. 15G) is capable of an overall performance of at about 0.7 to 0.74 degrees C. per Watt (° C/w), based on performance tests where for a 50 w power GPU’s die temperature was maintained at 58° C. as compared to an ambient air temperature of 21° C. Likewise the single slot or taller fin height device (e.g., FIG. 15H) is capable of an overall performance of at about 0.57 degrees C. per Watt (° C/w), based on performance tests where for a 60 w power GPU’s die temperature was maintained at 55° C. as compared to an ambient air temperature of 21° C.

As will be understood by those skilled in the art, the present invention may be embodied in other specific forms without departing from the essential characteristics thereof. For example, the base plate and the finned section may be made of the same or different high conductivity materials and may be joined together using any suitable techniques, including soldering. These other embodiments are intended to be included within the scope of the present invention, which is set forth in the following claims.

What is claimed is:

1. A heat dissipation device, comprising:
   a base plate for making contact with a heat producing integrated circuit;
   a plurality of fins disposed on and partially covering said base plate, said fins forming flow channels and said fins and said flow channels having proximal ends and distal ends,
a fan mounted on said base plate for delivering air flow to said plurality of fins, said fan configured to deliver air to said proximal ends of said fins;

a shroud disposed over said fins and said fan, said shroud having an aperture having a shape generally matching the overall shape of said fan, said aperture acting as an air inlet for said fan; and

means for fastening said heat dissipation device against the heat producing integrated circuit, wherein said means for fastening hold in alignment said shroud and said base plate against a printed circuit board having the heat producing integrated circuit.

2. The device of claim 1 wherein said flow channels extend radially outward in a fanned-out manner from said proximal ends to said distal ends, said proximal ends being arranged along an arc which is complimentarily shaped with a portion of said aperture of said shroud.

3. The device of claim 2 wherein a first flow channel of said plurality of fins is generally parallel with a longitudinal axis of said printed circuit board and a last flow channel of said plurality is nonparallel and angled with respect to said first flow channel, and the remaining flow channels between said first and said last flow channel are incrementally angled away from said first channel and incrementally aligned with said last flow channel, so to form a radially extending fan-shaped plurality of flow channels formed by said plurality of fins.

4. The device of claim 2 wherein said plurality of fins comprise a corrugated fin section having a generally corrugated shape, such that said corrugated shaped fins when disposed on said base plate form said flow channels for delivering air flow provided by the fan.

5. The device of claim 5 wherein said inverted U-shaped folded fins have an aperture formed in their top portions.

6. The device of claim 3 wherein said plurality of fins comprise a plurality of individual C-shaped fins, said plurality of C-shaped fins arranged in a stacked manner to form a stacked fin array to form said flow channels.

7. The device of claim 3 wherein said plurality of fins are arranged such that the fins are spaced at a distance of 2 to 3 times that of the fin's thickness.

8. The device of claim 1 further comprising a back plate for making contact with the back side of the printed circuit board, wherein said back plate, and said base plate are held in alignment against opposite sides of a board having a heat producing integrated circuit using said shroud.

9. The device of claim 1 wherein the top internal surface of said shroud is located a distance above the top of the fins so as to create a flow channel for directing airflow provided by said fan over said top of said fins.

10. The device of claim 1 wherein said shroud comprises openings along its periphery, wherein said openings are aligned with and project outward over the distal ends of said fins, so as to direct the air flow existing the flow channels to exit from said device along said openings.

11. The device of claim 1 further comprising a plurality of stiffeners, said stiffeners extending vertically downward from the top internal surface of said shroud and inward from and along said openings, wherein said stiffeners are aligned with the flow channels formed by said fins.

12. The device of claim 1 further comprising an intake shroud, having a proximal end and a distal end, said distal end of said intake air shroud configured to be coupled with said aperture of said shroud, said proximal end of said intake air shroud configured to receive air from the outside of a chassis of a workstation holding the printed circuit board, said intake air shroud configured to provide unheated air from the outside of a chassis of a workstation holding the board into the fins via the fan.

13. The device of claim 1 further comprising a heat pipe in thermal contact with said base plate.

14. The device of claim 1 wherein said base plate and said fins are made of the same high thermal conductivity material.

15. The device of claim 1 wherein said base plate and said fins are made of different high thermal conductivity materials.

16. The device of claim 1 having a temperature rise of no more than approximately 0.7 degrees C. per watt.

17. The device of claim 1 having a temperature rise of no more than approximately 0.6 degrees C. per watt.

18. The device of claim 1 having an overall width that is less than the width of a single personal computer interface expansion slot.

19. A heat dissipation device, comprising:

   a base plate for making contact with a heat producing integrated circuit;
   a plurality of fins disposed on and partially covering said base plate, said fins forming flow channels and said fins and said flow channels having proximal ends and distal ends, wherein said plurality of fins comprise a plurality of individual C-shaped fins, said plurality of C-shaped fins arranged in a stacked manner to form a stacked fin array to form said flow channels;

   a fan mounted on said base plate for delivering air flow to said plurality of fins, said fan configured to deliver air to said proximal ends of said fins;

   a shroud disposed over said fins and said fan, said shroud having an aperture having a shape generally matching the overall shape of said fan, said aperture acting as an air inlet for said fan; and

   means for fastening said heat dissipation device against the heat producing integrated circuit, wherein said means for fastening hold in alignment said shroud and said base plate against a printed circuit board having the heat producing integrated circuit,

   wherein said flow channels extend radially outward in a fanned-out manner from said proximal ends to said distal ends, said proximal ends being arranged along an arc which is complimentarily shaped with a portion of said aperture of said shroud, and

   wherein a first flow channel of said plurality of fins is generally parallel with a longitudinal axis of the printed circuit board and a last flow channel of said plurality is nonparallel and angled with respect to said first flow channel, and the remaining flow channels between said first and said last flow channel are incrementally angled away from said first channel and incrementally aligned with said last flow channel, so to form a radially extending fan-shaped plurality of flow channels formed by said plurality of fins.

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