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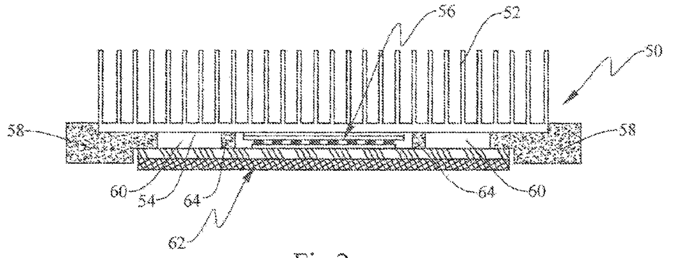

Fig.2

(57) Abstract: An improved mechanical support for a personal heat control device is provided. The improved mechanical support includes a heat sink, a heat spreader assembly, a heat pump and a plurality of mechanical support structures. The heat sink has a hot side and the heat spreader assembly is disposed adjacent the heat sink at the hot side. The heat pump is disposed at the hot side. The plurality of mechanical support structures are configured and arranged to support the heat sink on the heat spreader assembly.

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IMPROVED MECHANICAL SUPPORT FOR A THIN-FILM THERMOELECTRIC COOLING DEVICE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 61/322,724 filed April 9, 2010, which is incorporated herein by reference in its entirety as if fully set forth herein.

FIELD OF THE INVENTION

[0002] The present invention relates generally to thin-film thermoelectric cooling devices and particularly to thin-film thermoelectric cooling devices for personal heat control applications. More specifically, the present invention relates to an improved mechanical support for a personal heat control device employing a thin-film thermoelectric cooling apparatus which may be worn by an individual to control his or her body temperature.

BACKGROUND OF THE INVENTION

[0003] The use of thin-film thermoelectric cooling devices (hereinafter, "TEC" or TEC's) employing the Peltier effect for controlling the temperature of electronic, electro-optical and electro-mechanical devices is known in the art. The Peltier effect is applied to heating and/or cooling situations in which heat is either drawn from or directed to an interface between two different conducting materials in response to a flow of electrical current therebetween.

[0004] By way of example, one such device is disclosed by Weigert et al. in U.S. Patent Application Publication No. US 2005/0138934 for "Optoelectronic Component with a Peltier Cooler, published on June 30, 2005. The Weigert publication discloses an optoelectronic assembly including a cooling element comprising a Peltier cooler of a thickness of less than one nanometer which is embedded in silicon and which may be either coupled directly to the optical component or mounted on a substrate material coupled to the optical component.

[0005] Another example of the application of a Peltier effect cooler is disclosed by Böttner et al. in U.S. Patent No. 7,084,502 issued August 1, 2006 for "Microelectromechanical Device and Method for Producing It." The '502 patent discloses a thermoelectric cooling apparatus for cooling a microelectromechanical device which addresses the problems associated with lateral mechanical stresses generated between thin thermoelectric cooler layers as a result of differences between the coefficients of thermal expansion of the substrate materials.

[0006] Innovative applications of thin-film TEC's have extended into using Peltier effect-based systems to cool the human body. One such system is disclosed by Arnold in U.S. Patent Application Publication No. US 2008/0141681 published on June 19, 2008. This system may be worn by an individual either as a stand-alone independent device or, alternatively, integrated into an article of clothing, to monitor the temperature of the surface of the skin and to control its and the wearer's body temperature.

[0007] One problem associated with such cooling devices, particularly as the size and thickness of the device is minimized, arises out of the balance between providing sufficient structural support for the cooling unit and, simultaneously, maximizing its operating efficiency. Typically, such devices incorporate a mechanical support for the TEC constructed of a material having physical property characteristics designed to support and minimize strain within the TEC caused by thermal expansion and contraction. However, the thermal resistance of materials having the desirable structural requirements may be such that the TEC's efficiency is reduced significantly.

[0008] Another problem associated with prior art TEC assemblies is the so-called "greening" of the copper material typically employed in such devices. Copper and its alloys possess desirable thermal conductivity properties and, accordingly, are advantageously used in TEC applications. However, the unattractive greening or discoloration results from a chemical reaction between the copper and its surface oxides and other dissimilar materials which may be incorporated into the apparatus, thereby impairing the efficiency of the cooling device.

[0009] Accordingly, a need has arisen for a mechanical support system for TEC's which possesses not only the physical properties required to provide adequate structural support for thin-film TEC's, but also possesses a low thermal conductivity to enhance the TEC efficiency and which will minimize or eliminate completely surface discoloring reactions.

SUMMARY OF THE INVENTION

[0010] It is therefore an object of the present invention to provide an improved mechanical support system for a thin-film thermoelectric cooling device having properties of strength and rigidity sufficient to provide adequate structural support, and which also possesses thermal conductivity characteristics and chemical reactive properties which will enhance the operating efficiency of the device and minimize surface discoloration.

[0011] In one embodiment, the mechanical support system of the present invention addresses the aforementioned problems associated with the prior art by providing a mechanical support for a TEC having sufficient holes or cutout regions formed therein to increase the thermal resistance between the hot and the cold sides of the TEC.

[0012] In another embodiment, a mechanical support system is provided which includes a pyrogel insulation layer disposed in a recess formed in the mechanical support system between that mechanical support system and the composite heat spreader assembly.

[0013] In yet another embodiment, a mechanical support system is provided which includes a thermally insulating mechanical support disposed intermediate the TEC and the composite heat spreader assembly.

[0014] In the above embodiments, portions of the composite heat spreader assembly may be formed of copper or a copper alloy and may further include an exposed silicon pad or SIL Pad positioned on the cooling face of the device to prevent the greening or discoloration of copper materials employed in the construction of the device.

[0015] These and other objects and features of the present invention will be apparent from the accompanying drawings, description of the invention and supplemental supporting materials provided herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Fig. 1 is a cross-sectional side elevational view of a prior art thermoelectric cooling device and mechanical support system;

[0017] Fig. 2 is a cross-sectional side elevational view of a thermoelectric cooling device and mechanical support system of an embodiment of the present invention;

[0018] Fig. 3 is a cross-sectional side elevational view of a thermoelectric cooling device and mechanical support system in accordance with another embodiment of the present invention; and

[0019] Fig. 4 is a cross-sectional side elevational view of a thermoelectric cooling device and mechanical support system in accordance with yet another embodiment of the present invention.

DESCRIPTION OF THE INVENTION

[0020] It should be noted that the present description is by way of illustration only, and that the concepts and examples presented herein are not limited to use or application with any single thermoelectric cooling device. Hence, while the details of the TEC mechanical support system described herein are for the convenience of illustration and explanation with respect to the exemplary embodiments, the principles disclosed may be applied to other types of TEC mechanical support systems without departing from the scope of the present invention.

[0021] Referring now to Fig. 1, an exemplary thin-film thermoelectric cooling device is shown generally at 10. The device includes a heat sink 12, a heat pump 14 having a hot side 16 and a cold side 18, a mechanical support structure 20 and a heat spreader assembly 22 forming the cooling side of the device constructed as a composite unit of a copper spreader layer 24 and a protective layer 26 an exposed face 25. The heat pump shown is a UPF Model 40 designed and manufactured by Nextreme Thermal Solutions of Durham, North Carolina; however, it is to be appreciated that other types of heat pumps may be used without departing from the scope of the present invention.

[0022] The heat pump 14 comprises a TEC unit 28, by way of example, a CP20151 module (which is not a thin-film TEC) that is commercially available from CUI, Inc.; although, other commercially available TEC modules may be used. The spreader layer 24 is positioned on the cold side 18 of the device to spread the heat over a larger surface area. The spreader layer 20 is typically manufactured from copper or a copper alloy due to their high thermal conductivity properties; however, other materials having comparable thermal properties may be used in this application as well. As described above, spreader layer 24 is overlaid with a protective layer or pad 26 generally known to those skilled in the art as a SIL pad, the primary function of which is to protect the copper layer from so-called “greening”. Greening is an undesirable surface discoloration attributable to chemical reactions which occur at the surface of the copper layer as a result of contact with other materials, moisture and oxygen.

[0023] The mechanical support structure 16 provides a parasitic shunt thermal path between the hot and the cold sides of the TEC, thereby reducing its efficiency. Accordingly, it is desirable to increase the thermal resistance of the support structure which may be accomplished by decreasing the area of support, or by introducing a layer of material having a low thermal conductivity, as will be described in greater detail below.

[0024] Referring to Fig. 2, a thin-film thermoelectric cooling device employing a mechanical support system in accordance with an embodiment of the present invention is shown generally at 50. The device includes a heat sink 52 forming a hot side 54 of the TEC, a thin-film Peltier cooler or heat pump 56 and a mechanical support structure 58. In the instant embodiment, the improved mechanical support structure 58 having air-filled apertures 60 formed therein is disposed intermediate a heat spreader assembly 62 (of substantially the same construction as the heat spreader assembly of the embodiment of Fig. 1) and the hot side 54 of the heat sink 52 to reduce the surface area of the supporting material and to, in effect, reduce the thermal conductivity of the support structure. The reduction in thermal conductivity increases the overall efficiency of the TEC. Stationary members 64 are disposed between the heat pump 56 and a corresponding one of the mechanical support structures 58 to form the air-filled apertures 60.

[0025] A thin-film thermoelectric cooling device employing a mechanical support system in accordance with yet another embodiment of the instant invention is illustrated generally by the numeral 150 in Fig. 3. The device includes a heat sink 152, a thin-film Peltier cooler or heat pump 156 having a hot side 154 and a cold side 155, and a mechanical support structure 158, as hereinabove described with respect to the embodiment of Fig. 2. However, in the instant embodiment, the mechanical support structure 158 includes recessed areas 170 formed therein containing an insulating member 159 disposed intermediate a heat spreader assembly 162 and the support structure 158 on the cold side 155 of the TEC. The insulating member 159 includes insulating material such as a pyrogel or other suitable material having a low thermal conductivity. The recesses 170 reduce the surface area of the supporting material, and the insulating member 159 positioned in the recessed areas 170 cooperates therewith to effectively reduce the overall thermal conductivity of the support structure, thereby enhancing the efficiency of the TEC. The mechanical support structure 158 further includes an extension member 172 extending inwardly so that an end portion of the extension member is disposed adjacent the heat pump 156. The extension member 172 is coupled to the hot side 154 on one side and coupled to the insulating member 159 on another side.

[0026] Referring to Fig. 4, a thin-film thermoelectric cooling device employing a mechanical support system in accordance with yet another embodiment of the instant invention is illustrated generally by the numeral 250. The device includes a heat sink 252, a thin-film Peltier cooler or heat pump 256 having a hot side 254 and a cold side

255, and a mechanical support structure 258, as hereinabove described with respect to the embodiments of Figs. 2 and 3. In the embodiment of Fig. 4, the mechanical support structure 258 is of a simplified, generally rectangular configuration when compared to the mechanical support structure configurations of the embodiments described earlier herein or the prior art and includes enlarged apertures 260. The apertures 260 do not contain any insulating material (other than the ambient atmosphere) and serve to reduce the thermal conductivity or the support structure, thereby increasing the overall efficiency of the TEC.

[0027] Changes may be made in the above methods, devices and structures without departing from the scope hereof. It should thus be noted that the matter contained in the above description and/or shown in the accompanying drawings should be interpreted as illustrative and not in a limiting sense. The following claims are intended to cover all generic and specific features described herein, as well as all statements of the scope of the present method, device and structure, which, as a matter of language, might be said to fall there between.

CLAIMS

WHAT IS CLAIMED IS:

1. An improved mechanical support for a personal heat control device comprising:

a heat sink having a hot side;

a heat spreader assembly disposed adjacent the heat sink at the hot side;

a heat pump disposed at the hot side; and

a plurality of mechanical support structures configured and arranged to support the heat sink on the heat spreader assembly.

2. The improved mechanical support of claim 1, further comprising stationary members each disposed between one of the mechanical support structures and a side of the heat pump.

3. The improved mechanical support of claim 1, further comprising an insulating member disposed between one of the mechanical support structures and a side of the heat pump.

4. The improved mechanical support of claim 3, wherein the insulating member includes an insulating material.

5. The improved mechanical support of claim 4, wherein the insulating material includes pyrogel.

6. The improved mechanical support of claim 1, wherein the mechanical support structure includes an extension member extending therefrom.

7. The improved mechanical support of claim 6, wherein an end of the extension member is disposed adjacent the heat pump.

8. The improved mechanical support of claim 1, wherein the mechanical support includes a recessed area.

9. The improved mechanical support of claim 8, wherein a portion of the heat spreader assembly is disposed therein.

10. The improved mechanical support of claim 9, further comprising an insulating member disposed between one of the mechanical support structures and a side of the heat pump and wherein the insulating member is disposed in the recessed area.

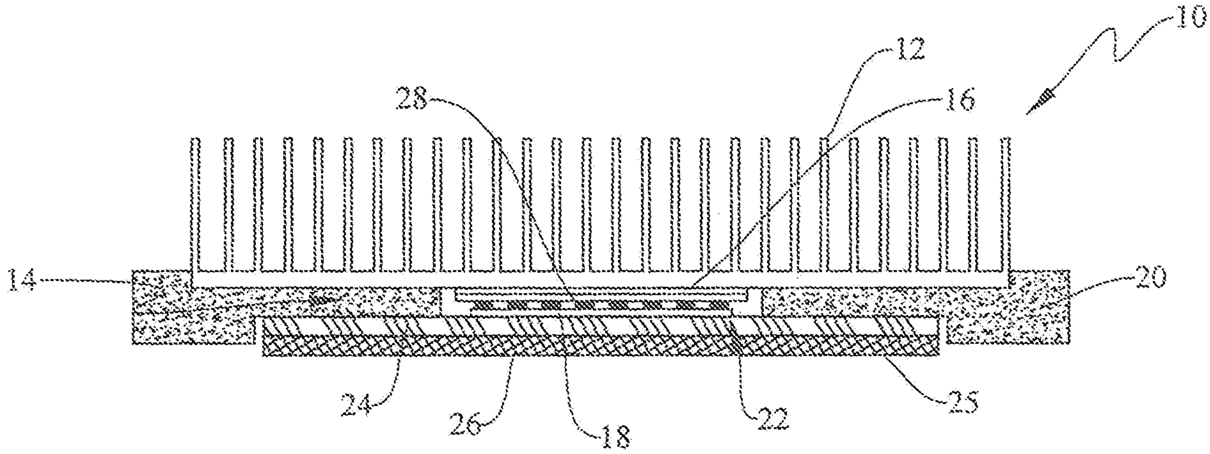

Fig.1

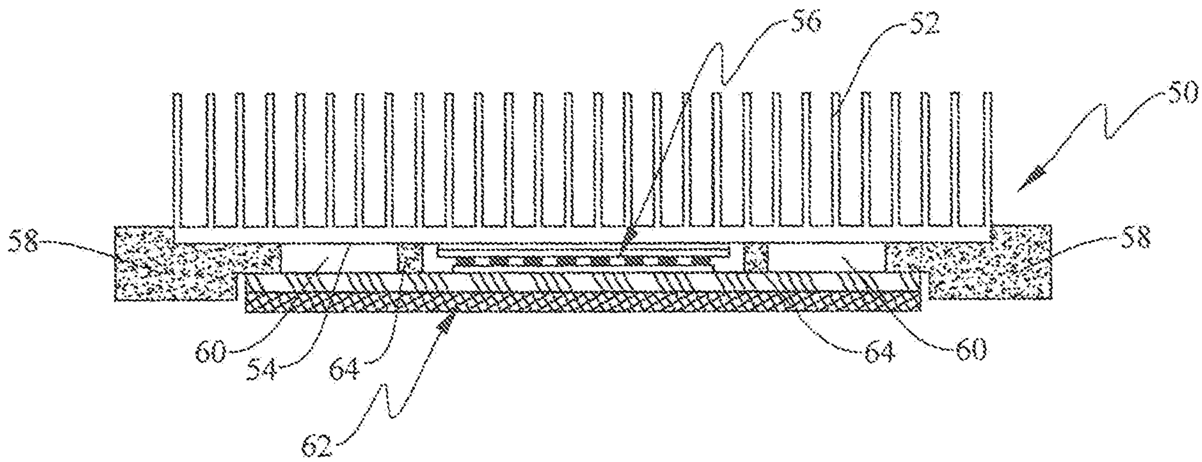

Fig.2

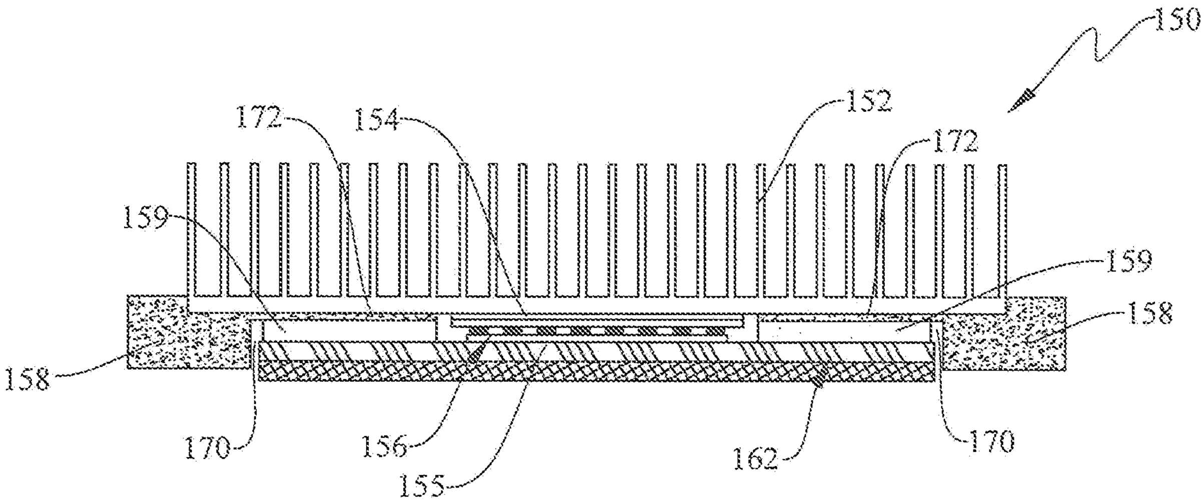
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Fig.3

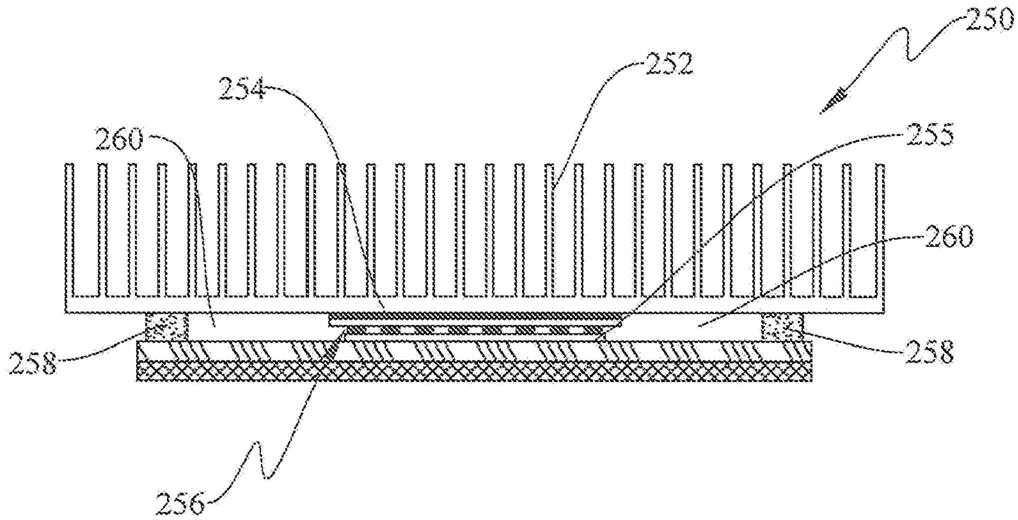
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Fig.4