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ABSTRACT

"An improved method for fabrication of improved single stage thermoelectric coolers"

This invention relates to an improved method for fabrication of improved single stage thermoelectric coolers comprising steps of:-Placement of thermoelements with metallization provided between metalized patterned substrates to obtain said thermoelectric coolers.

Further, this invention also relates to an improved method for fabrication of improved single stage thermoelectric coolers comprising steps of :- -placing patterned metalized bottom ceramic substrate without tinning in a slot of jig, -placing a plurality of thermoelements as per the pattern on the ceramic substrate thereunder, -processing the thermoelements, - placing the substrate with thermoelements on top of a patterned metalized ceramic substrate having the same pattern with the tinning in the slot of jig, -heating of the assembly thus obtained on a hot plate and treatment of said substrates.

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WE CLAIM:-

1. An improved method for fabrication of improved single stage thermoelectric coolers comprising steps of:-

   - Placement of thermoelements with metallization provided between metalized patterned substrates to obtain said thermoelectric coolers.

2. An improved method as claimed in claim 1, wherein the metallization is provided on both opposite cross section of said thermoelements and the substrates are made of preferably Alumina.

3. An improved method for fabrication of improved single stage thermoelectric coolers comprising steps of :-

   - placing patterned metalized bottom ceramic substrate without tinning in a slot of jig,
   - placing a plurality of thermoelements as per the pattern on the ceramic substrate thereunder,
   - processing the thermoelements,
   - placing the substrate with thermoelements on top of a patterned metalized ceramic substrate having the same pattern with the tinning in the slot of jig,
   - heating of the assembly thus obtained on a hot plate, and
   - treatment of said substrates.

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4. An improved method as claimed in claim 3, wherein the jig is preferably made of graphite with a plurality of graphite rods provided horizontally (x-axis) and vertically (y-axis) through a number of holes on the edges of said jig.

5. An improved method as claimed in any of the preceding claims, wherein the thermoelements with metallization are fixed onto the pattern on said ceramic substrate by means of water soluble and fast drying adhesive followed by removal of the substrate from the jig.

6. An improved method as claimed in claim 5, wherein the thermoelements are subjected to tinning by means of a solder followed by application of soldering flux.

7. An improved method as claimed in any of the preceding claims, wherein the patterned metalized ceramic substrate is subjected to radiation in the slot of the jig, and the thermoelements face downward to be in contact with the patterned ceramic substrate in the slot.

8. An improved method as claimed in any of the preceding claims, wherein heating of the assembly is followed by separation of the substrates from each other by placing in water.

9. An improved method as claimed in claim 8, wherein the exposed edges of said thermoelements are subjected to tinning using a lower melting solder followed by application of flux.

10. An improved method as claimed in claim 9, wherein the metalized ceramic substrate having the pattern for top plate is subjected to tinning with the lower melting solder followed by application of flux which is placed in slot of the jig.

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11. An improved method as claimed in any of the preceding claims, wherein the ceramic substrate having the soldered thermoelements is placed in such a manner that the tinned edges of the thermoelements are in contact with the tinning on the ceramic substrate.

12. An improved method as claimed in claim 11,wherein the assembly is placed on the temperature controlled hot plate to obtain the thermoelectric cooler.

Dated this 25th day of February, 2014

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FIELD OF INVENTION

This invention relates to an improved method for fabrication of improved single stage thermoelectric coolers.

BACKGROUND OF INVENTION

Thermoelectric coolers can convert electrical energy into temperature gradient. They are solid state devices which work on the principle of Peltier effect. A thermoelectric cooler consists of atleast two thermoelements of semiconductor material. The thermoelectric cooling effect is obtained when a direct current is passed through at least a pair of thermoelements. Depending on the direction of the current the heat is liberated to the atmosphere at one end of the device and it is absorbed from the atmosphere at the other end. These thermoelectric elements and their electric interconnects typically are mounted between two ceramic plates/substrates. These ceramic substrates define the cold side and the hot side of thermoelectric cooler.

Both n-type and p-type Bismuth-telluride thermoelectric materials are used in a thermoelectric cooler. N-type material is doped so that it can have an excess of electrons and p-type material is doped so that it can have deficiency of electrons. The extra electrons in a N-type material and the holes resulting from the deficiency of electrons in p material are carriers which move the heat energy through the thermoelectric material.

Most thermoelectric cooling modules are fabricated with an equal no. of n-type and p-type elements where one n and p element pair form a thermoelectric couple. A thermoelectric module can contain one or several couples. Thermoelectric couples are connected electrically in series and thermally in parallel for single stage thermoelectric coolers.

The cooling as well as heat actively pumped through the thermoelectric module is proportional to the magnitude of the applied DC electric current. For

continuous working of the thermoelectric cooler it is necessary to remove heat dissipated from the hot side using a heat sink. By varying the input current from zero to maximum, it is possible to adjust and control the heat flow and cooling.

Thermoelectric coolers are associated with the following advantageous features:-

reliable, noise free, maintenance free, vibration free since they do not contain any mechanical moving parts, environment friendly as they do not contain CFC. Small in size and light in weight. They allow very precise temperature control (0.1 C). They have a very long life of more than 100000 Hrs.

PRIOR ART

Several thermoelectric coolers are known to have been provided in the art, which are discussed hereinbelow:-

US 6514791 B2:- In this patent, thermoelectric coolers are fabricated using method which are very complex, time consuming and error prone. Two separate structures are required for p and n type of thermoelements. The thermoelements are lapped and polished after attaching with the adhesive which can result in cleaving of the fragile thermoelements. This results in failure of the process. Therefore, the whole process is to be repeated again.

US 4493939A:- In this patent, the thermoelectric coolers are fabricated using methods requiring sophisticated equipment like conveyer belt and vacuum chuck having precise orifices. The thermoelectric coolers are assembled while carrying the disc of thermoelectric material on the conveyer belt. Belts move at 90 degrees to each other. Discs are sectioned into the thermoelements on the conveyer belt. Error or cleaving of elements results in failure of the whole process. This results in loss of material as well as the time as the whole

process is to be abandoned. Moreover the vacuum chuck lifts only certain elements and rest are to be discarded resulting in loss of material.

US 5824947:- In this patent, the thermoelectric coolers are fabricated using methods where difficulty level is quite high and a person having average skill level cannot fabricate the coolers.

GB 941487:- The thermoelectric coolers are assembled using very impractical approach, wherein the final thermoelectric coolers do not resemble the commercially available devices. Each element is surrounded by some insulating material which is quite a difficult task as sometimes the thermoelectric coolers consist of hundreds of thermoelements. This is quite an impractical approach considering large number of thermoelements.

Hence, the present invention proposes an improved method for fabrication of improved single stage thermoelectric coolers which can address the aforesaid drawbacks.

OBJECTS OF THE INVENTION

Primary object of the present invention is to provide an improved method for fabrication of improved single stage thermoelectric coolers which is simple, cost effective and easy to implement.

Another object of the present invention is to provide an improved method for fabrication of improved single stage thermoelectric coolers which overcomes disadvantages associated with the prior art.

Further object of the present invention is to provide an improved method for fabrication of improved single stage thermoelectric coolers with large number of thermoelements with small dimension.

SUMMARY OF THE INVENTION

The present invention discloses an improved method of fabrication of improved single stage thermoelectric coolers having large number of small thermoelements, leading to efficient thermoelectric cooler devices with low contact resistance resulting in improved performance in terms of delta T.

The present invention uses simple assembly techniques, self fabricated jigs and fixtures. It comprises reusable, demountable self assembled jigs to fabricate thermoelectric coolers having thermoelements of small length and small cross sectional area as well as bigger thermoelements. The jigs and fixture facilitate the alignment and proper positioning of the thermoelements at the designated place.

The present invention can be used to fabricate thermoelectric coolers having less or large number of thermoelements with equal ease. Further, it removes the possibility of any error or failure as individual element is replaceable. Again, it minimizes or even avoids the possibility of loss of material.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

Further objects and advantages of this invention will be more apparent from the ensuing description when read in conjunction with the accompanying drawings and wherein:

Fig. 1 shows: top ceramic substrate and bottom ceramic substrate with patterned metallization.

Fig. 2 shows: P and N type thermoelements.

Fig. 3 shows: graphite jig with slot and holes on the side walls.

Fig. 4 shows: graphite rods.

Fig. 5 shows: dummy bottom ceramic substrate in slot of graphite jig and graphite rods through holes.

Fig. 6 shows: P and N type thermoelements on the ceramic substrate.

Fig. 7 shows: bottom ceramic substrate with thermoelements following removal from graphite jig.

Fig. 8 shows: bottom ceramic substrate with tinning placed in the graphite jig.

Fig. 9 shows: dummy ceramic substrate with the thermoelements placed over bottom ceramic substrate in the jig.

Fig. 10 shows: assembly after removal from jig.

Fig. 11 shows: bottom ceramic substrate with thermoelements soldered thereon.

Fig. 12 shows: top ceramic substrate with tinning placed in the graphite jig.

Fig. 13 shows: bottom ceramic substrate with soldered thermoelements placed over ceramic substrate in the jig.

Fig. 14 shows: the assembled single stage thermoelectric cooler.

Fig. 15 shows: the assembled single state thermoelectric cooler with electrical wire.

Fig. 16 shows: delta T vs I curve for TE cooler fabricated without graphite jig assembly.

Fig. 17 shows: delta T vs I curve for TE cooler fabricated with graphite jig assembly.

DETAILED DESCRIPTION OF THE INVENTION WITH REFERENCE TO THE ACCOMPANYING DRAWINGS

The present invention discloses an improved method for fabrication of single stage thermoelectric coolers. The coolers comprise a plurality of small cuboidal thermoelements with metallization on both opposite cross section provided between metalized patterned Alumina substrates forming the top and bottom plate of the thermoelectric coolers.

In second embodiment of the invention the patterned metalized bottom ceramic substrate without the tinning, is placed in a slot (cut according to the size of the ceramic substrates) in the graphite jig. The graphite rods of appropriate diameter are placed horizontally and vertically (in both x and y directions) through the holes on the edges of the graphite jig. These rods define the position for placing the thermoelements as per the pattern on the ceramic substrate thereunder. The thermoelements with metallization and without tinning are fixed using the water soluble and fast drying adhesive through the slots made by graphite rod on to the pattern on ceramic substrate. When the thermoelements are firmly fixed on to the pattern ceramic substrate, the rods are pulled out of the holes and the ceramic substrate is removed from the slot of the graphite jig. This ceramic substrate has small thermoelements fixed on it firmly and straight. These thermoelements are now tinned using a suitable solder and suitable soldering flux is applied.

Now another patterned metalized ceramic substrate having the same pattern and with the tinning is placed in the slot of graphite jig as earlier. The suitable flux is applied on the substrate. The ceramic substrate having the thermoelements fixed on it is placed on top of the ceramic substrate in the slot in such a way that the thermoelements face downward by touching the ceramic substrate in the slot. Now this assembly is placed on the temperature controlled hot plate which is already heated to the required

soldering temperature. The assembly is kept there for the required time period and thereafter the hot plate is turned off. At room temperature, the assembly is removed followed by placing in water for some time. The adhesive gets dissolved in the water and the two ceramic substrates get separated, one is bare now and the other is having the thermoelements soldered on to it firmly and properly aligned.

The ceramic substrate with the thermoelements soldered on to it is removed from the slot and the exposed edges of the theroelements are cleaned thoroughly with water. These are now tinned using a lower melting solder than the previous one and flux is applied on it.

Now other metalized ceramic substrate having the pattern for top plate is tinned with the lower melting solder and placed in slot of the graphite jig followed by application of flux. The ceramic substrate having the soldered thermoelements is placed in such a manner that the tinned edges of the thermoelements touch the tinning on the ceramic substrate in the slot. The assembly is again placed on the temperature controlled hot plate which is preheated to the soldering temperature for the lower melting solder. The assembly is kept therefore for the time required for the soldering and thereafter the hot plate is switched off. At room temperature the assembly is taken out from the graphite jig and thoroughly cleaned in water.

The single stage thermoelectric cooler is now ready. Now it is tested for the various parameters such as:

- AC resistance.
- Temperature difference (ΔT) obtained across it.

- for evaluation of performance of the coolers.

Thermoelectric coolers from sizes 2" x 2" to sizes 1.0cm x 1.0cm having thermoelements of various dimensions were fabricated using the said method. Improvement in terms of low AC resistance and high ΔT was observed.

Now, reference may be made to the accompanying figures, wherein fig. 3 shows the graphite jig with the slot of the size of the ceramic substrate so that the ceramic substrate can be placed in it for the assembly. Fig. 4 shows the graphite rods which can be used along with the graphite jig to place and align the thermoelements with the pattern on the ceramic substrate.

Firstly, one ceramic substrate, say bottom as shown in fig. 1 is placed in the slot of the graphite jig. Now graphite rods are incorporated through the holes in the side walls of the jig to form the pattern as shown in fig. 5. Both p and n type of thermoelements are fixed in the place in the jig alternately with the help of fast drying adhesive used on one side of the thermoelements, as shown in the fig. 6. After all the thermoelements are fixed in the jig, the assembly is left for ten minutes for the adhesive to get dry. After that all assembly is taken out from the graphite jig as shown in fig. 7. Now the top edges of the thermoelements are cleaned carefully and tinned with the appropriate solder. A suitable flux is applied on the tinned edges of the thermoelements.

Now the other bottom patterned and metalized ceramic substrate with tinning from the same solder as used to tin thermoelements is placed in the graphite jig as before and shown in fig. 8. A suitable flux is applied on the tinning of the ceramic substrates. Now the ceramic substrate having the thermoelements

fixed by the adhesive is placed on top of this ceramic substrate upside down so that it touches the tinning on the bottom ceramic substrate. This is shown in fig. 9. Now this assembly is placed on a hot plate which is preheated to temperature of 30-40 deg. higher than the soldering temperature of the solder being used for tinning. The assembly is kept there for the required time. Then the hot plate is switched off. At room temperature the assembly is taken off the hot plate and rinsed thoroughly in water. This action dissolves the fixing adhesive and the thermoelements are detached from one of the ceramic substrates. This is partially shown in fig. 10. But the thermoelements remain soldered on to the other ceramic substrate as shown in fig. 11.

Now the other i.e. patterned metalized top ceramic substrate is tinned using a solder of lower soldering temperature than the previous solder. This ceramic substrate is now placed in the graphite jig and flux is applied as shown in fig. 12. The thermoelements soldered on the bottom ceramic substrate are also tinned using the same lower melting solder and flux is also applied. Then, this substrate is placed upside down on the top ceramic substrate in the jig so that the thermoelements touch the tinning of the lower substrate. This is shown in fig. 13. This whole assembly is again placed on the temperature controlled hot plate. The hot plate is preheated to the appropriate soldering temperature. The assembly is kept there for the required time and then the hot plate is turned off. At room temperature the assembly is taken off the hot plate and rinsed thoroughly in water. The single stage thermoelectric cooler is now ready. The electrical wire for the current connection is soldered as shown in the fig. 14 so as to obtain assembled single stage thermoelectric cooler with electrical wire as shown in fig. 15. Further, reference may be made to fig. 16 and 17 indicating Delta T vs I curve for TE cooler fabricated without and with graphite jig assembly respectively.

Advantageous Features

- Cost effective assembly used for fabrication of single stage thermoelectric coolers.
- Avoids wastage of thermoelectric material during the fabrication.
- Each individual thermoelement is replaceable, thereby avoiding abandonment of the whole process in case of any error.
- Easy to perform assembly, which requires no expert to carry out the assembly.
- Improved performance in terms of ΔT and AC resistance.
- Facilitates alignment, simultaneous soldering and uniform soldering of a plurality of small thermoelements.

Applications

Current thermoelectric coolers are suitable for many applications where low efficiency is not a drawback. They are used in various applications where space limitations and reliability are important factor.

Applications are thermoelectric devices cover a wide spectrum of product areas including military, medical, industrial, consumer, scientific/laboratory, and telecommunications. Uses range from simple food and beverage coolers for an afternoon picnic to extremely sophisticated temperature control systems in missiles and space vehicles. More often, however, the use of a TE device is the only practical solution to a thermal management problem. Unlike a simple heat sink, a thermoelectric cooler permits lowering the temperature of an object below ambient as well as stabilizing the temperature of objects which are subjected to widely varying ambient conditions. A theremoelectric cooler is an active cooling device whereas a heat sink provides only passive cooling.

Thermoelectric coolers generally may be considered for applications that require heat removal ranging from milliwatts up to several hundred watts. Most single-stage TE coolers, including both high and low current devices, are capable of pumping a maximum of 3 to 6 watts per square centimeter (20 to 40 watts per square inch) of module surface area. Multiple modules mounted thermally in parallel may be used to increase total heat pump performance. Large thermoelectric systems in the kilowatt range have been built for specialized applications such as cooling submarines and railroad cars, but systems of this magnitude are not common.

It is to be noted that the present invention is susceptible to modifications, adaptations and changes by those skilled in the art. Such variant embodiments employing the concepts and features of this invention are intended to be within the scope of the present invention, which is further set forth under the following claims:-