Application Note

NEE International

Thermal Management for Microwave PCBs

High power printed circuit board designs typically contain devices that generate excessive amounts of heat, which requires designers to pay special attention to thermal management from the outset of the design process. There are several ways that heat can be dissipated from the heat source on a PCB. Thicker copper planes on internal layers can help to "wick" heat away from mounted devices. Other techniques include the "heat pipe" approach, where an array of plated and/or filled vias underneath the device conducts heat to other internal and external layers. High power designs can also benefit from the attachment of a metal heat sink to dissipate the device's performance degrading heat energy. Metal printed circuit board heat sinks are normally made from Cu, Al or Brass, depending on system requirements for weight or operating temperature.

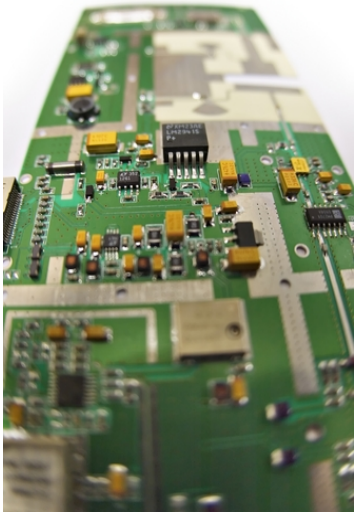
Historically, heat sinks have been provided as an integral part of the high performance laminate to be used in the manufacture of the PCB. This "preclad" material requires very specialized fabrication capabilities to perform complex machining of the PTFE/metal composite, relegating these designs to very high reliability/military applications where cost was not a primary or even secondary concern.

Today's high-volume, high-power commercial wireless PCB designs require a more economical method of heat sink attachment in order to be considered a viable design approach. Several methods offer volume capable, low-cost post bonded heat sink attachment processes can be employed.

A majority of the board configurations containing heat sinks utilize a metal heat sink attached to one side of a board that allows the device to be mounted through a cutout in the PCB. The heat sink can be the same size as the board itself or much smaller, localized to the site of the device itself. This smaller heat sink approach is sometimes called the "coin" approach.

NEE has developed the volume production capability to attach post-bonded heat sinks with two attachment methods, with either full board size or smaller coin type heat sinks.

Heat Sink Attachment Methods



As an alternative to costly preclad heat sink designs, NEE can offer several variations of post-bonded heat sink attachment. In general, post-bonded designs utilize a process where the printed circuit board is economically fabricated separately from the heat sink, then attached to the heat sink using either a conductive adhesive or high temperature solder.

Post bonded heat sink boards utilizing either method are able to withstand subsequent surface mount solder operations and still provide outstanding microwave electrical performance and long-term reliability. The relative economies of processing separately the heat sink and PCB, prior to heat sink attachment, are easily realized in the lower total cost of the assembly compared to preclad designs. This approach is attractive for high volume applications due to the inherent high volume capability of most printed circuit and metal machining operations, when compared to the more specialized and typically lower volume abilities of preclad PCB fabrication specialists.

NEE is capable of attaching post bonded heat sinks with a variety of conductive adhesives, non conductive adhesives, laminate prepregs or high temperature solder attachment. In any case, we can supply metal heat sinks that are custom machined and plated to suit your specifications.

Heat Sink Metal Types

For applications where high thermal conductivity is most important, NEE recommends Copper heat sinks, due to superior thermal conductivity. Where weight is most critical, Aluminum is preferred. For high-frequency, low-loss applications, Copper or Aluminum offer lower resistivity than Brass.

Heat Sink Alloy Type	Al (6061)	Cu(C110)	Brass
Specific Gravity	2.7	8.9	8.5
Specific Heat(J/Kg°K)	960	385	375
Thermal Conductivity(W/m°K)	180	390	120
Thermal Expansion (ppm/°K)	24	17	20
Resistivity (microohm-cm)	5	2	6
Relative Cost	1	1.5	1.4

Conductive Adhesive Attach

Many thermally and electrically conductive adhesive choices exist that can potentially be used for heat sink attach. These adhesives are sold as films or a screenable "ink" and are normally comprised of epoxy adhesives filled with silver conductive particles for electrical and thermal conduction.

It is important to have a good balance of strength, adhesion, flexibility and conductivity when choosing the right adhesive for your application. The conductive adhesive approach can be used on all heat sink metal types and is recommended for heat sinks thinner than 5mm. Costs for the conductive adhesive attach process are somewhat higher than for other methods due to material costs, although it does provide more flexibility for fragile or thin substrates. We have listed two common adhesives we use in the table below. While not an exhaustive list of what is available to the market, it is representative of what we have found to be a good fit for the microwave applications we support. We are also willing to consider other adhesive options beyond those identified.

Product	CF3350	Coolspan 500
Type	Silver/Epoxy	Silver/Epoxy
Thickness	.002" or .004"	.002" or .004"
Thermal Conductivity	7.0 W/m-K	6.4 W/m-K
Resistivity (Ohm-cm)	< .0005	.0002
Configuration	Film	Screened Ink

Sweat Solder Attach

An alternative to adhesive attach is solder attach of heat sinks. Although marginally a less costly approach than the adhesive attach method, the sweat solder process has a narrower SMT temperature window and is not recommended for designs with thin heat sinks (< 5mm).

NEE uses high temperature solder to attach heat sinks so that lower temperature solder can be used for SMT components on the board. Where RoHS/WEEE requirements apply, the higher temperature solders required used for SMT operations can limit the temperature separation between heat sink attach temperature and SMT attach temperature. The table at right illustrates typical solder temperatures for heat sink and SMT assembly processes. NEE recommends using a Sn95/Sb5 solder alloy for heat sink attach, for either coin or full sized heat sinks. Care must be taken to prevent delamination of the heat sink during SMT attach when the temperature window is small, although we have many customers who routinely use this assembly approach with little difficulty. NEE also recommends that heat sink thickness should be 3x the dielectric thickness for better PCB flatness after attach.

Lead Free Solder Types		
Alloy	Melt Point	Thermal Conductivity
Sn95/Sb5	240C	28 W/m-°K
Sn/Cu	227C	
Sn/Ag/Cu	217C	

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