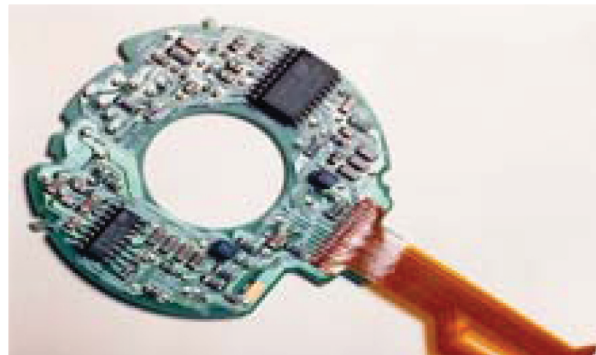
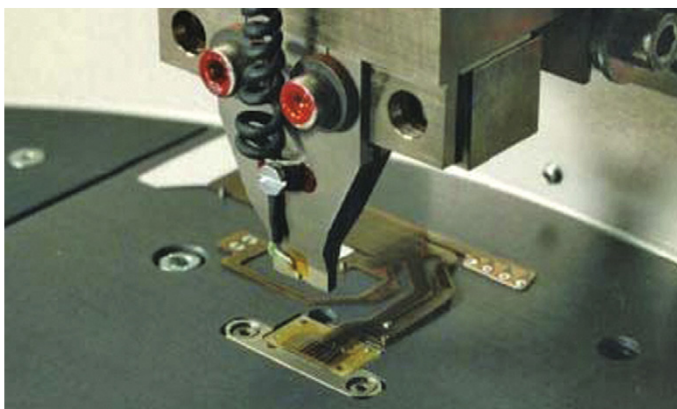


Pulsed-Heat Hot-Bar

A high-quality Selective Soldering Technique

PROCESS INTRODUCTION

Pulsed-Heated Hot-Bar Reflow Soldering is a selective soldering process where two pre-fluxed, solder coated parts are heated to a temperature sufficient to cause the solder to melt, flow, and solidify, forming a permanent electro-mechanical bond between the parts and solder. Pulse heated soldering differs from the traditional soldering process in that the reflow of solder is accomplished using a heating element called a "thermode" or "hot bar" which is heated and cooled down for each connection. Pressure is applied during the entire cycle including heating, reflow, and cooling. This technique is most commonly used to connect flex circuits to printed circuit boards.



ALTERNATIVE NAMES

The process described is known under a wide range of names, to name a few:

Pulsed-Heat HOT-BAR Reflow soldering
Pulsed-Heat THERMODE Reflow soldering
Pulsed-Heat HOT-STAMP Reflow soldering
Abbreviated: HBR SOLDERING

APPLICATION RANGE

HBR soldering reflows solder by using a thermode that is heated and cooled for each connection. This 'selective' heating makes the process suitable for heat sensitive parts like CCD camera chips, connectors, etc. Furthermore, since pressure is applied during the entire cycle, the process is suitable for parts that might otherwise 'jump' loose during cooling using other soldering techniques.

With HBR Soldering, all connections can be

made simultaneously. Up to 200 leads or wires can be connected in one process cycle (typically around 15 seconds)! Making the connections simultaneously also prevents one wire jumping loose while soldering the neighboring one. Typical applications includes multiple small coax cables.

The power output of a good quality hot-bar is very high. A hot-bar as small as 10mm can generate up to 4000 Watts compared to 50 Watts for a conventional solder iron

and 30 Watts for diode laser soldering. This enables short process times and good results on parts with high-energy requirements, like Metal Composite PCB and ceramics.

HBR Soldering is a process that is reproducible, quantifiable, and traceable to quality standards like ISO / NIST. It is safe for the operator, highly operator independent and easy to automate.

SUMMARY

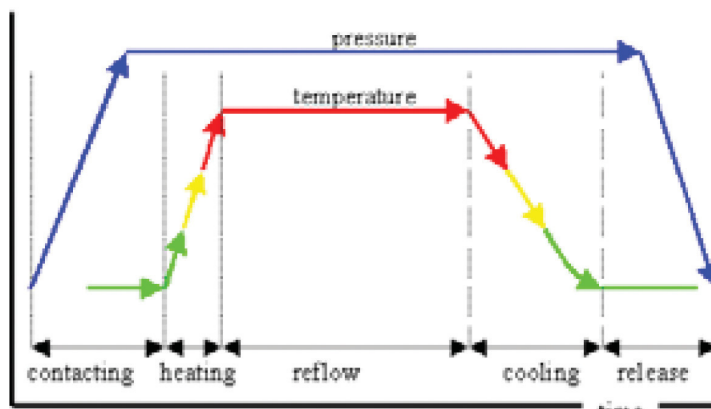
This article describes HBR Soldering process, the appropriate joint designs, materials, process setup, working procedures and equipment. For more detailed info please visit our website: www.miyachiamerica.com

PROCESS DESCRIPTION

In preparation for the HBR soldering process, the following steps need to be taken:

1. The base substrate is located in a fixture, and flux is applied to the pads.
2. The flex is positioned in the parts fixture, ensuring alignment of both sets of pads.
3. A process start signal is given to the soldering control unit.

More info about the parts, fixtures and fluxing can be found further in this article. The HBR Soldering process itself consists of the following process steps: heating up, reflow and cooling down. These process steps are described below.



PROCESS DESCRIPTION: CONTACTING

The “Hot-Bar” or “thermode” is mounted to a bonding head by means of a quick connect block. The bonding head has an accurate and stable linear guidance for the hot-bar. Movement is done with a pneumatic cylinder or an electrical motor. An internal spring system generates an accurate force. Most reflow joints of this nature require fewer than 23 lbs. pressure. Force should be calibrated and set to the correct level to achieve the right transfer of thermal energy to the solder joint. The bonding head should have an accurate coplanarity adjustment to set the flatness of the thermode to the product accurately. These heads are modular in construction and therefore versatile for integration.

After the start signal is given, the thermode is gently lowered until it seats on the product. The head senses this. Force is built up until the preset force is reached.

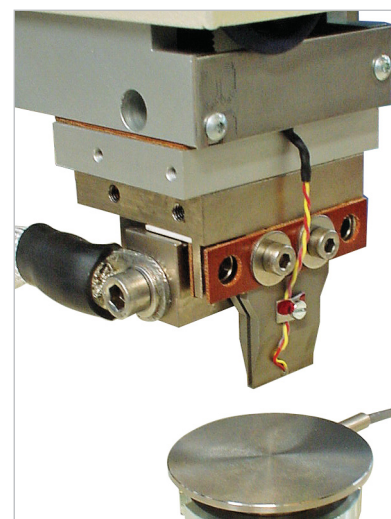


PROCESS DESCRIPTION: HEATING UP

The hot-bar, which is at room temperature, holds down the product with the preset force. The solder control unit, also called a “power supply” (Uniflow4) receives the start signal for the soldering process.

The Uniflow4 sends current through the hot-bar. The hot-bar is designed so that the electrical resistance is highest at the bottom (where it touches the product). Heat is generated because of the combination of current and electrical resistance. A small thermocouple is welded on the front of the thermode which feeds back the actual hot-bar temperature to the power supply. This makes a complete closed-loop regulation for the temperature-time cycle.

Normal rise time for most hot-bars is 1.5 to 2 seconds, equalling a heating rate of about 200°C a second. The newest generation of solder control units controls the temperature all the way through the heating up phase. When the “REFLOW temperature” is nearly reached the solder control unit needs to slow down the heating rate to prevent a temperature overshoot. A good solder control unit and hot-bar combination will compensate for all differences in heat-loads that can occur during normal production circumstances.



PROCESS DESCRIPTION: REFLOW

During the reflow period the flux is activated, which cleans the surfaces, and the solder is heated until it starts melting on all pads. This normally takes 3-8 seconds at hot-bar temperatures around 300°C (hot-bar touches the leads), 400°C (hot-bar touches kapton) or 500°C (ceramics and MC-PCB soldering). Although normal solder will melt at 180°C, ideal solder temperature is above 220°C to get a good flow and wetting behaviour but below 280°C to prevent

burning of the solder. The hot-bar must be set higher due to the thermal transfer losses. Ideally, time can be programmed on the Uniflow4 in 0.1-sec. increments and temperature in one-degree increments. Use the minimum time and temperature to achieve the desired joint to minimize the parts exposure to heat and chance of damage.

PROCESS DESCRIPTION: COOLING

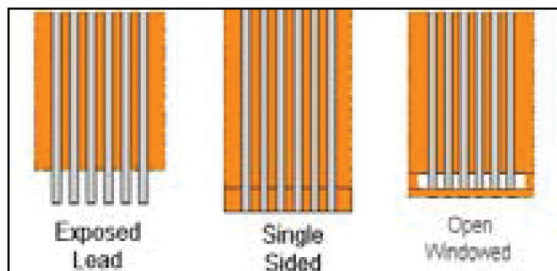
When the solder is connected on all pads, the energy delivery to the hot-bar can be stopped and the hot-bar will start cooling down. The cooling process can be shortened by the use of forced air-cooling. The Uniflow4 can switch a relay that controls the flow of air at the end of the reflow period and cool the joint and hot-bar rapidly. For optimum process control, cooling is done to a specific temperature. This temperature is set below the solder solidification tem-

perature. Therefore, as soon as the solder becomes solid, the process is complete and a joint is formed. Because most connections have a relatively high heat sink, the temperature in the solder is lower than the measured hot-bar temperature, even when using forced air-cooling. Therefore, the release temperature can be set to 180°C in most cases without the chance of releasing the parts before solidification has taken place.

CONNECTION DESIGN: CONNECTION TYPE

Three common types of termination designs used on flex circuits for the HBR reflow soldering process are:

- **Exposed lead design** — This design has both sides of the polyimide (kapton) material removed, leaving the traces free of insulation. The hot-bar contacts the traces directly and conducts heat to the parts. If the PCB pads and hot-bar footprint are sized correctly, this design will be most tolerant to excess solder on the pads, as solder may flow into open areas. During the process, solder will also wet to the top of the trace. Caution must be exercised in part handling as the traces may be easily bent or damaged. Because of the direct hot-bar to lead contact, this design will have low hot-bar temperatures and short process times. The hot-bar will pollute with flux residues, and will require cleaning. A kapton feeder module (see the section on equipment) will solve these objections.
- **Single-sided flex design** — This design has the polyimide removed on one side only. Heat is conducted from the hot-bar through the solid polyimide surface to the exposed traces underneath. The polyimide conducts heat through the insulation to the exposed traces and pads on the PCB. The polyimide thickness in the joint area is limited to about 50 microns, enabling conduction. If the polyimide has to be heated past 400 - 425°C, burning of polyimide and hot-bar contamination can result. This design is less tolerant of excess solder on the PCB pads because little room exists



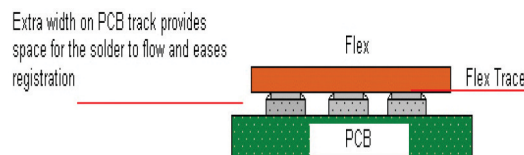
for excess to flow. The single-sided flex is most suitable for small pitches. Pitches as small as 200 micron, arranged in one or two rows, are possible.

- **Open-windowed flex design** — This design has both sides of the polyimide material removed from the joint area but has support from the remaining polyimide material on the sides and also along the end of the traces. This design gives some strength to the assembly and is resilient to harsher handling. As the traces are exposed, the thermal transfer to the parts is good and excess solder has extra space to flow. Thermode sizing is critical as it must fit into the window and allow space for the molten solder to flow. This design behaves similar to the exposed lead design.

CONNECTION DESIGN: FLEX AND PCB TRACE SIZES

Ideally, the flexible circuit pads should be narrower in width than that of the pads on the PCB. As the solder melts and the parts compress, solder is forced to the side. This design will allow space for the solder to flow on either side of the flex pad and will be more tolerant of solder quantity on the PCB, avoiding solder bridging problems.

A smaller pad width on the flex will help with registration and alignment of the two parts. For most applications, the width of the PCB trace should be

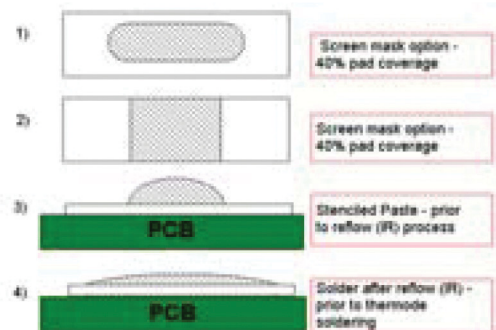


designed to be 55% of the pitch. This design reduces the risk of short circuits due to misalignment. Flex trace would be ideally around 45%.

CONNECTION DESIGN: SOLDER AMOUNT

The repeatability of solder deposit is critical to achieve good process control. In many cases experimentation may be required to achieve the ideal solder volume. The normal screenprinting process for components will deposition the solder. A good starting point is using a 125 microns thick screen print stencil, masked to give 40% pad coverage.

The amount of solder required on the pad of the PCB is dependent on several factors. The pad size and pitch determine the maximum and minimum solder quantity that can be applied, using the screen stencilling process. Stencilled solder should be fused prior to the reflow process. Small pad and pitch dimensions require less solder, preventing bridged joints. Average solder height after reflow should be between 10 microns for the smallest pitch connections to about 50 microns for the largest pitches.



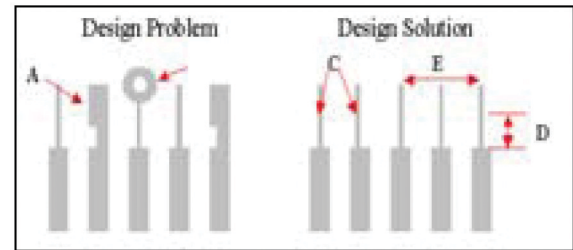
The flex design will also influence the volume of solder. Windowed flex and the exposed trace flex will stand a slightly greater solder volume in comparison to the single-sided flex.

CONNECTION DESIGN: HEAT SINKING

HBR soldering is a selective soldering process, meaning that only a part of the PCB will be heated, not the complete PCB (as would be the case in a reflow oven). This means that heat conduction from the connection area to the large and relative cold PCB is very, very important!

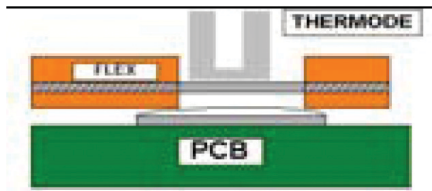
Heat sinking differentials from one lead to the other are the most common design problem to overcome. Small differences will have a minimal effect, but any large thermal mass or heat conduction change along the joint area will cause inconsistency of lead (solder) temperature and solder joint quality. The heat from the hot-bar will flow 3-5 mm in all directions on the surface of the PCB and through the PCB. Differences within these 3-5 mm are important, further away is unimportant.

Heat may be easily transferred away from the joint area to the large land-mass, if it is positioned too near the joint area (see "A"). Increased trace width and plated through-holes draw excessive heat from the joint area (see "B"). The reduced width trace acts as a thermal dam and prevents any heat sinking of the pad (see "C"). Equally sized small traces act as a thermal dam and ensure equal heating across the joint area (see "E"). Traces leading from



pads should be of equal width and as narrow as possible. This design will act as a thermal dam and prevent excessive heat drain from the pad area during soldering. For multilayer boards, restrict the traces under the bonding area to the smallest width (signal) traces and spread equally under the pads on the PCB. Any shielding on the PCB should have an equal effect along the joint area.

CONNECTION DESIGN: HOT-BAR SIZING AND POSITIONING



Hot-Bar Length

Hot-bars should be sized according to the pad and flex sizes. The hot-bar length must completely cover the traces and overlap by a minimum of one-pad pitch on each side.

In real dimensions this means that the thermode is normally chosen a minimum of 2mm longer than the connection. If wear from cleaning or heat conduction is a problem, the thermode can be up to 5mm longer than the connection. A longer connection to the substrate.

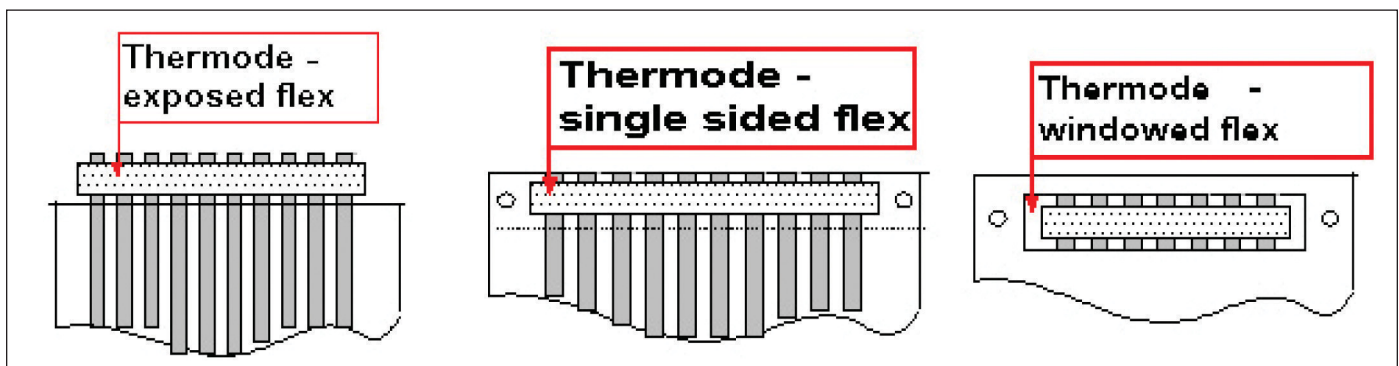
A wider Hot-Bar width will contact the trace over a larger surface and have an easier time getting the heat in the parts in the minimum time. Resistance against wear from cleaning will be largest. A smaller hot-

bar will leave more of the trace length open for the excess of solder to flow to, so solder balling/ bridging is less likely. For the best thermal performance and lifetime of the hot-bar, the minimum size should be 1.2 mm.

The standard size is 2.0 mm. Wider hot-bars are only common for connections where heat-input is a real problem, or where the connections are positioned in two rows.

HOT-BAR POSITIONING

When positioning a hot-bar on an exposed or windowed flex, the hot-bar should not be positioned too closely to the edge of the main body of the flex. Some flex circuits have thinner and thicker coatings on either side of the traces running through them. If so, position the thinner side next to the PCB, which will reduce the chance of the hot-bar damaging the trace as the hot-bar pushes the trace down.



MATERIALS: PRINTED CIRCUIT BOARDS (AND OTHER SUBSTRATE)S

The most commonly used printed circuit board material is from the FR4 category. Alternatively FR2 can also be used. The PCB will have copper traces, normally around 20 microns thick. These traces can be plated with gold (with nickel as diffusion barrier), tin, tin rich solder (Pb90Sn10), eutectic solder (Pb63Sn37 or Pb62Sn36Ag2) or OPC (Organic Passivated Copper). Wetting and flow behaviour of the solder can be a problem with OPC. With the gold plating, the flow behaviour of the solder can be a problem too, as the solder will dissolve the gold, and gold-rich solder phases can develop. Gold-rich solder phases can cause embrittlement of the solder connection.

With larger pitches, additional solder is normally positioned on the PCB. See info on this topic under the chapter on solder amount.

MC-PCB (Metal Composite PCB) can be treated as normal PCB. Ceramics will have traces made with thick film technology.

APPLICATION RANGE

This process can be used for a wider range of application then can be described here, for example:

OUTER LEAD BONDING
HEAT SENSITIVE COMPONENTS
FINE WIRE SOLDERING

Please contact the application experts of Amada Miyachi America for more info.

MATERIALS: SOLDER AND FLUX

Flux has two important features: conducting heat to the solder and promoting wetting of the surfaces by cleaning and removal of surface oxides.

The pulse-heated soldering process requires only a minimum of flux. No-clean fluxes are commonly used, sometimes RMA (Rosin Mild Activated). The use of a flux with low solids content is recommended. The lower the solids content, the less pollution of the hot-bar. Any solvents present should be allowed to dry prior to commencing the soldering process.

Flux can be manually applied with a pencil, or automated with a flux spray nozzle. Flux amount is critical for a good solder result. Too much will give solder balling and bridging, too little will give a poor wetting result.

MATERIAL SUPPLIERS

Amada Miyachi America is a system builder that supplies turn-key solutions and emphasizes the value of application knowledge. We have very good working relationships with, but independent from PCB / Flexfoil / solder or flux suppliers.

If you need info about material suppliers, feel free to contact us.

SMALL TROUBLESHOOTING GUIDE

Amada Miyachi America has a team of process specialists that can help you design parts for HBR Soldering, evaluate applications, provide soldering parameters and help keep a perfect solder joint quality. Feel free to ask the experts!

<u>PROBLEM</u>	<u>> INCORRECT PARAMETER</u>	<u>INCORRECT PARAMETER</u>	<u>> CAUSE</u>
Open solder joints	> not enough heat input on the lead	not enough heat input on the lead	> process temperature too low
	> too much heat drawn away		> process time too low
	> not enough pressure on the lead		> hot-bar size too small
	> not enough solder on the lead		
	> not enough flux on the lead	too much temperature	> process temperature too high
Solder bridging	> too much pressure on the leads	too much heat drawn away	> wrong product design
	> too much flux		> wrong jig design
	> poor solder flow behaviour		
Solder balling	> too much flux	not enough pressure on the lead /	> hot-bar not flat
	> heating up too fast	too much pressure on the lead	> hot-bar not planparallel
	> too much pressure on the lead		> not enough / too much force
			> wrong hot-bar position
			> jig not flat
Burning	> not enough pressure		> product not flat
	> too much temperature		> wrong product design
		poor solder flow behaviour	> wrong PCB / flex coating
			> wrong / insufficient flux



EQUIPMENT: COMPLETE HBR SOLDERING INSTALLATION

A complete HBR soldering installation consists of the following components:

- Uniflow4 power supply
- Bonding head
- Hot-Bar (thermode)
- Starting switch

Products are positioned in a product holder / jig tooling nest. Alignment can be done over reference pins, manually or with a camera / monitor system. The product holder can be stationary, or have movement (manual or automatic slides / turntables). Amada Miyachi America can build up to complete automatic inline production lines.



EQUIPMENT: SOLDER CONTROL UNIT (UNIFLOW4)

Uniflow4 features:

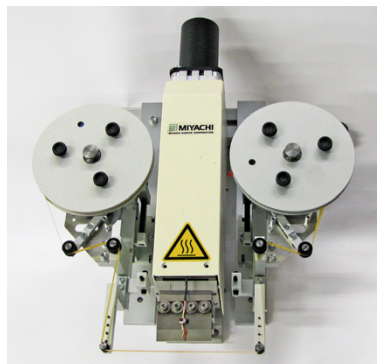
- Excellent temperature regulation over a wide range of applications
- Real-time temperature graphical temperature displaying
- Programmable rise-time
- Safety limits and continues process monitoring
- User programmable process limits
- Easy interfacing to various automations (I/O, RS232, RS485, PC)

For more info on this topic see the datasheet on the "Uniflow4".

EQUIPMENT: BONDING HEAD

- Force firing switch
- Head-is-up limit switch for safety in automation
- Adjustable force generation module
- Accurate bearings for perfect hot-bar guidance
- Fine-adjustment for hot-bar plan parallelism

See datasheet for more info.



EQUIPMENT: HOT-BAR / THERMODE

Modern wire erosion techniques such as EDM and advanced materials have allowed the manufacture of precisely designed thermodes to suit most applications. Three-dimensional thermodes pass the current around the face and thus have zero voltage potential across the traces.

These technological advances in machining processes produce designs with constant temperature across the length, and special alloys achieve flatness and coplanarity under heating. Solder will not wet to the materials used and they are resilient to oxidation.

For more info on Hot-bars see our special "Hot-Bar" datasheet.

EQUIPMENT: KAPTON INTERPOSERS

With the exposed lead and the open-windowed flexes it is possible for the flux to make direct contact with the hot-bar. To prevent flux attaching to the hot-bar and causing a heat barrier, and reduce flatness of the hot-bar, a foil of kapton between the hot-bar and the product can be used. A kapton interposer module will hold a reel of kapton and pull a clean piece of kapton below the hot-bar for each connection.



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