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SMT Package Rework

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Surface Mount Technology (SMT) packages include the leaded family packages (Quad Flat Pack (QFP) and Plastic Leaded Chip Carrier (PLCC)) and the Ball Grid Array (BGA) packages. SMT rework can be necessary for any of the following reasons: assembly related defects, such as shorts, opens, wrong orientation, and solder ball defects; device/package related defects/failure analysis; and engineering change or system upgrade.

This white paper contains guidelines for the rework process, but does not guarantee the success of every rework process. Note that a maximum of *three* reflow cycles (including initial assembly, rework, and reballing) are allowed.

For information on reworking flip-chip packages, refer to Xilinx application note **XAPP426**.

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Leaded Package (QFP and PLCC) Removal and Replacement

Reworking the leaded packages can be quite straightforward. Because of the absence of plated through-holes, the components are easier to remove and the possibility of thermal damage is decreased. Methods available for component removal and replacement include conduction (using soldering iron and tip) and convection (hot air). If the component to be removed is needed for failure analysis, ensure its electrical testability by making sure the leads are not distorted, bent, or cut off. Make certain that the solder is completely molten before removal. The direction of removal must be normal to the plane of the board. After the component is removed, avoid moving or tilting until the solder completely resolidifies.

The process steps involved are:

1. Prebaking – Like BGA packages, preheating the board assembly 150°C to 200°C for 15-20 minutes before rework prevents thermal damage and avoids the "popcorning" phenomenon. If the board has been exposed to "out of dry-pack" environment for more time than allowed (that is, 24 to 96 or more hours, depending on the moisture sensitivity level of the package and the surrounding conditions), the entire board must be baked at 125°C for at least 12 hours.

2. Part Removal – Manual reworking entails clipping all the leads of the defective package and subsequently removing them. The leads that are still attached to the lands are then melted using a solder wick.

   a. Solder Removal – Use a soldering iron and tip that is matched to the component size, shape, and temperature range. The solder joint is physically touched and heated. The success of the process depends on the skill of the technician. It is best to use the minimum temperature possible when doing rework. The tip temperature should allow reflow in a reasonable time while posing minimum damage to the board.

   b. Hot Air Removal – This is the preferred process especially when the component is to be reused. Hot air is directed onto the leads of the component to be removed until the solder melts and the package is lifted off the board with a vacuum wand or tweezers. The lands on the board are cleaned with a solder wick. Because of the possibility of heating the adjacent components when using hot air convection, care must be observed. The temperature might also be raised in adjacent areas causing deformation of the board. To reduce the possibility of board warpage, it is recommended that the board be heated from underneath to a temperature of 80°C to 120°C.

3. Site Preparation – After the reworked component has been removed, some excess solder might remain on the board. The excess solder can be removed using a soldering iron with a solder wick. Special care must be taken to avoid damaging the solder mask material and the solder pads. As a final step, alcohol can be used with a brush to clean the rework area.

   Allow the board to dry and inspect it to ensure a clean solderable surface. The specific steps for this can be different from board to board and from company to company. As a minimum, the removal of the excess solder is an essential requirement.

4. Package Placement and Reflow – Component placement is relatively simple except for fine lead pitches. Most rework equipment comes with a vision system. Solder paste is reapplied to the cleaned solder lands. The new package is placed by manually aligning the package on the lands with the aid of a microscope. Hot air is then applied to the solder leads to reflow the solder pads. Great care must be exercised in handling, not to distort or bend the leads, because any distortion affects the coplanarity of the overall component lead plane to the contact pads on the board. This distortion can affect the ease of which a package is placed. It is recommended to add a little more flux to the contact area to ensure thorough wetting, but it is important that not too much flux is applied, otherwise the component will float off position during reflow.

5. Cleaning – Remove all residues from the board. However, if no-clean solder paste/flux is used, cleaning is not required.

6. Inspection – This is the final step in the process. Visually inspect the solder joints to check for gross misalignment, joint quality, wrong orientation, board delamination, or any damage to adjacent components.

Typical BGA Rework Process Flow

One drawback to BGA packages is the rework process. Since the solder joints are hidden underneath the component, it is difficult to inspect and repair when a joint fails. Nevertheless, equipment, tools, and processes are available today to perform BGA rework. Figure 1 shows a typical BGA rework process flow diagram.

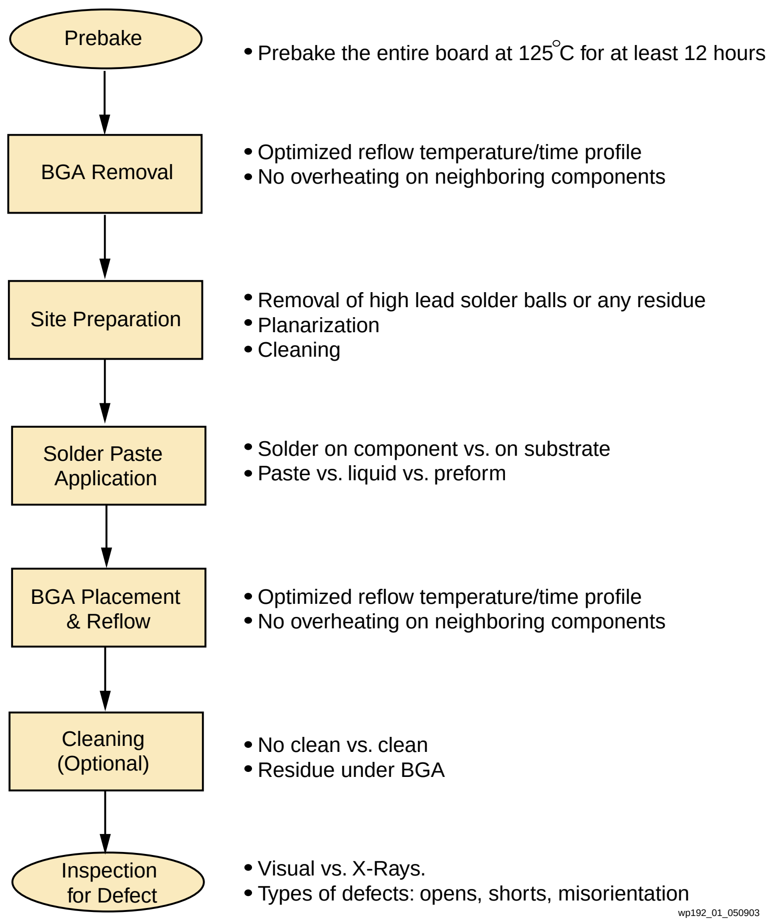

Figure 1: **Typical BGA Rework Process Flow**

BGA Removal

The following procedure applies to array package (BGAs) removal. The process steps that apply are:

1. Prebaking – Since the BGA packages are quite moisture sensitive, pre-rework precautions must be taken to avoid the "popcorning" phenomenon. If the board has been exposed to "out of dry-pack" environment for more time than allowed (24 to 96 or more hours, depending on the moisture sensitivity level of the package and the surrounding conditions), the entire board must be baked at 125°C for at least 12 hours.

2. BGA Removal – An accurate thermal profile needs to be established for the component removal process. This will determine the exposure duration and the maximum component/board temperatures.The profile should be adapted to each board and component to be removed. Although the typical profile should provide a peak temperature between 210°C to 220°C (at the solder joint) for a maximum of 75 seconds. It is best,

however, to consult with equipment manufacturer for the recommended profile. Research also indicates that a short delta T and a short dwell time above 183°C are preferred to minimize intermetallic growth and control board warpage. It is also important to ensure that the component and the board are not overheated and that all balls are reflowed on the specific component being removed. In general, preheat the entire board to a minimum of 85°C to avoid large temperature differentials and potential board warpage.

In terms of the equipment and tools available, hand-held as well as automatic hot gas rework systems with vacuum suction have been developed for BGA removal. First, position the nozzle (same size as component or smaller) around 100 mils from the top of the component and apply heat from the top side using the rework profile developed (ramp the temperature for 45-60 seconds with a maximum temperature between 210°C to 220°C). Finally, remove the component using a vacuum tip. Do not attempt to remove a partially reflowed component from a board by prying it off as this could likely damage the component and potentially destroy the board.

3. Site Preparation – After the reworked component has been removed, some excess solder might remain on the board. The excess solder can be removed using a vacuum desoldering system or a soldering iron with a solder wick. Special care must be taken to avoid damaging the solder mask material and the solder pads. As a final step, alcohol can be used with a brush to clean the rework area. Allow the board to dry and inspect to ensure a clean solderable surface. The specific steps used here can be different from board to board and from company to company. As a minimum, the removal of the excess solder is an essential requirement.
4. Solder Paste Application – There are several options available to apply the solder paste to the component site. The BGA package itself can be screened with paste prior to placement. In addition, the site can receive solder paste with a dispensing method. Finally, the application of flux to a prepared pre-tinned site can produce acceptable results in most situations.
5. BGA Placement and Reflow – The next step is to replace the component on the board. The replacement component should be baked prior to assembly to the board if the component has been exposed to the environment for more than the allotted time. Place the component on the site observing all the alignment precautions. Reflow the balls using hot air in a manner similar to the removal process. Again observe total board temperature to avoid any thermal gradients that can result in board warpage. Allow the board to sufficiently cool before lifting the nozzle to avoid any chances of misalignment.

   For larger BGA components that are more sensitive to heat, extra precautions are necessary to ensure successful results. It is critical to minimize the temperature gradient on the part. A high temperature gradient creates thermal shock that leads to package warpage. The temperature delta between the following locations should be 5°C or less than the solder balls on the corners, the solder balls at the center of the package, and the top surface side of the package. To achieve a minimal temperature gradient, a slower ramp up rate (0.5°C/s) and a lower peak reflow temperature (195°C to 200°C as measured at the solder balls) is recommended. Additionally, the parts should be allowed to cool down by ambient air instead of blowing cool air on the parts with the nozzle. Blowing cool air on the component while it is still hot at the solder ball locations creates an undesired temperature gradient which might lead to package warpage.
6. Cleaning – Remove all residue from the board. However, if no-clean solder paste/flux is used, cleaning is not required.
7. Inspection – This is the final step in the process. Visually inspect the outer rows of the solder joints to check for gross misalignment, joint quality, wrong orientation, board

delamination, and damage of adjacent components. If detailed inspection is required, X-Ray can be used to inspect for solder bridging and missing balls.

BGA Reballing

Parts that require reballing should be done by a professional reballing service provider. Xilinx parts that are reballed will not be guaranteed by Xilinx.

A maximum of three reflow cycles (including initial assembly, rework, and reballing) are allowed.

Typical SMT Rework Equipment

Finding good rework equipment should not be a problem because there are many good hot air rework stations on the market (Table 1). Prices start around $40K, with additional costs added for vision capabilities and nozzles. More information can be obtained from the equipment vendor sites listed in Table 1.

Table 1: **SMT Rework Equipment**

SMT Rework Equipment Vendor	Solder Reflow Heat Source	Component Removal Method/Tool
Air-Vac	Hot Gas	Vacuum
Conceptronic	Hot Gas or Focused IR	Vacuum
Manix Manufacturing	Hot Gas	Vacuum
APE	Hot Gas	Vacuum
Finetech	Hot Gas	Vacuum

References

The author gives credit to the following authors who provided helpful information for this white paper:

1. “Rework and Repair" in SMT Magazine, July 2001, by Howard Reproach.
2. “Product-Oriented Microelectronics Packaging and Interconnection,” a course given by Tom Chung, PhD.

Revision History

The following table shows the revision history for this document.

Date	Version	Revision
05/12/03	1.0	Initial Xilinx draft.