PROCESS ISSUES FOR FINE PITCH CSP REWORK AND SITE SCAVENGING

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Introduction

Chip-scale (or chip-size) packages are rapidly becoming an important element in electronics due to their size, performance, and cost advantages [Hou, 1998]. The Chip Scale Package (CSP) is becoming a key semiconductor package type, particularly for consumer products. Due to their relatively smaller size, new challenges are presented in the rework and repair of CSPs. Although rework processes have been developed for Ball Grid Array (BGA), [Primavera, et.al. 1998-A], several issues need to be addressed pertaining to rework of fine pitch 0.75 mm to 0.5-mm pitch area array components. For example, factors such as component size and construction, make certain aspects of rework extremely challenging. Hidden solder interconnects in area arrays require the assembly be thermally profiled with preheat, soak, ramp and cool down stages to establish the most effective reflow parameters for all joints. This paper describes the issues related to rework of fine pitch CSP devices, and give examples of experiments that were carried out to develop a satisfactory rework process. The specific focus of this paper is the removal process for rework of CSPs and the site scavenging methods required to properly prepare the circuit board for a new component. Process factors such as the heating, fluxing and, atmosphere are discussed.

General Overview of Rework Process

The method of rework for CSPs is very similar to the rework procedure for BGAs. As described in [Primavera, et.al. 1998-A], there are four main types of factors that influence area array rework process. These factors that affect the rework process yields can be classified into four categories including personnel, methods, materials, and machines / tooling. The “personnel” category can be further sub-divided into human factors such as handling, training, and education, as well as setup and quality control. The “methods” (or process steps) include the removal of the component and dressing of the site, deposition of solder and flux, component placement, reflow soldering, and other factors such as preheating. Also considered is the impact of “materials” on assembly yields including; solder paste, flux, component, and the PCB. The “machine / tooling” factors address equipment, the phenomenon of self centering, as well as the need for proper board support and heating conditions. While CSPs can in many cases be treated as small BGA devices, tighter tolerance and smaller size of the package have to be taken into account. This paper is focused on the removal and site preparation steps required for proper CSP rework.

COMPONENT REMOVAL

A reliable rework process should include a component removal process that uses a reflow profile and associated process parameters that provide for effective and efficient component removal while concurrently minimizing negative effects like component delamination, overheating of adjacent components, and board warpage. The component removal process consists of heating the component to a temperature above the liquidous temperature and then lifting the component off the substrate. There are three basic ways to heat Printed Circuit Boards (PCBs) whose assemblies include surface mount components. They are:

- Conductive heating;
- IR reflow;
- Convective heating.

The conductive method involves heating the solder joints with a hot tool that effects reflow. The different tools include soldering irons, fixed socket heads, and grips. While, these tools are capable of both highly precise and distributed heat deliveries, sometimes pressure is required to effect contact on all the joints simultaneously, which might at times result in pad or lead damage. This method is typically used for the rework of peripheral-leaded devices.

IR reflow tools transfer heat via radiation. There are several types of IR emission sources such as: lamp, diode and laser, and various methods of focussing the energy. These systems are noted for their faster ramp rates and removal cycles. IR rework systems do not use air to heat the component and therefore do not have the propensity to propagate thermal energy across larger areas. The main drawback to IR heating is component shadowing making it difficult for the IR source to reach the hidden joints or leads.

Convection employs hot gas or air focussed through an engineered nozzle to accurately concentrate heat on the component and solder joints. The nozzle design is perhaps one of the most important process parameters in this type of heating. Horizontal flow and perimeter heating nozzles blow hot gas under the component, conductive heating nozzles deliver hot gas to the top of the component, while the area reflow nozzles supply hot gas both under and on top of the package [Primavera, et al., 1998-B]. A successful rework process is possible with any of the nozzle designs as long as reliable and repeatable reflow profiles can be developed. However, a nozzle that matches the specific component to be removed is preferable. In dense assemblies it is imperative to match the dimensions of the nozzle to the size of the component. Heating from the topside of the component minimizes the possibility of overheating adjacent components. Regardless of the nozzle used, the thermal profile should include a PCB preheat stage. Preheating the entire assembly to 80 – 100^0 C achieves two goals. First, it reduces the heating time required and second, it reduces the temperature difference between the area of rework and the rest of the board. The heat profile is shortened since the preheating can be performed offline, or in a box oven near the rework equipment. For large and massive boards, an area pre-heater is required to effectively reduce the temperature gradient across the board.

Thermal profiling is perhaps the most critical step in the component removal process. On most area array components, fine gauge thermocouples can be installed directly underneath the package. However, for very fine pitch devices the effective insertion of thermocouples into the solder joints between the CSP and the PCB may be limited by the size of the available thermocouple. For process development, accurate temperature measurements can be obtained, in such a case, by drilling a small diameter hole, slightly larger than the diameter of the thermocouple wire, through the bottom of the board in order to touch the ball/pad interface. This permits real-time solder joint temperature to be fed to the profile. If the rework station provides low temperature gradients across the heating areas, the temperature measured at a solder joint will reflect those at the others, thus ensuring profile repeatability and accuracy. Several experiments were conducted for the removal of CSPs. The experiments focussed primarily on the evaluation of heating criteria, the development of reflow profiles, and the process parameters needed to optimize the component removal process for CSPs. The objectives also include:

- Profile development for removal of various CSPs by use of different heating strategies.
- Evaluating the effect of flux for component removal.
- Evaluating the effect of air and nitrogen atmospheres for component removal.

While evaluating each parameter, it is important to first characterize the rework equipment and understand the factors that affect the component removal process. Specifically, factors such as board thickness, pad metallurgy, package size, and component construction are critical when developing thermal profiles. Experiments conducted for this work were performed using either a SRT-2000 or a 1100, rework station. Both machines are semi-automated rework stations, with the model 2000 station having a built-in solder scavenger. The entire process of component removal, scavenging, component placement, and reflow are computer-controlled and sequences using pre-defined commands can be used to create these operations. The software tools allow the reflow process to be adjusted for the desired profile characterization, such as ramp rates, dwell times, and the set point temperatures for the top and bottom heater. The machine uses the top and bottom hot gas heaters with either air or nitrogen atmospheres.

Two test boards, one being a four layer 0.062” thick board and the other a 4 layer 0.031” thick board, were selected for the thermal profile development. Thermocouples were inserted and fixed using ultra violet cure adhesives from the bottom side of the assembly by drilling holes that were about 12 mil in diameter and a depth of 65 mils for 0.062”-boards and 34 mils for 0.031”-boards. This ensured that the thermocouple bead was at the solder joint of the component. Profiles were adjusted and ten runs of each were conducted to analyze the temperatures, and time plots of each of the profiles. Following this setup step, component removal was performed with each of the profiles, using a sample set of ten assemblies. Upon component removal, the sites were evaluated for the qualitative responses of removal quality and board/component damage.

Two components were evaluated in this experiment. The first device (Figure 1) was a 12 mm 144 I/O 0.8 mm pitch CSP with a BT laminate component carrier and an overmold wirebond configuration. The package has mask-defined pads with eutectic Sn/Pb solder balls. The bump diameter is 15 mils and the mask diameter is 12.5 mils. The second device is a 5.5 mm 48 I/O 0.5 mm pitch laminate carrier CSP as shown in Figure 2.

Figure1. 144 I/O CSP

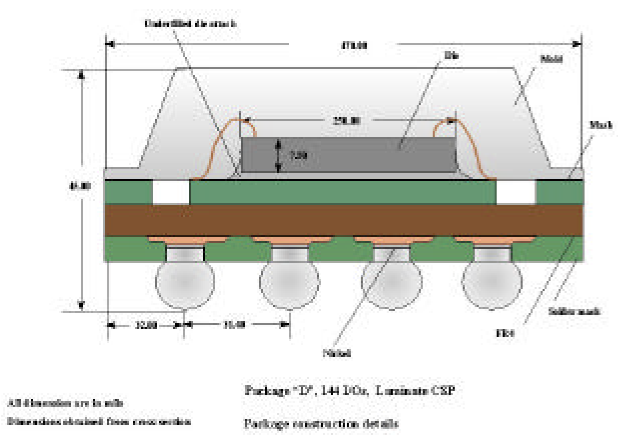
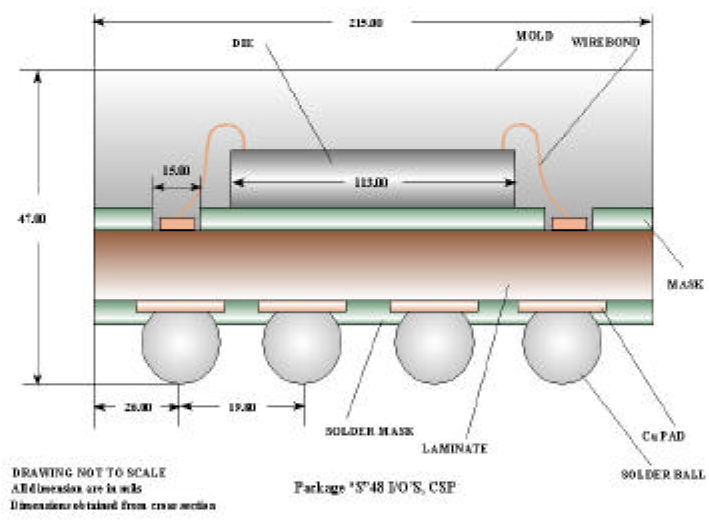


Figure 2 48 I/O CSP



Each component was assembled onto a tetra functional FR-4 PCB with a minimum glass transition temperature (Tg) of 170 ^{0} C. Conventional subtractive fabrication methods were used for creating the double sided, board. Each 9.35” x 9.5” board has 16 individual component sites, one each on its own routed coupon. The pad metallurgy is copper with Enthone Entek 106A, an Organic Solderability Preservative (OSP). The components were initially assembled using a no clean tacky flux film 4 mils in depth. A nitrogen atmosphere (50 PPM oxygen) was used in reflow. For component removal, the following criteria was used:

- Minimum temperature gradient
- Maintain less than 2^{o}C/sec ramp.
- Prevent secondary reflow
- Keep die temperature below 225^{0}C.
- Limit time above liquidous to 45-60 seconds.
- Establish a maximum peak temperature of 205^{0}C.

A 0.75” square component nozzle was used for removal of both components. The reflow profile consists of preheat, reflow, and post reflow (or cool down) sequences that were incorporated using pre-defined system commands. Previous experiments have shown that components with a small body size show movement and subsequent misplacements during reflow due to high gas flow rates. Therefore a “low air flow” option available on the rework machine was included between preheat and reflow after the initial profile was developed. In this profile, after the “preheat” zone is completed, the airflow reduces automatically to a preset rate during reflow. The use of “low airflow” consequently changed the dwell times and ramp-up times in the reflow zone. The final profile for both removal and replacement include:

- Initial ramp up from 50^{o}C to 70^{o}C and a secondary ramp up to 160^{o}C;
- Preheat dwell at 160^{o}C for 120 seconds;
- Time above liquidous of 70 seconds;
- Peak temperature of 20^{o}C above reflow;
- Maximum board temperature of 140^{o}C, 150 mils outside the nozzle area;
- Preheat ramp rate of 1^{o}C/second;
- Cooling rate of 1.3^{o}C/second.

Two different heating strategies were evaluated to meet the objectives of the study. The two strategies differ in the application of the machine top and bottom heaters.

Heating Strategy – 1(HS-1)

Here, both the top heater and the bottom heater are employed simultaneously to heat the assembly from both sides, throughout the entire removal cycle. Figure 3 is a schematic diagram of the heating strategy. The goal was to obtain a profile that would have as short a reflow cycle time as possible. A representative profile is shown in Figure 4. This profile consists of a preheat and reflow, wherein the entire assembly is preheated to about 100-110^{o}C using both the heaters. Then, using slightly higher ramp-up rates, the entire system is heated to a temperature above liquidous, followed by the cool-down cycle.

Heating Strategy – 2(HS-2)

This strategy preheats the entire board from the bottom side, followed by preheating the component and board with the top heater and finally raising the temperature of the solder joints to the target temperature using both the heaters. Figure 5 is a schematic diagram of the way both heaters are utilized for this strategy. The profiles that are obtained with this method are similar to the typical reflow profiles that employ the traditional four zones of preheat, pre-reflow, reflow and cool-down. Figure 6 shows a representative profile obtained. In this profile, there is a preheat segment, where the entire assembly is heated to 100-110^{0}C using only the bottom heater. Then, the assembly is heated to 150-160^{o}C. There is a dwell time of about 120-150 seconds and then a ramp-up to above liquidous temperature followed by the cool-down sequence. Comparison of several quality measures were performed including the following:

Figure 3 Strategy 1

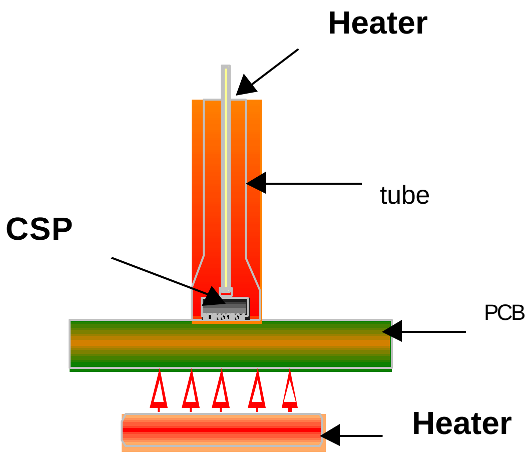


Figure 4 Profile for Strategy 1

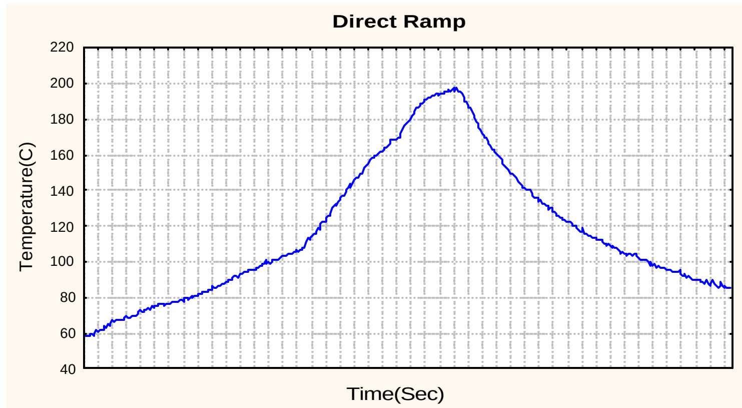
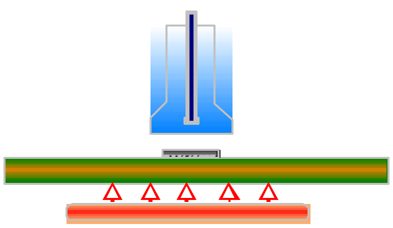
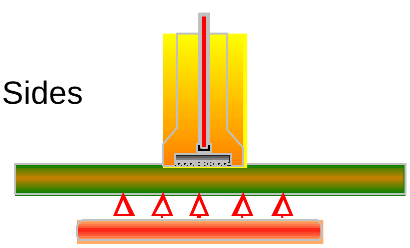


Figure 5 Strategy 2

Step1
Bottom
Heat



Step 2
Heat Both Sides



Step 3
Reflow

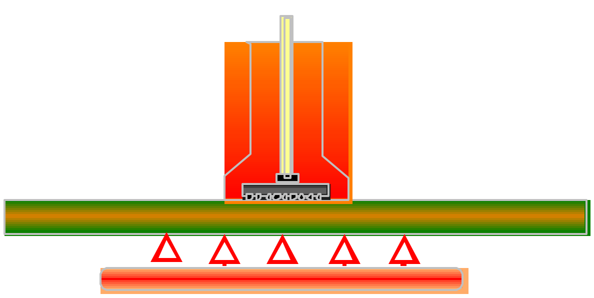
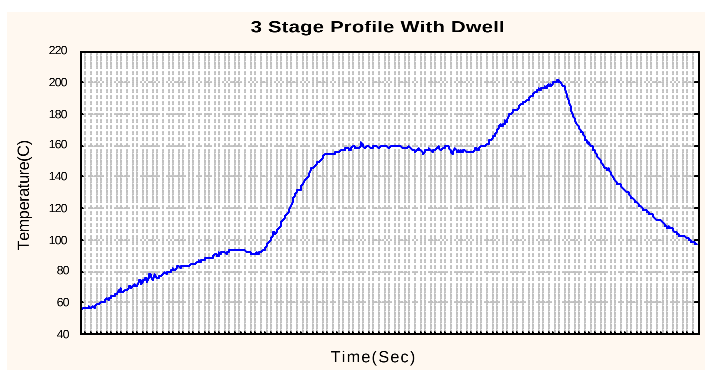


Figure 6 Profile for Strategy 2



Product Damage

This damage can be either component related or PCB related. Component related damage includes; delamination, thermal shock/fracture, and induced solder bridging. PCB related damage includes lifted pads and traces, delamination, mask damage and warpage.

Temperature Differentials

This consists of the temperature differential across the component site itself, the temperature spread to the adjacent components, and the temperature at the component's die-substrate interface. For CSP rework, the temperature differential across the rework site should be 10^{o}C or less. For adjacent components, a temperature of 150^{o}C at about a distance of 100 mils from the reworked component is considered safe.

Quality of Residual Solder

The scavenging operation follows the component removal process. Hence for proper site preparation, it is important that the solder residue left behind is uniform. This will prevent problems for automated site redressing, where the height of the nozzle tip for solder removal is fixed, and will minimize variation in the amount of solder on each pad.

Time or Speed

Speed defines the throughput, which directly impacts the efficiency of the process in terms of cost. Choosing the right type of profile depends on the complexity of the assembly, limitations of the equipment, and various other factors.

Component Pick-Up

Once the component has been reflowed using the profiles developed, the vacuum pick-up tip lifts the component off the substrate and then drops it off at the designated location. This can be accomplished in two ways:

1. Zero-force pickup.
2. Force pickup.

During the typical component pick-up sequence, the pick up tool touches the component after the reflow cycle is complete. The pickup tube pushes the component down to activate a breakaway sensor which requires approximately 5 grams of force. After this limit is sensed, the vacuum is activated and the component is lifted. The second option is to trigger the vacuum following the reflow cycle without a force sensor trigger.

Experiment Results – Removal Process

Once the profiles were obtained, ten runs of each strategy were carried out. The two profiles were then compared and evaluated in terms of the temperature differential, the dwell times, the ramp rates, and the time needed. Component removal was performed using the two strategies and profiles for ten assemblies of each. The components and the boards were evaluated for the quality of removal. Components were visually examined for any form of defects such as bridging, uneven solder residue, and damage to the package. They were also checked for package delamination by C-mode acoustic microscopy.

Profile Evaluation

Two temperature profiles, using two different heating strategies, were successfully developed for the component removal process. These are the direct ramp-up profile and the traditional 3-stage profile. The direct ramp up profile provides for relatively high throughput and can be used where components will not be reused. Despite the lack of a sufficient soak time, the temperature differential across the solder bumps at the component site was less than 5^0C. Primarily, this is due to the small component size. However, for large BGAs, it was found that the direct ramp up profile is unacceptable [Chung, 1997]. When using the direct ramp profile the temperature was found to be less than 150^oC at distance of 150 mils from the edge of the reworked device. The profile takes approximately 7-8 minutes.

The 3-stage profile, though it takes slightly more amount of time, approximately 10 minutes, can be used for the removal as well as the replacement process. The board preheat and soak / dwell ensure uniform temperature distribution across the entire assembly than the direct ramp up profile and thus avoid any form of thermal shock to the assembly. The temperature difference across the site was found to be 1-2^0C. In addition, the board showed less warpage than the direct ramp up.

Removal of Fine Pitch Components

The removal sequence in both the direct ramp-up profile and the 3-stage profile utilized similar steps for each CSP, with the exception of airflow rate. For the 48 I/O device, the low airflow option was required to make sure that the component did not move. The low airflow resulted in slightly higher temperatures at preheat and reflow zones. The use of a zero-force removal with the nozzle tip to component top gap of less than 20 mils was found to eliminate solder balling around the site due to component compression during removal.

Component / Board Damage

Excessive heating of the components during the component removal process could result in delamination of the component. For the profiles developed, no cases of delamination were found. Thus, no conclusion could be drawn for comparing the two thermal profiles.

Reflow Atmosphere

All the components that were removed using the direct ramp up profile in a nitrogen atmosphere were properly removed with no visible board or component damage. The solder bump residue on the component was also uniform as well. However, the quality of removal was poor in an ambient air atmosphere, with a non-uniform solder residue. It was found that for the same profile, the use of nitrogen atmosphere resulted in a smaller temperature spread across the site than air.

Board Support

It was found that the board support played a significant role in the solder residue on the board and the component. A slight difference in board support resulted in PCB warpage and subsequent solder balling. Components that were removed in regions of inadequate board support, showed solder balling/bridging on the component side for both profiles used.

Pick up Force

The use of a component force sequence was found to result in bridging of the reflowed solder, as the pickup tool tends to push the component down during sensing. The sequence is programmed such that the pick up tool is moved and taught the component location before the reflow is carried out. The pickup tool moves to the component, locates it, stores the z-height, and then retracts. Reflow is then carried out followed by component pickup, whereby the pickup tool picks the component without deforming the solder. This phenomenon was found to be suitable for the smaller packages since the CSP packages have comparatively small amounts of warpage compared to BGA devices. Large package warpage could prevent the part from being picked up properly with the zero force option.

Component Removal: Conclusions

Following profile evaluation, some observations and recommendations are presented:

- Preheating the board to a fixed temperature of 85-100^{o}C, before applying heat to the component helps ensure process repeatability.
- Both heating strategies achieved a small temperature gradient across the part. The temperature distributions across the solder joints were less than 5 ^{0}C for a direct ramp profile, and 2^{o}C, for the 3 stage profile. The time required for the direct ramp up is very short as compared to the three-stage profile, and is thus recommended for rework of small CSPs. For larger arrays, the temperature differential is an important factor for rework, and the three-stage profile should be considered.
- A nitrogen atmosphere was found to be superior to the air atmosphere, in that it provided for a smaller temperature differential across the site. In addition, the residual solder was more uniform with a nitrogen atmosphere.
- Board support should be as uniform as possible, since even a slight tilt or bend in a particular side results in solder bridging or balling.
- Component removal is recommended using the zero removal force for fine pitch CSPs as this ensures minimum component and board damage.
- Air velocity during the heating cycle should be kept as low, as excessive flow settings resulted in the component skewing during reflow. For the machine used in this research, the "low air flow" option can be activated during the reflow cycle.
- Component delamination was not found in any of the components removed using the developed profile. Thus, the temperature settings specified were safe for the CSPs used.

Recommendations

- The assembly to be reworked should be free from any moisture to prevent possible component/board delamination. A 4 hour 125^{o}C bake was found sufficient for most CSPs.
- 3 Stage profile settings: Preheat the entire assembly to 100-110^{0} C within 3 minutes. The profile is then ramped to about 150^{0}C and held at this temperature for a dwell of 150-160 seconds. The assembly is then spiked into reflow to a maximum peak temperature of 200-205^{0}C. The time above liquidous should 55-65 seconds.
- Direct ramp-up profile settings: The entire assembly is pre-heated to 100-110^{0}C and then ramped to above the liquidous temperature. The peak temperature is 200-205^{0}C and the time above liquidous is 60 seconds.
- Flux is not recommended for the removal process since it adds an extra process step and cost. Also, flux compatibility with other process materials is a major concern.
- The gap between pickup tube and the top surface of the component, should be 10-20 mils.
- The air velocity should be minimized and the profile developed accordingly. For all the experiments performed, the air velocities for the top heater were maintained at about 500 FCH and around 100 FCH for the bottom heater. Excessive airflow sometimes results in the component getting skewed.
- Nitrogen atmosphere is recommended for removal to ensure uniform residual solder.
- Larger components (> 0.8 mm BGA) do not show any solder bridging with the force pickup sequence. Zero force pickup should be used for smaller area array components.

REWORK OF CHIP SCALE PACKAGES – SITE REDRESSING

Once a CSP is removed in a rework process, the site must be cleaned in preparation for a new package. The goal is to effectively remove the residual solder without damaging the solder mask material and/or lifting the pads. Currently, two methods are commonly used for the removal of residual solder. They either use a vacuum de-soldering system or a soldering iron with a solder wick. These are manual site-cleaning methods. An automated site cleaning system called the "scavenging system" is provided on the rework system used in this research effort. The goal of this study was to establish a comparison between the different site preparation options for fine pitch CSPs. The site redressing process is critical since it poses significant risk to the integrity of the board. Damage to the board usually takes the form of lifted pads, lifted traces, and more commonly damaged solder mask [Hallee, 1998]. With many area array packages, the space between pads is densely populated with traces and vias. As a result, the smallest defect in the solder mask may result in bridging and shorts. In its simplest form, site cleaning involves the application of heat to the residual solder and subsequently removing the solder.

Vacuum De-soldering Pump

In this method, the residual solder is melted using the hot tip of a vacuum pump. The vacuum tip is placed in direct contact with the solder ball to be removed. When the solder reaches its melting point, the vacuum in the pump pulls the solder into the waste chamber. Initial experiments for this method did not show satisfactory results. Significant mask damage, as well as pad and trace rip off was observed. Additionally, solder removal was not uniform.

Soldering Iron with a Braid

Flux-coated copper braid or a solder wick is usually used in conjunction with a conductive heat source, such as a soldering iron, for the removal of residual solder. The solder wick is placed on the pads to be cleaned and the heat source is placed onto the wick. When the solder reaches melting temperature, it is drawn into the wick. When the wick is saturated with solder, it is discarded. The best results were achieved with a sharp-edge conductive tool with the tip matched to the width of the pad array. A tool with a low source temperature and excellent heat transfer is ideal for redressing. The use of flux on the site before redressing is recommended for use with a fluxless braid. In this experimentation, a solder braid with a width of 30 mils was used to redress the 0.5 mm pitch devices, while a 60 mil braid was used for the 0.8 mm pitch devices. A thin film of flux was manually applied over the site to be redressed to facilitate heat transfer. The time that the soldering tip touches the braid should be short as possible to ensure that the pads are not overheated. A well-cleaned site is shown in Figure 7, before and Figure 8 after scavenging. After redressing, the site should be thoroughly cleaned with isopropyl alcohol to remove any flux residues.

Experimentation

Critical factors that affect the efficiency of the site cleaning process are the size of the solder wick, the size of the soldering tip, application of flux, and operator's dexterity. Some of the important observations during the site cleaning operation using a solder iron and wick are listed below.

- It was found for 12 – 15 mil pads, a 30 mil (0.8 mm) wide wick was sufficient to remove an entire row of solder balls, in one stroke. The removal of multiple rows in one single stroke is not recommended, as some solder may travel to and remain at the area between two adjacent pads. For 25 mil pads, the volume of residual solder is large and hence a 60 mil wide solder wick is recommended. For example, for a 256 ball array (1.27 mm pitch, 23 mil pad size), a 60 mil wide solder wick would be appropriate while the 30 mil braid would be used for the 48 0.5 mm device. The residual solder removal was more uniform and required less time when flux was used during site scavenging. Repeated strokes were required without the use of flux.

- A straight-edged soldering tip was used for the removal of the solder. The corner of this edge was placed on the wick and strokes applied to melt the solder. The corner is sufficient to cover the entire width of the wick. Moreover, it acts like a flat base, enabling the application of flat strokes, which may not be possible using a pointed soldering tip. Care should be taken to lift the part of the solder wick (over which the soldering iron has already traveled) simultaneously while applying the stroke. If this is not done, the wick, loaded with the molten solder, will stick to the pads and either cause pad rip off or require repeated strokes for release.
- For the solder wick, the removal of residual solder is uniform with and average of 100 – 200 micro-inches of solder left behind on the pads.
- The time required for a solder iron and wick is considerably less than that for the vacuum de-soldering tool as a row of pads can be cleaned in one stroke.
- For the sites dressed with a solder wick, one case of solder mask damage was observed. In addition, several cases of pad peel occurred when using a 60 mil braid on the 0.5 mm device. It was determined that the braid was too wide and that pads on adjacent rows of bumps were partially reflowed into the braid.
- During the redressing of the pads having microvia-in-pad structures, it was observed that it was possible to dress the site and have the residual solder remain in the microvia. In addition, it was found that voids typically induced during via in pad assembly was removed during the scavenging operation. However, the use of the solder iron and wick was inconsistent and the solder was sometimes removed from the entire pad and via structure.

Figure 7 CSP Site With Uniform Solder Residue

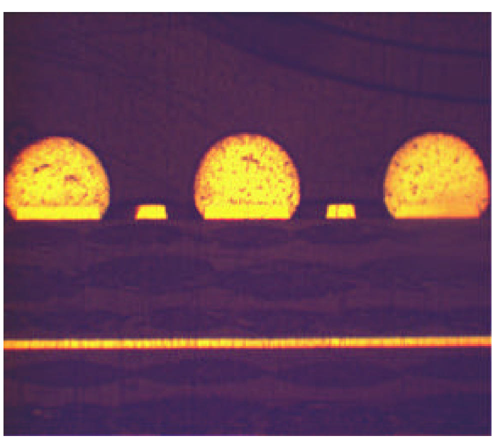
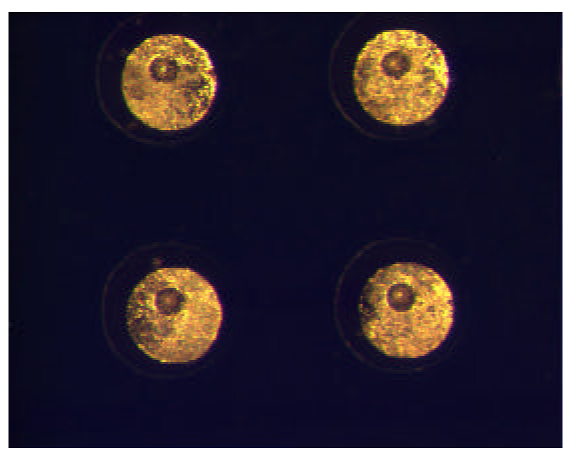


Figure 8 Dressed Site



Scavenging Tool

The equipment used in this study had a semi-automated scavenging tool attached to the rework station. The tool combines a vacuum de-soldering heated tip with a precision motorized gantry and X-Y table. The scavenging tool consists of two concentric tubes with hot air flowing through the outer plenum (to melt the residual solder) and vacuum drawn in the inner tube. The efficiency of the scavenging pump depends on the distance of the tip from the land, the speed at which the scavenger moves across the site, the temperature and flow rate of the hot air, and the vacuum strength applied at the tip of the scavenging pump. Three scavenging options are provided in the software module including:

- High Pass–Low Pass (HPLP) wherein the scavenging system cleans the residual solder in two passes, first at a higher level and the second at a lower height close to the board. The HPLP is useful when a large amount of residual solder is left on the site after the component removal process. However, this method uses considerably more time.
- Single Pass With Retract (SPWR) wherein the scavenging tip retracts (moves to a higher level) between the pads, and moves down to the pre-determined height to scavenge.
- Single Pass No Retract (SPNR) wherein the scavenging tip moves at a pre-determined height over the entire array of the pads.

When scavenging, the SPWR method occasionally, scattered the residual solder while the scavenger moved down towards the pad site. Moreover, the retraction increases the dwell time at each pad site by 0.5 seconds, thus increasing the overall time for which the board is exposed to the hot air. For large sites (256 I/Os), this increases the time by at least 1.5 – 2 minutes. Therefore, the SPNR method was used for all the further experiments. For efficient removal of the solder, a scavenger set point temperature of 400 to 420 °C is recommended. Temperatures as high as 450 °C, and as low as 380°C were tested. Keeping the scavenger temperature constant at 410 °C and the scavenger tip height at 6 mils from the board, 3 different dwell times of 0.2, 0.5 and 0.8 seconds were tested. A 1 mm pitch, 256 array component site with a pad size of 12 – 15 mils was used for the test. A tacky, no-clean flux was applied to the site prior to solder removal. At 0.8 seconds dwell time, the pads became burnished and discolored. There was no significant difference in pad quality for the 0.2 and 0.5 second dwell times, however, a dwell time of 0.2 seconds required 5 – 6 minutes to traverse the entire array of 256 pad sites, while a dwell time of 0.5 seconds required 8 minutes. A second experiment was performed using a 0.2 second dwell time and a temperature of 410°C, in which the scavenger tip height was varied at 1, 5, 10, and 15 mils above the board surface. It was observed that in the case of the 15 mil height, almost no solder had been removed, while intermittent solder removal was observed for the 10 mil height. Excellent solder removal and no board damage was observed for the 5 mil height. However, high solder mask damage was exhibited at a height of 1 mil. Finally, runs were carried out varying the temperature and velocity settings of the scavenger tip. A similar study was conducted to test the effect of nitrogen on the quality of the solder removal. The samples showed a slightly better scavenged pad when nitrogen is used.

SCAVENGER RECOMMENDATIONS

- It was found that the following parameters resulted in excellent solder removal when using the scavenger tool. The set temperature of 410 °C, with a dwell time of 0.2 – 0.5 seconds at each pad is sufficient to effectively remove the residual solder. A scavenger tip height should be (5 – 10) mils for 12 – 15 mil pads and (10 – 15 mils) above the board surface for 23 –25 mil pads.

- Before every scavenging operation, the scavenger tip physically locates the top of the board to determine board thickness. This is carried out at a maximum of three points around the component site. To sense the board location, the scavenger tip actually pushes down against the board until a sensor is triggered. The board tends to bow if there is improper board support and an incorrect tip height is set.
- Underboard heating is recommended to reduce the thermal shock to the board. For the present study, the overall board temperature was maintained at 85 °C.
- The use of flux for solder removal is recommended as this gives slightly better removal due to the enhanced heat transfer obtained.

PROCESS RECOMMENDATIONS

- Both, the solder wick as well as the scavenging system, can achieve effective removal of residual solder, provided adequate precautions are exercised while using the solder wick and successful characterization of the scavenging system is accomplished.
- The use of flux is recommended for the removal of residual solder using a solder wick or the scavenging operation.
- The scavenging tool provides a more consistent method for site dressing however, machine costs are much higher than the solder braid and iron.

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