10 steps to lead-free array package rework

The higher temperatures of lead-free soldering, combined with the more delicate nature of array package components, means that suitable rework stations must feature excellent profiling and tolerances, plus offer easy calibration if thermal damage is to be avoided and optimum results achieved.

1. Time, cost, quality, repeatability

These are the primary concerns of the repair and rework cycle: too much time means excess cost, while poor quality has never been acceptable and repeatability requires good process control. But the ability to duplicate precise heating profiles from operator to operator, facility to facility and country to country underlies the entire repair and rework process, and feeding back in to the time, cost and quality equation.
Today's manufacturers have to deal with small, sensitive array packages with complex profiles and hundreds of connections that can only be seen with sophisticated vision systems. Operator turnover is also often high; yet, conversely, experience with array packages is essential if time and quality goals are to be achieved. Now with lead-free solders as an added variable, reflow temperatures are higher, time above the higher reflow temperatures are different, appearance of the joint is considerably different, and the need for process control is even greater than for eutectic solders. But with the right thermal profiles, equipment and knowledge, it is still possible to reach the time, cost and quality goals with array packages and lead-free solder.

2. The basic steps

Reworking array package components using lead-free solder follows similar steps to leaded components with eutectic solder: establish the thermal profile, remove the failed component, clean and prepare the site, place a new component with flux or solder paste, reflow, and inspect. But forget the soldering iron for these devices, as convection, not radiation, is the heating method of choice, as in the assembly process, allowing the greater process control without this repeatability is impossible.

3. Solder Paste Compositions

Different lead-free compositions exist and these will be fine-tuned as time and processes mature. The most common are based on tin alloyed with small amounts of silver, copper or bismuth, with melting points in the range 206-221°C. Solder peak temperatures are higher 217°C to 235°C.

4. The lead-free temperature squeeze

The operating window for lead-free is being squeezed by component suppliers and solder manufacturers. The maximum solder temperature peaks around 235°C, but the component suppliers' maximum temperature is 265°C, with most ranging from 240 to 250°C – and these are very close to the 225-233°C soldering temperature. The time above reflow is also reduced from 60-90 seconds for eutectic tin-lead solder

down to 15-30 seconds for lead-free. So rework systems must be capable of ramping up and down very fast to achieve this small temperature peak.

5. Thermal profiling

Using convection makes it easier to establish a repeatable thermal profile that won't overheat the package or hold it above reflow for too long. Establishing the ideal profile takes experience, patience and knowledge of lead-free. In addition to the standard pre-heat, soak and reflow (plus cool down) zones, lead-free demands an extra ramp zone and more precise heating control.

6. Extra heating required

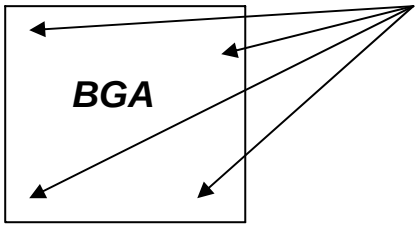
The higher temperatures needed for lead-free, coupled with the thermal sensitivity of BGAs and CSPs, demands precise temperature and the addition of a ramp stage where temperatures rise at a rate that will not harm packages. That's why today's more sophisticated rework systems employ four heating zones and one cooling zone. Lead-free rework is doomed without this extra step, because the higher temperature requirements and thermal sensitivity of area arrays can be problematic without the ability to ramp temperatures at a rate that will not harm components. Having a controllable pre-heater allows for efficient pre-heating that avoids the thermal damage risked when working with expensive, but sensitive, packages unsuitable for heating above 235°C with quick reflow times.

7. Ramping up the temperature

Thermal profiles for lead-free are different from those of eutectic solder, as tolerances are tighter and some type of repeatability and process control is required in the rework station. A typical lead-free profile would be to pre-heat to 140°C in 100s, followed by a soak zone below 170°C for 90s, then a ramp up to 225°C in 100s, reflow up to 235°C for 20s and then cool down for 60 seconds. The differences between this and a tin-lead profile are substantial, and the key is system control with the ability to ramp up faster and cool down quicker.

8. Delta T considerations

Another factor to consider with lead-free is the temperature difference, or delta T, across the soldering area. A delta T of 10°C is considered acceptable to produce a good tin-lead joint, but this is halved to 5°C for lead-free, which is difficult to achieve in practice. The second delta is vertical this is usually 10 °C from lid to solder ball, and also the underside of the BGA this is the bottom surface of PCB under component opposite surface of the board.



Delta Measurements across the surface of the components used to be 10°C but lead-free requires 5 °C.

9. Accurate control

The wetting process and temperature profiles must be controlled to make sure the resulting joints are strong and not brittle. Improved heating regulation and faster ramp-up are needed with lead-free – particularly in the under-board heater, which means that hot plates should not be used. Temperatures must be high enough to melt and form intermetallics, activate flux and optimise wetting, yet low enough to avoid damaging the PCB and component.

10. Inspection

Lead-free solder joints look grainy compared to traditional soldering and inexperienced operators often reject them for quality reasons. When lead-free is implemented, companies must set a new standard and train operators in proper inspection criteria. X-ray inspection works well, because joint appearance is not then an issue, but visual systems are becoming more popular due to the expense of X-ray. There are also some newer vision systems on the market, such as Metcal's VPI-1000 series, that feature endoscope-like technology that can look at the top and bottom of the solder balls to check the formation of the intermetallic joint.

Array packages and lead-free processes will continue to require post production processes and rework is not going away anytime soon. The basic rework steps are the same, but substantial temperature differences between eutectic and lead-free solders mean tighter processes, better temperature profiles and the use of precise rework systems with closed-loop process control are required if high quality, low cost rework is to be achieved.