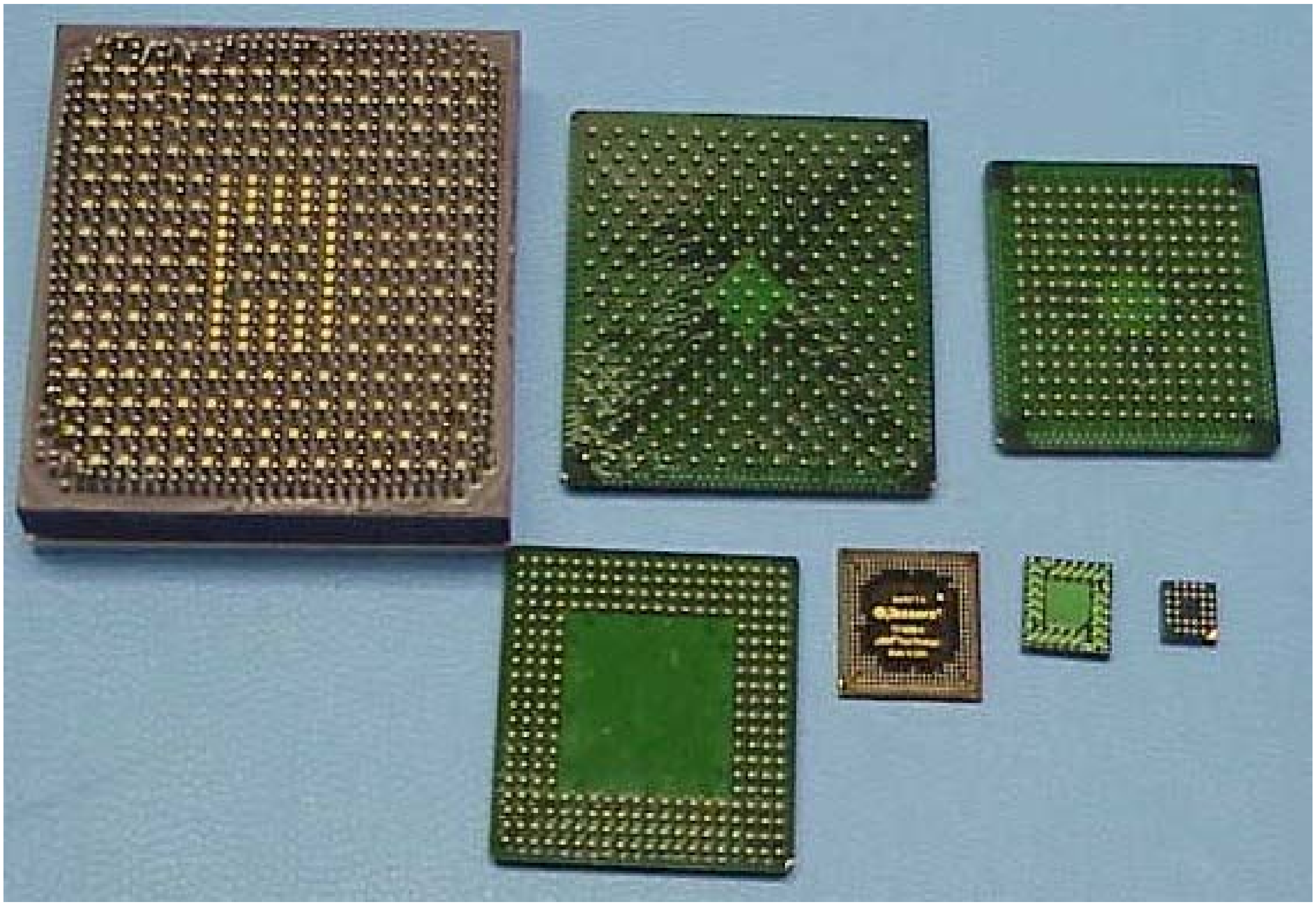

BGA/CSP Re-balling

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The trend in the electronics interconnect industry towards "Area Array Packages" type packages (BGA's, CSP's, CGA's etc.) and away from high pin count leaded packages (primarily Quad Flat Packs) has increased dramatically over the last several years. The primary reasons for this are:

1. High BGA I/O (Input/Output) density (up to and exceeding 1000 I/O's, compared with the largest QFP packages of 304 pins).
2. Increased reliability/robustness in all PCB assembly processes.
3. Improved electrical and thermal characteristics of area array packages
4. Higher first pass yield over conventional QFP's.
5. Easier and more reliable rework if the proper equipment is used
6. The ability to touch up (re-ball) and re-use BGA's after removal in the rework process.

Ball Grid Array packages are fundamentally different from other types of Surface Mount Devices (SMD's) in that they do not allow visual inspection of solder joints unless the user has very specialized equipment. This is due to the interconnects being hidden "under" the package. Therefore all parameters of the BGA rework process, including the consistency of the interconnect balls on the package, must be precise and consistent. For example, in the re-balling process of a 1000 I/O package, if just one ball size is incorrect (a 99.9% accuracy), the rework will look good but will not work properly due to co-planarity issues. Even under simple 2D X Ray, an insufficient ball size will not be noticeable. It will require a much more time consuming 3 dimensional X Ray analysis to reveal that the solder ball was to small and therefore did not make contact with the corresponding pad. So, the re-balling process must be 100% accurate, there is no room for error. The most important factor in BGA re-balling is deciding if you should re-ball or not. Some packages are very difficult and therefore not good candidates for re-balling as the yield is too low. Also, an inexpensive BGA is probably not worth re-balling as the cost of fixtures ($300.00-$1,200.00 typically) is prohibitive. The quantity of parts to re-ball will also affect the ROI for the project. A thorough understanding of the common area array packages is essential to making the decision to re-ball.

Common" Ball Grid Array Packages (see figure 1)

Plastic Ball Grid Arrays (PBGA) – Figure 2.

The PBGA is the most common of the BGA package types. It uses an overmolded resin substrate to encapsulate the die/chip and either SN63/PB37 eutectic solder bumps or SN62/PB36/AG2 solder bumps are used for attachment to the mounting site. See figure 5 & 6. These solder bumps collapse during reflow creating the electro-mechanical connection to the PCB. Most PBGA's use a solder bump diameter of .030" so the same 0.030" size is best for re-balling. PBGA overmold epoxies are generally moisture sensitive (hydroscopic) in that they absorb moisture from the surrounding environment. This can lead to a condition termed "popcorning" during the reflow/re-balling process as the entrapped moisture turns to steam and expands. Popcorning is the delamination of the plastic packaging material or the delamination of the plastic material from the die itself and needs to be avoided at all costs. Therefore dry storage or pre-baking the PBGA in an oven @ 125°C (257°F) for 24 hours is necessary for the re-balling process.

Micro BGA's and CSP's (Chip Scale Packages)
Micro BGA's and CSP's are actually the same thing! Tessera Inc. trademarked the term μBGA, and CSP is the term used by the rest of the industry. A μBGA or CSP is commonly defined as a package that is no more than 1.2 times the size of the actually chip in the package. Pitch, or the center-to-center bump/ball spacing, is usually less than a PBGA, sometimes down to as little as .5mm or .020". Therefore the re-balling process is a little more difficult than standard BGA's however all the same process parameters apply. μBGA's and CSP are also subject to moisture absorption and related defects and the necessary precautions outlined above should be taken.

Ceramic Ball Grid Arrays (CBGA) – Figure 3.
The CBGA package employs a "flip-chip" technology where an actual chip is bonded to the top of a fired ceramic substrate using a technology pioneered by IBM called "C4". C4 is an acronym meaning "controlled collapsible current conductor". CBGAs use an array of .035" (.89mm) diameter SN10/PB90 (melting point 325°C/617°F) solder balls which have been joined to the bottom of the ceramic substrate using eutectic solder. During reflow the eutectic solder at the ball/substrate and the ball/PCB complete the electro/mechanical connection. Hence, it is required to screen solder paste onto the component land pattern to facilitate the bond. The high melting point solder balls do not reflow, but instead maintain a .035" standoff between the substrate and PCB. These type connections provide the required flexure to accommodate the thermal coefficient of expansion (TCE) mismatch between the ceramic substrate and the PCB.

Ceramic Column Grid Array (CCGA) – Figure 4.
The CCGA is a variation on the CBGA in that instead of using non-eutectic high temperature solder balls it employs solder columns measuring .020" in diameter and between .050" and .087" in height. These solder columns are designed to provide greater flexure to accommodate high power dissipation levels. Re-balling is NOT recommended for these package types due to their extreme complexity. However, due to the high cost, it may prove to be cost effective, even with the longer processing time and lower yield.

Typical ball size guideline for re-balling
Note: refer to individual component spec. sheet for exact ball diameter

Part	**Pitch**	**Ball Dia.**	**Reduction**
PBGA	**0.050"**	**0.030"**	**40%**
μBGA	**0.020"**	**0.013"**	**35%**
CBGA	**0.050"**	**0.035"**	**30%**
CCGA	**N/A**	**N/A**	**N/A**

The Re-balling Process

Once you have determined that re-balling is a good option, the process is actually very simple. The steps are:

1. Remove all residual solder from the BGA. A vacuum solder extractor is preferred however solder wick is OK as well.
2. Flux the part with a high viscosity "tack gel". It is the same flux medium used in solder paste and is readily available from all paste suppliers.
3. Place the fluxed part into the re-ball fixture (figure 5).
4. Slide the corresponding stencil into the fixture. Make sure the apertures in the stencil line up with the BGA pads by looking through the stencil.
5. Pour the appropriate size solder spheres on top of the stencil and brush the spheres into every hole.
6. Pour the excess spheres back into the vial.
7. Place the fixture on a aluminum or other thermally robust substrate in your rework machine. Use a nozzle that is at least 1.5X the dimensions of the fixture. Since the fixture and substrate are much heavier mass that the PCB, a new profile will need to be developed. On the first attempt, slide a thermocouple between the stencil and component The same profile for standard SMT reflow applies (see tin/lead profile below). It usually takes 2-4 attempts to perfect the profile but one perfected, is very repeatable.
8. When the profile is finished the fixture is very hot and very fragile. Let it cool for at least 3 minutes
9. When cooled, rinse the fixture with solvent (or water if using water soluble flux) to break the adhesion of the flux residue to the fixture.
10. Remove the part and inspect your workmanship.

Typical Surface Mount Reflow Profile

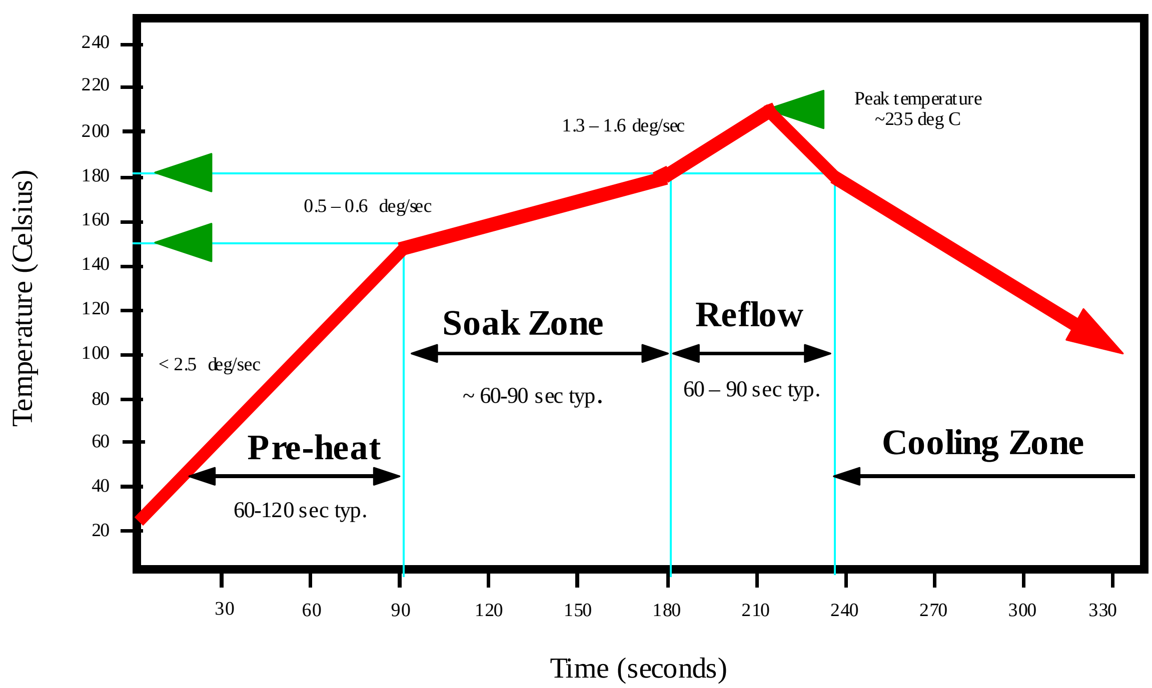

Figure 1 – BGA Assortment

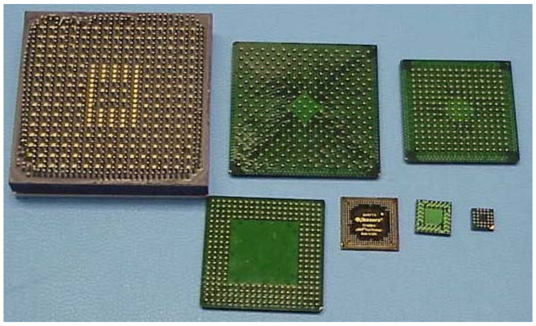

Figure 2 – PBGA solder spheres

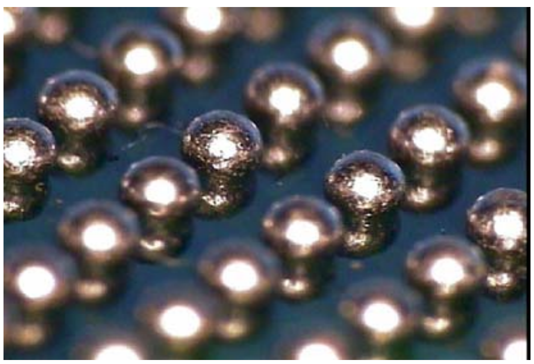

Figure 3 – CBGA solder spheres

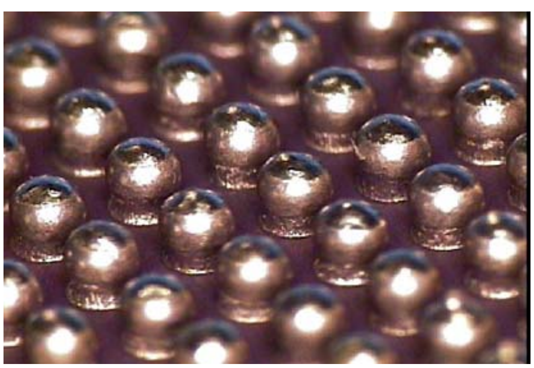

Figure 4 – CCGA columns

Figure 5 – re-balling fixture and solder spheres