Ceramic and Plastic Ball Grid Array Packaging for High Reliability Applications

Ceramic and plastic ball grid array packaging configurations are relatively new to the electronic industry, in particular when applied to high reliability applications. Ball grid array packages over the past few years have been clearly demonstrated to be the package of choice for many digital and RF electronic system designs. Its advantages are numerous both at the design and manufacturing levels and some are presented below:

1. They occupy less space on the circuit card (increases circuit density & reduces hardware size)
2. BGA packaging technology provides the designers with all the I/Os’ they may need to route high density electronic signals
3. Streamlines assembly of high I/O components
4. Robust thermal and mechanical attach to CCA
5. Provides significant cost savings to electronic hardware assembly processes: Reduced CCA assembly time with automation
6. Eliminates need for lead forming tool and eliminates the fear of bending or deforming fine pitch leads during component handling.
7. Eliminates the manual assembly of high I/O count components

Torrance, CA (PRWEB) August 29, 2006 -- When designing ball grid array components for high reliability applications it is very important to first understand the material system that will be used to manufacture the circuit card and electronic components that will be assembled into the desired electronic system. Designers need to be able to balance the material system of these components and circuit cards to reduce the mismatch between the material properties used to manufacture the electronic components. The deltas between these physical material properties should be estimated and dealt with respectively in the design phase. Electronic component manufacturers should therefore consider providing the same electronic component with different interconnecting substrate materials. Some well documented material properties which are commonly used to manufacture PCBs’ and electronic components are listed.

Many different technical issues come to play when designing and manufacturing high reliability ball grid array components. The thermo-mechanical behavior of these components will depend on the physical constants of the materials utilized to fabricate the electronic components.

Therefore, it becomes important to study the interaction of these materials when in contact with each other. These behaviors can be predicted by utilizing computer finite element analysis tools and then by verifying the theoretical predictions by testing actual electronic hardware test articles. EPS performed finite element analyses on BGA electro-magnetic BGA components and the results obtained are summarized herein.

Advantages of Finite Element Analysis:
Locate and Address Locations in Assembly Where Structural Failure Would Occur.
Models Should Be Created For:
Largest and Smallest of Substrate Designs
Multiple Combinations of Materials
Models Run Through Temperature Excursions to Simulate Fabrication and Environmental Testing.

BGA Magnetic Components Are a Complex Assembly of Several Materials:
Ceramic Substrates
Organic Substrates
Exotic Ceramics /SiO2 / GaAs / InP
Epoxies (Cond. / Non-Cond)
Encapsulants / Coatings
Solders / Brazes / Metals
Heat sinking Materials / Tabs
Wire / Ribbon Bonds

Finite element analyses confirmed previously reported findings. The center of the BGA package is the lowest stress area called the Neutral Point. Stress levels are highest in the package corners and along the outside edges. The levels of stress will be directly proportional to the mismatch in the material properties used to fabricate the components & PCBs.'

Electrical circuit performance can also be predicted by utilizing advanced electrical performance simulation models. These tools can be utilized to help determine the design boundaries required to ensure the hardware design will meet required electrical performance specifications. This is particularly important when designing RF circuits for high frequencies. Below we present the results obtained by one of these RF circuit performance simulation tools while varying the CBGA ball diameter to predict the electrical performance above 20GHz.

The finite element analysis and RF circuit performance simulation results require they be submitted through theoretical and actual testing validation processes. The theoretical validation process should entail the fine tuning of material properties in the laboratory and then re-entered into the software models. The actual testing validation process entails actually building electronic hardware and submitting them to accelerated stress inducing tests which enables designers and manufacturing engineers to optimize the designs used for high reliability applications.

Thermo-Mechanical BGA Test Articles:
This validation processes requires that actual electronic test articles be submitted to different types of electrical and thermo-mechanical stress inducing tests. The environmental stress inducing tests utilized were Accelerated Thermal Cycling, Vibration (three axis), Thermal Shock and Highly Accelerated Stress Test (HAST). Typical failure modes were analyzed to understand the interactions between the different materials that compose the BGA packaging configurations. Using Coffin-Manson relationship, exponent of 2.4, 14 year, 25°C on-orbit temperature delta, -40°C to 100°C & 5°C/min, 30 min dwell test range (82 cycles = 1 GEO mission / 409 cycles = 5 GEO missions).

Results of Highly Accelerated Stress Test (HAST) Conditions
High temperature and humidity conditions are Temperature up to 150°C and Relative Humidity up to 95%. Commonly used correlation relates failure time to temperature and relative humidity. But relative humidity is also a function of temperature. Better correlation relates failure time to temperature and water vapor concentration.
Conditions 1 and 2: Same pH20, different temperatures. Determines Ea.
Conditions 2 and 3: Same temperature, different pH20. Determines n.

Failure criteria - material failure of package
Delamination, cracking, pinholes, swelling, etc.
Electrical measurements also taken at each aging test cycle
I-V measurements of input pad protection circuits
Material failure occurred before electrical failure

The Importance and Dangers of Gold in BGA Solder Joints:
CBGAs’ & PBGAs’ Should Be Installed With Complaint Solder Joints so Stresses / Strains produced are relieved During Work Periods / Storage and Meet Mission Life Gold plating on the LGA pad surface is necessary to protect the underlying Nickel layer from passivating prior to ball attach. Gold concentrations > 5% by weight in Sn63 solder joints affects their mechanical performance. Useful conclusions will be drawn from all the test results obtained. Recommendations will also be formulated to help industry designers and electronic component manufacturers successfully design and manufacture electronic ball grid array components. After all, we all are together in this endeavor to advance the electronic packaging technologies to ensure success in performance and reliability. The defense of our nation depends on it.

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