IC Socket – Carrier for Semiconductor Devices in Finished Product

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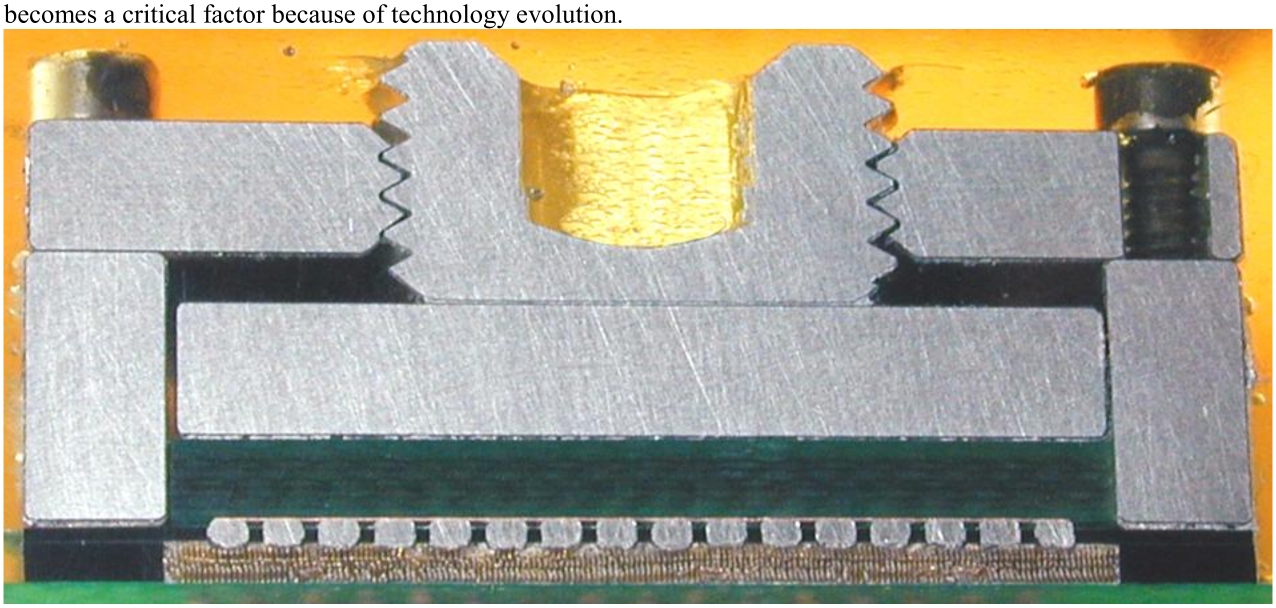
Introduction

Today's electronic packages have high clock speeds (multi GHz range), fine pin densities (below 0.4 mm pitch) and high pin counts (over 2000). When these packages assembled onto a printed circuit board (PCB), they perform certain functions at certain speed. Socketing is one of the avenues to mount IC packages to PCB semi permanently. Socketing these high-speed and high-density IC packages requires an innovative solution to the challenges of designing a socket with shorter signal path (less resistance), good electrical insulation (prevents signal loss), and proper thermal management. Design of the socket is dictated not only by the functions mentioned above, but also by the other parameters such as durability, power consumption, assembly methods and the environment in which the system will operate over its lifetime.

Socket Function

A socket can be defined as an electromechanical device, which provides removable interface between IC package and system circuit board with minimal effect on signal integrity. Removable interface is the major reason for using a socket and it is required for a variety of reasons, including ease of assembly, reworking, upgrading and cost saving. The socket is permanently (soldered) or semi-permanently (solder less) attached to the PCB, while the IC device can be inserted into or removed from the socket without disturbing the connections to the PCB. Socket helps to test, evaluate and inspect the complete product system. Also, socket allows in the field for maintenance, testing, replacement or upgrades. This becomes a critical factor because of technology evolution.



GHz Socket

Ironwood Electronics has developed a GHz socket, which can test IC packages with 0.3mm pitch and above. GHz Socket provides a range of high-speed, high-density socket solutions from very compact production sockets to robust test and prototype applications. A cross-section photograph revealing socket design is shown in Figure 1. The sockets are designed such that force is evenly distributed on the top of the IC pushing the solder balls into a very high speed, Z-axis, elastomer connection medium. Elastomer is the only medium between IC package and the circuit board. A heat sink screw and the socket body provide heat dissipation for the IC in the socket. Precision guides for the IC body and solder balls position the device for perfect connection.

Embedded Wire in Elastomer

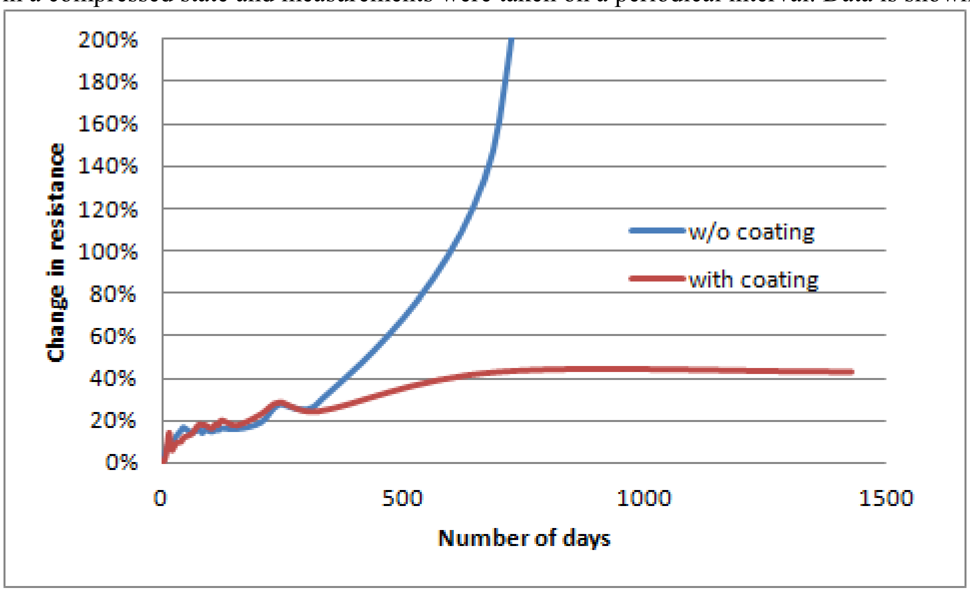
The Z-axis conductive elastomer used in the socket is a low-resistance (<0.01Ω) connector. The elastomer consists of fine pitch matrix (0.05mm x 0.05mm) of gold plated wires (20 micron diameter), which are embedded at a 63-degree angle in a soft insulating sheet of silicone rubber. The insulation resistance between connections with 500V DC is 1000 MΩ. It is ideal for high-current (50mA per filament) applications where a thin, high-density anisotropic connector is required. The gold-plated brass filaments protrude several microns from the top and bottom surfaces of the silicone sheet. The operating temperature range for the elastomer is -35° to 100° C.

Production Socket

A production socket is a carrier for semiconductor device in the finished product that electrically connects IC device to PCB. The main criteria for any production socket are to retain electrical connection between IC device and PCB throughout product lifetime. Biggest hurdle came due to oxidation effect of solder balls/leads of IC device. Because of RoHS considerations, most of solder composition is an alloy of tin, silver and copper with major percentage of tin. This tin reacts with oxygen in the environment and forms tin oxide which is an insulator. This insulator restricts electric current to pass through. Thicker the oxide layer, higher the resistance will be and this causes functional issues in the application of finished product. The protrusion of gold plated brass filaments in the elastomer break the oxide layer and make electrical connection.

Oxidation Experiment

In the field, the devices were not functioning properly around 1 year period when connected through elastomer socket. The devices were removed and the elastomers were cleaned. When re-engaged the device in the socket after cleaning, the system functions properly. It can be concluded that solder oxide starts building up around 1 year and causing the resistance to go up resulting in functional failure of the system. Cleaning is not an option as it disrupts field function. Experiments were conducted with various oxide solvents and a solution was identified. The below experiment describes functioning of elastomer socket without coating and with oxide solvent coating. Two sockets were built with elastomer medium. One of the elastomer was coated with oxide solvent on both sides. Both sockets were assembled on to a daisy chain test PCB. A daisy chain test device was placed inside each socket and compressed to make electrical connection. Contact resistance was measured by connecting the two end of the daisy chains to a multi meter. The test setup was kept in a compressed state and measurements were taken on a periodical interval. Data is shown in Figure 2.



Results and Discussion

In the Figure 2, horizontal axis represents the number of days the socket is in test condition. Vertical axis shows change in contact resistance represented by %. It can be seen that during the initial period of 1 year, contact resistance changes around 20% in both sockets. After a year, socket without coating shoots up in resistance. This is due to the excess build up of tin oxide which is an insulator that restricts electric current to pass through. Whereas the socket with coating maintains resistance throughout 1500 days. More experiments were planned to verify the repeatability.

Conclusion

A primary concern to anyone utilizing the high density micro BGA is that the socket must provide electrical connection with low and stable value of resistance throughout its lifetime. GHz Sockets solve such concerns and provide unmatched solution for high-speed, high-density, high pin count application needs using special coating process. The test results share the stability of the contact interface throughout a period of 5 years. The simple design of the socket makes it cost efficient and allows assembly to the target board using existing hardware. A unique feature of this socket is its separable components that can be easily replaced and reused.

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