Role of Sockets in IC Product Life Cycle

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Introduction:

For over half a century, the semiconductor industry has been governed by a commonly known principle described as Moore's Law. This "law" predicts that through technological advancement a doubling of the number of transistors per integrated circuit will occur within a given geometric area on regular 18 month intervals. The realization of this doubling effect over time has resulted in an ever-widening range of semiconductor (IC) devices exhibiting increases in functionality and processing speed combined with an increased demand for power and effective thermal management. This doubling effect has also driven a matching rapid evolution in IC package types and I/O interface configurations. Typical IC starts with concept/prototype phase, moves to design validation phase, leaps into application development phase, rides into production phase and ends with upgrade/replacement phase (Figure 1). During these phases innovative interconnects have kept pace with the rapid evolution in semiconductor technology. IC sockets have been developed for a complete range of performance requirements and I/O configurations for each of those phases. This article will describe form, fit and function of IC sockets requirement in each of those phases.

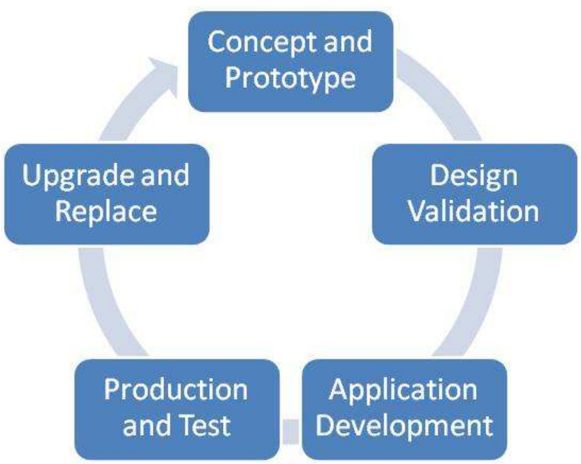

Figure 1 – Five stage IC product life-cycles

Concept/Prototype Phase:

The important step in this phase is to verify whether the prototype functions as per the design intent. Since there can be revisions to the IC, an IC socket in the development board helps to avoid solder/de-solder routine of the precious device. The IC socket plays a major role in determining whether the device met design intent or not. Because of these criteria, the IC socket has to be carefully selected. The number one factor is bandwidth. Because the IC has to perform certain functions at specific speed, the signal loss has to be minimal. Since additional socket interface is introduced in the signal loop, either the socket has to have sufficient bandwidth to pass signal without insertion/return losses or the socket specifics has to be de-embedded in the functional verification. Since it is very complex to de-embed specific parameter, safer solution is to find a socket with higher bandwidth. Next to bandwidth, DC series resistance plays important role. Socket technology that can provide low and consistent contact resistance is preferable to avoid false failures. The next factor is current carrying capability. An image sensor may require a low current such as 100mA to 200mA per ball whereas a power management device may require 3A to 5A per ball. Socket contact technology that accommodates this requirement has to be selected properly. The next critical factor is contact technology compliance. Because the devices have wide co-planarity, the contact technology chosen has to accommodate the flatness variations. One more factor plays significant role in prototype stage is temperature requirement. Various socket contact technologies available for this market include embedded wire-on elastomers, plated flex circuit capped elastomers, diamond particle interconnects (Figure 2), stamped contacts, spring contacts, hybrid contacts and other variations. Also socket features such as small footprint, easy chip replacement, easy mounting methodology, moving socket from board-to-board and low cost are must for this market.

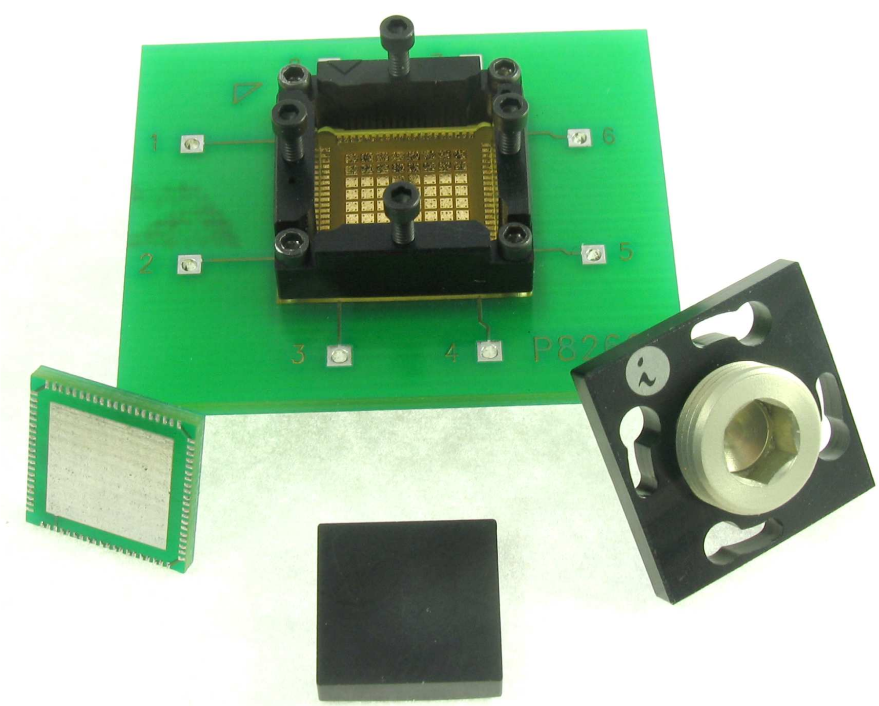

Figure 2 – 40GHz, Small footprint, Diamond particle interconnect socket

Design Validation Phase:
In this phase, a typical IC goes through many kinds of environmental tests. Typical tests include thermal shock, temperature cycling, humidity exposure, vibration test, salt spray and other tests based end usage. Validation is required to verify whether IC performs in all environments. Socket contact requirements such as air tight connection (low and consistent contact resistance), repeated cycles, temperature extremes, wear, cleaning plays top role. Socket features which are used in prototype stage are not relevant for this validation stage. In this stage, robust lid, tight latching, permanent mounting and extremely low cost because of one time usage are factors that satisfies this market.

Application Development Phase:
Now that IC function was proved and it is capable of withstanding end user environments, the next step is to develop application software for the IC. Sockets that are used in prototype stage will satisfy the requirements of application development stage as the need is to simply swap devices during the software development process. Since the performance is verified by executing software routines, the socket contact technology should accommodate high bandwidth, low signal loss, low contact resistance and appropriate current flow capability. Since the devices are not swapped frequently, socket lids can be screw mounted as opposed to easy open latch to reduce overall cost of test.

Production Phase:
This is a key stage of any IC's life. After verification and development, customer agrees to buy those ICs in millions. When the ICs are fabricated, it needs to be tested before shipped to customer. Various tests such as burn-in, functional, fuse test, failure analysis, etc happens in this production phase. All ICs go through burn-in and functional test. A typical ICs life is exemplified by bath tub curve. Because of inherent nature of IC manufacturing processes, few percentage of ICs fail very early in their life and the failure is very minimal during its life time and then failure percentage goes up at end of their life. Burn-in tests are conducted to screen those early failures. Typical burn-in test includes testing IC device at 125C for 8 hrs. If the IC passes this test which means it is ready for primetime. Typical socket requirements are high temperature and high insertion/extraction cycles. Since millions of manufactured ICs go through this burn-in test, more sockets are needed which drives the cost to extremely low. Socket technology using molded housing and low cost stamped contact satisfies burn-in test market

After passing burn-in test, these ICs go through functional test which is often called production test. Since function is verified at this stage, bandwidth and current capacity requirements ranked high. Since millions of devices are being tested, higher the insertion/extraction cycle count, lower the overall cost of test. Spring pin sockets (Figure 3) dominate this production test market.

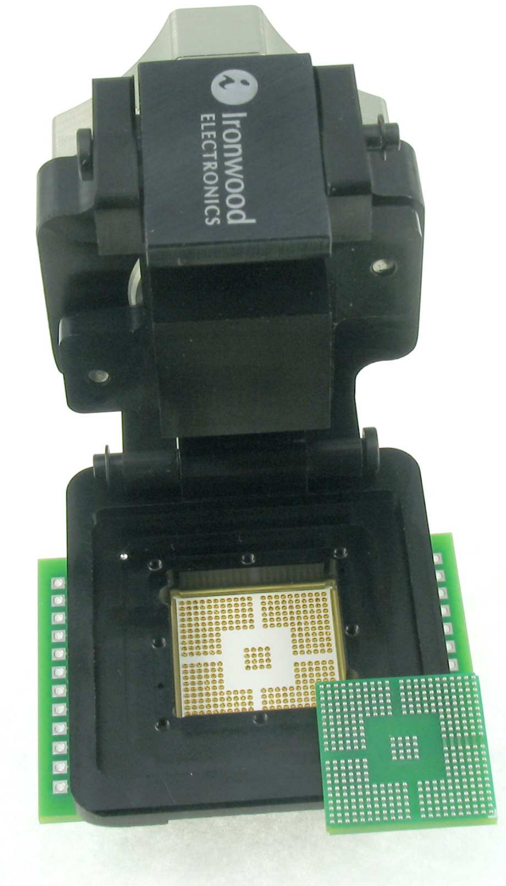

Figure 3 – 500K cycle, High endurance spring pin socket with removable clamshell lid

<u>Upgrade/Field Replacement Phase:</u>

After production test, the devices either soldered to the board or sometimes placed inside the socket for replacement with future IC that has upgraded functions. These sockets are very similar to validation stage sockets which are more robust with few insertion/extraction requirements and costs fraction of a dollar in volume. Sockets (Figure 4) made out of FR4 with screw machined contacts are prevalent for this market.

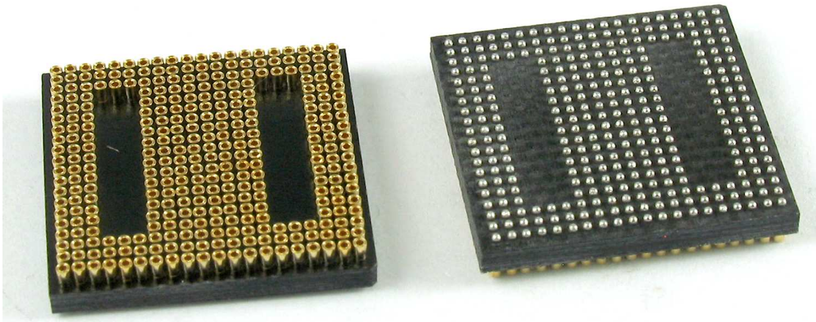

Figure 4 – Low cost field upgrade socket

Conclusion:

A single contact technology cannot satisfy all requirements for IC verification throughout its life cycle. Selecting a socket that has replaceable modules of different contact technologies to accommodate all the test requirements of IC life cycle is a fruitful solution. Socket footprint defines component proximity to IC. Series resistors, capacitors, tuning inductors and others need to be placed minimal distance from IC in GHz applications. Socket footprint is important in Concept/Prototype, Design Validation, Application Development and Upgrade/Field Replacement phases if the bandwidth requirements are in GHz range. Also socket footprint standardization will pave way for overall low cost of test per IC life cycle.

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