IC Interconnects for the Life of Your Product

Background:
For over 40 years 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 devices (or gates) 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 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. PC board level processing, with the related interconnection components in the form of IC sockets and adapters, has simultaneously been developed to meet the needs of manufacturers and end-users alike.

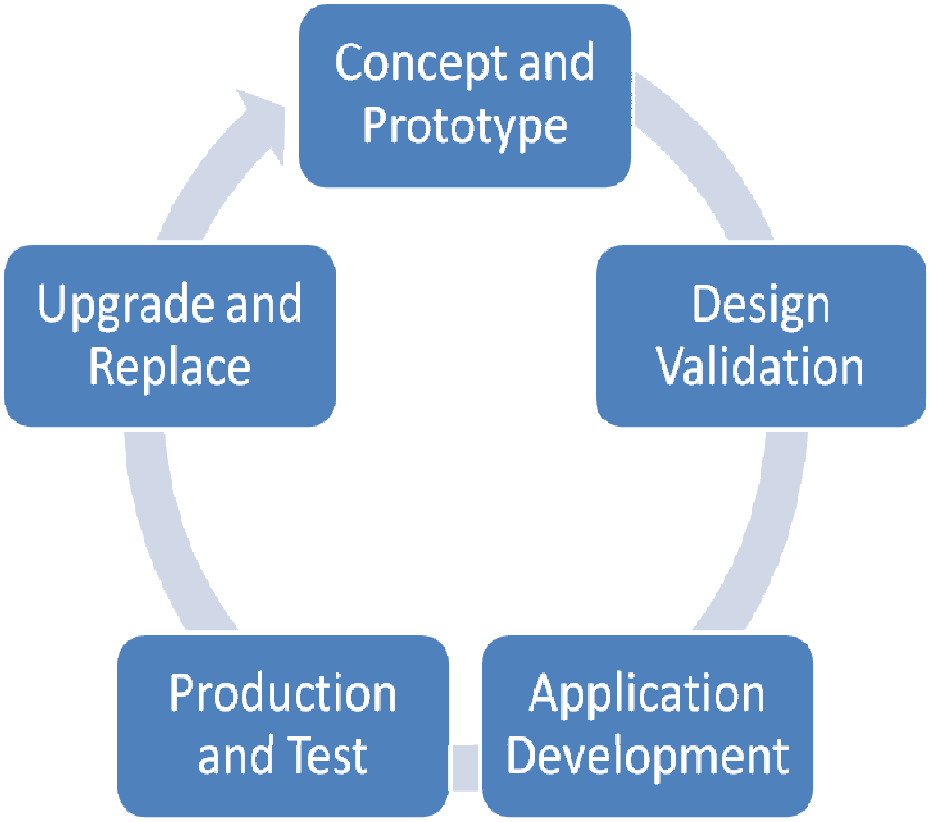
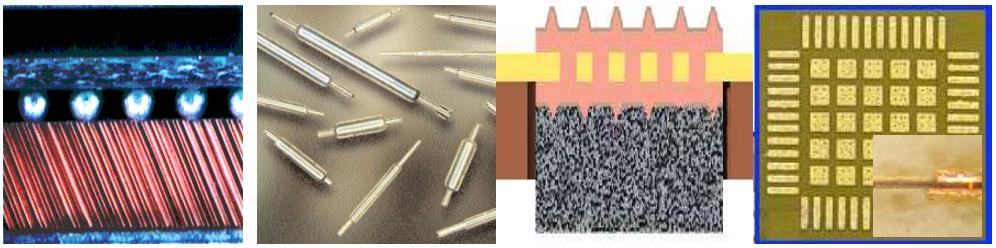


Figure 1 – Five stage IC product life-cycles

Throughout this period of time intra and inter-board level interconnects have developed concurrently to provide the necessary functionality for product development and end-user product applications. Beginning with the design phase, and ending with the design replacement or end-of-life phase (Fig. 1), these 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 (Fig. 2). Specialized adapters have followed suit in terms of meeting the needs for prototyping, programming, testing, production, and product replacement applications (Fig. 3).



Characteristics *	SG Elastomer	Pogo Pin	XG Elastomer	Diamond Particle
Bandwidth, *GHz*	8 to10	6 to 12	40	40
Endurance, *Cycles*	2K	500K	10K	100K
Resistance, *mOhm*	20	50	50	3
Self Inductance, *nH*	0.15	1.1	0.11	0.11
Max Current, *Amp*	2	5	5	5
Temp Range, *ºC*	-35 to 100	-40 to 150	-40 to 100	-70 to 200
Pitch, *mm*	0.3 to 1.27	0.3 to 1.27	0.25 to 1.27	0.4 to 0.8
Package Types	BGA, QFN, QFP	BGA,QFN,QFP,LGA	BGA,QFN,LGA	QFN,LGA
Relative Cost	Lowest	Highest	Middle	Middle
Lab Test	X	X	X	X
Production Test		X	X	X
Field Upgrade	X			
Temperature Test	X	X	X	X
Kelvin Test	X	X	X	X
Burn-in Test		X		X

Figure 2 – Range of IC sockets in terms of I/O count, spacing, and frequency with pictures

Market Trends:

Beginning in the year 2000 a noticeable shift in market driving forces began to occur. The quest for higher and higher performance was often replaced by a need for lower and lower cost as semiconductor products spread into a widening range of new products across most major market segments. As this useable performance level began to peak, the need for reduced power capabilities continued to grow as battery life became more and more of a defining limitation on use. At the present time we discover that many markets are adequately served in term of performance, but many still are pressing for smaller and smaller devices capable of operating at lower and lower power levels with higher levels of functional integration. Coincident with this need for lower power is the growing need for flexibility in product design capability due to the high investment costs for new IC fabrication facilities and the limits this places upon new product development and eventual speed to market.

Technology Trends:

The above-mentioned need for greater design flexibility, reduced power consumption, and shortened product introduction cycles have driven the major shift in IC technology we see today. This combination of market trends has required the development of semiconductor devices with increased functionality along with the ability to program in place based on intended use. This software flexibility has in many cases eliminated the need to commit

dedicated hardware to defined functions. Both System-on-chip (SOC) technology and Programmable Logic Device (PLD) technology are examples of shifts which have occurred in response to important market needs. Field Programmable Gate Array (FPGA) technology has risen to the forefront with its ability to fill additional needs and is anticipated to grow significantly over the next several years as advances in technology take hold and more and more programmable devices replace those that are created for specific applications.

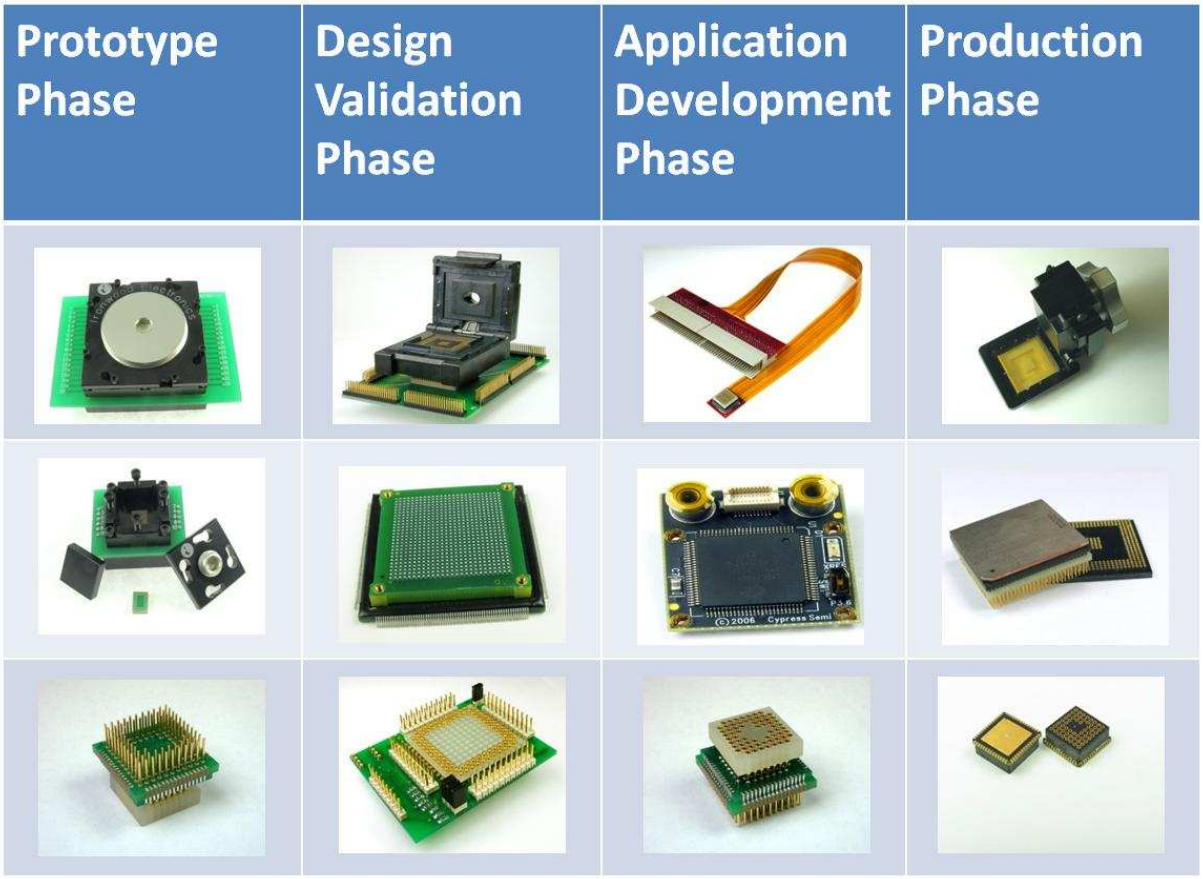


Figure 3 – Pictures of selective adapters for prototype, design validation, IC replacement and production applications.

<u>Board–level Interconnect Technology:</u>

Board-level interconnect technology has continued to evolve in response to the aforementioned market and technology trends. (See Table 1) From a mechanical perspective both sockets and adapters have demonstrated increasingly dense patterns with greater variability in I/O configurations. Finer pitch interconnects with a variety of both standardized and custom configurations have become the norm. From an electrical perspective demands leading to improved impedance control and frequency response at reduced geometries have driven the development of new interconnect solutions. Working partnerships with IC manufacturers have been strengthened beginning with prototype development and continuing through the design verification and product application phases of new product introduction. This partnership commitment has continued into specific product requirements for end-user applications where flexibility in design and future upgradeability are the expectation and the

need. Turnkey solutions are now available to both reduce cost and improve time to market where standard sockets and adapters are unable to meet unique customer specific requirements. Cost effective IC sockets and adapters for production and end-of-life IC continue to gain in importance.

New Technologies for the Life of Your Product:

What is in store for the IC interconnect products of the future? Since these products evolve in response to the needs of the market, interconnect technology will evolve in close partnership with IC manufacturers and end-users alike. Novel sockets and adapters that enable quick replacement of IC's for product upgrades or reconfigurations will be required. Ever-increasing requirements for speed to market will place a premium on rapid response of custom turn-key solutions. The integration of new materials into the IC manufacturing process will bring significant change. One such change will occur in the demand for thermal management and the importance of sockets and adapters capable of providing temperature control with new thermal compensation methods. Another need will be for prototyping sockets with the ability to operate at higher temperatures. As performance once-again increases in relative priority new package types with integral heat sinking and unique I/O configurations will need to be accommodated throughout the life of the product.

Conclusion:

For many years IC interconnect technology has kept pace with major changes in the industries that it serves. Solutions for the effective utilization of semiconductors from the design and prototype phase through end-of-life and product replacement phases have been developed in partnership with IC manufacturers and end-users alike. This capability will be enhanced into the future to meet the needs of the growing number of semiconductor applications. As unimagined new ways appear for the utilization of semiconductors, IC interconnection technology can be counted on to be available for the life of your product.