Achieving a 75GHz test socket

By Ila Pal [Ironwood Electronics]

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 (IC) will occur within a given geometric area at regular 18-24 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. Typical ICs are tested using sockets and the current testing needs exceed 70GHz performance. This article will describe an IC socket contact technology that can reach 75GHz performance without compromising other electrical and mechanical requirements of typical IC applications.

Socket function

Testing can be classified into two categories: IC-level and system-level. IC-level testing involves evaluating the life and performance of IC devices such as microprocessors, ASICs, and chipsets. System-level testing involves evaluating the functional application of those devices under different environments. Both kinds of testing need different sets of criteria for validating the final product. The function of a socket is to provide a connection mechanism from the IC to the circuit board with as little electrical load as possible. This allows the IC to function as it is soldered into the PCB (printed circuit board) but can be replaced by another IC to upgrade or test multiple ICs. **Figure 1** shows a typical BGA socket mounted on a test board.

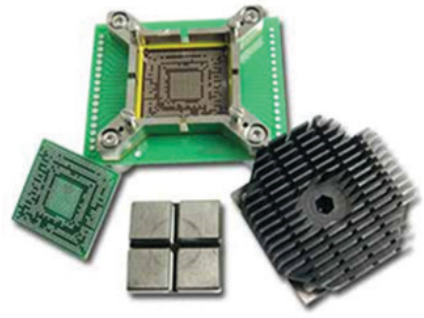

Figure 1: A 75GHz BGA socket with a heat sink.

A 75GHz elastomer socket (GT)

Ironwood Electronics has developed a sequel to the standard GHz socket that can test IC packages up to 75GHz. GT elastomer provides a range of high-speed, high-density socket solutions from very compact production sockets to robust test and prototype applications. A magnified photograph revealing a GT contact is shown in **Figure 2**. The sockets are designed such that the force is evenly distributed on the top of the IC thereby pushing the solder balls into elastomer buttons with a silver particle. GT contact technology has 2-3μm silver particles held together by a proprietary conductive formulation. These conductive buttons (the diameter is optimized for a 50 ohm impedance) are suspended in a non-conductive polyimide substrate for enhanced durability and reliable performance over time, temperature and cycles. The elastomer is the only medium between the IC package and the circuit board. Precision guides for the IC body and solder balls position the device on the elastomer for a good connection.

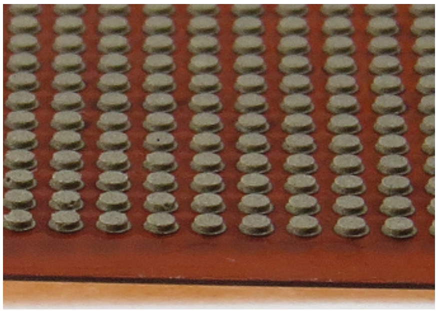

Figure 2: An elastomer contact showing silver buttons for interconnecting individual IC pins.

Electrical characterization

Electrical requirements are generally stated in terms of the bandwidth. Measuring bandwidth determines if this contact technology is right for particular test application that requires performance at a specified frequency. Bandwidth is typically specified in terms of insertion and return loss. Because the commonly available network analyzers can handle up to 40GHz only, CST microwave studio software was used to simulate electrical performance. The silver button with polyimide substrate was modeled. Key input values include silver button conductivity and polyimide dielectric loss. A signal is sent from port 1 (top of the contact) and received at port 2 (bottom of the contact). Signal reflections are measured and reported as S21 curves shown in **Figure 3**.

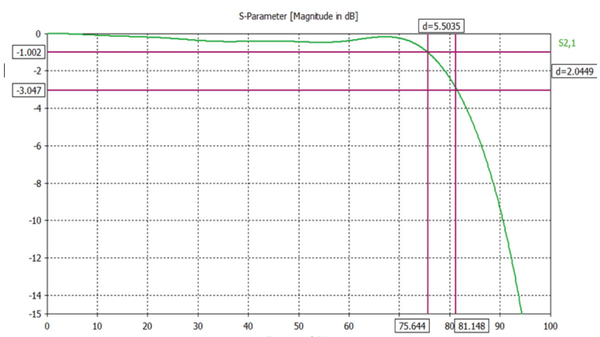

Figure 3: S-parameter curve showing frequency on the x-axis and signal loss in terms of decibels on the Y-axis.

An insertion loss of -1dB @ 75GHz is interpreted as 90% of the signal passed through the interconnect medium and only 10% of the signal was lost through the interconnect transition at 75GHz. This is very critical for the test engineer because the IC functionality is being verified at this specific frequency.

Mechanical characterization

Removable interface requirements are generally stated in terms of the insertion/extraction force and number of insertion/extraction cycles a socket can support without degradation. Insertion/extraction forces become increasingly important as the pin count of the device increases, as well as the more delicate the ICs become. The mechanical test described below examines the relationship among the deflection of the contact, the force, and the contact resistance.

A displacement force (DF) test station was used to measure the contact deflection and its corresponding force. Force increases linearly as the displacement increases. Similarly, the contact resistance decreases as the force increases. Stable contact resistance has to be identified based on the minimum force required. A desired displacement has to be identified based on the compliance requirement of each device/application. This information is very important for the test engineer to establish failure criteria when performing device tests using this contact technology. **Figure 4** shows force vs. deflection vs. resistance of the elastomer contact.

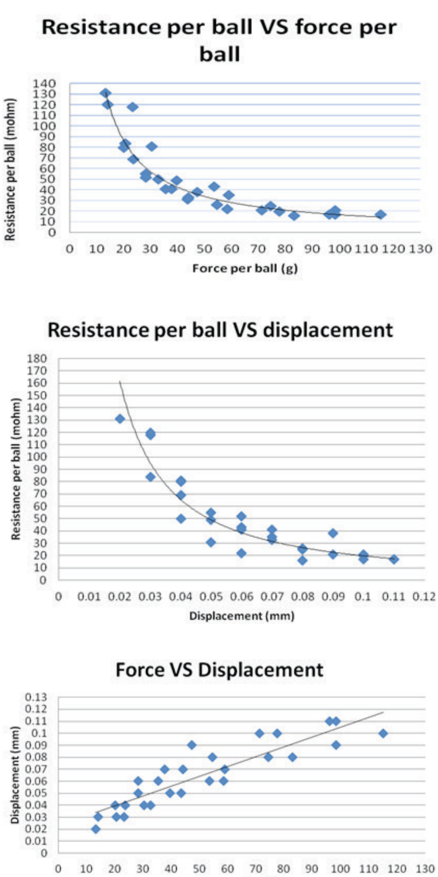

Figure 4: Force deflection resistance curve for GT elastomer contact.

From the resistance vs. force graph, it can be seen that in order to achieve a 30mOhms contact resistance, the force needed is 50g per pin. From the resistance vs. deflection graph, it can be seen that in order to achieve a 30mOhms contact resistance, the deflection needed is 0.065mm. From the force vs. deflection graph, it can be seen that a force of 50g per pin causes a deflection of 0.065mm. A test engineer uses these values to determine if the particular contact is suitable for IC testing.

Summary

A single contact technology cannot satisfy all requirements for IC testing throughout its life cycle. The GT elastomer contact has a bandwidth of 75GHz, but the required force of 50g per pin may not be suitable for thin wafer-level packages. The new contact technology has a wide operating temperature range from -55C to +160C, however, it is suitable for low endurance testing because the suspension elastomer contact is rated for 1000 cycles. A primary concern for anyone utilizing high-speed ICs is that the socket must provide a high bandwidth. GT elastomer sockets solve such concerns and provide a solution for high-speed, high-density, high pin count application needs. The test results share the electrical and mechanical characteristics of the contact interface. The simple design of the socket makes it cost efficient and allows assembly to the target board using existing hardware. This socket also has separable components that can be easily replaced and reused.

Biography

Ila Pal received his MS in Mechanical Engineering from Iowa State U., MBA from U. of St. Thomas, and is Chief Operating Officer at Ironwood Electronics; email ila@ironwoodelectronics.com