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Test Socket Industry Faces Issues Scaling Below 0.4 mm Pitch

Shrinking package pitch sizes and higher pin counts are among the many factors forcing the test socket industry to consider new approaches below a 0.4 mm pitch.

Sally Cole Johnson, Contributing Editor -- Semiconductor International, 8/4/2008 8:05:00 AM

WEEKLY TOP5

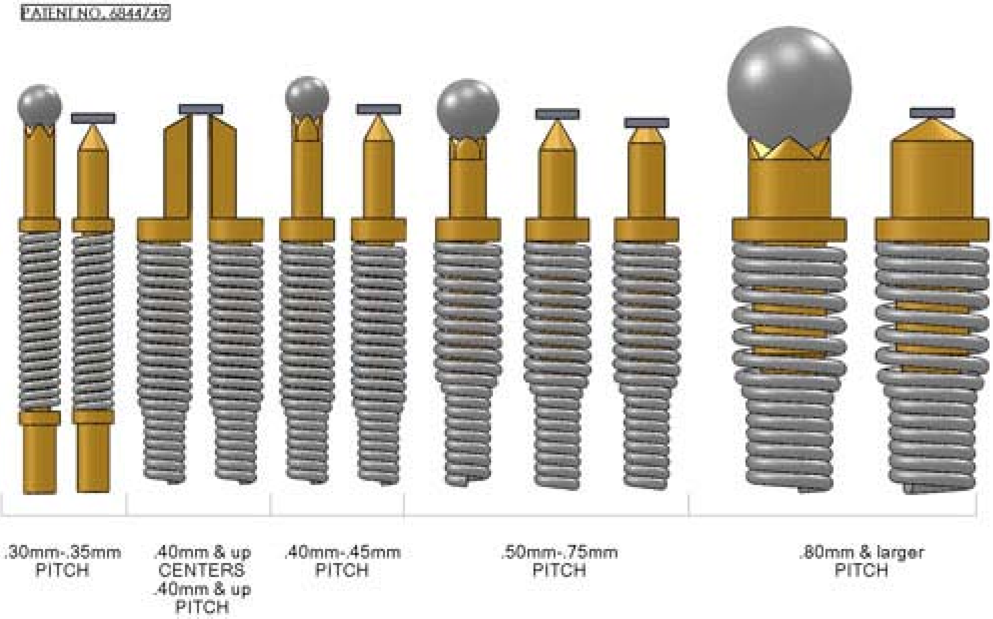
The test socket industry is encountering both electrical and mechanical issues as package pitch sizes shrink below 0.4 mm. The major challenges include increased package size, which means more I/O to test. Add RF testing requirements, and signal integrity issues enter the mix. It appears that new materials, designs and contacting technologies are necessary for test sockets to continue scaling to tighter pitches.

As a point of reference, **test sockets contacts are now smaller than the lead found in a mechanical pencil**, which is typically 0.5 mm (Fig. 1). Spring pins used in 0.4 mm test sockets are about half that diameter. Even more amazing is that these spring pins are assembled by hand.

1. Test sockets will face many challenges moving to pitches tighter than 0.4 mm. (Source: Antares Advanced Test Technologies)

Right now, the test socket market is being driven at a much faster pace than in the past from mechanical and electrical perspectives — in terms of form factor, pitch, high-speed and RF drivers. “Mechanical packages are shrinking rapidly as the electrical needs are increasing much faster, which puts tremendous pressure on test socket suppliers to develop new technologies,” noted Ila Pal, engineering manager at **Antares Advanced Test Technologies** (Vancouver, Wash.). “Shrinking from 1.0 mm pitch to 0.5 mm was easily scalable, but that’s not the case moving from 0.5 mm down to 0.3 or 0.2 mm pitch. That’s one of the biggest challenges facing the test socket industry right now — we need to look at new technologies.”

The trend toward tighter pitches is one **Aries Electronics Inc.** (Bristol, Penn.) is also responding to. Its customers are requesting test sockets not only for ball grid array (BGA) devices, but also other surface-mount-type devices, on increasingly smaller pitches. “We offer five different outer shell housings, with **pin pitch options ranging from 0.8 mm to 0.3 mm** (Fig. 2). These housings consist of a frame for the base, hood and pressure pad — all with different closing mechanisms. All that's missing are the 'guts' of the socket — the middle part designed to accommodate the specific device for the customer," said Frank Folmsbee, Aries' national sales manager. The guts of the socket consist of an interposer set, which is drilled to the footprint of the device, then a male probe and the female spring are fitted into these holes.



2. This is an example of spring probe outer shell housings available in a variety of pitches. (Source: Aries Electronics Inc.)

While demand for a 0.2 mm pitch hasn't begun yet, 0.4 mm is becoming increasingly common and the test socket industry is already seeing signs of a slow migration to 0.3 mm. "Both 0.3 mm and 0.2 mm are still in the initial stages of prototype testing; there isn't a high volume driving those packages yet," Pal said. "We have a robust solution for 0.4 mm, but we can't scale that same technology down to 0.3 mm and expect the same performance as 0.5 mm. Our 0.25 mm solution is in the prototype stage."

One of the greatest challenges associated with pitch decreasing and 0.4 mm becoming more mainstream is that the package size is actually growing larger than initially anticipated, according to James Forster, CTO at Antares. "It was originally thought that packaging sizes for 0.4 mm would be 12 or 14 mm square, but now they're going up to 24 to 25 mm square," he explained. "This means a lot of I/O in a very small space, which creates challenges for test and burn-in socket suppliers. As the pitch gets finer, the available space for the springs and contact tips is less. One solution that's gaining ground is the use of elastomers, which have Z-axis conductivity. Some are not pitch-specific and there is no pre-load, meaning that the mechanical strength to hold the contacts is a non-issue with elastomer sockets. There is, however, some concern about the reliability and lifespan of elastomers in a production handler, as well as concerns about the materials at higher test temperatures."

Another challenge is that the move to 0.2 mm will likely require new contacting technologies. There are methods to contact at 0.2 mm, but not at the expected frequencies or cost point, Forster pointed out. "For example, flip-chip devices with pitches of 0.2 mm are routinely tested today. I think we're going to see a merging of the kinds of technologies used at probe with the kinds of technologies that are used for test," he added. "How we'll see those come together for wafer scale and wafer-level chip-scale packages is uncertain. But certainly some of those technologies are available now, and some companies who build membrane probes are supplying solutions for test at 0.2 mm. The problem is that the cost on a per socket basis is orders of magnitude too high."

Aries has a test socket design for 0.2 mm, according to Folmsbee. While not able to divulge any proprietary details, he acknowledged that it will involve a different type of spring altogether and the socket will hopefully be ready to introduce next year.

Other issues

Because of the European Union's RoHS lead-free regulation, materials are now an issue for test sockets. "A challenge here is that package manufacturers optimized lead-free from an assembly perspective, which is what they should have done," Pal explained.

“But the major step that happens prior to assembly is testing the packages with test sockets. The packages aren’t optimized for test, so we’re encountering lots of issues here. Packages that are optimized for assembly behave completely different in the test industry.”

Packages with high pin counts (4000-5000) are also an issue because the existing test socket material isn’t able to withstand the force and stress being applied, according to Pal. “It’s a big challenge for the test socket and is driving materials suppliers to do innovative things such as embedding nanotubes inside their materials to add strength,” he said. “Obviously a thin socket is desirable, but it needs to be able to withstand 4000 to 5000 pins without deflecting. For a plastic to do that, more innovation will be required.”

Electrical changes ahead? Forster believes that will be signal integrity. “I think we’ll see some coaxial-type sockets or sockets that use innovative ways to bring in some of these high-frequency signals,” he elaborated. “We’ve seen new packaging types, and testing of some PoPs requires socket suppliers to build sockets that can contact not only the bottom of the package, but also the top. That’s challenging us a bit. And if a requirement to test at higher frequencies emerges, it will add another element of design to think about.”

And last, but not least, power problems. As the I/O pitch decreases on a socket and the chip voltage decreases and total functionality increases, a power problem emerges. “We’re already experiencing power problems and this means smaller contact systems must handle higher powers than in the past,” Forster said. “There are two opposing requirements — smaller pitch and increasing power. The cross-sectional area of the contact is smaller due to the smaller space available, but it must carry more current. The only way to carry more current is to increase that cross-sectional area, not decrease it. Now we get into the problem of I^2R heating, the additional thermal load due to self-heating of the contact, and that’s a challenge. To address this, chip designers are putting in more pins to carry the current in and out. And the socket people are looking at different ways of doing what we do today. If it’s a peripheral leaded device, we can easily go to 0.4 mm, and because we have the space around the edge of the package, we have the benefit of being able to make the contact fairly substantial. With an area array package, such as a BGA or a multi-row QFN, getting all that power in can be a challenge.”

Because devices are doing more today, they’re consuming more power. “This generates more heat during the test and that thermal load must not only be monitored, it must now be controlled,” Forster said. “We’re seeing temperature monitoring, sensing and controlling of the test board or tester and the use of thermal control units to maintain the temperature of the device under test at a specific temperature.”

The next few years should be interesting ones for the test socket industry, with plenty of innovation ahead, as new packages are introduced and pitch scaling continues.

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