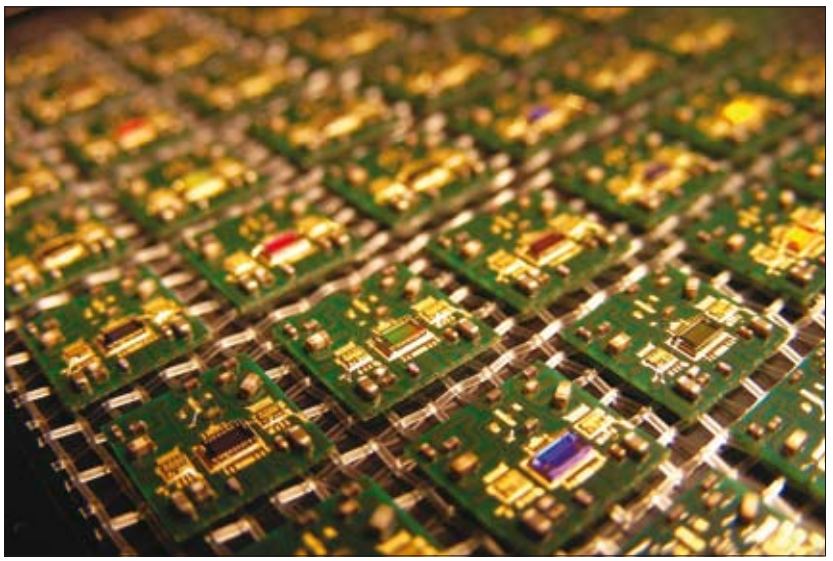
GaAs MANUFACTURING

PA makers seek module standard

JEDEC standards offer the assurance that high-volume electronics manufacturers are producing quality goods, but they are not all well suited to RF chips. **Andy Extance** learns how the GaAs industry plans to resolve its qualification issues.



Laminate modules – like these TriQuint GSM PAs, shown without plastic overmolding – and the GaAs chips used in them are stressed more than intended in tests developed for silicon devices.

Not all semiconductor components are created equal. The III-V niche typically benefits greatly from processes and products developed initially for larger-scale silicon manufacturing. However, the differences between the two are not limited to the differences in chip volumes produced.

This much is clear when considering the varying functions that III-V and silicon die perform. That fact is masked because, once the whole manufacturing process is complete, one semiconductor package looks much like another. When it comes to testing the final packages, this appearance has proven to be a reasonably reliable guide. Consequently, testing standards devised for silicon have been transposed to compounds, and consumer electronics manufacturers often use them to assure the suitability of semiconductor modules for their products. Members of the GaAs manufacturing community are now questioning the wisdom of following this approach.

The mechanism through which this quiet transformation is occurring is JEDEC. JEDEC was incorporated in 1999 as an independent association from its previous existence as the Joint Electron Devices Engineering Council of the US Electronic Industries Association. With headquarters in Arlington, VA, the organization provides a forum in which the world's leading semiconductor manufacturers work together to develop open industry standards across a wide range of sectors covered by JEDEC's committees. Formed from volunteer participants in the industry, it's JEDEC's JC-14.7 subcommittee for GaAs reliability and quality standards that's looking after the interests of cell phone power amplifier (PA) manufacturers and related organizations.

"If you talk to the phone manufacturers, they do have specific requirements for reliability," explained Bill Roesch, fellow for reliability science at GaAs manufacturer TriQuint Semiconductor and member of the JC-14.7 subcommittee. The lack of dedicated standards means that GaAs manufacturers can find themselves tackling different testing challenges at different customers, Roesch explains. "The people at RFMD and Skyworks have suggested that we do need our own standard because so many of the users of laminate-based modules have different qualification requirements. They'd like some standardization."

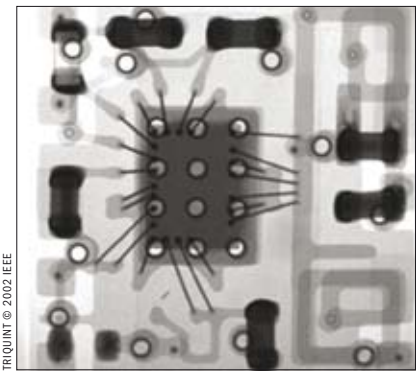
In October 2008, at the Compound Semiconductor Integrated Circuit Symposium in Monterey, CA, Roesch drew up a list of about 20 reliability testing issues particular to GaAs laminate modules. There, members of the PA-making community voted on which they saw as most critical to develop standards for. "We had votes from M/A-Com, RFMD, Freescale and TriQuint, and the one that came out as the most important was acceleration factors," Roesch said.

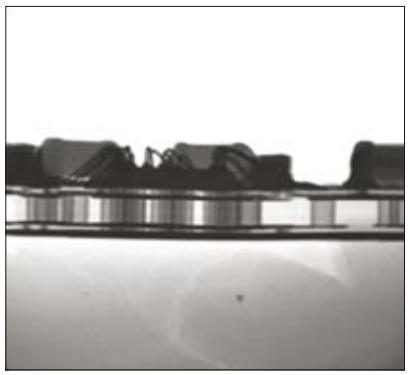
In semiconductor reliability testing, it is common to stress packaged chips at 85 ºC and 85% relative humidity, where they would be expected to survive 1000 hours under bias before being passed for use in subsequent manufacturing. An increasingly popular approach called HAST – highly accelerated stress testing – reduces this to just 96 hours by raising the temperature to 130 ºC.

"It's 10 times faster, but that acceleration is based on silicon devices," explained Roesch. "What we've found is that for compound semiconductors the acceleration is much higher. So, a 96 hour HAST test is actually much harder on our devices than it is on a silicon device because of the different failure mechanisms."

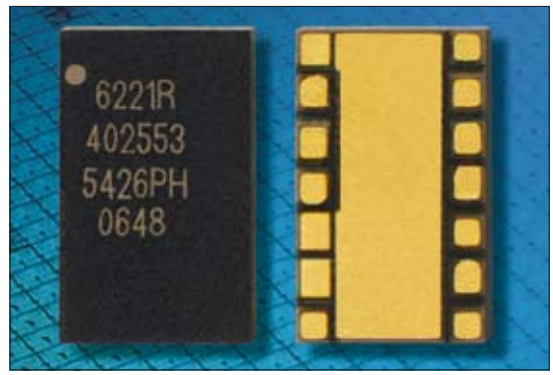
The laminate modules into which PAs are packaged are also generally specific to the GaAs industry. Some members of JC-14.7 believe that these may also respond differently under HAST conditions – via delamination, for example – than the chip packages that the test standard was designed for.

A second area of concern surrounds RF testing. The unique RF capability of GaAs is central to its importance in cell phones, so it's perhaps unsurprising that silicon standards do not measure up. In fact, although a reliability testing standard that passes a digital signal through a chip exists, there isn't one





A typical overmolded laminate module contains at least one GaAs die and support circuitry, which normally includes passive components like resistors, capacitors and inductors.



Anadigics' wideband CDMA/HSPA PA is a typical example of the laminate modules that JEDEC is developing a standard for.

for RF signals. "There really is no standard to say what that should be," said Roesch. "What frequency should it be? Should it be sine wave, should it try to simulate the actual phone signals, should we put the device in 1 dB compression or 3 dB?"

Finally, the industry representatives who gathered in Monterey specified that any new standard should take into account failure mechanisms occurring only in compound semiconductors, although at this point these are not precisely defined.

Roesch is now charged with producing an early draft standard for the three key issues that emerged in Monterey. That draft will then be up for discussion at the 2009 International Conference on Compound Semiconductor Manufacturing Technology – better known as CS Mantech. While much of the industry is already represented, Roesch says that he would welcome additional input prior to or indeed during that event, to be held on May 18–21 in Tampa, FL. "We would definitely like to have input from everybody that's building PA modules," he said.

Specified advantages

The ultimate aim of developing this standard is to provide tests assuring cell phone manufacturers that the GaAs chips will work for long enough. Having one such hurdle specify that all PA modules must clear before use would be a big advantage to the chipmakers, says Peter Ersland, JC-14.7 chair.

"It allows us to bring to our potential customers a prescribed set of tests used to assure the quality and reliability of the products that we're selling," said Ersland, who is also a senior principal engineer at M/A-Com Technology Solutions. "A second benefit is that it allows the customers an easier way to see how products compare. If we have a set of standards that all GaAs manufacturers are expected to comply with, then you can compare across companies more easily."

Before any such qualification can be used, chipmakers must determine how long a typical product that passes the test can be expected to continue operating for. This initial mean-time-to-failure – or "life" – test for compound semiconductors must also take their individual properties into account. To date this is what JC-14.7 has been responsible for developing and administering, with a standard known as JEP-118.

"GaAs technologies have a set of failure mechanisms that may be unique when compared with other semiconductor technologies," Ersland said. "To identify how those mechanisms are going to evolve over the life of a product, in many cases we need a slightly different set of tests than most of the silicon industry." The aim of this life test is to work out how an individual product fails and whether or not it has been operating for sufficiently long when it does so.

"If you think about GaN, right now they're in that mode of trying to make sure that the devices will actually last for a reasonable length of time," explained Roesch. "Most of their work is a life test to find out what fails and how long it would last. With new technologies that's usually shorter than what people would want."

> **"We would definitely like to have input from everybody that's building PA modules."**
> **Bill Roesch**

The new qualification standard that Ersland and Roesch are trying to develop would come into play when the JEP-118 life tests have been performed extensively, yielding a mature, reliable device. It, like the range of self-developed qualification tests called for by cell phone makers and legacy tests from silicon firms, assesses a greater number of chips for a more limited length of time than is typical for life tests.

Qualification tests, like the HAST test, are intended to prove that products will last long enough to keep the average consumer happy. If JC-14.7 is successful in creating a widely accepted standard, the net result will be subtle but significant. From the standardized tests will emerge data that are more meaningful to GaAs manufacturers and their customers – smoothing business between the two in the process.

● If you have any suggestions to make about qualification testing for GaAs devices prior to CS Mantech, contact Bill Roesch at bill.roesch@tqs.com.

Further reading

W J Roesch *et al.* 2002 *GaAs Reliability Workshop Proceedings* **69**.