Team Torture: Developing a Standard Qualification for Power Amplifier Modules.

Panel Members: Bill Roesch, TriQuint Semiconductor
Leslie Marchut, RF Micro Devices
Bryan Shelton, Mimix Broadband
Alex Young, ANADIGICS
Steve Randle, Avago Technologies
Lance Rushing or CS Bhasker, Skyworks Solutions

There is no doubt that a "killer" application for compound semiconductors is the power amplifier module used in all cell phones. With the advances from 3G to 4G and beyond, the compound semiconductor power amplifer content has grown within the recent phone models of the largest consumer electronics market known to mankind. But did you ever think that the aspects of a Power Amplifier Module's niche also make it unique in terms of reliability qualification?

The different functions that compound semiconductors and silicon die perform are not the only considerations for reliability. Once the fabrication and assembly processes are complete, one semiconductor package may look just like any other. In the past, reliability professionals have used the appearance as a reasonable guide for determining stressing, aging, qualification, and monitoring requirements for integrated circuits. Consequently, many of the reliability testing standards for silicon have been transposed to compound semiconductors, and consumer electronics manufacturers often use standards to assure the suitability of modules for their products. Eight years ago, members of the PAM (Power Amplifer Module) community began to question the wisdom of using the historical silicon reliability approach for PAMs.

The forum for transformation of reliability and quality standards is JEDEC. JEDEC was incorporated as an independent association from its previous existence as the Joint Electron Devices Engineering Council of the Electronic Industries Association in 1999. Headquartered in Arlington, Virginia, the organization provides standards to the world's leading semiconductor manufacturers across a wide range of sectors covered by JEDEC's committees. Formed from 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 with the phone manufacturers, you will find that each one has their own ideas about specific requirements for reliability. Many of the special requirements have evolved from experiences on what can go wrong with the various components and modules in their products. But the lack of standards means that PAM manufacturers can find themselves performing different testing challenges for each mobile phone. Starting in 2002, the folks at RF Micro Devices suggested that PAMs need their own standard because so many of the users of laminate-based modules have different qualification requirements. So, a task group was formed and comparisons between PAM suppliers and phone manufacturers' favorite tests were compiled.

The task group was reinvigorated in 2008 when the members decided to rank approximately 20 reliability testing issues particular to GaAs in laminate based modules. Members of the PA making community voted on which they saw as critical. The one area that came out as the most important was acceleration factors. In semiconductor moisture aging, it is common to stress packaged semiconductors at 85°C and 85% relative humidity, where they would be expected 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 moisture test to just 96 hours by raising the temperature to 130°C. The lore out there is that HAST is ten times faster than 85/85, but that acceleration is based on silicon devices. When the compound suppliers tried various moisture conditions, they found that the acceleration is much higher than 10X. So, a 96 hour HAST test is actually much, much, harder on a compound semiconductor than it is on a silicon device because of the different accelerating effects on the failure mechanisms. The laminate modules into which

power amplifiers are packaged are also specific to the PAM industry. Some members of the task group believe that these Systems In-a-Package (SIPs) also may respond differently under HAST conditions – by delamination, for example – than the chip packages that the humidity standard was designed for.

A second area of concern revolves around radio-frequency (RF) testing. The unique RF capability of PAMs is central to their importance in cell phones, so it's expected that silicon standards do not measure up. In fact, there is no standard to say how to stress a device with RF bias. What frequency should be applied? Should it be sine wave? Should the RF try to simulate the actual phone signals? Should we stress samples in 1dB compression or 3dB compression? There are a lot of questions to be answered about the reliability impact of RF signals.

Thirdly, the PAM industry representatives decided to define a short list of qualification requirements for a stress-test-driven method of qualification. This list would be specific for the known failure mechanisms unique to both compound semiconductors and PAMs, so that all aging tests (not just humidity) can be properly defined.

Last year, the task group answered questions to provide guidelines in the three selected areas of interest, and this year the team is developing draft documents to speed up the discussion. The development of standards allows the compound semi folks to bring potential customers a prescribed set of tests used to assure the quality and reliability of the products. A second benefit of standardization is that it allows the customers an easier way to see how products compare. If all compound semiconductor manufacturers can comply with a set of standards, then phone manufacturers could compare across companies a lot more easily. The ultimate aim of developing a standard is to provide tests assuring cell phone manufacturers that the PAMs will work reliably in any expected environment. Having one common hurdle specified that all PA modules must clear before use would be a big advantage to the chipmakers.

The task group members on this Panel will discuss the process of bringing together customer and supplier points of view in order to develop a JEDEC standard describing reliability requirements for the unique aspects of power amplifier modules. Each panelist will describe their suggestions for required tests, and their descriptions of weird and wacky stresses that are not so desirable. The panelists will elaborate on distinctive characteristics of power amplifier module qualifications, such as RF life testing, laminate-based packaging, and unique moisture acceleration factors - which justify the need for a special standard.