

A Call to Higher Quality in GaAs

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Introduction

An increase in customer demand for higher quality has triggered Freescale to rethink its quality strategy. The quality legacy embedded in our products goes back to well-known Motorola quality initiatives such as 6-Sigma and Zero Defect. Our customers expect the highest quality from us. Recently Freescale has enhanced its quality strategy in many areas including incident reduction, flawless new product introductions, 1st pass qualification success, rapid problem resolution, and improved quality system processes. In the pursuit of total customer loyalty, Freescale has installed a global, high quality culture that results in manufacturing excellence across all areas. As Freescale continues developing and supporting GaAs products for the wireless infrastructure markets, it was necessary to adopt this new high quality transformation. The major shift in culture was the change from detection and correction proficiency to defect prevention methodologies. The process starts with the adoption of a rigorous NPI phase gate methodology, continues with a comprehensive product qualification process, and ends with the execution of product safe launches. This initiative is aligned with our customers' expectations and it has been driven from our top executives to every employee in the corporation.

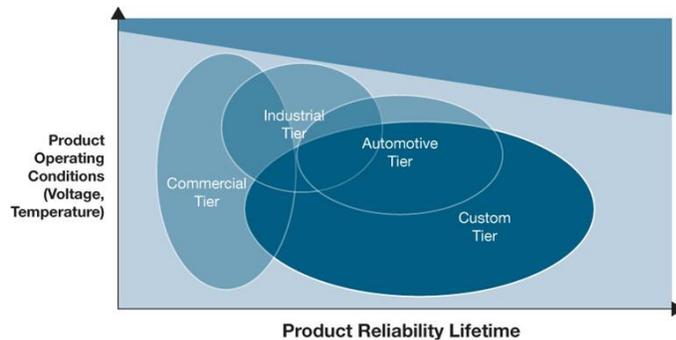
We are not only focused on quality of our GaAs products at the time of purchase, but are also concerned about product reliability as our products are used in specific tiers and environments over time. Freescale product reliability rests on a strong foundation of proven validation principles. Our pre-qualification efforts include designing, modeling, testing and test vehicle investigations to drive low-risk manufacturing processes, providing a proven path to the highest quality.

Methodology

Our approach starts at the front end (wafer fab) and moves step by step to the back end (assembly, final test and distribution). It is difficult for fab engineers to get exposure to the entire process of developing a new product in particular the assembly challenges. Educating fab engineers on the key assembly factors plays an important role in the success of manufacturing high quality products. GaAs products in particular carry many challenges due to the intrinsic brittleness of the compound material and the immaturity of the assembly processes. Continuous feedback from product engineering can proactively impact new product introductions by eliminating gaps and bringing awareness to the fab. One example is the impact of dicing methodologies on the die strength and die crack avoidance. Another is the consistency of die thickness (grind repeatability) as a major driver of bond line thickness especially for thin die (≤ 3 mil). In a similar case, product engineers do not have exposure to the complexities of fab processes. Without exposure to the fab it is not easy to understand that changes in fab processes carry tremendous risk of introducing variances. Product engineers are more familiar with final manufacturing and final test as opposed to the complexities of fab processes. Our approach is to make the product engineer the liaison for fab and assembly; it is a great advantage when the product engineer is the

binding element of the entire manufacturing process. Another layer of complexity is the assembly engineer view of the fab and product combination. Freescale GaAs products are often assembled at external factories that have extensive experience dealing with Si products but limited GaAs assembly experience. GaAs, being lower volume, generates many challenges that translate into many risks. A proactive position to educate assembly engineers in the intrinsic characteristics of GaAs (a material with much lower fracture strength than Si and poor heat transfer requiring very thin die) can avoid long term reliability issues due to unnecessary induced stresses during assembly.

The complexities of product introduction not only depend on the technology or the application of the product but a complete understanding of the market where the product will compete. The market is commonly divided in tiers: commercial, industrial, and automotive. Each tier has its own set of requirements that need to be understood to ensure alignment from wafer fab to final test. One of the most important factors is the reliability requirements. As the product moves up in the tiers, the reliability expectations increase exponentially. Product functionality is more demanding in challenging environments for a longer life time. Graph # 1 shows product reliability lifetime as a function of tier operating conditions.



Graph 1: Reliability Lifetime Tiers

In order to appropriately assess product reliability over a range of product applications, Freescale follows industrial reliability tier requirements as defined by the Joint Electron Device Engineering Council (JEDEC) and other industry standards. The operating conditions (power, temperature, life time) and reliability requirements (early failure rate, failures in time and wear out) are the main factors during product qualification. A zero failure constraint applies for all conditions.

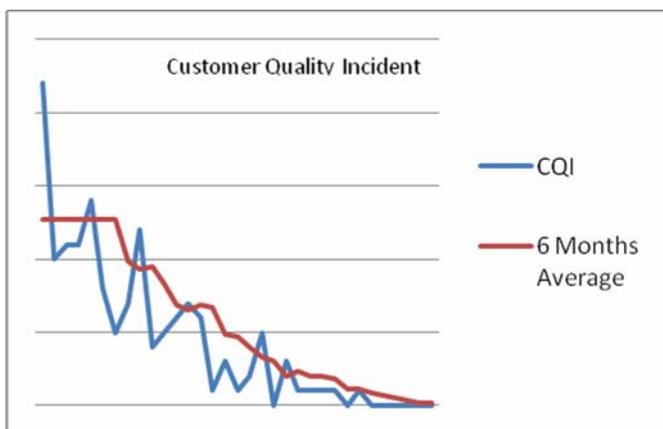
A second important step is the product launch. Safe Launch is a verification of product and process robustness and reliability. The safe launch concept was originally introduced by the Automotive Council as an initiative to ensure product quality. Safe Launch is normally implemented in production to minimize risk of new parts assumed to be acceptable in meeting customer requirements. It provides documented evidence of process stability, establishing the process reliability growth baseline. The

purpose of Product Manufacturing Safe Launch is to minimize quality risks during new product production ramps. To introduce a safe launch for GaAs products at Freescale, a Core Team Leader was assigned the responsibility of ensuring that the appropriate elements of the Safe Launch Plan (SLP) were implemented on qualification, risk production, as applicable, and production builds. A core team (device, package, product, and assembly engineering) was formed to review available data from Safe Launch implementation and update Safe Launch plan as appropriate. This methodology requires a detailed plan of the best practices to include increased sample size, increased frequency, design new inspection methodologies, phase gates and exit criteria. The core team is also responsible for creating reaction plans such as material review board specifications for non-conforming material disposition. In some cases the non-conforming material review can be quite extensive and complex in order to ensure quality and long term product reliability. Another common quality gate is to establish minimum yield requirements at each of the key steps of the fabrication, assembly, and test. Well designed triggering factors for non-conformities can detect potential defects before the product gets too far down the manufacturing line.

The third factor is direct contact with the fab, assembly, and test factories. The core team has a primary task to promote these initiatives to each party. In addition, the core team needs to continuously visit (audit) each site to ensure that the communication is direct and each party conforms to the plan and understand the importance of the execution phase. Communication is the key for a complex process such as Safe Launch. Success depends on each and every step. A single mishandling could potentially setback the entire initiative.

Results and Conclusion

Freescale's GaAs quality team has been able to deploy these initiatives from wafer foundry to multiple external assembly and test sites. The success has been significant as seen on an exponential decline of customer quality incidents as shown on graph #2. The key factors have been clear expectations in the qualification process, the execution of the safe launch program, and the communication stream amongst all parties. Freescale GaAs quality has launched multiple GaAs products to the satisfaction of the customers, always ensuring the highest quality and proven reliability.



Graph 2: Customer Quality Incidents

Acknowledgements

Freescale engineering teams: RFD, QA, EFM, EMQ, EWM, PSD, GAO