How to Succeed as a GaAs Foundry

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Abstract – TriQuint Semiconductor has been a leader in the GaAs foundry market for 23 years and continues to hold the top spot today. TriQuint achieved this success even as it has grown its IDM business that sometimes competes with its foundry customers. The number of GaAs foundry suppliers continued to grow in the late 1990's until the communications market bubble burst in 2001. Today, only a handful of foundry suppliers are still in business. In order to survive and flourish, successful foundry suppliers not only have to offer superior technologies and services, but also they must ensure they are engaged with the right customers and markets. Additionally, they must demonstrate to new customers that GaAs is an economical choice versus silicon. This extended abstract will highlight how to succeed as a GaAs foundry with the thesis that technology, support, and trust are the key foundations needed to realize strategies to grow and develop new markets and customers.

INTRODUCTION

In simple terms, GaAs foundry suppliers are companies that receive chip designs in electronic files from their customers, and in return supply GaAs wafers embedded with those designs for their customers to package, test, and ship end products to OEM's. The foundry business model has seen great success in the silicon IC world, enabling a plethora of fabless semiconductor companies to bring their products to market. Likewise, in the GaAs world, foundry suppliers enable companies to access state of the art GaAs semiconductor technology to build high speed RFIC and MMIC products without the high barriers to entry of process technology development and capital investment. So what does it take to be successful as a GaAs foundry?

GaAs foundry suppliers can be either a business unit within an IDM or a stand-alone pure play company. The corporate ownership of the foundry is not an indicator of success. The GaAs foundry market overall is relatively small, so criteria for success is different than the silicon world. It is not about making multibillion dollar investments in new fab capacity, but rather about providing the right technology with great support and establishing trusting relationships with customers. There are a limited number of GaAs designers in the world and they talk to each other. Successful GaAs foundries know this and go to great lengths to build solid, long lasting relationships. However, relationships alone are not enough to grow the business. Successful foundries also need to develop a business process for identifying and pursuing new market opportunities. New wireless applications are appearing everyday such as WiMAX, WirelessHD, and automotive radar. Typically, startups are the first to exploit these new markets and will need foundry suppliers to realize their products. GaAs offers a great value proposition versus silicon for addressing these new applications and successful GaAs foundries proactively engage startups, providing product design kits, applications assistance, and access to high performance process technologies.

FOUNDRY MARKET

The GaAs MMIC market of approximately $3 billion in 2007 as reported by Strategy Analytics [1] is a niche within the overall $255 billion semiconductor market reported by the SIA [2]. Thus, the GaAs foundry market is essentially a niche within a niche, because it represents less than 10% of the total GaAs MMIC market.

Strategy Analytics reported that the worldwide GaAs foundry market in 2006 was $218 million [3] with the leading suppliers being TriQuint Semiconductor and Win Semiconductor, accounting for 61% of the market collectively (Fig. 1).

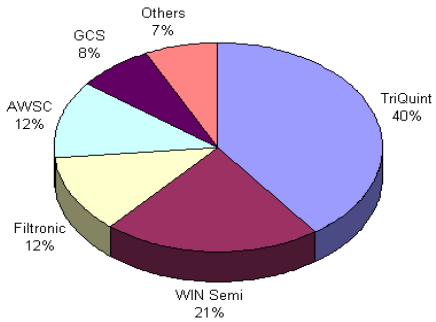

Figure 1 – GaAs Foundry Market Shares 2006
(Strategy Analytics 10/8/07)

In 2002, Strategy Analytics predicted that only a few pure-play GaAs foundry companies would remain with the depth of investor pockets being a key determinant for survival. [3] This, of course, was just after the enormous collapse of the communications semiconductor market in 2001. That prediction has rung true with the early exit of Suntek, the acquisition of GCTC by Win Semiconductor in 2004, and the recent acquisition of Filtronic by RFMD. This essentially leaves only four major players in the market today: TriQuint Semiconductor, Win Semiconductor, AWSC, and GCS.

Win Semiconductor's investors have allowed the company to progressively add capabilities. Strategy Analytics expects Win Semiconductor to continue building their capabilities with expansion plans that effectively double their capacity. AWSC has survived via a long standing second source supplier agreement with Skyworks, a leading supplier of RF modules to the handset market. However, over reliance of its business on a single vendor may hinder its ability to mount a run at an industry leadership position. GCS continues to offer a wide array of process technologies, but not in great volumes because of what appears to be capacity limitations. In 2007, Strategy Analytics predicted that TriQuint Semiconductor will continue to be the world's largest GaAs foundry. TriQuint believes its continued investment in overall capacity expansion, its strong position in the military and defense markets, and its commercial focus on expanding into new markets will enable it to continue its leadership position.

Support from investors is clearly a factor for success. Although capacity expansion is cheap relative to silicon wafer fabs, it can be quite costly if it is a multiple of a foundry's annual revenue.

NEW AND EMERGING APPLICATIONS

A successful GaAs foundry needs to focus on new and emerging markets in order to grow. Fortunately, the overall market for GaAs RFIC's and MMIC's continues to expand, driven by the unquenched thirst for more wireless communication bandwidth and new wireless applications. Establishing a business process for identifying and targeting new market opportunities is the first step towards actually engaging these new markets. Successful GaAs foundries will develop the technologies needed by these new markets and engage beta customers to establish early market leading positions.

Wireless communications is the largest segment of the GaAs market accounting for a little over $2 billion of the $3 billion overall in 2007 (Fig 2) according to Strategy Analytics.[1] The remainder of the market is made up of military, fiber optic communications, consumer, automotive, and other applications.

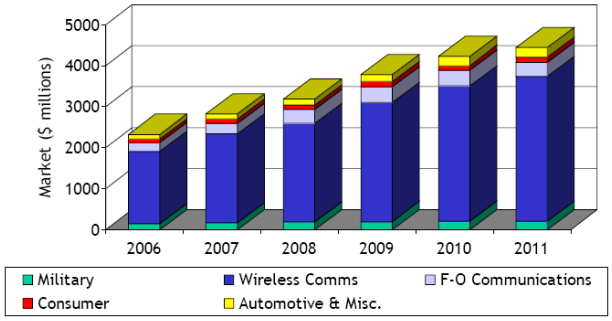

Figure 2 – GaAs MMIC Merchant Market by Application
(Strategy Analytics GaAs Industry Forecast – April 2007)

Within wireless communications, the largest market opportunity is the cellular handset market comprising of 1G (analog), 2G (digital), and 2.5G/3G (broadband digital) technologies (Fig 3). The long awaited commercialization of 3G cellular is now here, with WCDMA networks growing to provide about 70% of the world's commercially launched 3G services. 3G WEDGE (WCMDA/EDGE) handsets have up to 4x the GaAs content of 2G (GSM) phones. Clearly this is a huge growth driver in the handset segment and GaAs market overall. However, given that handsets represent over half of the total GaAs market and are margin challenged due to a small set of powerful handset manufacturers driving down ASP's, the handset market is better served by IDM's rather than foundry suppliers and fabless companies. Through vertical integration, IDM's are more likely to achieve the lowest BOM costs.

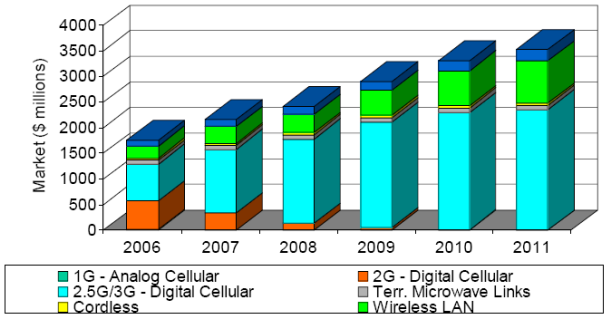

Figure 3 – GaAs MMIC Merchant Demand from Wireless Applications
(Strategy Analytics GaAs Industry Forecast – April 2007)

The best opportunities for GaAs foundries lie in the other half of the GaAs market. In this half, there are applications such as WLAN, terrestrial microwave links (point to point radios), cordless phones, military, fiber optic communications, consumer, and automotive applications. Successful GaAs foundries will develop a funnel of market opportunities (Fig 4) to identify and develop technologies to establish market leading positions in new segments.

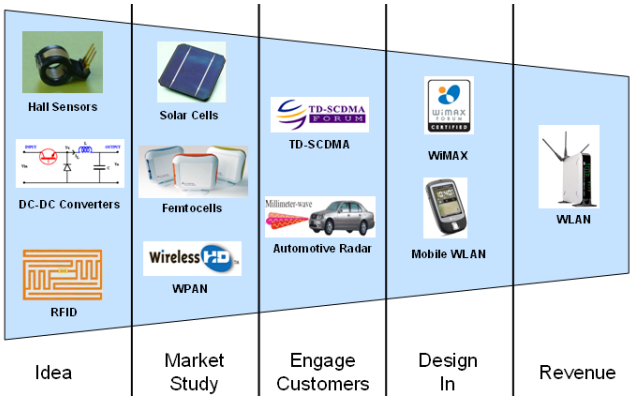

Figure 4 – Example New Market Opportunities Funnel

Ideally, there are many ideas at the front of the funnel that are studied by the foundry marketing team. In these studies, the marketing teams should identify the size of the market, the technologies needed, and the potential customers. If there is sufficient ROI, the GaAs foundry should either target an existing technology or develop a new technology in conjunction with a beta customer. Once developed, a broader set of customers can be engaged, establishing an early market lead for the foundry. Note that most of the ideas are already known broadly by most companies. The key is not necessarily the strategy, but the rather the execution. Successful foundries develop the right technologies for target markets and provide excellent support to customers to enable new products using those technologies.

THREAT OF SILICON

Silicon has driven GaAs out of mainstream markets in the past, with the cellular transceiver market being the most recent poster child. Today, GaAs has firmly established itself as the technology of choice for RF front ends in applications such as cellular handsets and WLAN. Will silicon displace GaAs in the RF front end as well?

Although silicon companies have demonstrated and are shipping in low volumes products like GSM power amplifiers, GaAs technology continues to make improvements in performance and cost. GaAs technologies such as BiHEMT, which integrate GaAs pHEMT and HBT on a single die, enable higher levels of integration and functionality. Although the costs of GaAs wafers are typically higher than silicon due to additional processing costs, die sizes tend to be much smaller per equivalent function. For low volume applications, GaAs R&D costs can be significantly lower when amortized across production units. A typical GaAs mask set costs between $25,000 to $50,000 compared to $50,000 up to $1 million for silicon processes. [4]

Successful GaAs foundries help their customers understand these cost models and demonstrate that GaAs can be not only cheaper to develop, but also lower cost in volume production than silicon.

TECHNOLOGY

Offering customers a broad technology portfolio is a key success factor for GaAs foundries. In order to meet the performance requirements for emerging wireless applications, successful foundries today must offer a wide palette of technologies including Passives, MESFET, HBT, pHEMT, E/D pHEMT, and BiHEMT. (Fig 5)

Process	Wafer Size	Link	Prototype Option
Passives only:	150 mm	TQRLC	PDQ
	150 mm	TQTRx	PDQ
MesFET:	150 mm	TQHiP	
InGaP HBT:	150 mm	TQHBT3	PDQ
Heterostructure FET:	100 mm	0.5-µm HFET 2MI	
Vertical PIN Diode:	100 mm	VPIN 2MI	
	150 mm	TQPED	PDQ
	150 mm	TQP13-N	PDQ
	100 mm	0.25-µm mmW pHEMT 2MI	
	100 mm	0.25-µm Ku pHEMT 2MI	
pHEMT:	100 mm	0.15-µm PWR pHEMT 3MI	PCO
	100 mm	0.25-µm mmW pHEMT 3MI	PCO
	100 mm	0.25-µm XKu pHEMT 3MI	PCO
	100 mm	0.35-µm Power pHEMT 3MI	PCO
mHEMT:	100 mm	0.15-µm LN mHEMT 3MI	PCO

Figure 5 – TriQuint Released Foundry Process Technologies

Successful foundries engage their customers in deep technical dialogue using their technology roadmaps as a guide. Customers often provide valuable inputs offering the GaAs foundry supplier insight that enables improvement to the process technology or ideas for entirely new process technologies. A broad technology roadmap and R&D resources to develop new technologies are absolutely essential for a GaAs foundry to meet the needs of their current and future customers.

SUPPORT

Support for customers is the second key success factor for GaAs foundries. Wafers are typically the physical product that GaAs foundries deliver to their customers. However, wafers are not the complete product. The complete product must also include quick turn prototyping services, device samples, design tool libraries, data sheets, design handbooks, training classes, real time applications engineering support, on-line order status portals, dedicated sales and customer service, die sort services, quality programs, reliability studies, and when needed, world class failure analysis capabilities. A successful foundry recognizes the value of these support elements and invests the necessary marketing, engineering, and administrative resources to realize them.

Furthermore, a successful foundry offers world class manufacturing support to its customers. The foundry must operate a high quality wafer fab managed with SPC and well documented quality guidelines. It must offer competitive leadtimes and the ability to support upside demand as the end customer's products find success in the market place.

TRUST

Finally, a successful foundry must develop trust with its customers. Trust is something that can't be dictated, it must be earned. For GaAs foundry suppliers that are part of an IDM like TriQuint, new customers always ask if an IDM can be trusted with their intellectual property. Also a concern is manufacturing support during periods of production allocation. At TriQuint, customer intellectual property is closely guarded and not shared outside of the foundry business unit. Also, in times of manufacturing allocation, all customers are treated fairly. This trust and support is rooted in TriQuint's 23 year history in the GaAs foundry business and well established among the customers who have done business with them.

However, trust is not a TriQuint only topic. Asian foundry suppliers are typically unfairly whitewashed with the brush that says IP is not respected in Asia. These foundry suppliers have to prove to their customers that they will protect their IP and not allow it to leak to their other customers or outside their company. Furthermore, all foundries must prove to their customers that everyone will be treated fairly in times of production allocation.

Developing trust takes time. New entrants will find it especially difficult, since trust is developed over several years. Existing suppliers with questionable pasts may need to take even more time to rebuild the trust with their customers.

CONCLUSIONS

To be successful as a GaAs foundry supplier, you must have technology, support, and trust as key components of your business. With this foundation, the successful GaAs foundry must then identify and engage the right new and emerging market segments to grow and gain market share. Sustained success in new market segments requires a broad technology portfolio with outstanding technical support, coupled with high-quality high-volume manufacturing capabilities. It is not easy becoming a leader in the GaAs foundry, but with the right technology, support, and trust, it is definitely achievable.

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ACRONYMS

ASP: Average Selling Price
BiHEMT: Bipolar and High Electron Mobility Transistors
BOM: Bill of Materials
EDGE: Enhanced Data rates for GSM Evolution
GaAs: Gallium Arsenide
GSM: Global System for Mobile communications
HBT: Heterojunction Bipolar Transistor
IC: Integrated Circuit
IP: Intellectual Property
IDM: Integrated Device Manufacture
MESFET: Metal Semiconductor Field Effect Transistor
MMIC: Monolithic Microwave Integrated Circuit
OEM: Original Equipment Manufacturer
pHEMT: Pseudomorphic High Electron Mobility Transistor
R&D: Research and Development
RFIC: Radio Frequency Integrated Circuit
ROI: Return On Investment
SIA: Semiconductor Industry Association
SPC: Statistical Process Control
WCMDA: Wideband Code Division Multiple Access
WEDGE: WCDMA and EDGE
WiMAX: Worldwide Interoperability for Microwave Access
WLAN: Wireless Local Area Network