What GaAs Market?
What will make GaAs win in wireless markets.

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Abstract

Over the next five years, analog GaAs semiconductor suppliers participating in emerging wireless applications face critical choices in markets, processes, levels of integration, product categories, packaging, and sales channel match. How will GaAs suppliers win?

Historically, GaAs vendors have focused on designs and processes which expand the envelope of performance. Now there are other factors which will be at least as important as maximum performance in determining the GaAs winners when competing against lower material cost technologies such as Silicon.

Markets

The first choice is which markets to address. The successful GaAs supplier will understand the markets and will match their performance, cost structure, and sales channel to the market requirements. An example of suppliers who are making an effort to do this are those who are leveraging their millimeter wave capabilities into the emerging collision avoidance market. Although this is probably a good first step, it is an example of fitting capabilities to a potential market, rather than letting markets drive capabilities.

The wireless markets fueling analog RF & microwave semiconductor growth over the next several years cannot be attached to any one technology. There are now more opportunities for various processes to compete and be successfully utilized in these new applications. Because there are many competent approaches to these applications, several technologies will coexist as improvements and new products are introduced. The winners will share some common attributes, regardless of whether their base engine is Silicon, GaAs, or some other competing technology. Figure 1 shows estimated available GaAs content in some of the larger growth markets over the next five years. As the

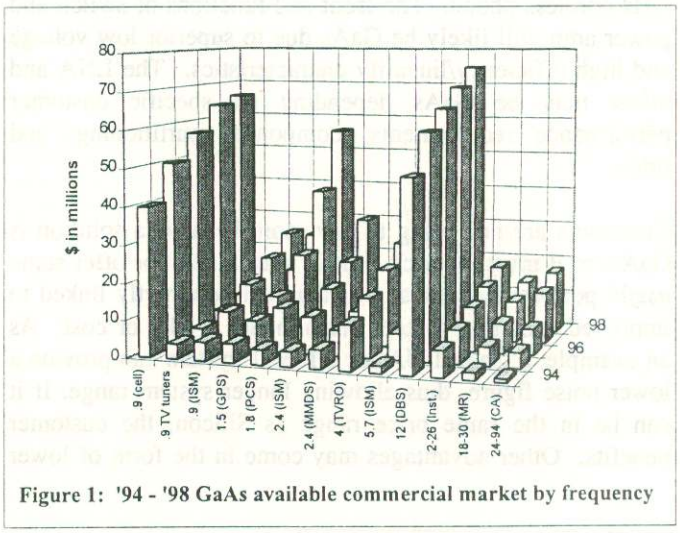

Figure 1: '94 - '98 GaAs available commercial market by frequency

title implies, these are not "GaAs markets", but systems which present opportunities for GaAs to be inserted. This chart was created by estimating total RF front end content, then subtracting those functions which may be served more cost effectively by non-GaAs solutions. The resulting numbers show tremendous opportunity.

Figure 2 shows a five year cumulative look at figure 1, divided into over 3 GHz and under 3 GHz markets. The over 3 GHz applications may be safely called "GaAs markets", because of the superior high frequency capability of GaAs. Few will argue that millimeter wave applications, DBS, and TVRO markets require the performance of GaAs. However the faster growing and larger portion of the market is under 3 GHz. The Cellular, ISM, TV tuner, and PCS markets are all under 3 GHz, and growing at up to 20% per year.

As an example of the under 3 GHz "battle zone" of

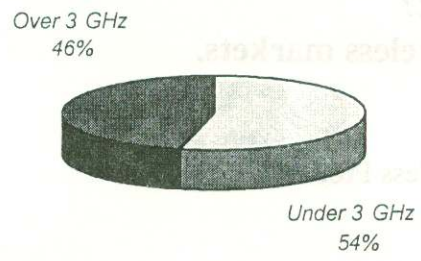

Figure 2: 1994 - 1998 cumulative market size by frequency

technologies, Figure 3 shows a generic block diagram of a 2 GHz cordless phone. The front end functions of switch and power amp will likely be GaAs due to superior low voltage and high efficiency/linearity characteristics. The LNA and mixer may be GaAs depending on specific customer performance requirements, component partitioning, and price.

Customers are not going to pay more because a solution is GaAs, so it must be price neutral with Silicon or offer some *useful* performance advantage that can be directly linked to improved customer system performance, yield, or cost. As an example, a GaAs LNA for a DECT system can provide a lower noise figure, thus allowing longer system range. If it can be in the same price range as Silicon, the customer benefits. Other advantages may come in the form of lower

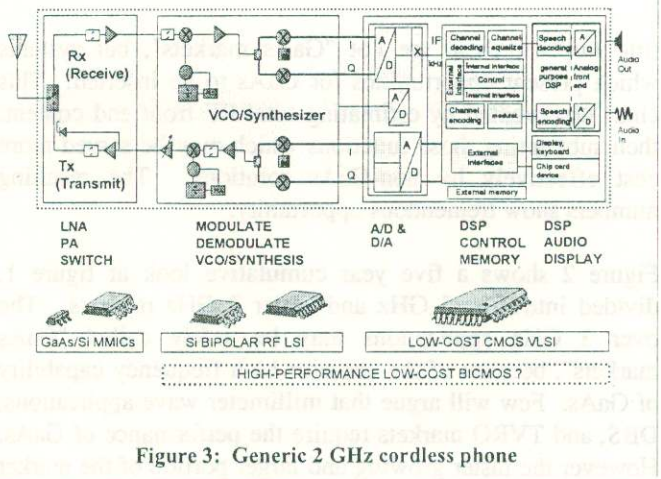

Figure 3: Generic 2 GHz cordless phone

voltage/current, higher efficiency, increased integration to reduce component count, smaller plastic packaging, or improved ease of use. These advantages can only demand a premium proportional to or less than the derived customer benefit. The low margin consumer markets will not support performance in excess of basic requirements unless customer end product differentiation requires it. Suppliers must avoid the temptation to force-fit their capabilities into the nearest apparently large market, but rather define products which capitalize on their process strengths while offering an advantage to the customer at the right price. Products must be "market priced", based on the value of comparable alternatives, and not "cost base" priced. Most customers in these markets rank price and delivery higher than premium performance.

Process

The next choice is process. I am not going to discuss the tradeoffs between MESFET, PHEMT, and HBT, but the winning suppliers will understand this very well. They will go beyond just looking at performance differences based on process, but will dig into cost advantages which may come as a result of a different technology. A seemingly more expensive technology such as PHEMT or HBT may allow lower current operation, smaller die sizes, or improved yield to spec which may offset higher process costs.

Successful vendors will concentrate on a few processes in which they are experts. They will obsolete all but a few process flows, and concentrate on driving out defects and increasing good parts shipped per wafer start through statistical process control. Improvement will be incremental rather than radical. A single-minded cost reduction and yield enhancement program will be essential for success. This optimization focus will allow quicker lead times for both product development cycles and reaction to unanticipated demand swings.

Levels of Integration

One of the major choices in product definition is the level of integration to pursue in a new product. Sometimes this is already decided by the customer's design, which may have already been partitioned in a particular way. Successful suppliers will need to know whether the customer's partitioning is common to other approaches in that market, or if they are alone in their approach. This has important implications when trying to find a large general customer base for the product.

When attempting highly integrated multi-function transmit or receive MMICs, successful suppliers will work with a

major customer who can assure high volume business. This guarantees a design win, and additionally gives them detailed market and system expertise as a result of "living with" the customer on the project. They know that the custom IC designed for one customer is usually not transferable to the general market, and that a complex MMIC designed for a broad customer base will generally suit none. Per Bob Dixon of Omnipoint Corporation, "If you design for a particular user's application, be sure its a big one, because that user will probably be the only one." [1] Some suppliers of these large scale MMICs will be successful but some will not be able to recoup their investment when the expected giant quantities do not develop as planned. Highly integrated multi-function GaAs MMICs are not as far along the learning curve as silicon MMICs, and the smaller wafer size and greater defect density amplifies the cost problem in these larger die applications.

Suppliers of building block MMICs (3 functions or less) have a greater chance of meeting a broad demand requirement because of their greater flexibility (although not as flexible as discretes). Figure 4 illustrates the tradeoffs with integration. Some building block examples are self biased LNA gain blocks, LNA/mixers, and LNA/switch/power amps. Building blocks allow customers quicker design cycles, reduced board space, higher yields, and lower assembly costs than discretes. This category will provide growth potential with less risk than custom large scale MMICs, and more opportunities for product differentiation than discretes. They will be thought of as "discrete" building blocks in the future, moving them lower in the pyramid.

Vendors who pursue discrete FETs will be able to address the broadest customer base because of the inherent flexibility of discretes. The disadvantage to the supplier is that there is less room for differentiation. Discretes are being replaced by more integrated building blocks and multi-function custom ICs. This rate of replacement of discretes in the wireless industry is probably greatly exaggerated by those wanting single chip solutions for everything. Discretes will be around for quite awhile because discretes give better performance, not all applications are large enough to warrant integration, there are not enough IC designers for custom chips for all applications, and so far there is no "universal" IC for wireless markets.

Other potential indicators of product attractiveness to a supplier are market growth rates and the number of years the product type has been available in the market. Figure 5 combines levels of integration with product type growth rates and age. The concept is that a new fast growing product type with few established competitors should be more attractive than a mature product type with several dominant players. Building block MMICs look attractive because of their high expected growth rates and relative newness to the market. There are less established suppliers with dominant market shares than in the discrete product category.

Packaging

The choice of packaging for the GaAs die is one of the most important. Historically there were few options, with ceramic and metal packages dominating for performance and hi-rel reasons. More recently, plastic packages have

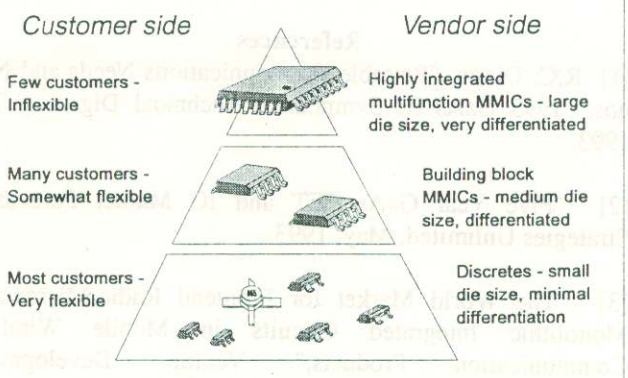

Figure 4: Product integration pyramid

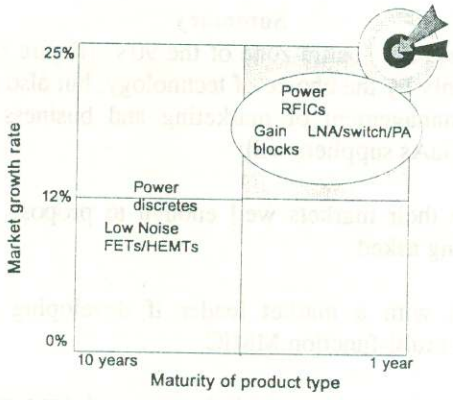

Figure 5: Product type attractiveness

been used for discretes and MMICs, with the S0-8 being one of the most popular. Plastic surface mount packages will continue to dominate, and may be the *differentiator* in future products. The trend to smaller customer end products will continue to exert pressure to make smaller machine-placeable Winning suppliers will have (or have access to) flexible low cost automated assembly and test capabilities for these plastic packages. These suppliers know that in many cases packaging expertise is as important as a higher performance die. In fact, for some new applications, such as PCMCIA cards, package size is a qualifier. As an example, a 6-lead surface mount plastic package is under development which will accept GaAs building block MMICs with multi-GHz performance. This package will be smaller than a SOT-143. Reduced board space is an obvious advantage, but improved high frequency performance as a result of lower parasitics is an additional benefit.

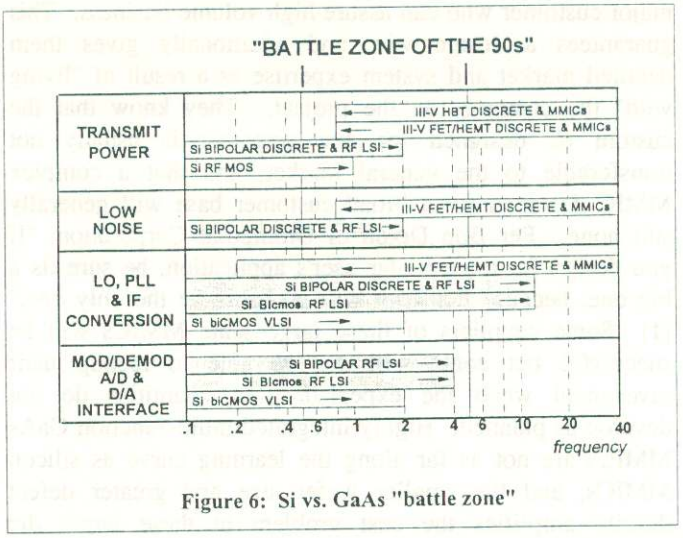

Figure 6: Si vs. GaAs "battle zone"

Sales channel strategy/product match

The choice of sales channel is usually not one of the first things suppliers think about when planning to enter markets. The successful supplier will develop products which match its sales channel (or vice versa), and develop an international presence for sales, applications, marketing, and local stock. This is essential to stay on top of trends in the electronics design and manufacturing base, while maintaining competitive lead-times worldwide. In order to have the most efficient method of getting their products to the customer on time and at the right price, the supplier's sales channel must be calling on the appropriate customer base at the right level in the organization. For example, a highly integrated receiver on a single MMIC which is suitable to only a few major customers does not leverage a broad line stocking distributor well. Conversely, a discrete product line with a broad customer base does not match a small factory sales force of highly trained design experts.

Summary

In summary, the "battle zone of the 90's" (Figure 6) will be won not only by the choice of technology, but also the well-planned management of marketing and business choices. Winning GaAs suppliers will:

1) Know their markets well enough to propose solutions before being asked

2) Work with a market leader if developing a highly integrated multi-function MMIC

3) Know their processes, pick the best, and drive continuous improvement in yields

4) Pick the right level of integration to achieve the maximum advantage and flexibility

5) Invest in (or have access to) high volume flexible automated miniature plastic packaging and test capability

6) Pursue the customers and product types which match their capabilities and international sales channels.

The emerging commercial/consumer growth markets do not allow the margin for error that accompanied the old defense markets. The winning vendors will focus and fine-tune their capabilities to gain maximum competitive advantage and return on investment.

Acknowledgments

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