Anadigics' consumer volume savvy

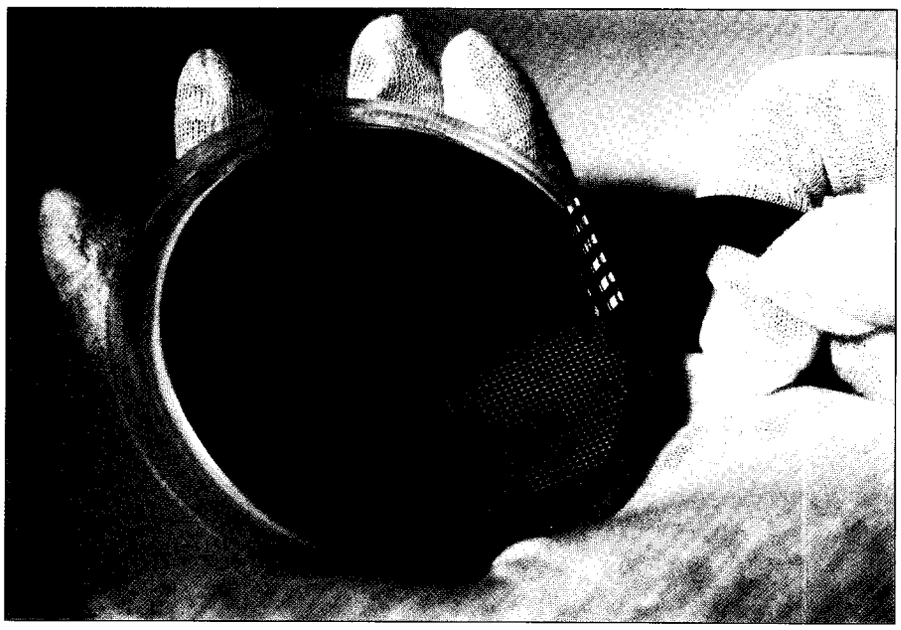
by Jo Ann McDonald, US Correspondent

Advanced technology professionals grasp the concepts surrounding the construction of the international communications infrastructure, but even they may not realize the growing importance of the GaAs technology that makes it work. Anadigics (Warren, New Jersey), one of the world's leading GaAs MMIC manufacturers, has had its hard hat on straight from the time the infrastructure blueprints were first conceived. In this profile of Anadigics, and in the accompanying interview with Anadigics' co-founder and CEO, Ron Rosenzweig, TFR takes a behind the scenes look at how Anadigics reached true high volume production status and what it takes to succeed in this unprecedented global industry.

When Anadigics went public in the Spring of 1995, the international GaAs community turned the corner to guaranteed success. Anadigics was the last of the remaining three USA GaAs start-ups to file its IPO out of what was originally an abundance of potential stars.

Although the first two, TriQuint and Vitesse, have also turned the corner and cashed in on the long years of hard work and perseverance, Anadigics is proving that being third really is the charm. The stock began trading at $14 on 21 April on the NASDAQ stock exchange under the symbol "ANAD," and by early September it was hovering near $30.

Founded in 1985, Anadigics was regarded as the most modern of the MMIC fabs and foundries when the Cold War suddenly ended. The demand for high cost, high performance GaAs MMICs virtually disappeared. While others lamented that "the party was over," Anadigics did an about face, led the search for low cost, high volume, highly reliable consumer applications, and claimed instead that "the party has just begun!" While less versatile MMIC houses began to fold, Anadigics began to concentrate on communication needs that silicon simply could not accommodate.



Direct Broadcast Satellite (DBS) service into European homes proved to be Anadigics' initial high volume application and represented an important industry milestone when the company was able to produce an individual MMIC part for under $10. Since that entré Anadigics has found equally rewarding high volume uses for MMICs in cable television and fiberoptic systems. In early 1995 Anadigics completed its ambitious gameplan and is also entering the cellular market by supplying Ericsson with an unprecedented 30-day turnaround of a key GaAs receiver part for Ericsson's planned production of 250 000 AMPS cellular phones.

The Receiver Project

The project with Ericsson, one of the world's largest cellular telephone manufacturers, required Anadigics to pick up and run with a ball that had

Process optimization through a cost driven mentality

Anadigics has optimized it's workhorse MESFET process over the years. According to Pat Fowler, Anadigics' Manager of Process Engineering, "for standard production, Anadigics employs a half micron gate length recessed MESFET process based on ion implantation. The process uses air bridge technology which allows for the integration of passive tuning elements. The recessed implant architecture has been configured to provide FET linearity without sacrificing the high breakdown voltages often required in analog applications.

"Typical FET parameters would be V_D = .7V, G_m = 220 mS/mm, and F_T = 22 GHz.

"Anadigics is also operating a 0.35μm gate length pilot process that provides an F_T greater than 30 GHz."

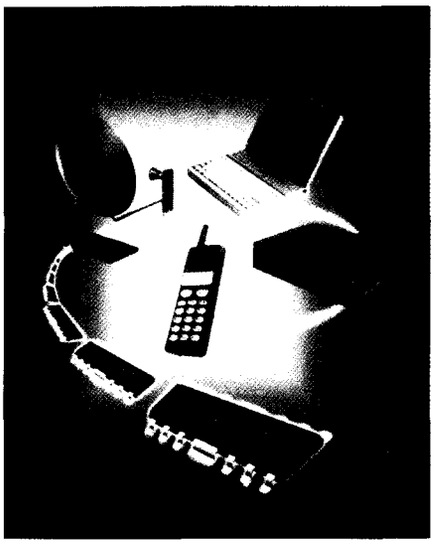
Key to Anadigics' success has been its cost-driven mentality which identified and eliminated all non-value processing steps in the manufacture of its MMICs. Since IC manufacturing is inherently a highly capital intensive business, high volume production is the way to get the fixed costs per unit down to acceptable levels. With GaAs wafer fabs now costing over $50 million, wafer fab run rates of at least 1000 to 2000 per month are required to keep the fixed fab cost per wafer within an acceptable range. While it may take less than $100,000 to demonstrate the feasibility of a given design, it can ultimately cost millions to make that design production worthy.

Another important cost-conscious aspect lies in the specification for the IC which must be highly compatible with the process capabilities. Anadigics concentrates on characterizing the manufacturing process and totally understanding its capabilities, stressing the importance of the design engineer working very closely with the customer on system partitioning to develop proper IC specifications, often using in-house systems experts in this optimization effort. The idea is to offer the customer the most cost effective solution rather than simply sell another IC. For example, the addition of an external inexpensive component by the customer may make IC specifications easier, resulting in higher yields and lower costs.

Obviously, one of the primary objectives for any manufacturing philosophy is higher yields. At Anadigics, yield enhancement efforts start in the very early stages of product development. Anadigics organizes a cross functional team consisting of the design engineer, product engineer, process engineer and application engineer conduct yield analysis as the first design hits the wafer fab. "Macro" yield analysis efforts include setting up engineering databases and identifying all statistically significant process sensitivities. These efforts parallel "micro" analysis strategies which include detailed failure analysis, problem-solving using Anadigics' "Design of Experiments," and other statistical problem solving methods. This continuous yield improvement continues through the life of the product, from starting substrates to finished chips shipped to customers, with an overall yield goal of greater than 75%.

Manufacturing dividends

These new manufacturing techniques have paid additional dividends for Anadigics and have resulted in a significant reduction in the overall cost of GaAs technology, benefitting the entire community. Today, the direct cost of producing a 4-inch GaAs MMIC wafer, including direct labor, and direct and indirect materials, is about $500. The actual cost,



including fixed cost and manufacturing overhead, is about $1500. For a GaAs IC with an overall yield of about 75%, the cost of a GaAs chip is about $0.25/mm^2, which is competitive with the cost of silicon IC devices. Although Anadigics is still at 3-inch, it has everything in place now to easily transition to 4-inch in 1996.

While manufacturing techniques were contributing to driving down the overall costs for GaAs technology to current competitive levels, performance characteristics benefitted. The conventional wisdom is that silicon devices are less expensive than GaAs devices because silicon materials are more readily available than GaAs. Anadigics helped prove that, in reality, GaAs MMICs offer two major advantages to offset the higher starting material cost. First, GaAs MESFET devices are much simpler and easier to manufacture than silicon bipolar devices with similar RF and microwave performance. Secondly, the semi-insulating property of GaAs substrate lends itself more readily than silicon to the integration of amplifiers, filters, spiral conductors, mixers and oscillators on the same chip.

Challenge to the international GaAs community

Despite Anadigics' current success, several obstacles remain before GaAs can make further inroads. Chief among these is the issue of supply and demand. Dr. Charles Huang, Anadigics' Executive VP, Market Research and Business Development, has posed a novel challenge to the

community to meet perspective ramp-up demands.

In the past 30 years, more than 100 GaAs facilities were constructed worldwide to meet demand for military applications. Today, only 40-50 of those facilities remain operational, and most are operating at 10% or less capacity. Current worldwide consumer demand for GaAs ICs is equivalent to 3,000 3-inch wafers per week. Assuming that each facility can produce 200 3-inch wafers per week, and taking into consideration that some facilities are working with 4-inch wafers, total worldwide production per week is an estimated equivalent of 12,000 3-inch wafers. This may be sufficient for right now, but what will the industry do when, as industry experts anticipate, demand for GaAs increases by a factor of 10? For those successful companies presently operating at more than the average 10% capacity level, two options exist. Either buy an existing facility operating at low capacity, or build a new wafer fab. Each strategy carries with it potential pitfalls. In the first option, since each facility utilizes different manufacturing processes, it would likely take 12-18 months before new production could begin. Lead time is even longer with the second option because it takes an average of 18-24 months to construct a new fab.

In both scenarios, fixed manufacturing costs would increase, making it more difficult to compete with discrete solutions.

The cost of a GaAs IC, while typically 25-30% more than the bill of materials for discrete devices, does not reflect the "true" cost of manufacturing, for example, wireless products. When yield maximization and 100% testing of GaAs ICs are considered, the actual cost is lower than its discrete counterpart.

As for the lag time involved in increasing production capacity, all is not lost. Charlie asserts Anadigics' position that the industry should band together to create a network of GaAs facilities that could be utilized to shore up production whenever demand outstrips supply. This type unprecedented cooperation would obviously benefit everyone involved and has the potential of becoming a model for subsequent compounds that successfully reach high volume production levels. It is indeed something worth considering.

Jo Ann McDonald, in conversation with Ron Rosenzweig

What does it take for a startup GaAs company to position itself to become a major international IC manufacturer? According to Ron Rosenzweig, founder, President and CEO of Anadigics, it takes the right national infrastructure and an unprecedented global market view. When Anadigics finally went public earlier this year, the classic USA GaAs MMIC startup opened another important chapter in its success story. A worthy model for the future, Anadigics' continued success is an inspiration to anyone in the world with a strong entrepreneurial streak. In this conversation with Jo Ann, Ron reveals just what it takes for a classic startup not only to survive, but thrive.

JM: How do things change after "going public"?

RR: You actually communicate much more than as a private company but what you say to anybody is much more restricted. The intent is that all relevant information should be distributed uniformly. Conversely, what you say has to be watched carefully not to mislead, tout, hype, etc. Although those rules have been in existence for a long time, litigation has increased and they become more noticeable.

JM: Lots more 'bosses' now?

RR: Actually, being a public company now is much closer to being a venture capital backed private company in the 1970s in the sense that a few institutions can own most of your stock. They may freely trade it, compared to the venture capitalists who own it and sit with it, but we're actually not dealing with 10,000 investors. It's really 50 to 30 of them.

JM: At over 300 employees and at truly high volume production, what drove the IPO and what was the process?

RR: It was driven by two needs. The company needed money to continue to grow the business, and we thought the company was finally ready to enter the public market. It happened that we had the best customer base, the right number and diversification of products, and the right market presence. We had thought about it seriously two years ago. To go public with the most attractive offering it was important for us to be in the cellular business as well as in fiberoptics infrastructure and the multichannel tv distribution business – cable and DBS – which are global markets for RF microwave front-end devices. The Ericsson deal (see accompanying article under "The Receiver Project,") added the 4th leg on the stool.

JM: What's looking hot these days?

RR: The information "superHYPEway." There hasn't been a phenomenon like the World Wide Web since the Gutenberg printing press in the history of the world and it may have that kind of impact on society because of the instant distribution of information to everyone. Although we're not an Internet story *per se*, it will probably require more bandwidth and more fiberoptics, so we participate in it that way. Someday you may have access over cable systems, for example, but today, the telephone companies have recognized that getting into the cable tv business isn't as easy as they thought and *vice versa*. Everybody is taking a second look at the capital needed and return on investment analysis. People really thought they'd be selling cable products to phone companies and telephone products to cable companies whereas we're still selling cable

products to cable companies and telephone products to telephone companies. All of the trends that people are talking about are merging and evolving throughout the world at differing rates. There's more reality now and less hype, but Anadigics is in a position to participate in almost all of the outcomes that require either wireless or wideband interfaces.

JM: Smaller, faster, cheaper...?

RR: ...lighter weight, better battery drain, lower power consumption, and most importantly, it's THE LOW COST SOLUTION. The thing that will create a billion dollar market opportunity early in the Third millennium is the fact that GaAs really WILL be able to do these things for the lowest cost. Making ICs is the best solution for electronics. It's what drives low cost, the whole personal computer revolution, and virtually everything. Once you can make ICs you get down the learning curve and make things smaller, faster and better. We're addressing areas that silicon has had a shot at for the last 30 years but has been unable to accomplish.

JM: Your fab is now moving to 7-day/week 24 hr/day production and moving to 4-inch wafers. That takes capital. What's really required in financing such a progressively ambitious operation?

RR: We really believed that there was a good chance to be successful if we could get the money. From an employee standpoint, we were very open so there were no dark secrets. When things got the worst (1988-89), rather than lay anyone off we all took a pay cut. At the same time, we always offered the investor community an opportunity for success. We also had multiple investors which I've always thought was a real asset because, for any given time, if you have ten investors, five may believe and five may not, but as long as you have a core group that believes and has capital, you have a shot. Companies with single corporate investors (such as Tachonics/Grumman and Gain/Mitsui) didn't have that latitude. In the case of Vitesse, it was able to move from a corporate financed company to a venture financed company which allowed them to then be successful.

JM: I maintain that you're one of the best new "Nasdaqers" because of your seasoned management and because you and co-founder George Gilbert starting and growing Microwave Semiconductor Corp. before selling it to Siemens.

RR: We've asked our key managers what kept them with us through the lean times. Most of them felt that, "if these guys can't make a go of it, nobody can." The late 80s and early 90s certainly weren't the time for any more spinoffs. The fact that George and I had successfully started MSC seemed to give them confidence. I'm sure our track record with former employees also kept the core team together.

JM: You developed core competencies which were your process and manufacturing know-how, as well as system and design expertise. How did you determine what was the right market/application that would make the best use of that core?

"You have to remember that we 100% test at RF or microwave, every part that we make, in every application. And that's the last time it ever gets tested."

RR: When we started the company, we believed that those core competencies would enable us to build a very successful business. The question then became: "what were the markets?" In the mid-80s it was the opportunities in defense, fiber, and the infrastructure based on price points that were higher. During that period we concluded that the volumes were trivially low and, in a sense, inconsequential. You can get to dollar volume two ways: by multiplying a big number times a small one, or a small number times a big one. The original strategy of most of the GaAs IC companies was to multiply a small number of units by a large price per unit.

JM: Obviously, your major contribution to the entire industry has been to show that the better strategy was to multiply a very large number of units times a relatively small price number.

RR: The first revelation in 1988-89 was that we didn't need to replace silicon, and secondly that those numbers could be large by going after consumer volumes. However, the term 'consumer' carried a horrible connotation among USA IC manufacturers at the time. I think the conclusion was that you had to go after markets where the numbers were going to be much greater. The price points were from $1 to $100 so it had to be an under $10 part. I remember when we bid on the first DBS product for the European DBS market. The conventional wisdom was that it was impossible to make the part for under $10.

JM: Did you take a loss at under $10?

RR: Every part shipped reduced our loss in those days. Put it this way, we were losing $8 mill before we took the business, and after we took it we were losing less. It wasn't enough to make us profitable, however.

JM: The other milestone was the realization that consumer products could use reliable parts.

RR: Reliability is defined by reproducibility, i.e. that the first, the thousandth, and millionth would all perform precisely the same. You have to remember that we 100% test at RF or microwave, every part that we make, in every application. And that's the last time it ever gets tested.

JM: Everyone always wants the formula to America's startup success. Another way of putting it is that the global market pays a $13/hr wage in the US versus $2 overseas. That's for the American entrepreneurial attitude.

RR: It's really just the American system and the attitude that the system brings. Take our summer company picnic where the theme was "an International Feast." We gave all 300 employees shirts with a globe showing the individual's country of origin. We're truly a multinational company, yet in very few countries do you have the business infrastructure whereby you can start an Anadigics. We're very fortunate.

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