

GaAs Semiconductors: New Market Opportunities and Emerging Application Trends

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Abstract: GaAs semiconductors have recently risen from obscurity to technological wonder. The use of GaAs semiconductors in consumer wireless applications has enabled the industry to emerge from its military roots to full-blown commercialization, where millions of units are shipped on a monthly basis and where the OEM community has accepted GaAs as a viable substitute for silicon. This paper will address some of the emerging wireless applications and market opportunities. In addition, the topic of competing technologies will be discussed.

Introduction and History

It is worth mentioning the significance of 1997 in relationship to the semiconductor industry. This December will mark the 50th anniversary of the discovery of the transistor effect by Dr. John Bardeen, Dr. Walter Brattain, and Dr. William Shockley of Bell Laboratories in 1947. Dr. Shockley was awarded a patent in 1948 for the first the invention of the transistor, which, by the way, was an HBT using germanium, not silicon!

In addition, it is appropriate to mention, since this conference is being held in Italy, that 1997 marks the 102nd anniversary of the invention of the radio in 1895 by Italian electrical engineer and inventor Guglielmo Marconi.

The history of GaAs can be traced back to the late 1960s and IBM's Leo Esaki and Ray Tsu, who demonstrated superlattice structures using GaAs/AlGaAs. The first MESFET was proposed in 1966 and the

first HEMT was demonstrated in 1978 by Bell Labs.

The industry has evolved and changed over the last 30 years and has finally escaped from its designation as the "technology of the future."

Silicon Semiconductor Market

Sometimes, because we are in a much smaller industry, we forget how big the total semiconductor industry is. The worldwide semiconductor market in 1996 was at \$141.7 billion, down 6.2 percent from 1995's market of \$151.3 billion. The drop was due in large part to the bottom falling out of the DRAM market in late 1995 and throughout 1996. Dataquest still believes that the market will surpass the \$300 billion point in the year 2001. Figure 1 shows the worldwide semiconductor

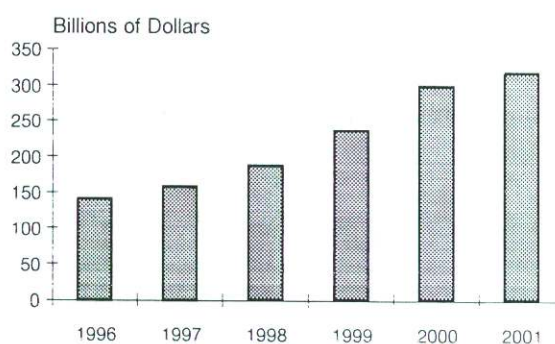


Fig. 1. Worldwide Semiconductor Revenues Forecast, 1996-2001
Source: Dataquest

forecast. Figure 2 shows the breakout of the semiconductor industry by product type for 1996.

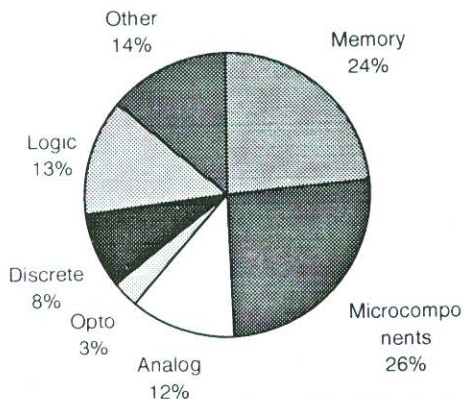


Fig. 2. Worldwide Semiconductor Revenue by Product, 1996
Source: Dataquest

European semiconductor market consumption revenue was at \$28.5 billion in 1996 and is expected to grow to \$62.1 billion by the year 2001.

GaAs Semiconductor Market

In 1994, the GaAs industry saw the "holy grail" of applications that would save it. The cellular phone single-handedly saved the GaAs industry and has propelled it to the forefront of the entire semiconductor industry.

Whereas silicon bipolar and MOSFET technology were considered mature RF technologies, system-level requirements quickly surpassed the performance that silicon was able to deliver. As supply voltages dropped under 5 volts and power amplifier efficiencies were expected to operate in the 50-70 percent range, GaAs MESFETs became an enabling technology that allowed the cellular phone industry to increase its performance and attract new subscribers. The emergence of the digital cellular phone market because of the GSM standard marked the advent of widespread use of GaAs semiconductors. Since 1994, the GaAs industry has grown at least 25 percent each year, reaching over \$1 billion in 1996. By far the most rapid growth area in GaAs has been the analog sector, which includes discretes, ICs, and hybrid modules.

GaAs Substrate Market

The market of semi-insulating GaAs wafers for wireless applications has grown from 3 million square inches (MSI) in 1994 to over 5 MSI in 1996, a compound annual growth rate (CAGR) of 29 percent. The GaAs wafer industry is expected to produce 8 MSI by the year 2000, a CAGR of 32 percent since 1995. Revenue is expected to increase from \$153 million in 1996 to over \$400 million in 2000, a CAGR of 27.5 percent. The year 1996 was a transition year in the wafer industry as 100mm wafers went into full-scale production, surpassing 75mm in square inches. European suppliers of GaAs substrates are:

- Freiberger Compound Semiconductors GmbH (Germany)
- Picogiga S.A. (France)
- MCP Wafer Technology (U.K.)
- Epitaxial Products International (U.K.)

The biggest issue concerning the worldwide production of GaAs substrates is the availability of raw materials, namely gallium metal and pure arsenic. The monopoly that Rhone-Poulenc has for gallium metal production and the fact that it is trying to reduce availability and drive up prices by mothballing its Australian operation has a tone of "Intel" in it.

Market Applications for Analog GaAs Cellular/PCS Handsets

Worldwide shipments of cellular/PCS handsets reached 58.3 million in 1996, an increase of 38.5 percent over 1995 handset shipments of 42.1 million. Figure 3 shows the Dataquest forecast for cellular/PCS handsets for 1996 to 2000.

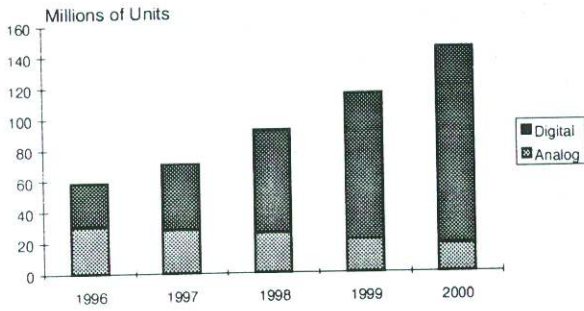


Fig. 3. Worldwide Cellular Terminal Unit Forecast, 1996-2000
Source: Dataquest

This forecast does not include the category of cordless handsets, which includes the DECT and PHS standards. Figure 4 shows the market share by manufacturer of worldwide cellular/PCS handset shipments.

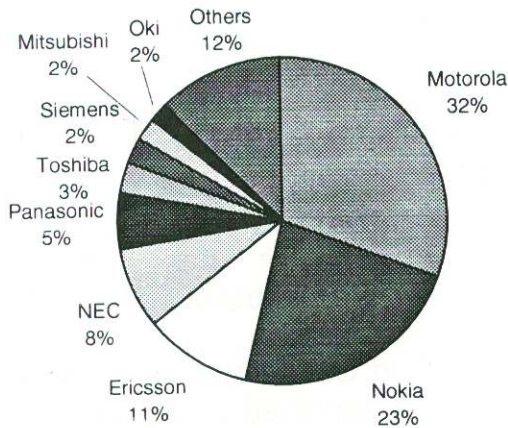


Fig. 4. Worldwide Cellular Terminal Market by Manufacturer, 1995
Source: Dataquest

Specifically in Europe, the digital cellular handset market (GSM/DCS-1800) produced 20 million units in 1996 and is expected to grow to 72.2 million by the year 2000. Figure 5 shows cellular telephone shipments by standards for 1995 in Europe with a total of 11.2 million units.

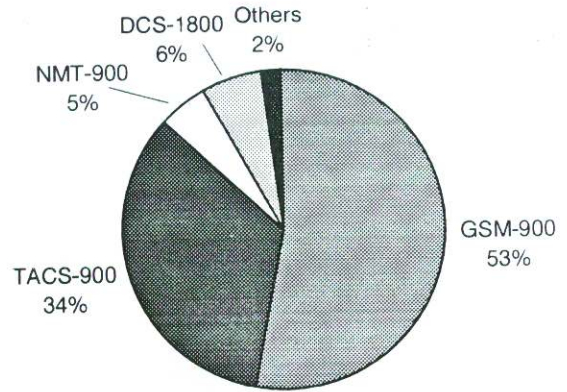


Fig. 5. Cellular Telephones in Europe Shipments by Technology, 1995
Source: Dataquest

As expected for Europe, GSM is the leading technology, both in terms of installed base and shipments.

In the United States, the PCS handset market is expected to grow from 347,000 units in 1996 to 15.1 million units in 2001, with CDMA technology accounting for more than 50 percent of the market. Figure 6 shows the forecast U.S. PCS market in 2001 by technology.

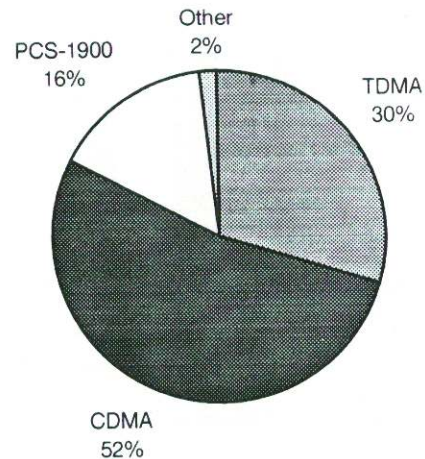


Fig. 6. Forecast U.S. PCS Handset Market by Technology, 2001
Source: Dataquest

In Japan, the cellular telephone market doubled in size, exceeding 20 million subscribers in 1997. Figure 7 shows the

growth for the total number of subscribers of cellular telephones in Japan, both analog and digital.

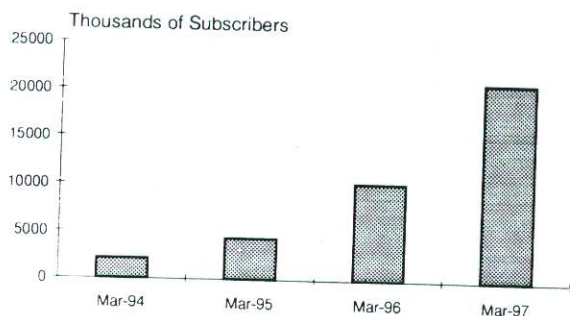


Fig. 7. Subscribers for Cellular Telephones in Japan
Source: Dataquest

Digital Cordless Handsets

Dataquest believes that an emerging area of wireless handsets is digital cordless, which is expected to grow from 3.6 million units shipped in 1995 to 37.5 million units shipped in 2000, a 1995-2000 CAGR of 60 percent. In Japan, subscribers for PHS systems have increased from 1.5 million in FY96 to 6.0 million in FY97, year ended March 31. Figure 8 shows the total number of subscribers for PHS systems in Japan.

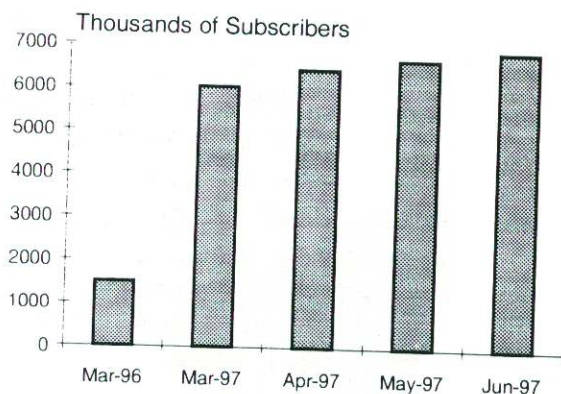


Fig. 8. Subscribers for PHS Systems in Japan
Source: Dataquest

Dataquest believes that GaAs semiconductors, primarily the power amplifier and switch, will continue to play an important role in PHS systems as Japan strives to deploy PHS in

Asia/Pacific countries such as Hong Kong, Thailand, Malaysia, and Indonesia.

Preliminary estimates for the DECT handset market have shipment volumes reaching roughly 8.5 million units by the year 2000, a 1995-2000 CAGR of 109 percent. Figure 9 shows the growth of the DECT handset market.

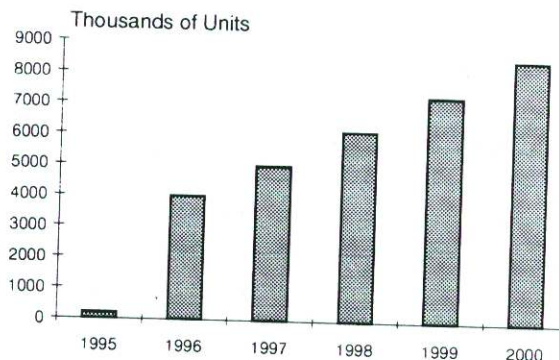


Fig. 9. Worldwide DECT Handset Production Shipments
Source: Dataquest

Other Emerging Applications

Wireless local loop (WLL) applications have yet to explode onto the market. Motorola and Qualcomm have taken the lead in this area for infrastructure and handsets using CDMA as a WLL technology.

Wideband CDMA at 2 GHz has just recently been approved in Japan as the next generation for digital wireless communications.

Automotive radar and communications, a much-talked-about subject last year at the Paris conference, are still evolving along with the IMT-2000 system.

Analog GaAs semiconductors will continue to play a significant role in digital communications systems because of the peak power, supply voltage, and signal distortion requirements. Discrete GaAs semiconductors still play a significant role in today's market, primarily because of analog and TDMA types of systems, ICs will be the wave of the future, especially for CDMA technology, where there is

currently no discrete solution available on the market. System-level integration (SLI) of the radio will continue to evolve as handsets continue to decrease in size.

Market Applications for Digital GaAs

It is quite obvious that digital GaAs has also made a comeback from the depths of obscurity, in the form of one company that has emerged as the market leader: Vitesse Semiconductor. Now the darling of Wall Street analysts, Vitesse has managed tremendous growth in an area in which digital GaAs is, again, an enabling technology. That market area is wired telecom.

The three major areas of opportunity for digital GaAs are:

- SONET
- Gigabit Ethernet
- Fibre Channel

Figure 10 shows SONET/SDH chip technology and where GaAs fits in.

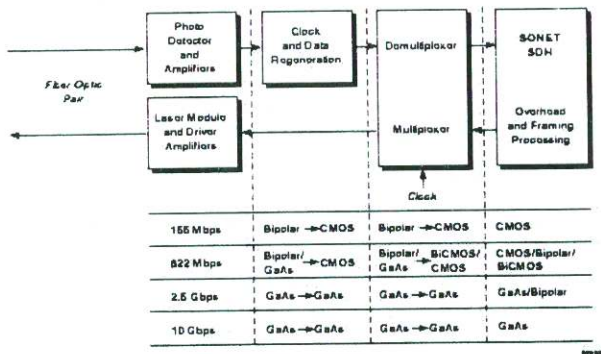


Fig. 10. SONET/SDH Chip Technology
Source: Dataquest

As can be seen, GaAs has opportunities in SONET/SDH applications above 622 Mbps up to today's 40 Gbps WDM systems.

The Gigabit Ethernet market is expected to grow from 46,000 ports in 1997 to 3.5 million in the year 2000, a CAGR of 327 percent. Fibre Channel is another emerging market in which digital GaAs ICs can play a role.

Competing Technologies

Always in hot pursuit of GaAs, other competing technologies are beginning to take shape and will emerge into the marketplace in 1998. These are:

- Si LDMOS
- SiGe
- SOI

Dataquest believes that as the equipment suppliers gain more confidence in using these new technologies, especially SiGe, the market for RF semiconductors in the 1 GHz to 2 GHz frequency spectrum will be a free-for-all. Multiple technologies will be competing for the same system socket, and, because of the integration capability of SiGe for SLI chips, it will start to carve away at the GaAs market, especially for low-tier applications such as cordless handsets.

What does the future hold for GaAs? Each successive wireless communication application increases in frequency, which creates more opportunity for GaAs and less for silicon. Supply voltages will continue to decrease to 3 volts and eventually down to 1.5 volts. Cost will be the deciding factor in which technology wins. Performance that is good enough versus extremely high performance will always win the majority of the market. The next few years will see GaAs in production using 150mm wafers, more and more larger silicon manufacturers entering the market, and, as always, some industry consolidation as the big players get bigger and the smaller players get smaller.