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ОРГАНИЗАЦИЯ И ЭКОЛОГИЯ ПРОИЗВОДСТВА, ЛОГИСТИКА И МАРКЕТИНГ

Учебное пособие

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Для слушателей программы переподготовки в области
промышленного производства наногетероструктурных монолитных
интегральных схем СВЧ диапазона и дискретных полупроводниковых приборов.

STRATEGYANALYTICS
GaAs & COMPOUND SEMICONDUCTORS

GaAs Industry Overview and Forecast: Custom Report for TUSUR

GaAs and Compound Semiconductor Technologies Service

Asif Anwar, aanwar@strategyanalytics.com

Viewpoint Snapshot

Despite macroeconomic trends still in flux at the end of 2009, the market for GaAs devices showed a strong recovery towards the end of the year as a result of trends in the wireless markets. While GaAs will see increased competition from silicon technologies in other end markets, GaAs will maintain its position as the enabling technology for next generation cellular handsets. Overall, the GaAs device market will grow at a CAAGR of 4% through 2015 to be worth $4.7 billion. The corresponding market for GaAs (bulk and epitaxial substrates will be worth $747 million in 2014.

September 2010

1 Executive Summary

Despite macroeconomic trends still in flux at the end of 2009, the market for GaAs devices showed a strong recovery towards the end of the year as a result of trends in the wireless handset markets. The smartphone category in particular provided a vital lifeline, boasting stronger than average annual growth while also increasing the average number of multiple GaAs device insertions per terminal. Importantly, for the GaAs industry as a whole, while other sectors will see increased competition from silicon technologies, GaAs technology will maintain its position as the enabling technology for next generation cellular handsets. Overall, the GaAs device market will grow at a CAAGR (compound annual average growth rate) of 4% through 2015 to be worth $4648.9 million. The corresponding market for GaAs (bulk and epitaxial substrates will be worth $747 million in 2014.

- The overall 2009 market was estimated at $3433.7 million and is forecast to grow at a 2009-2015 CAAGR (Compound Annual Average Growth Rate) of 4% to reach $4355.0 million by 2015. While other sectors will see increased competition from silicon technologies, GaAs technology will maintain its position as the enabling technology for next generation cellular handsets.

- The total (Merchant & Captive) market for discrete GaAs FETs in 2009 was $241.4 million, representing a 5% year-on-year decline. While the overall merchant market will grow to $278.4 million by 2015, this will represent CAAGR of 3% as the market essentially flattens out over 2012 – 2014.

- The temporary digital GaAs IC bubble has burst with the 2009 total market for digital GaAs ICs was declining year-on-year by 5% to $19.7 million in 2008. Demand for digital GaAs ICs, largely centered in the telecoms and datacoms market sectors for 10Gb and above markets, the market for digital GaAs ICs continued on its negative trajectory in 2009 and will show negative growth through 2015.

- The total market for SI GaAs epitaxial substrates will grow from 22703 ksi in 2009 to 36483 ksi in 2014, a CAAGR (compound annual average growth rate) of 10%. Strategy Analytics estimates that the total SI GaAs epitaxial substrate market was worth over $389 million in 2009 and will grow at a CAAGR of 6% to just under $530 million in 2014.

- The overall SI GaAs substrate market will grow from 24646 ksi in 2009 to 39900 ksi in 2014, a CAAGR of 12%. The corresponding market for GaAs bulk substrates will be worth $160 million in 2009 and will grow at a CAAGR of 7% through 2014 to be worth $217 million in 2014.

Contents

Exhibits

2 Introduction

This report sets out Strategy Analytics' analysis and forecast for the vertical GaAs market supply chain from bulk substrates through to epitaxial substrates to MMIC, discrete and digital ICs. The analysis is based on extensive supply-side and user-based research of the GaAs industry and draws heavily on the expertise of analysts in other divisions of Strategy Analytics, who closely monitor many of the end-application systems areas in which GaAs is being applied.

This custom report was developed for TUSUR and provides the presentation material presented on September 9th, 2010 along with supporting text.

2.1 Methodology

The industry outlook is based on a comprehensive supply-side and user-based analysis of the GaAs industry, and brings together data from three major worldwide GaAs industry surveys;

GaAs IC Vendor Survey; includes detailed interviews with the major North American, Japanese, Asia-Pacific and European GaAs IC producers.

GaAs Wafer User Survey; includes feedback from users which represent over 80% of demand for GaAs bulk and epitaxial wafers, the mainstream material for GaAs IC manufacture.

GaAs Wafer Vendor Survey; includes interviews with the leading GaAs substrate (bulk and epi) suppliers.

Respondents are interviewed in-depth about the present status of the GaAs industry, and the outlook for the next five years in terms of their expected usage or expected revenue growth, as appropriate. Several different market estimates are thereby obtained.

At the applications level, key sources of systems information are Strategy Analytics' Advisory Consultancy Programs including Connected Home Devices, Wireless Device Strategies and Automotive Electronics amongst others. For the RF component end-demand model, we have worked closely with Strategy Analytics' RF and Wireless Components service.

Finally, the forecast draws on recent Industry Reports and Viewpoints published by Strategy Analytics GaAs and Compound Semiconductor Technologies Service, which contain detailed analyses of key target markets for GaAs ICs and GaAs SI wafers.

Economic conditions and the position of GaAs within the overall semiconductor industry have also been taken into account, and these factors are implicitly included in our data.

2.2 Exchange Rates

All data contained in this report are presented in US dollars. In calculating revenues in other currencies the following exchange rates are used:

Exhibit 2-1 Exchange Rates

Exchange Rates to US Dollar			
Currency	2008	2009	% change 2008-2009
British Pound	0.55	0.64	16%
Euro	0.68	0.72	5%
Japanese Yen	103.5	93.5	-10%

Strategy Analytics forecasts always assume constant exchange rates going forward from the base year. No exchange rate forecasts are included in our figures. The forecasts included in this report assume a constant dollar exchange ratio with other currencies. Significant deviations from this assumption in the future will require correction in the forecast information.

To explore this topic in more detail or to hear how our solutions (Workshops, Presentations, Consulting engagements, annual multi-client services) can support you please visit www.strategyanalytics.com/solutions.html

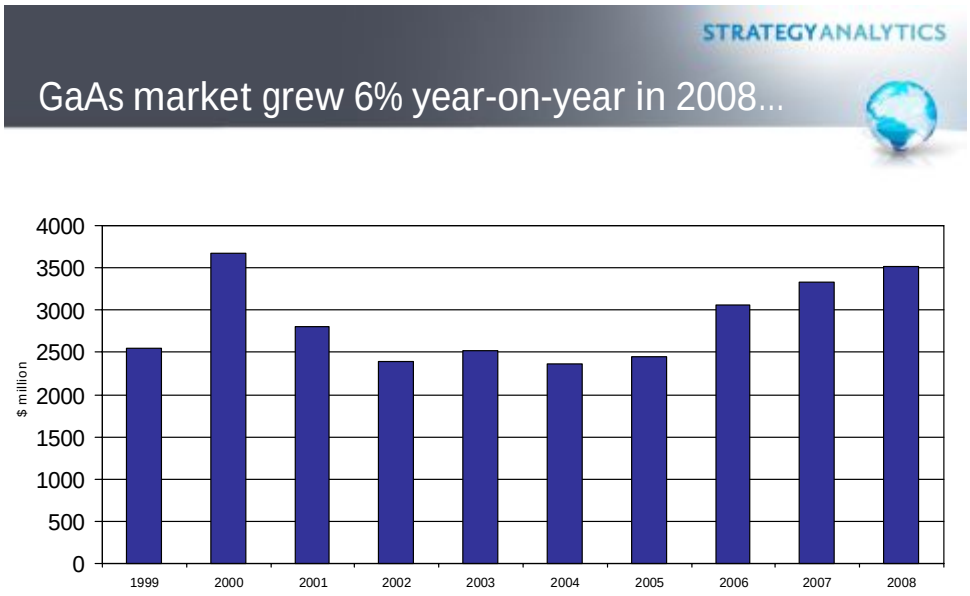
If you have inquiry privilege, please contact the author of this report Asif Anwar using aanwar@strategyanalytics.com or the following number: +44 1908 423 635.

3 GaAs Industry Review and Forecast

3.1 GaAs Industry Performance through 2009

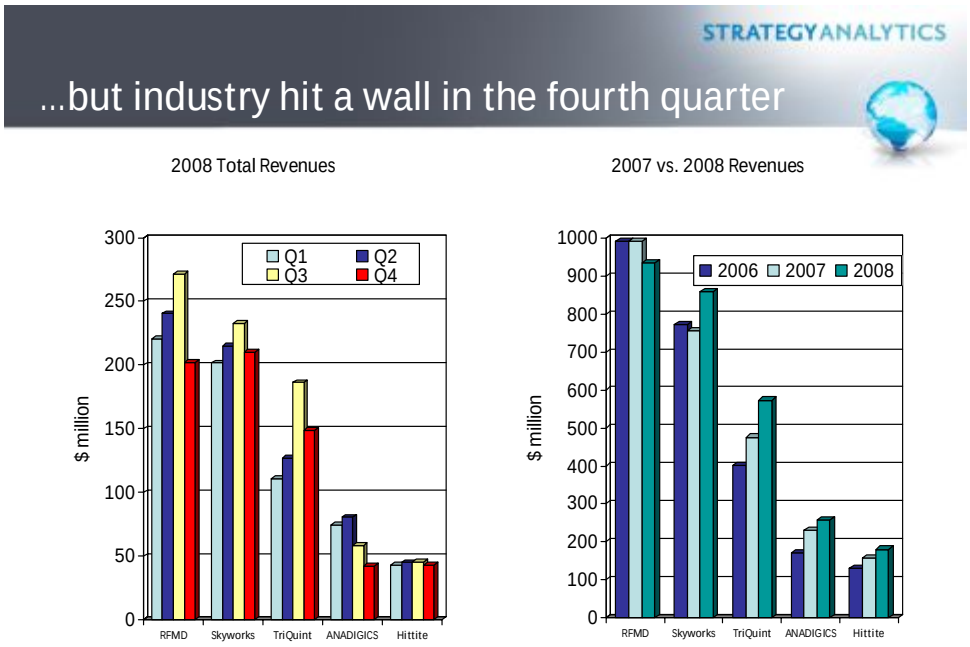
Following the downturn in 2001, the GaAs industry has shown stead growth through 2008, but the industry hit a wall in the final quarter of that year as the global recession caught up with the GaAs industry (Exhibit 3-1 and 3-2)

Exhibit 3-1 GaAs performance through 2008



Analysis of leading GaAs device IDMs (integrated device manufacturers) demonstrates the significant negative impact that the fourth quarter of 2008 had on company revenues for leading bellweathers of the GaAs industry including RFMD, Skyworks, TriQuint, Anadigics and Hittite.

Exhibit 3-2 Impact of Q4'08 on Industry Performance

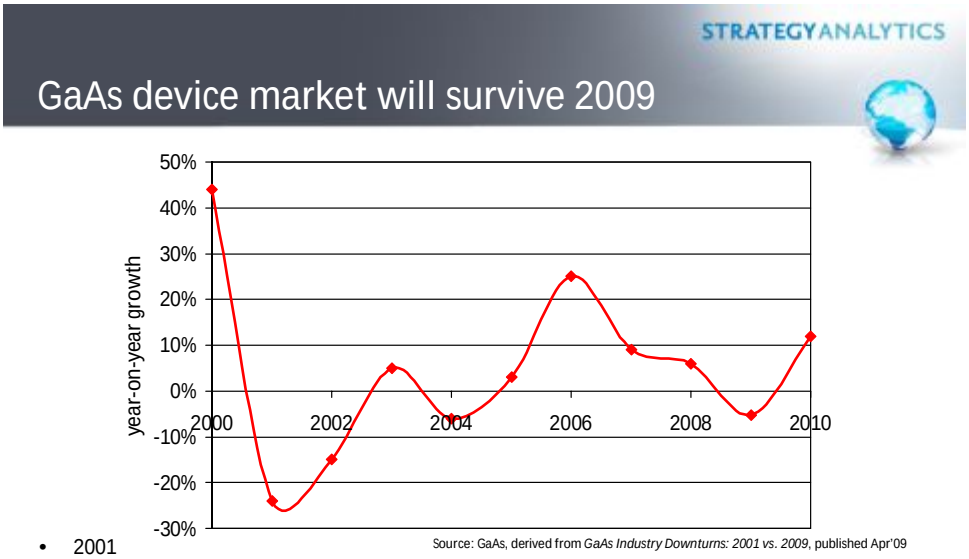


Despite the dramatic all off in revenues in the last quarter of 2008, overall revenues still grew and Strategy Analytics predicted that the 2009 downturn would not be a repeat of dynamics in 2001, which saw industry revenues drop 25%.

Strategy Analytics analysis suggested number of differences between the 2001 and 2009 downturns;

- In 2001, there was a lot of talk about 3G technologioes and wireline broadband services that would drive demand for bandwidth. However, it was clear that 3G technology was not ready for the market and there were no services available to the consumer that required the bandwidth offered by 10G and 40G fiber-optic networks.
- 2001 also saw extremely high excessive inventory build-up in the cellular handset supply chain that extended from operator and cellular handset distribution channels through to the GaAs device and material suppliers.

Exhibit 3-3 Projections for 2009 vs. 2001



Source: GaAs, derived from *GaAs Industry Downturns: 2001 vs. 2009*, published Apr'09

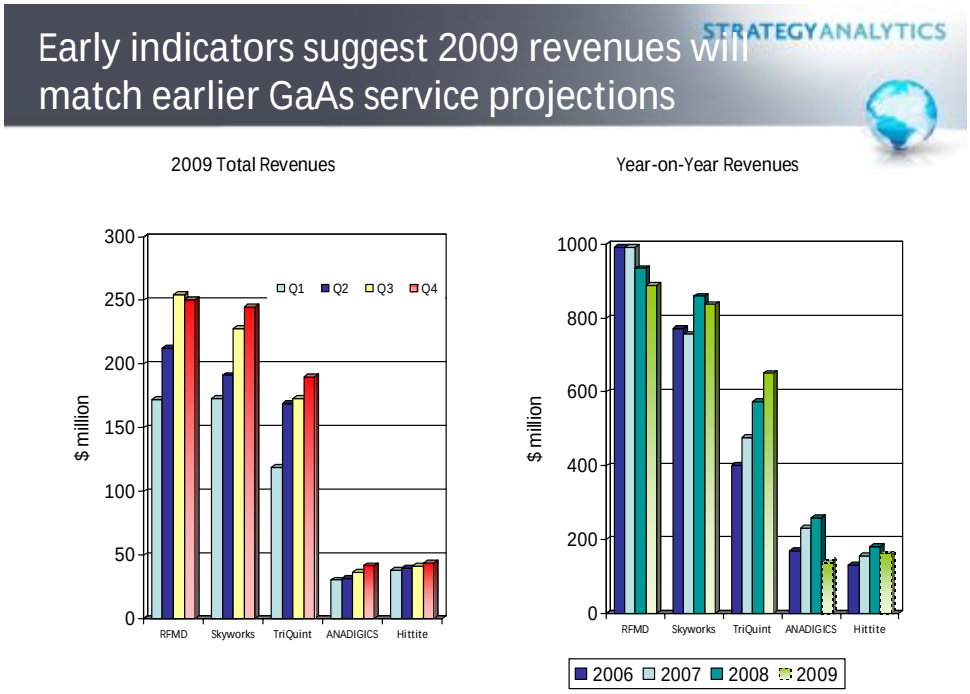
- 2001
  - Telecoms bubble burst
  - Excessive inventories in the cellular handset supply chain
- 2009
  - Demand for bandwidth increasing
  - No excessive inventory

- In 2009, broadband was an integral part of the consumer's portfolio of products both on wireless and wireline platforms. Moving forwards, the demand for bandwidth will increase as the viewing of streaming content becomes increasingly commonplace with internet content now extending to the living room via the TV and connected devices (outside the conventional realms of cellular handsets) becoming the norm moving forwards.

- Inventory build-up in 2009 was not at the same level as 2001 levels and while there was a general slowdown in demand for GaAs devices and materials, inventories were being cleared by the first quarter of 2009 with major handset OEMs such as Nokia starting to resume placing orders from their suppliers from the second quarter of 2009 onwards.

This resulted in industry revenues starting to ramp-up again from the second half of 2009 and a snapshot of the same five companies highlighted in Exhibit 3-2 showed that the market was beginning to pick-up, slowing down overall year-on-year revenue declines (Exhibit 3-4).

Exhibit 3-4 Industry Performance in 2009



3.2 Drivers for GaAs Industry

Key drivers for GaAs industry growth moving forwards include the following factors:

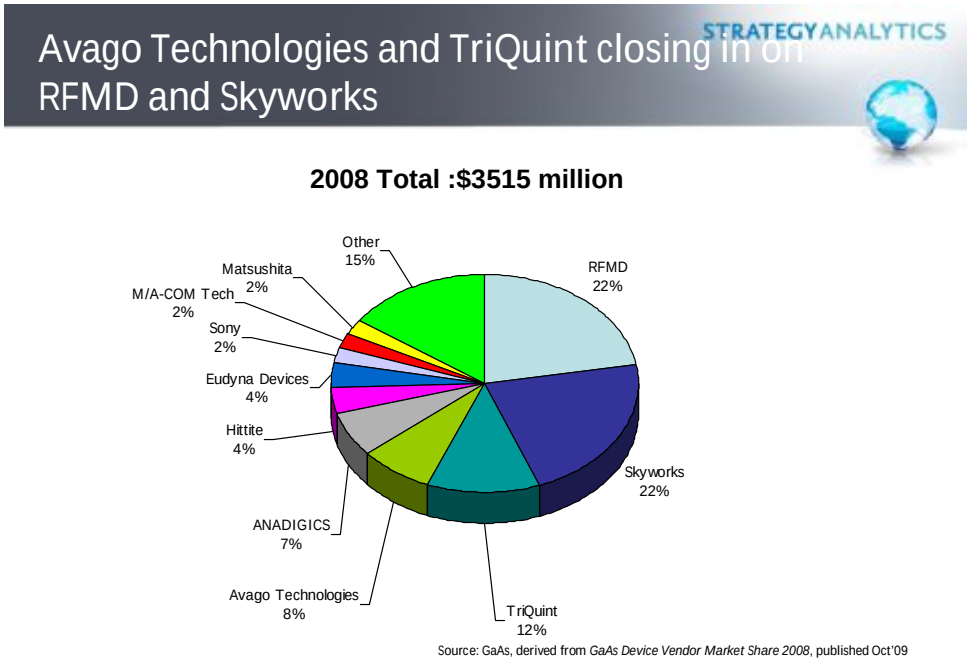
- GaAs is at the forefront of wireless markets, enabling consumer devices such as cellphones and other wireless platforms such as Wi-Fi and WiMAX. Future growth will also come from the utilisation of cellular platforms in machine-to-machine (M2M) communications.
- GaAs technology is also supporting the underlying infrastructure that is required to support next generation devices and will be increasingly utilised in cellular base stations, wireless backhaul and fiber-optic networks.
- GaAs is also a critical technology used for the delivery of digital TV content to the consumer in the home, e.g. CATV (cable television) and DBS (direct broadcast satellite).
- The automotive industry is implementing safety systems into their vehicles that incorporate radar technologies realised using GaAs.
- With a background stemming from defence research, there is increasing use of GaAs technology in communications and radar platforms.

4 GaAs Device Vendor Dynamics

4.1 2008 Market Share and Market Leaders

In 2008, the GaAs device market (excluding captive demand and foundry revenues) was worth $3.5 billion.

Exhibit 4-1 2008 Merchant IDM Revenues



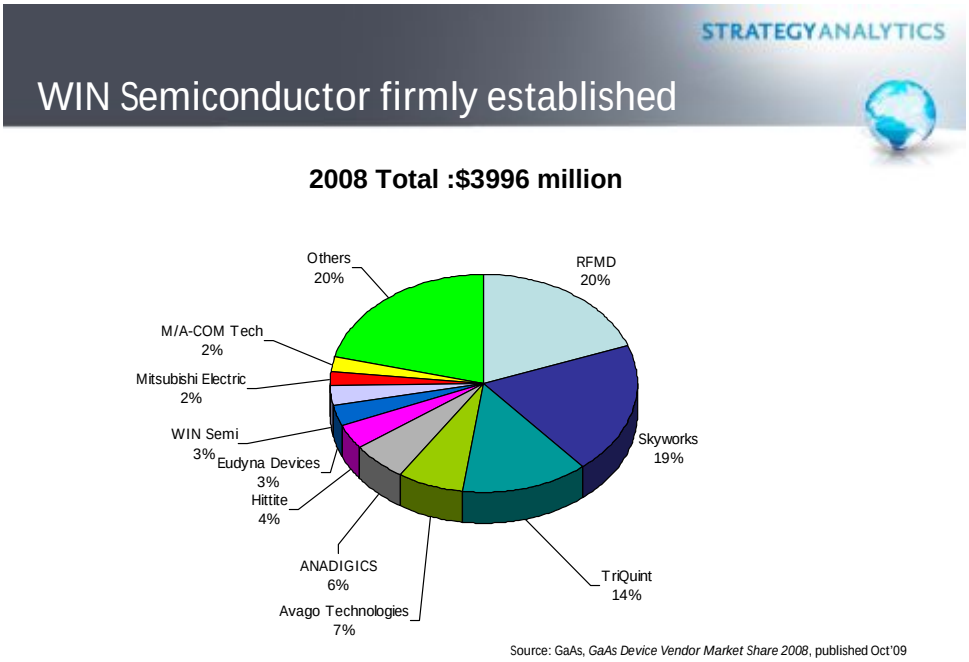
Merchant IDM revenues; excluding foundry market

RFMD and Skyworks have maintained the number one and two position respectively for several years as a result of strong ties with the cellular handset industry.

Overall, the GaAs leadership is dominated by North American companies, with the top six companies all based out of the US.

Most of the companies are IDMs, which means that they operate their own fabrication facilities, but companies such as Hittite have adopted fabless models, while other companies have looked towards "hybrid" manufacturing strategies. This has led to the emergence of pure-play foundries such as Win Semiconductor and these companies are increasing their overall position in the GaAs industry (Exhibit 4-2).

Exhibit 4-2 2008 GaAs Industry Revenues



Source: GaAs, *GaAs Device Vendor Market Share 2008*, published Oct'09

Merchant & captive including foundry market

4.2 2009 Market Share and Market Leaders

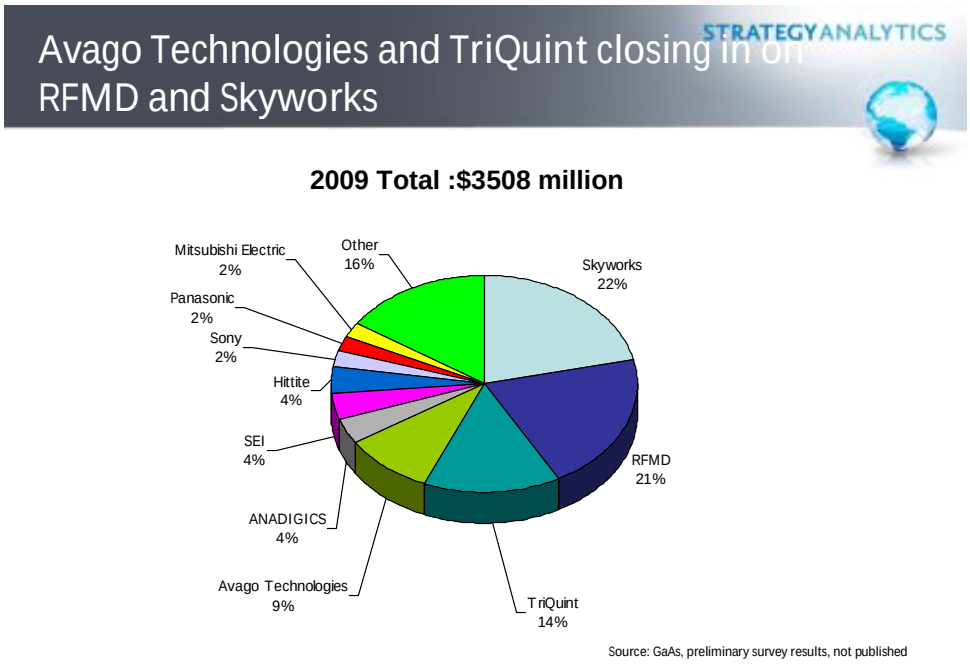
The overall GaAs IDM revenues were maintained in 2009 with RFMD and Skyworks continuing to be the top two merchant suppliers of GaAs devices. However, RFMD has slipped from the top spot and both companies are facing increasing competition from Avago Technologies and TriQuint.

Both Avago Technologies and TriQuint have increased market share year-on-year as a result of continued strength in the cellular handset market, with a specific focus on emerging 3G and 4G markets.

Anadigics also remains a key supplier in the handset market and is also the leading supplier of GaAs technology into the CATV infrastructure sector.

Hittite maintains a focus on specialised and niche sectors such as defense and infrastructure which has allowed the company to maintain revenue growth and profitability.

Exhibit 4-3 2009 Merchant IDM Revenues



Merchant IDM revenues; excluding foundry market

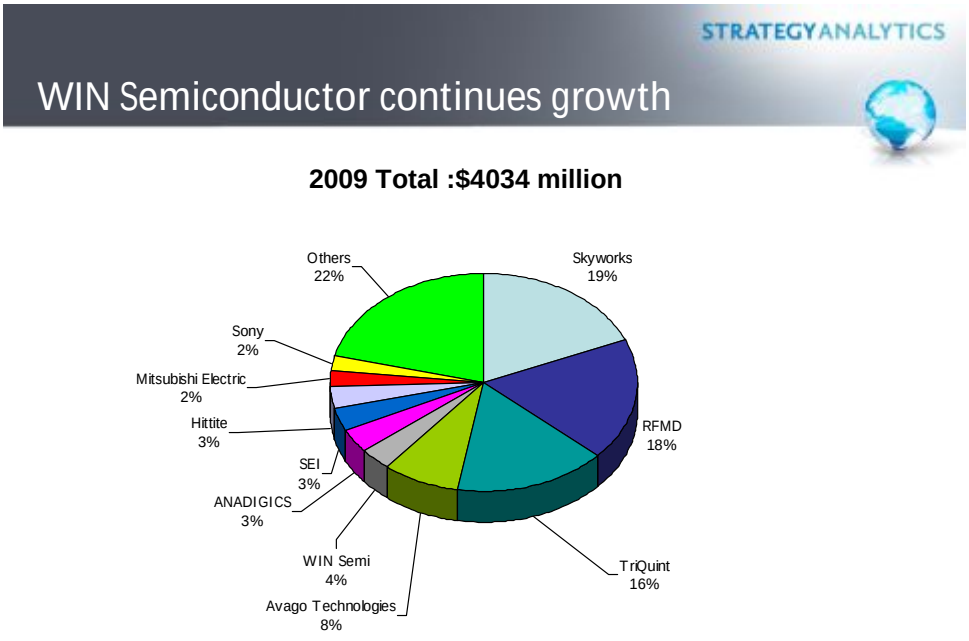
The Japanese leaders include SEI (Sumitomo Electric Industries), Sony, Panasonic and Mitsubishi Electric. SEI has a focus on infrastructure markets including cellular base stations and point-to-point radio, while Panasonic and Sony are entrenched in the Japanese handset market. Mitsubishi Electric has a focus on both volume and infrastructure markets.

Japanese companies continue to lag behind North American counterparts as a result of a lack of focus outside of their domestic markets. Strategy Analytics believes this is partly due to the GaAs manufacturing capabilities of these companies being part of much larger multinational semiconductor operations which limits the ability of the Japanese companies to effectively target markets outside of Japan.

There are only two main European GaAs device manufacturers and they do not feature in the top ten. UMS and OMMIC are based in France and focus primarily on niche markets. UMS is engaged with the leading European defense houses such as EADS and Thales.

Win Semiconductor has continued to grow in-line with demand for foundry services. This also helps TriQuint to increase its overall share of the GaAs market, as this company also offers foundry services.

Exhibit 4-4 2009 GaAs Industry Revenues



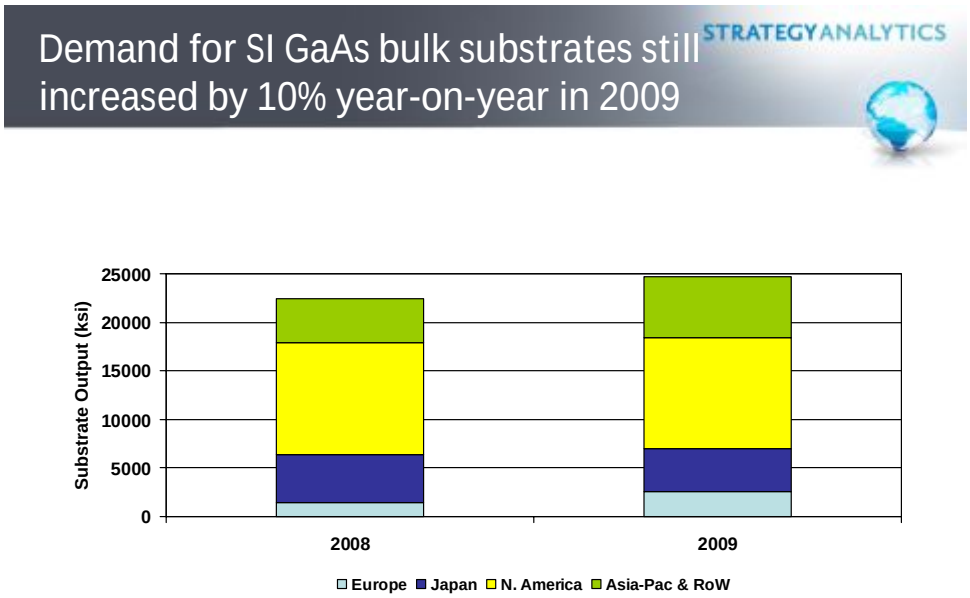
Merchant & captive including foundry market

5 Supply Chain Dynamics

5.1 Semi-insulating GaAs Bulk Substrate Market

A robust recovery in the second half resulted in the demand for SI GaAs bulk substrates still increasing by 10% year-on-year in 2009.

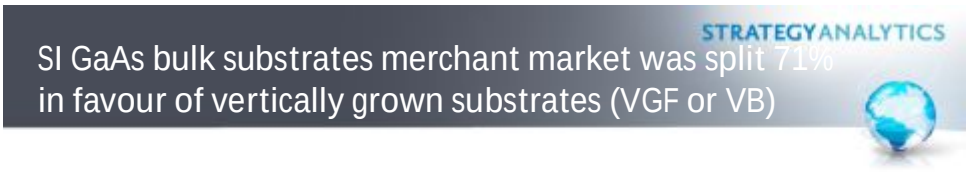
Exhibit 5-1 World SI GaAs Bulk Wafer Market: 2008-2009

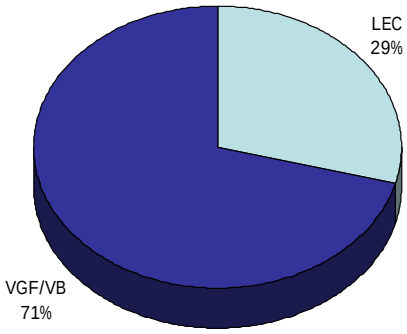


Source: GaAs, *Semi-insulating GaAs Substrate Markets: 2009-2014*, published Jul'10

Strategy Analytics estimates that the SI GaAs bulk substrates merchant market was split 71% in favor of vertically grown substrates (VGF or VB) (Exhibit 5-2).

Exhibit 5-2 SI GaAs Bulk Substrate Demand by Growth Method





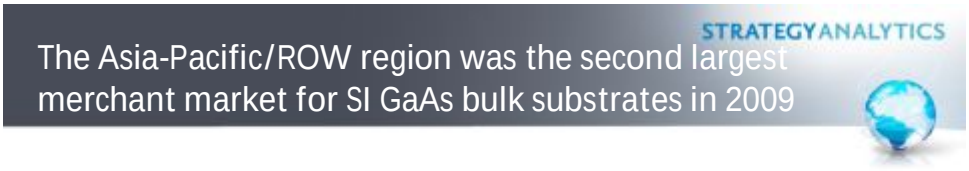
Source: GaAs, *Semi-insulating GaAs Substrate Markets: 2009-2014*, published Jul'10

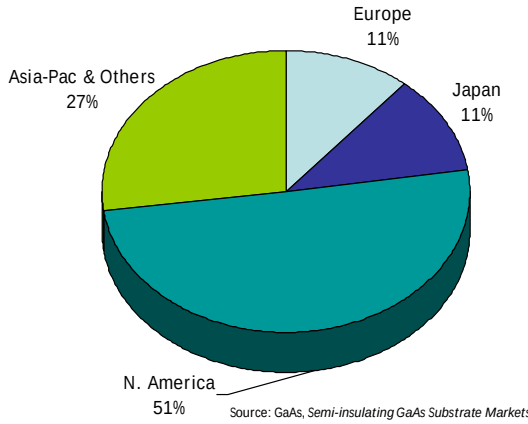
Of the total merchant demand for SI GaAs wafers, 11427 ksi (50% of the total) is due to demand from North American users, 2570 ksi (11%) from Japanese users and 2531 ksi (1%) from users in Europe (Exhibit 3-2 and Exhibit 3-6). The Asia-Pacific/ROW region represented the second largest merchant market for SI GaAs bulk substrates in 2009.

Demand from Asia-Pacific users increased significantly in 2009 versus 2008. This reflects the growing strength of epitaxial substrate suppliers based in the region (Exhibit 5-3).

Strategy Analytics estimates that demand for larger diameter material largely incorporating six-inch substrates grew 22% year-on-year with demand driven by both GaAs device manufacturers and epitaxial substrate suppliers. Overall, this market accounted for 77% of the merchant market in 2009 (Exhibit 5-4).

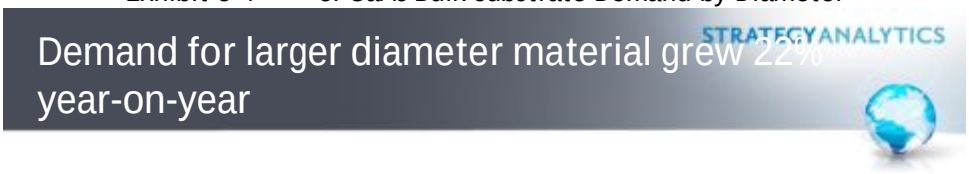
Exhibit 5-3 SI GaAs Bulk Substrate Demand by Region

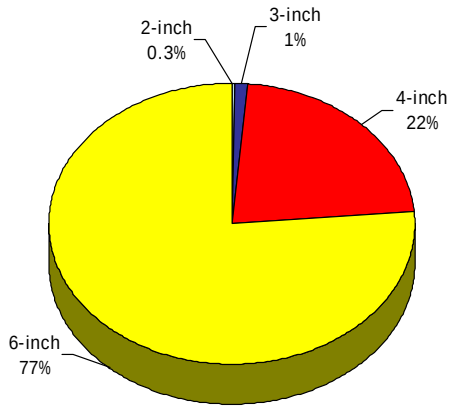




Source: GaAs, *Semi-insulating GaAs Substrate Markets: 2009-2014*, published Jul'10

Exhibit 5-4 SI GaAs Bulk Substrate Demand by Diameter

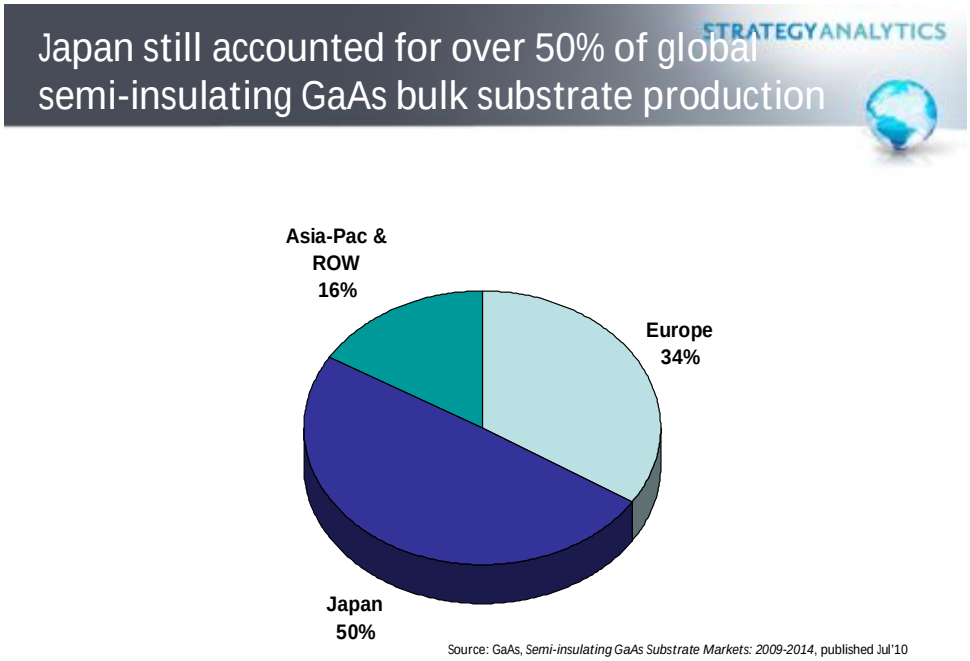




Source: GaAs, *Semi-insulating GaAs Substrate Markets: 2009-2014*, published Jul'10

Total global production of semi-insulating GaAs bulk substrates in 2009 was estimated at 24646 ksi. European production accounted for 28% in 2008, while Japan still accounted for 51% of global semi-insulating GaAs bulk substrate production.

Exhibit 5-5 SI GaAs Wafer Production by Region



Source: GaAs, *Semi-insulating GaAs Substrate Markets: 2009-2014*, published Jul'10

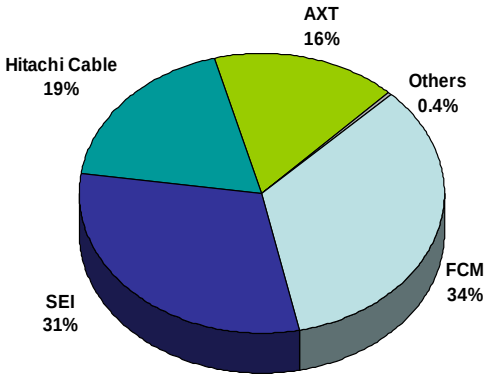
European production is dominated by one company, while Sumitomo Electric and Hitachi Cable dominate supply to both the Japanese market. Production from the Asia-Pacific region is led by AXT, but the Chinese company, Compound Crystal Technology (CCT) is also starting to attack the SI GaAs bulk substrates market.

Strategy Analytics estimates that Freiberger Compound Materials (FCM) continued to occupy the number one position in 2009, staying ahead of SEI (Exhibit 5-6).

Hitachi Cable continues to be a key supplier to the industry and was the world's largest supplier of LEC material to the merchant market in 2009. Hitachi Cable was also the world's largest captive consumer of SI GaAs bulk substrates in 2009.

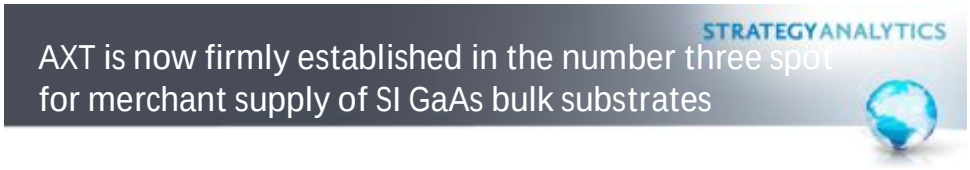
Discounting this captive element, AXT is now firmly established in the number three spot for merchant supply of SI GaAs bulk substrates (Exhibit 5-7).

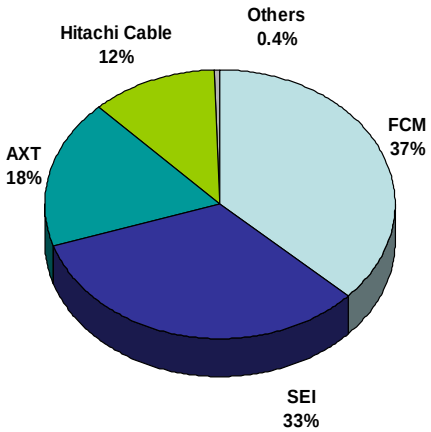
Exhibit 5-6 World SI GaAs Wafer Vendor (M&C) Market Share



Source: GaAs, *Semi-insulating GaAs Substrate Markets: 2009-2014*, published Jul'10

Exhibit 5-7 World SI GaAs Wafer Vendor Merchant Market Share

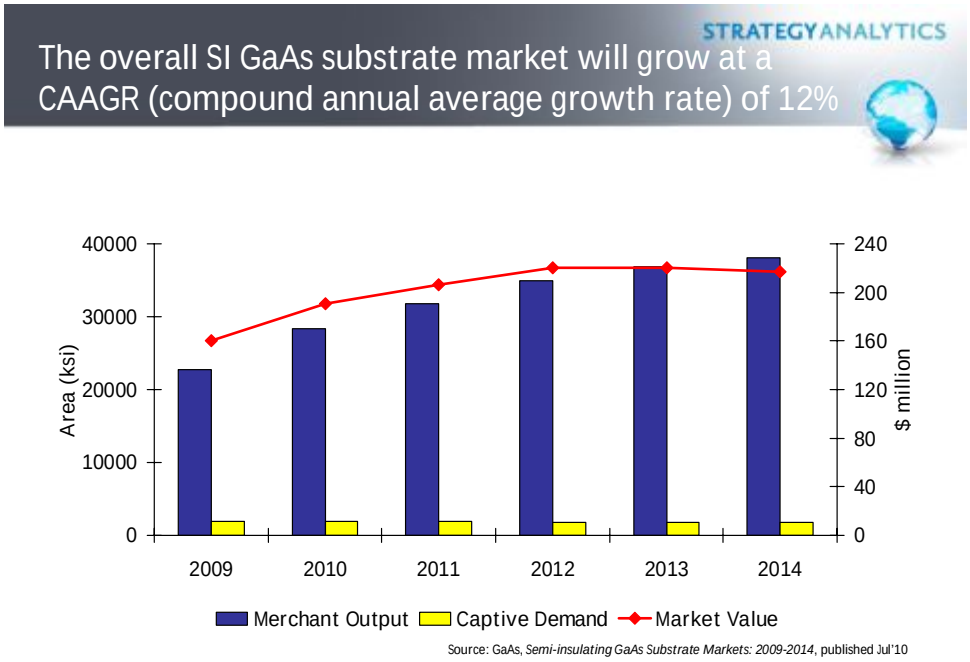




Source: GaAs, *Semi-insulating GaAs Substrate Markets: 2009-2014*, published Jul'10

The overall SI GaAs substrate market will grow from 24646 ksi in 2009 to 39900 ksi in 2014, a CAAGR (compound annual average growth rate) of 12%. Merchant demand accounted for 92% in 2009 and will grow at a CAAGR of 11% through 2014. Captive demand for substrates will decline to 5% by 2013. The corresponding market for GaAs bulk substrates will be worth $160 million in 2009 and will grow at a CAAGR of 7% through 2014 to be worth $217 million in 2014.

Exhibit 5-8 SI GaAs Bulk Substrate Market: 2009-2014

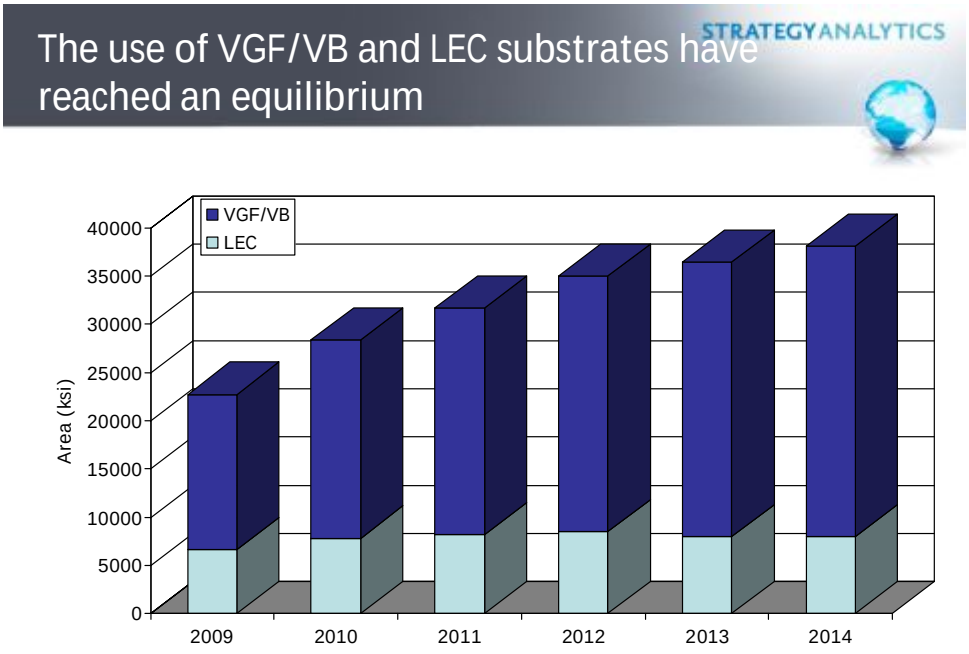


Source: GaAs, *Semi-insulating GaAs Substrate Markets: 2009-2014*, published Jul'10

The use of VGF/VB and LEC substrates have reached an equilibrium of sorts in the marketplace, with LEC substrates preferred for HEMT and MESFET device production, while VGF and VB substrates will dominate overall output driven by the prevalence for GaAs HBT devices based on vertically grown substrates (Exhibit 5-9).

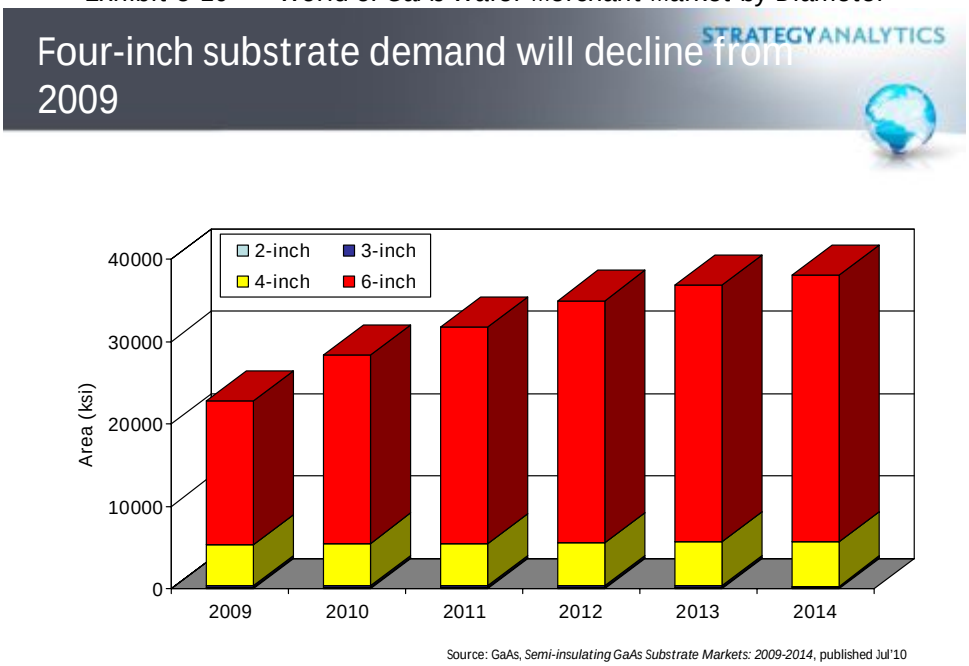
Strategy Analytics estimates that six-inch diameter wafers accounted for 77% of the total merchant market supply in 2009 versus 69% in 2008. Year-on-year market demand for six-inch diameter wafers will continue to grow at a CAAGR of 13% through 2014, and account for 85% of total merchant demand. With major four-inch to six-inch transitions completed, demand for four-inch material will drop (Exhibit 5-10).

Exhibit 5-9 World SI GaAs Wafer Merchant Market by Growth Technique



Source: GaAs, *Semi-insulating GaAs Substrate Markets: 2009-2014*, published Jul'10

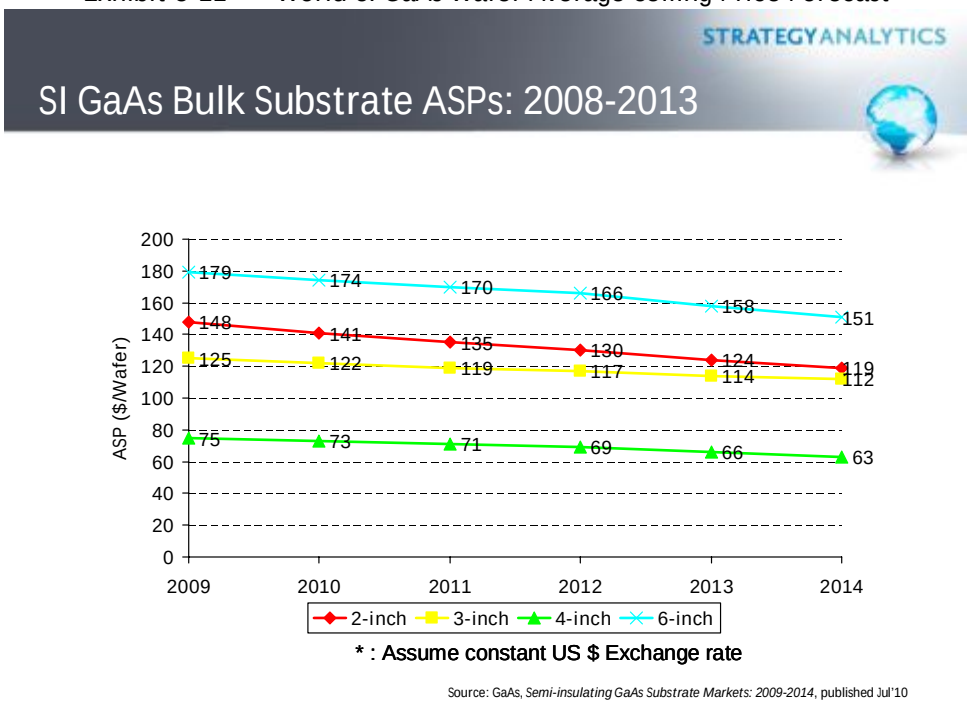
Exhibit 5-10 World SI GaAs Wafer Merchant Market by Diameter



Source: GaAs, *Semi-insulating GaAs Substrate Markets: 2009-2014*, published Jul'10

Strategy Analytics forecasts that while external factors such as slowing demand in 2009, raw material pricing etc will offset and/or slow ASP declines for the duration of the forecast timeframe, there will be increased pressure on six-inch pricing from 2011-12 onwards as demand for this material increases in place of four-inch and other diameters. Overall, we expect wafer pricing to decline at an average of 1% through 2013.

Exhibit 5-11 World SI GaAs Wafer Average Selling Price Forecast

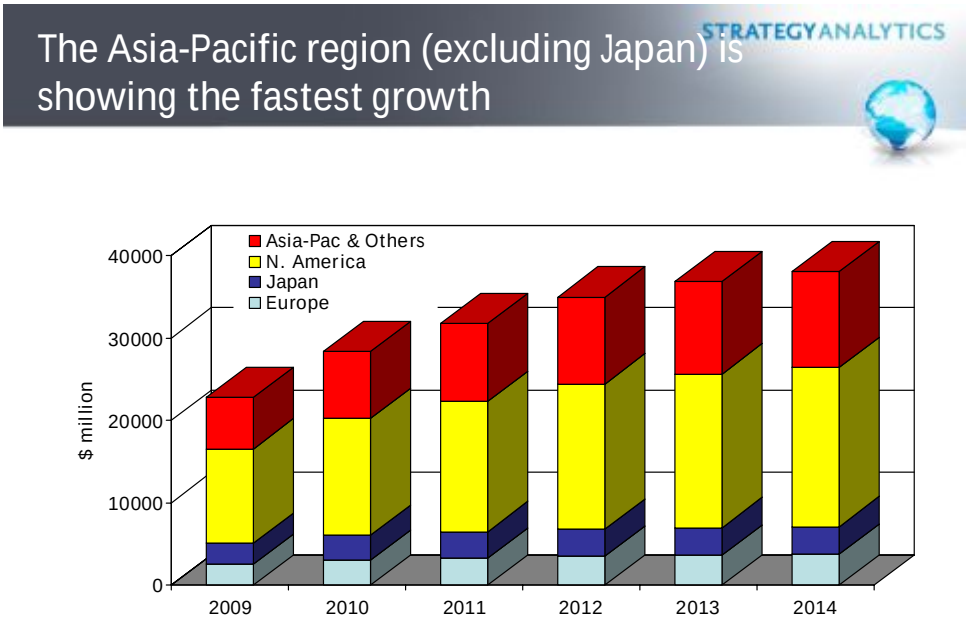


Source: GaAs, *Semi-insulating GaAs Substrate Markets: 2009-2014*, published Jul'10

The Asia-Pacific region (excluding Japan) is showing the fastest growth with year-on-year growth in 2009 of 38% and CAAGR of 13% through 2014. However, North America will remain the largest regional market (Exhibit 5-12).

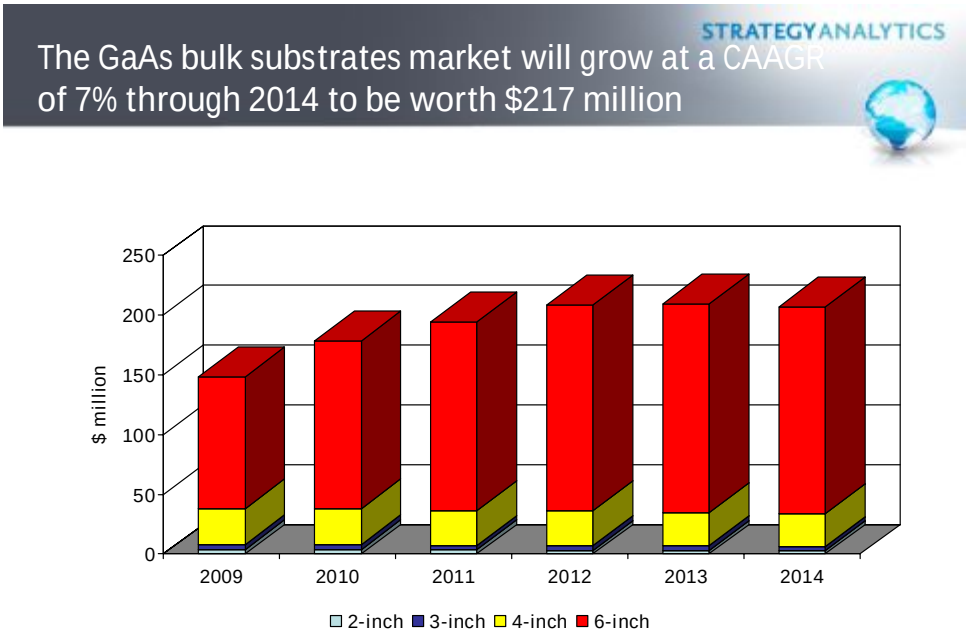
Strategy Analytics estimates that the SI GaAs bulk substrate merchant market was worth $148 million in 2009. With projected growth in volumes of around 25% in 2010, year-on-year substrate revenues will increase 21%, but we maintain the overall market will still peak in 2012, and will be worth $209 million before a combination of pricing pressure and slowing demand will result in year-on-year revenues flattening in 2013 and then declining by 1% in 2014. The overall CAAGR will be 7% for the 2009 – 2014 timeframe (Exhibit 5-13).

Exhibit 5-12 World SI GaAs Wafer Merchant Market by Region



Source: GaAs, *Semi-insulating GaAs Substrate Markets: 2009-2014*, published Jul'10

Exhibit 5-13 World SI GaAs Wafer Merchant Market Revenues

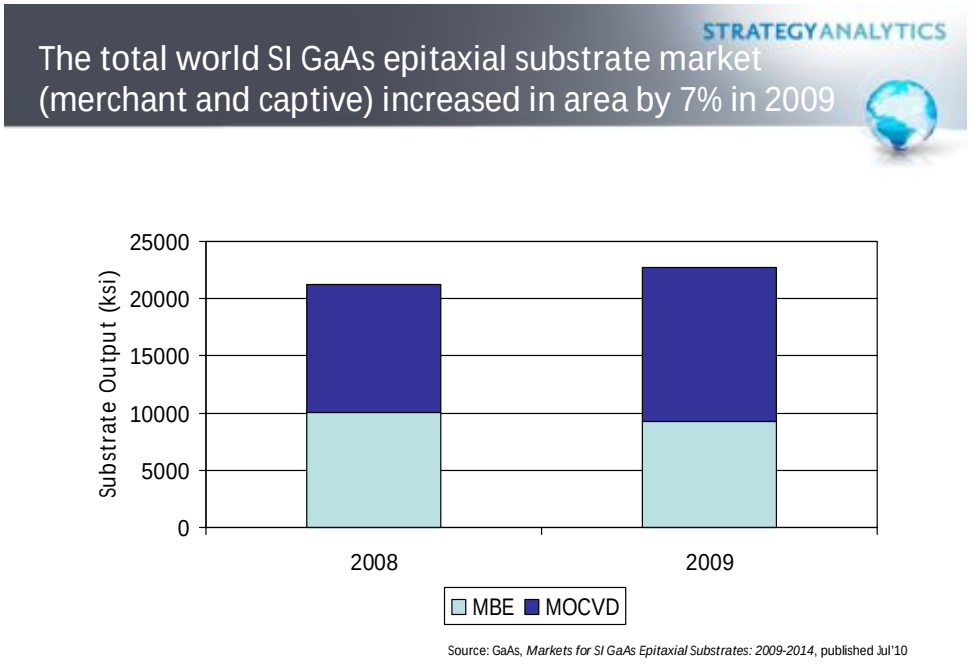


Source: GaAs, *Semi-insulating GaAs Substrate Markets: 2009-2014*, published Jul'10

5.2 Semi-insulating GaAs Epitaxial Substrate Market

Strategy Analytics estimates that the total world SI GaAs epitaxial substrate market (merchant and captive) increased in area by 7% in 2009 to 22703 ksi from 21239 ksi in 2008 (Exhibit 5-14).

Exhibit 5-14 World SI GaAs Epitaxial Substrate Market: 2008-2009



Source: GaAs, *Markets for SI GaAs Epitaxial Substrates: 2009-2014*, published Jul'10

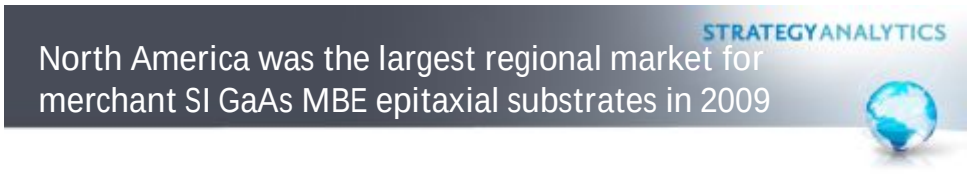
The total market has traditionally been split almost evenly between MOCVD and MBE processed substrates, but the MOCVD epitaxial substrates are supplied through commercial channels while captive capabilities feature heavily for MBE epitaxial substrates.

There is significant captive output of MBE substrates at companies such as RF Micro Devices and Skyworks

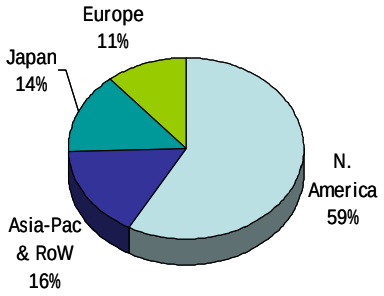
North America was the largest regional market for merchant SI GaAs MBE epitaxial substrates in 2009, accounting for 79% of the total (merchant and captive) market (Exhibit 5-15).

The overall trend for SI GaAs MBE epitaxial substrates is similar for both the total market and merchant demand with six-inch diameters dominating the market (Exhibit 5-16).

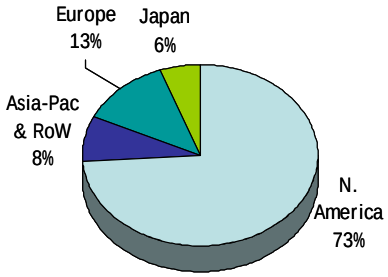
Exhibit 5-15 SI GaAs MBE Market by Region



Merchant MBE: 4517ksi

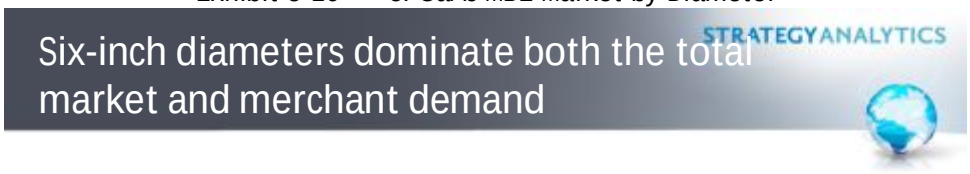


Merchant & Captive MBE: 9232ksi

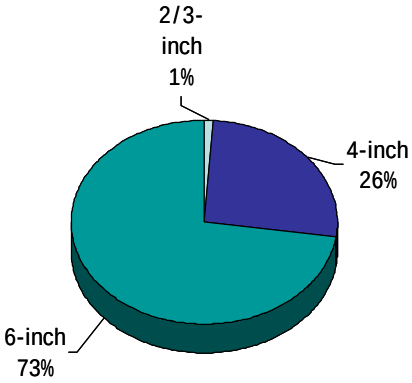


Source: GaAs, *Markets for SI GaAs Epitaxial Substrates: 2009-2014*, published Jul'10

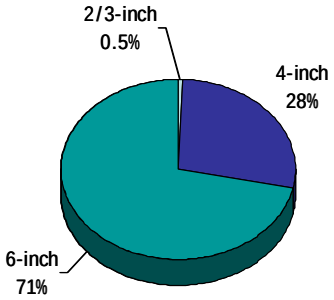
Exhibit 5-16 SI GaAs MBE Market by Diameter



Merchant MBE: 4517ksi



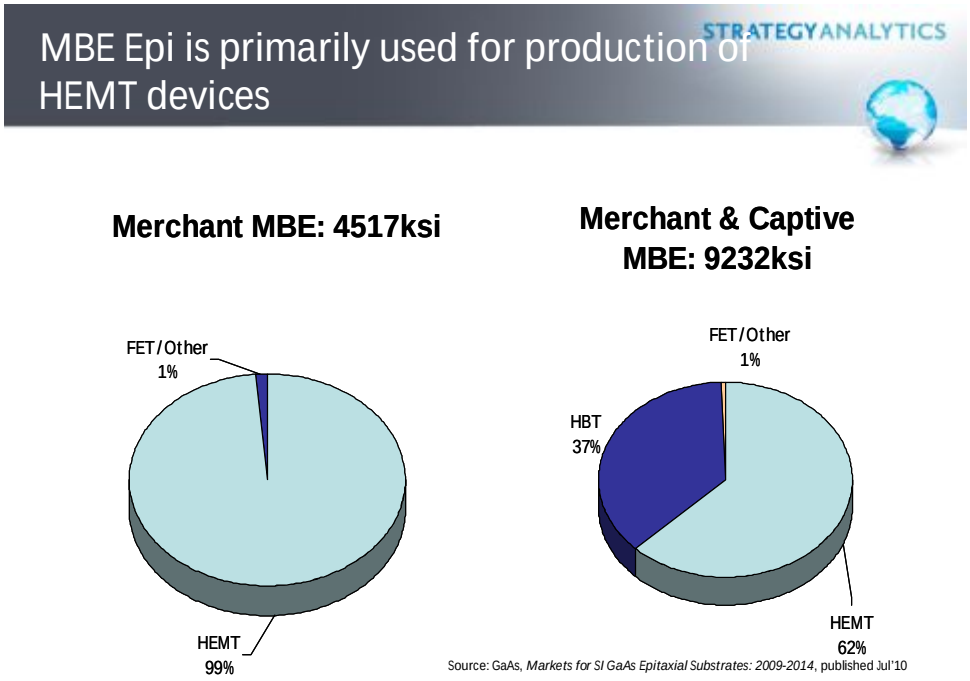
Merchant & Captive MBE: 9232ksi



Source: GaAs, *Markets for SI GaAs Epitaxial Substrates: 2009-2014*, published Jul'10

Overall, HEMT devices accounted for 62% of the total MBE epitaxial substrates market in 2009, up from 60% in 2008, while 96% of all MBE substrates sourced from merchant suppliers were used for the production of HEMT devices. Taking into account, the captive element of the MBE market has the most marked effect on segmentation by structure. We estimate that RFMD's captive MBE output is focused primarily on the production of AlGaAs HBT devices.

Exhibit 5-17 SI GaAs MBE Market by Structure



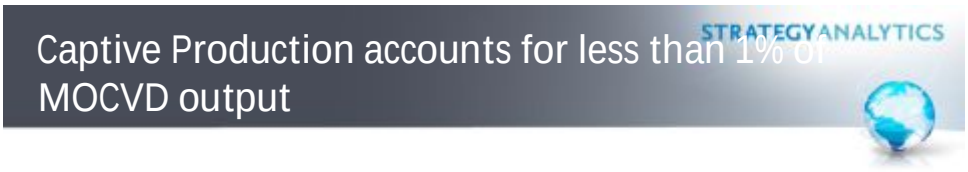
Source: GaAs, *Markets for SI GaAs Epitaxial Substrates: 2009-2014*, published Jul'10

In contrast with the MBE market, SI GaAs MOCVD epitaxial substrates are primarily sourced from merchant suppliers. Strategy Analytics estimates that captive production of MOCVD substrates accounted for less than 1% of the total market in 2009.

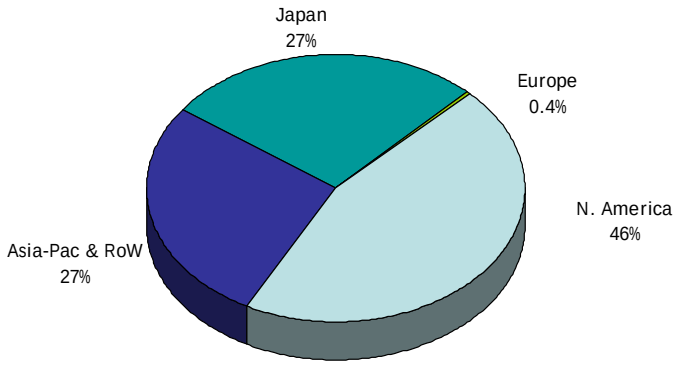
On a regional basis, increased demand from both Asia-Pacific and Japan resulted in these two end markets accounting for 54% of the total MOCVD merchant market, but North America continued to represent the largest market for MOCVD material (Exhibit 5-18).

The market for six-inch MOCVD material was driven by increased demand from Asia-Pac as well as six-inch upgrades taking place at North American companies such as Skyworks, meaning that demand for six-inch MOCVD material increased by over 14% year-on-year in 2009, and accounting for 73% of total demand (Exhibit 5-19).

Exhibit 5-18 SI GaAs MOCVD Market by Region

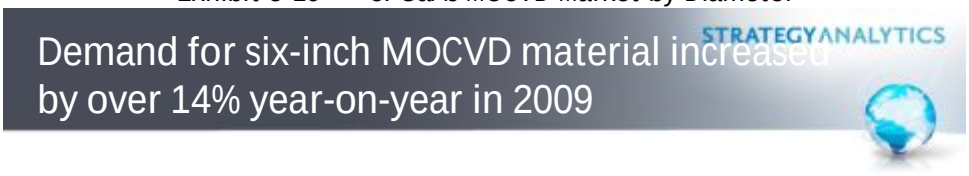


Merchant MOCVD: 13466ksi

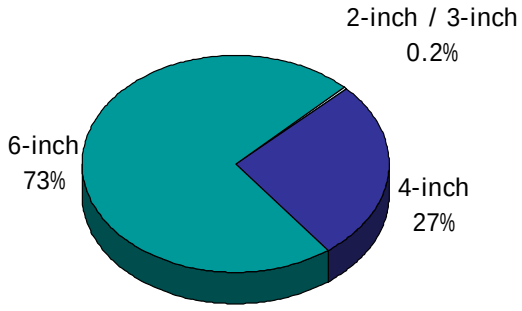


Source: GaAs, *Markets for SI GaAs Epitaxial Substrates: 2009-2014*, published Jul'10

Exhibit 5-19 SI GaAs MOCVD Market by Diameter



Merchant MOCVD: 13466ksi

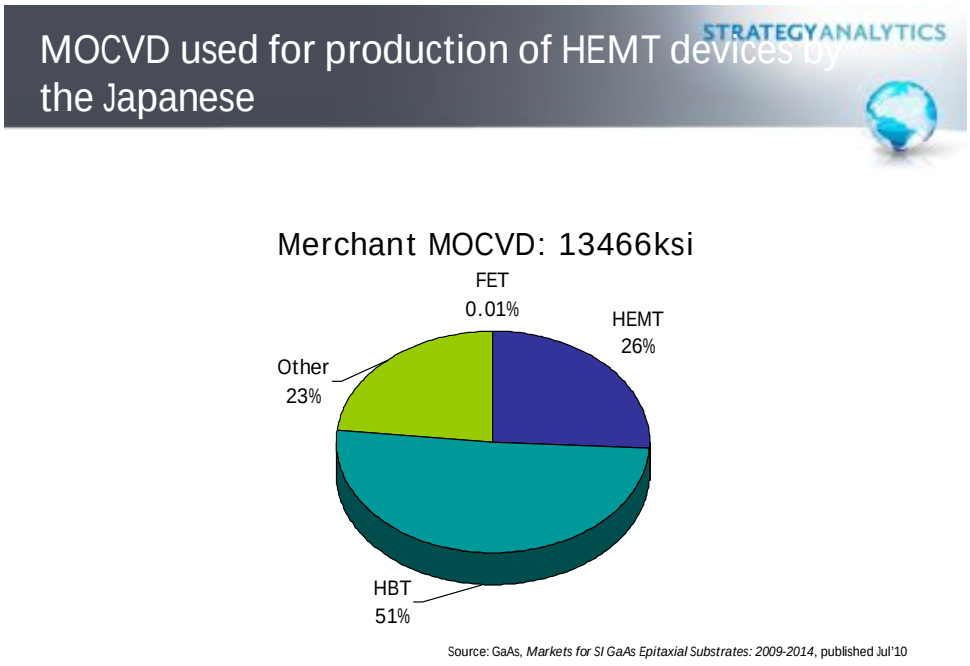


Source: GaAs, *Markets for SI GaAs Epitaxial Substrates: 2009-2014*, published Jul'10

Strategy Analytics estimates that consumption of MOCVD substrates for the production of HBT devices accounted for 51% of the total merchant SI GaAs MOCVD epitaxial substrate market. Conventional HBT epi is being replaced by increasing demand for BiFET and BiHEMT structures which typically incorporate HBT structures alongside a FET or HEMT structure.

There remains a significant proportion of HEMT structures grown using MOCVD material, dominated by Japanese GaAs device manufacturers.

Exhibit 5-20 SI GaAs MOCVD Market by Structure



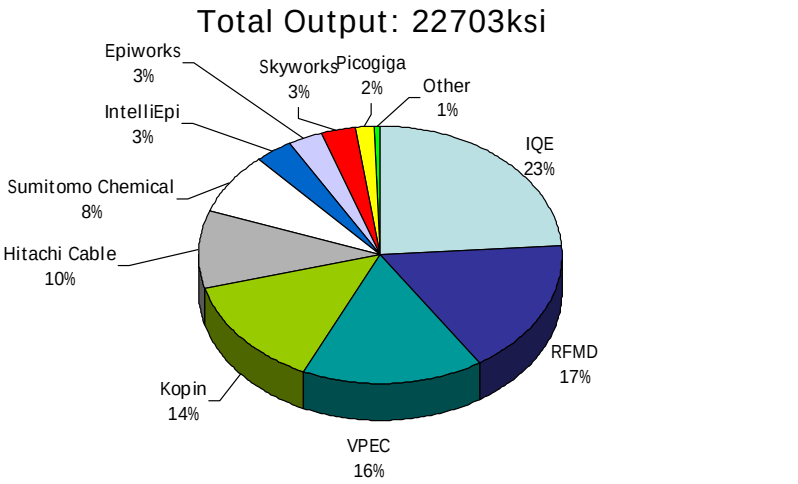
Source: GaAs, *Markets for SI GaAs Epitaxial Substrates: 2009-2014*, published Jul'10

Strategy Analytics estimates that 21% of SI GaAs epitaxial substrates production was derived from captive output at GaAs device manufacturers in 2009. The largest concentration of captive output is at North American companies. RFMD is the most prolific example of captive production and has traditionally been the world's largest producer of SI GaAs epitaxial substrates (Exhibit 5-21).

IQE maintained its status as the world's top supplier of SI GaAs epitaxial substrates, leveraging the consolidated strength of its respective operations to supply both MOCVD and MBE material to the market. Strategy Analytics believes VPEC increased its market share year-on-year and displaced Kopin as the largest supplier of MOCVD material in 2009. However, Kopin retains strategic relationships with leading GaAs IDM companies such as Skyworks (Exhibit 5-22).

Exhibit 5-21 SI GaAs Epitaxial Substrate Output by Company

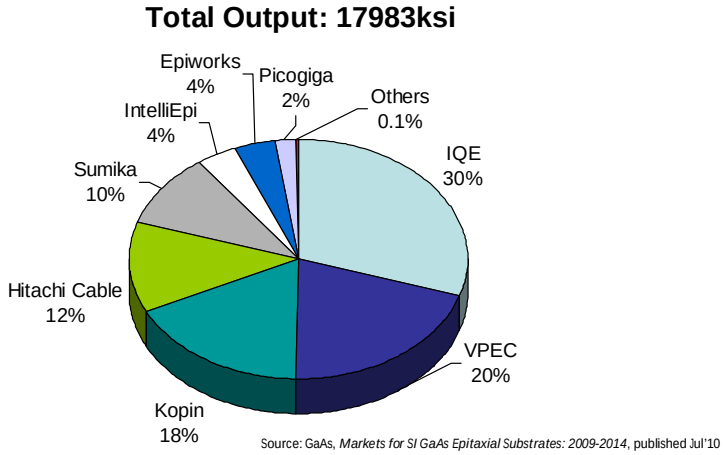
21% of SI GaAs epitaxial substrates production was derived from captive output in 2009



Source: GaAs, *Markets for SI GaAs Epitaxial Substrates: 2009-2014*, published Jul'10

Exhibit 5-22 SI GaAs Epitaxial Substrate Merchant Market Share

IQE maintained its status as the world's top supplier of SI GaAs epitaxial substrates

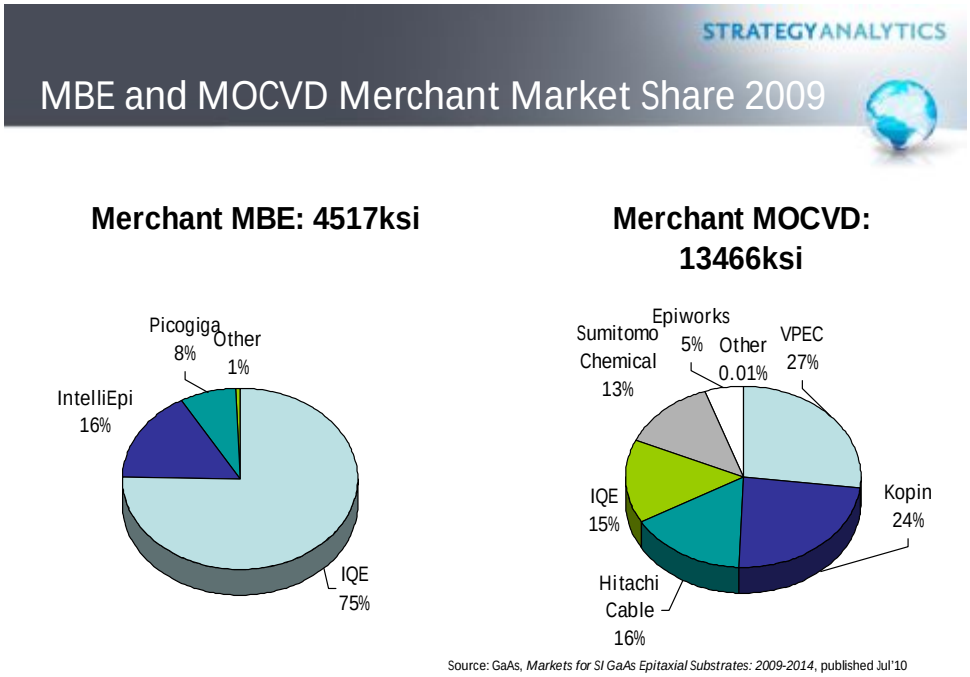


Source: GaAs, *Markets for SI GaAs Epitaxial Substrates: 2009-2014*, published Jul'10

There has always been a substantial difference between the size of the merchant markets for MOCVD and MBE substrates as a result of over 51% of the MBE material output coming from captive production.

- IQE had always been the market leading merchant supplier of MBE material. The acquisition of MBE TEchnology has only served to consolidate this leading position with the company continued to account for 75% of the merchant MBE market in 2009.
- VPEC increased its market share, increasing its position from second place in 2008 to the top spot in 2009 of the MOCVD segment, pushing Kopin down to second place.

Exhibit 5-23 MOCVD and MBE Merchant Market Share

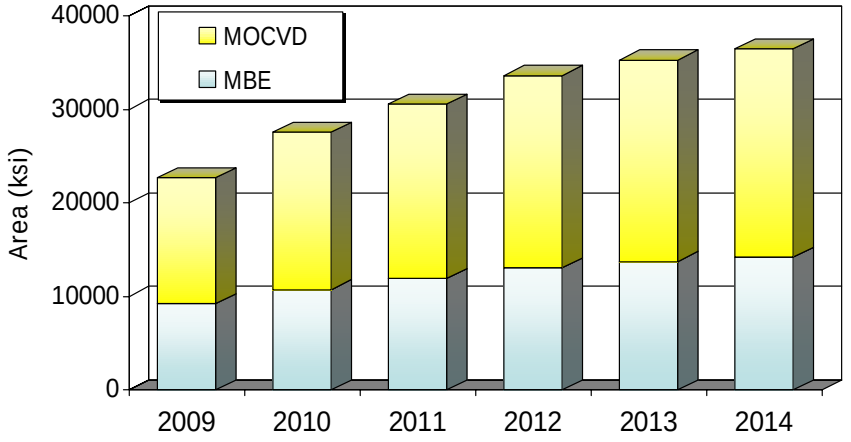


Source: GaAs, *Markets for SI GaAs Epitaxial Substrates: 2009-2014*, published Jul'10

total market for SI GaAs epitaxial substrates will grow from 22703 ksi in 2009 to 36483 ksi in 2014, a CAAGR (compound annual average growth rate) of 10% (Exhibit 5-24).

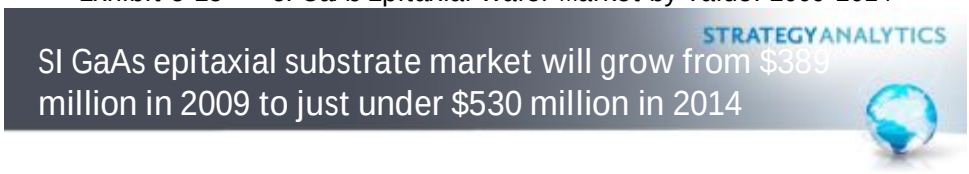
Strategy Analytics estimates that the total SI GaAs epitaxial substrate market was worth over $389 million in 2009 and will grow at a CAAGR of 6% to just under $530 million in 2014 (Exhibit 5-25).

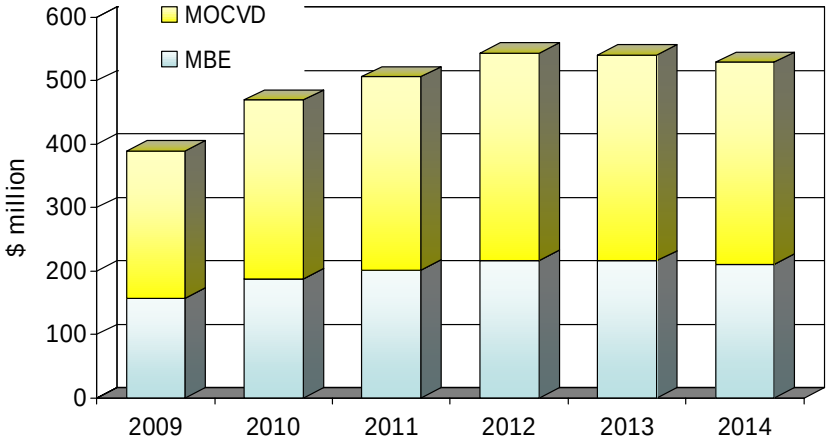
Exhibit 5-24 SI GaAs Epitaxial Substrate Market: 2009-2014



Source: GaAs, *Markets for SI GaAs Epitaxial Substrates: 2009-2014*, published Jul'10

Exhibit 5-25 SI GaAs Epitaxial Wafer Market by Value: 2009-2014

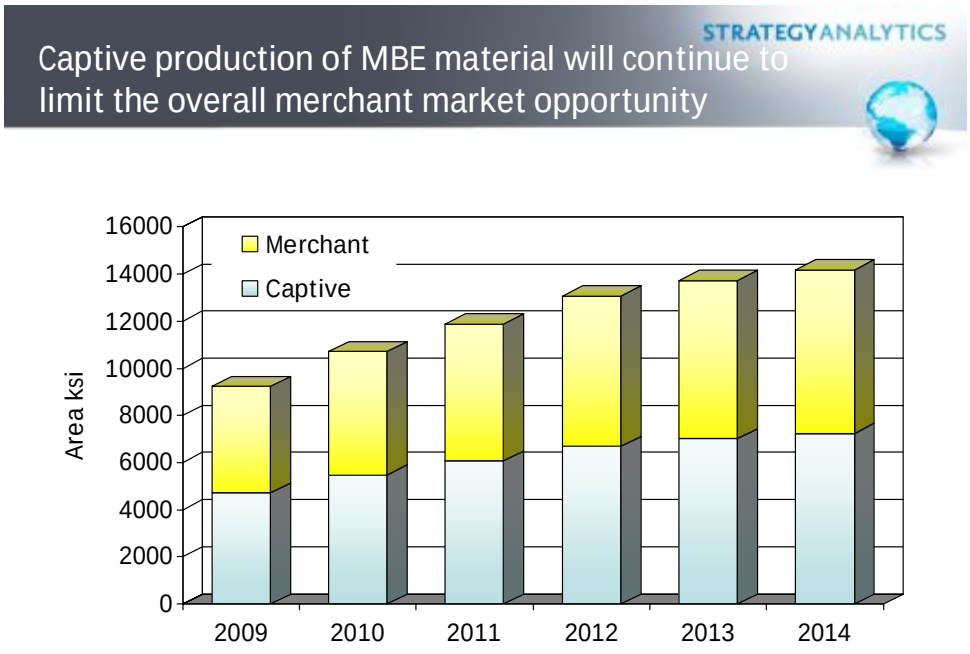




Source: GaAs, *Markets for SI GaAs Epitaxial Substrates: 2009-2014*, published Jul'10

Strategy Analytics forecasts the market (merchant and captive) for SI GaAs MBE epitaxial substrates will grow at a CAAGR of 9%, from 9232 ksi in 2009 to 14182 ksi in 2014. A key driver in this forecast is the assumption that captive production of MBE material will continue to limit the overall merchant market opportunity through 2014. In particular the model assumes that RFMD will continue to develop future generations of its AlGaAs HBT process technology to produce HBT PA devices.

Exhibit 5-26 MBE Epitaxial Substrate Market: 2009-2014

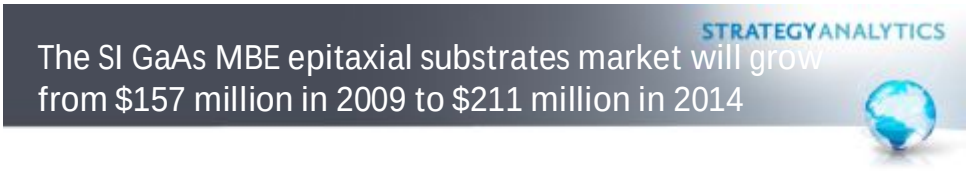


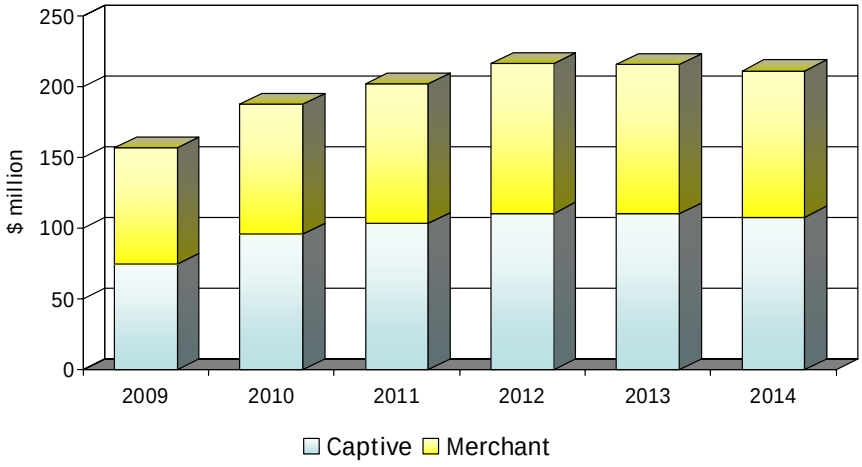
Source: GaAs, *Markets for SI GaAs Epitaxial Substrates: 2009-2014*, published Jul'10

Merchant suppliers of MBE material can expect to see revenue gains through to 2012, before ASP declines and a slowing market will lead to market revenues slowing down. The market for SI GaAs MBE epitaxial substrates will grow to from $157 million in 2009 to $211 million in 2014, a 6% CAAGR (Exhibit 5-27).

We believe six-inch substrates will remain above $400 through 2014 (Exhibit 5-28).

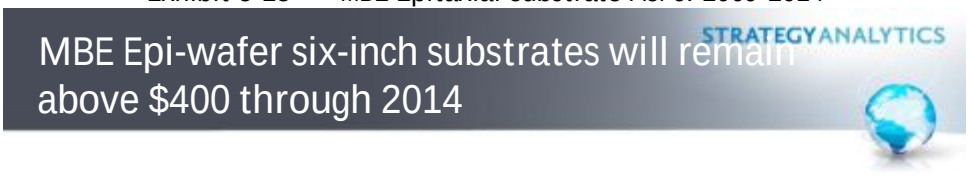
Exhibit 5-27 MBE Epitaxial Substrate Market Value: 2009-2014

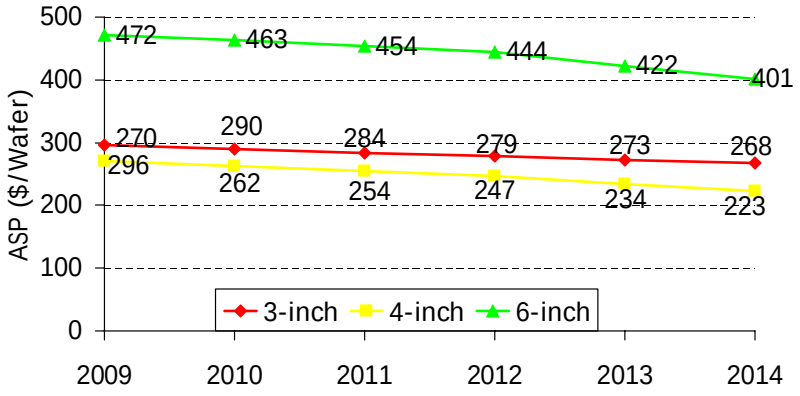




Source: GaAs, *Markets for SI GaAs Epitaxial Substrates: 2009-2014*, published Jul'10

Exhibit 5-28 MBE Epitaxial Substrate ASPs: 2009-2014

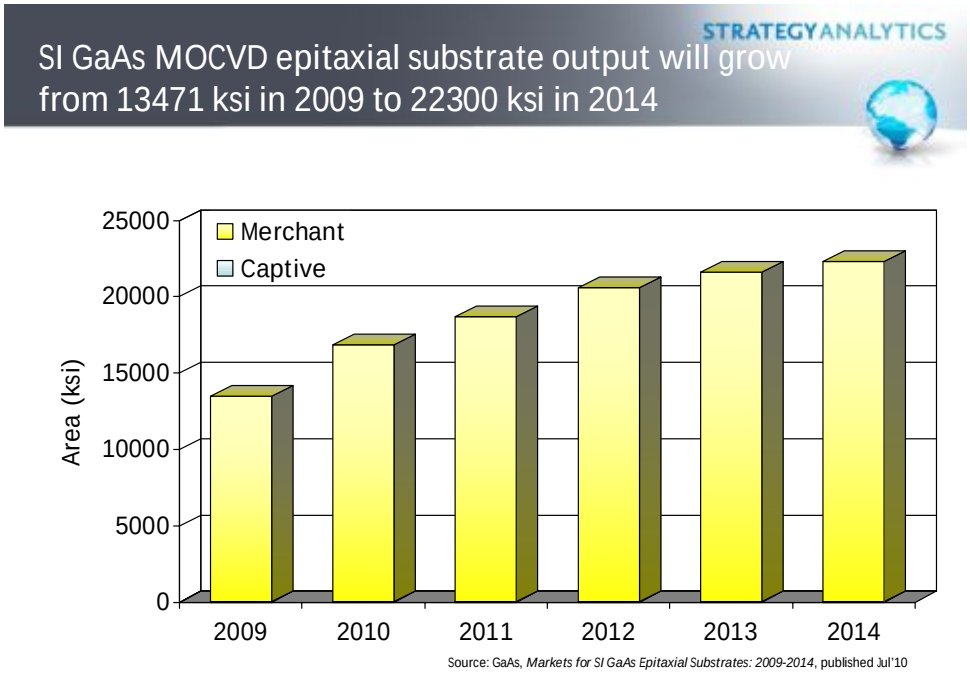




Source: GaAs, *Markets for SI GaAs Epitaxial Substrates: 2009-2014*, published Jul'10

Strategy Analytics forecasts the market (merchant and captive) for SI GaAs MOCVD epitaxial substrates will grow at a CAAGR of 11%, from 13471 ksi in 2009 to 22300 ksi in 2014. MOCVD material will continue to be supplied through merchant channels through 2014 and we expect GaAs device manufacturers to maintain a predilection for outsourcing of MOCVD material.

Exhibit 5-29 MOCVD Epitaxial Substrate Market: 2009-2014

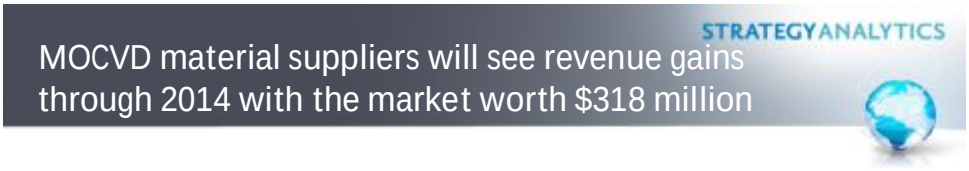


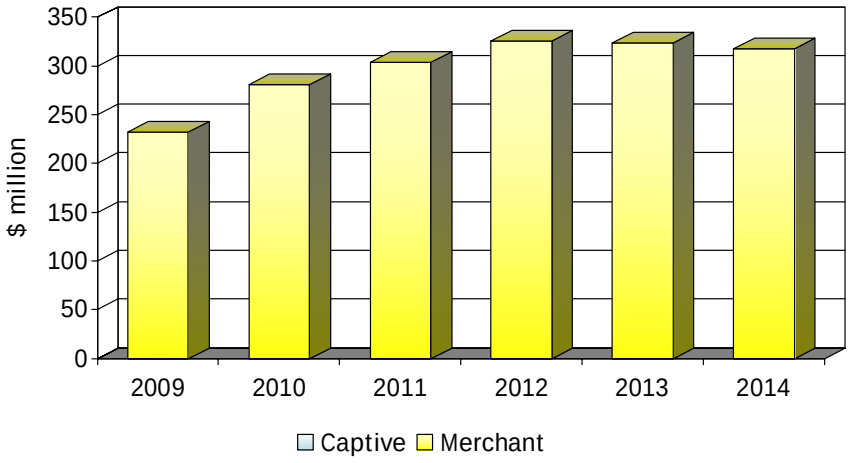
Source: GaAs, *Markets for SI GaAs Epitaxial Substrates: 2009-2014*, published Jul'10

Merchant suppliers of MOCVD material will also see revenue gains through 2014. Strategy Analytics forecasts that the market for SI GaAs MOCVD epitaxial substrates will grow from $232 million in 2009 to $318 million in 2014, a CAAGR of 6% (Exhibit 5-30).

Six-inch MOCVD wafer ASPs are lower than MBE wafers and will drop below $400 by 2014 (Exhibit 5-31).

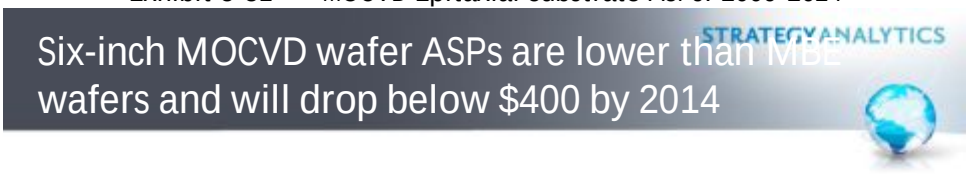
Exhibit 5-30 MOCVD Epitaxial Substrate Market Value: 2009-2014

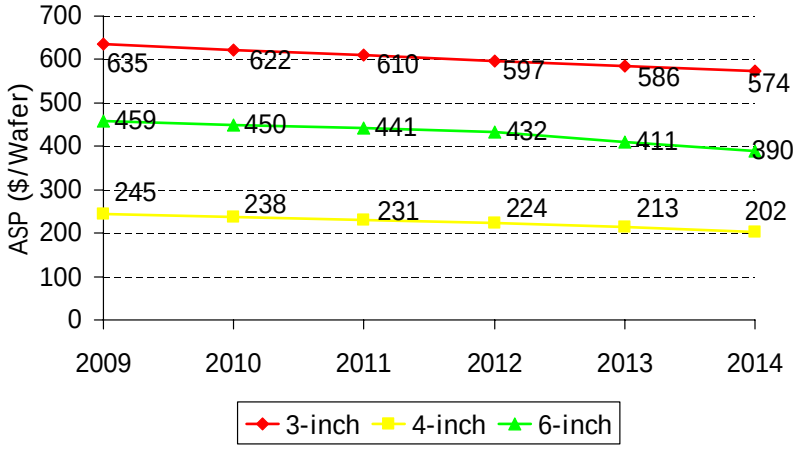




Source: GaAs, *Markets for SI GaAs Epitaxial Substrates: 2009-2014*, published Jul'10

Exhibit 5-31 MOCVD Epitaxial Substrate ASPs: 2009-2014

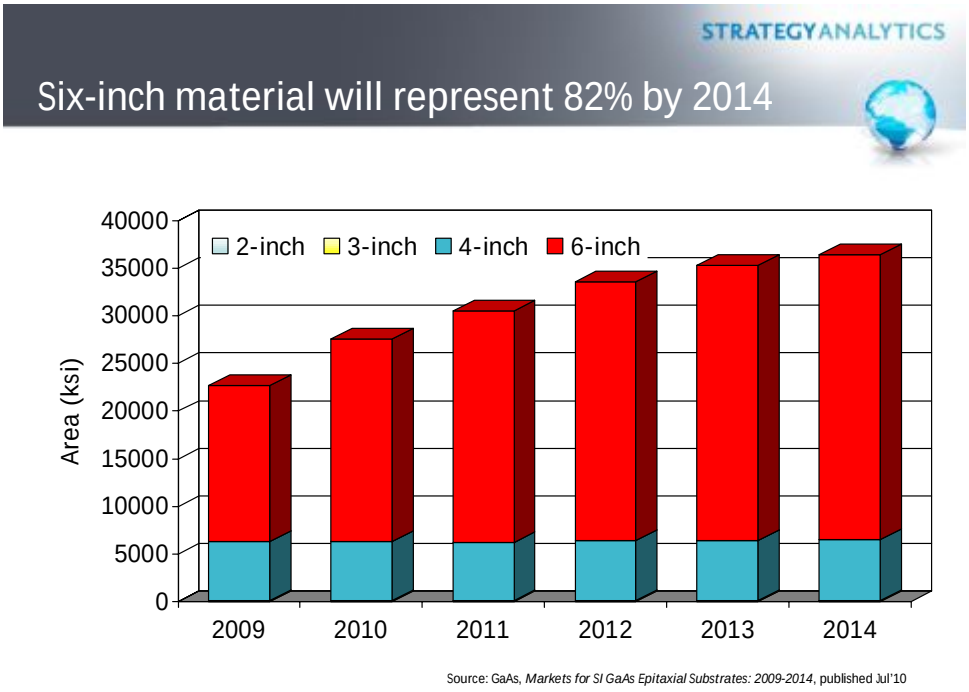




Source: GaAs, *Markets for SI GaAs Epitaxial Substrates: 2009-2014*, published Jul'10

Six-inch material represented 72% of the total SI GaAs epitaxial substrate market in 2009 and this will grow to 82% by 2014, representing a CAAGR of 13%.

Exhibit 5-32 SI GaAs Epitaxial Substrate Market by Diameter

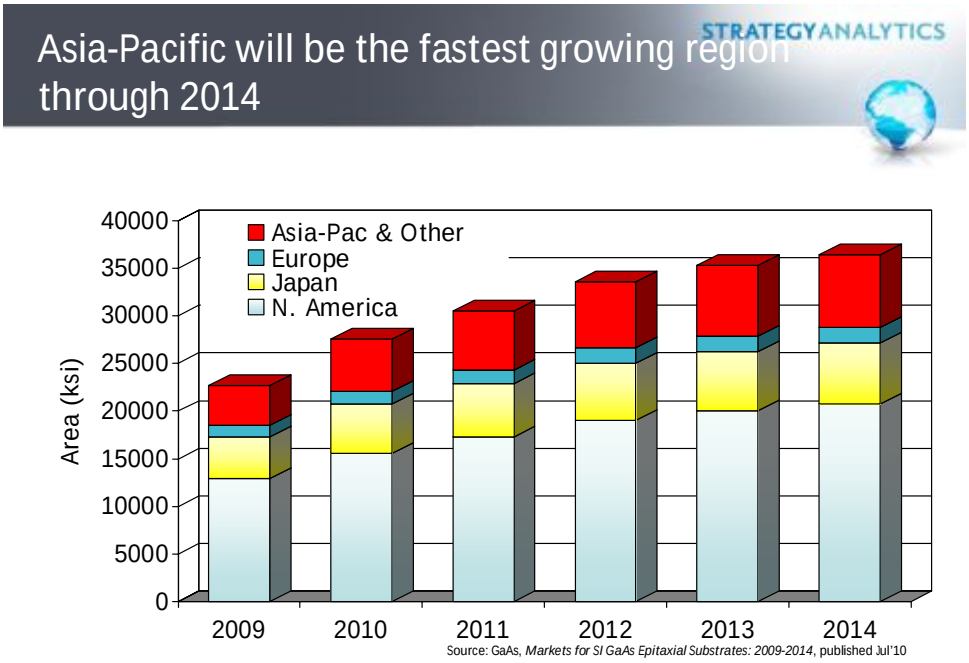


Source: GaAs, *Markets for SI GaAs Epitaxial Substrates: 2009-2014*, published Jul'10

Asia-Pacific will be the fastest growing region through 2014. Demand from Asia-Pac will be driven by the GaAs foundry companies with Win Semiconductor and AWSC in particular, expected to be the mainstay customers for both MBE and MOCVD material. North America will continue to be largest regional market for SI GaAs epitaxial substrates, maintaining a 57% share of the total market through 2014 (Exhibit 5-33).

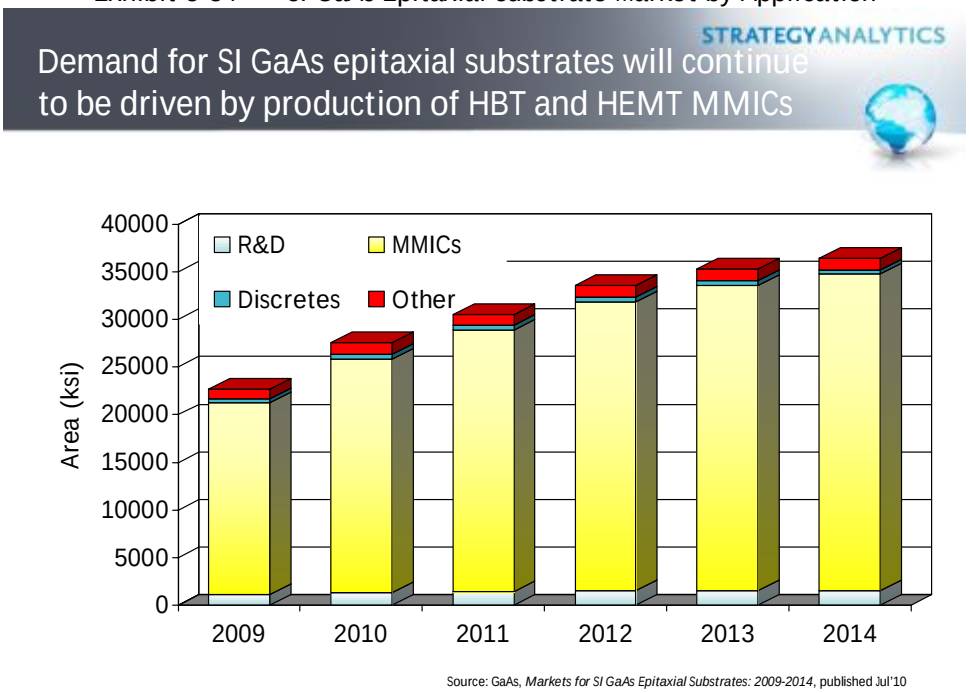
Strategy Analytics predicts that demand for SI GaAs epitaxial substrates will continue to be driven by production of HBT and HEMT MMICs used first and foremost by the cellular handset market (Exhibit 5-34).

Exhibit 5-33 SI GaAs Epitaxial Substrate Market by Region



Source: GaAs, *Markets for SI GaAs Epitaxial Substrates: 2009-2014*, published Jul'10

Exhibit 5-34 SI GaAs Epitaxial Substrate Market by Application

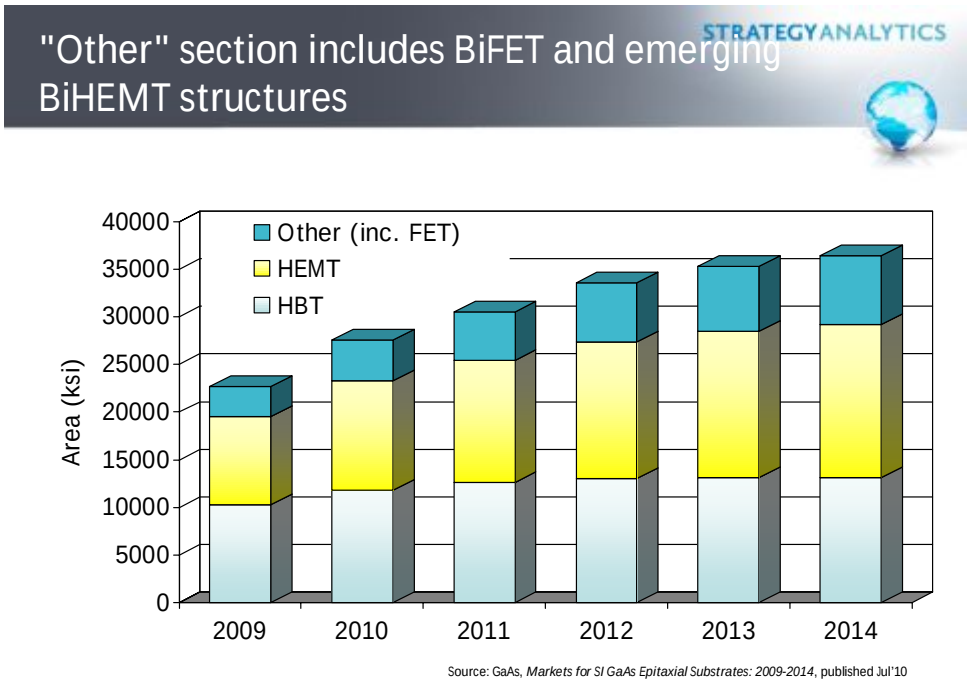


Source: GaAs, *Markets for SI GaAs Epitaxial Substrates: 2009-2014*, published Jul'10

Strategy Analytics' analysis shows that 45% of all SI GaAs epitaxial substrates were used for the production of HBT structures. The use of SI GaAs epitaxial substrates for HBT structures will increase at a CAAGR of 5% through to 2014 and represent 36% of total demand.

Strategy Analytics forecasts that BiFET / BiHEMT structures will supplant conventional HBT structures for the production of GaAs PAs in cellular handsets. This will translate to the "other" segment growing at a CAAGR of 18% through 2014, from 3205 ksi in 2009 to 7270 ksi.

Exhibit 5-35 SI GaAs Epitaxial Substrate Market by Structure



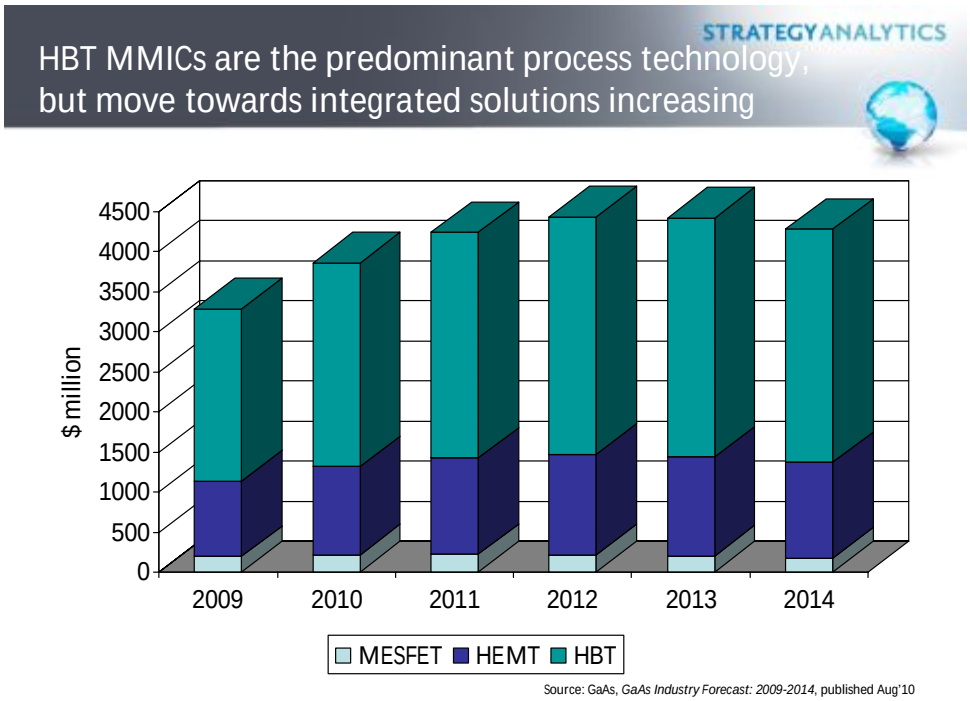
Source: GaAs, *Markets for SI GaAs Epitaxial Substrates: 2009-2014*, published Jul'10

The forecast assumes that the BiFET/BiHEMT structures will be produced on MOCVD GaAs epitaxial substrates and account for over 96% of the "other" segment in 2014. At this time, BiFET/BiHEMT structures will account for 31% of the total MOCVD market and 19% of the overall market.

6 MMIC Technology Trends

The cellular PA market has driven demand for HBT devices and the market continues to favor GaAs PAs for the cellular handset with overall content expected to increase as a result of multi-mode and multi-band architectures. The use of pHEMT switches in handsets will increase and the move the requirement to support multiple bands and modes will necessitate more complex switches. pHEMT devices also dominate millimeter-wave and other infrastructure markets. The market for MESFET devices remains limited and Strategy Analytics estimates that cable infrastructure was the largest market for MESFET-based MMICs in 2009.

Exhibit 6-1 GaAs MMIC Merchant Market by Process Technology



Source: GaAs, *GaAs Industry Forecast: 2009-2014*, published Aug'10

GaAs device manufacturers have also continued to improve the integration capabilities of GaAs technology, increasing the value-add to their customers.

Key examples include: Anadigics' BiFET process that combines HBT and FET structures on one substrate and has also showcased a fully integrated 802.11 a/b/g WLAN front-end IC that integrates the high and low band PAs and LNAs, the RF switches, filters and all other associated circuitry on a single die with the final product measuring 4.0mm x 4.0mm (Exhibit 6-2). Skyworks' BiFET process also combines a FET on a HBT substrate to offer biasing and power output on a single chip for both cellular handset and Wi-Fi front-ends (Exhibit 6-3).

Exhibit 6-2 Anadigics BiFET Technology

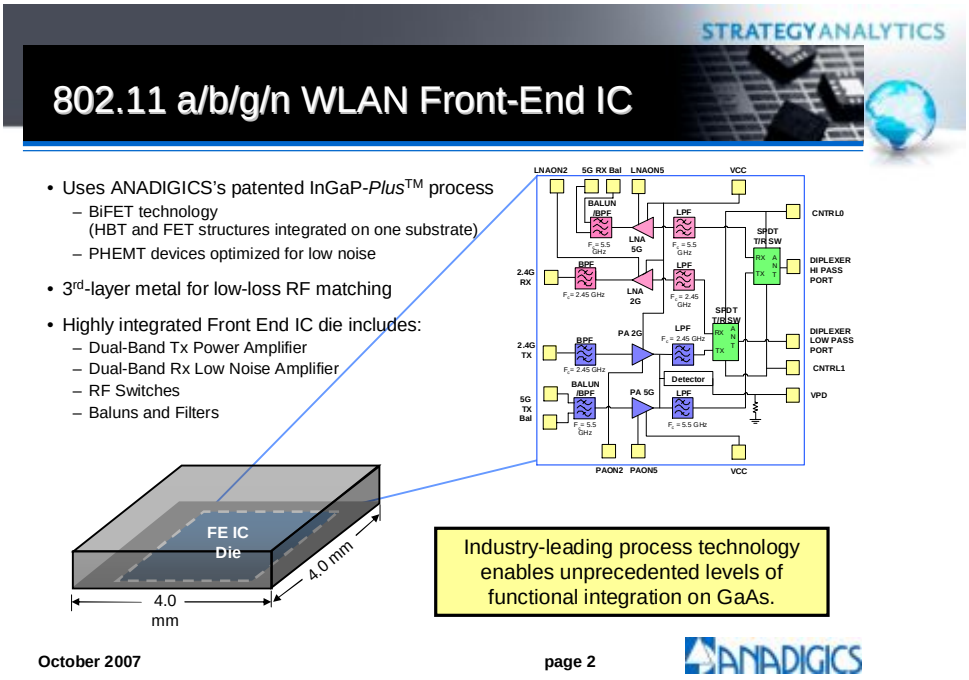
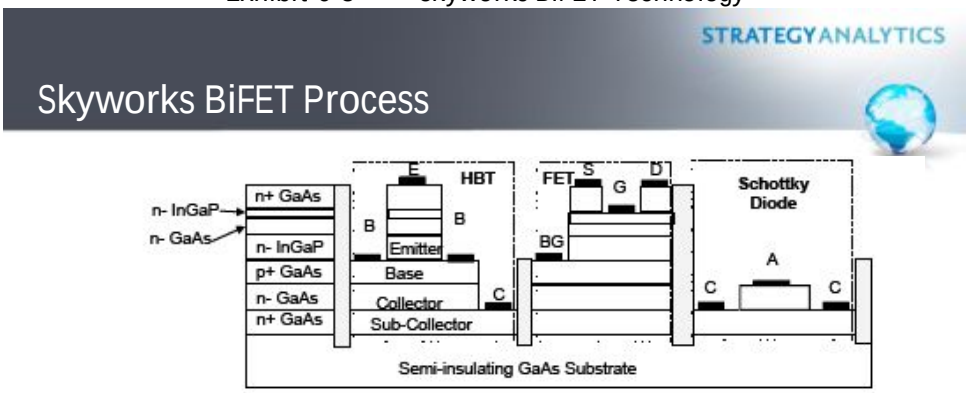


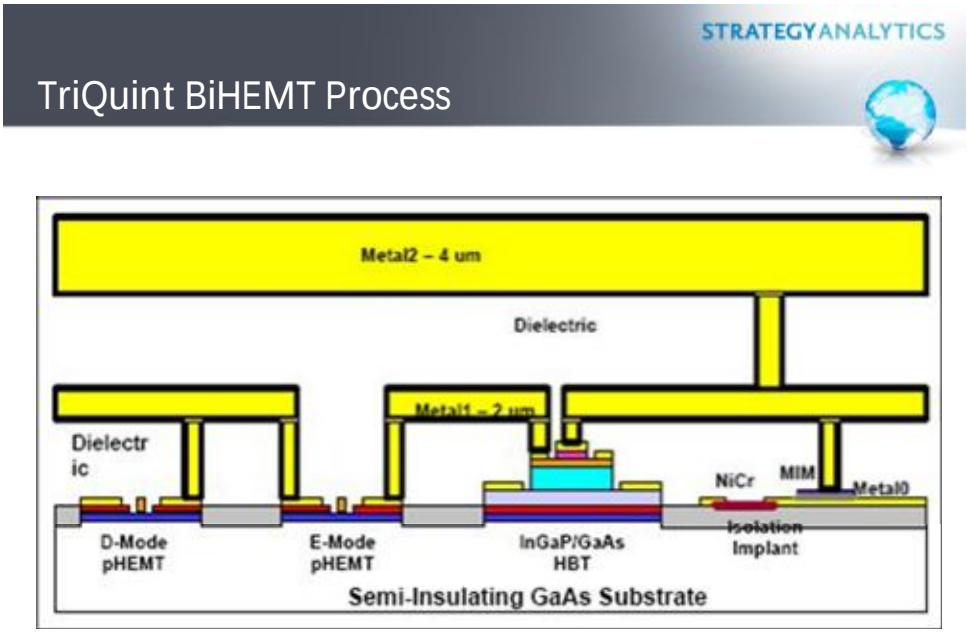
Exhibit 6-3 Skyworks BiFET Technology



- Replaces two-chip solution
  - Si-based biasing and GaAs HBT PA
- Technology outperforms conventional HBT PAs
- Enables low cost single-chip solutions for cellular handsets and Wi-Fi applications

TriQuint's TQBiHEMT process combines TriQuint's high volume InGaP HBT process, TQHBT3 with it's InGaAs E/D pHEMT process, TQPED, to enable the creation of single chip products, incorporating the best possible PA, switch and LNA components.

Exhibit 6-4 TriQuint BiHEMT Technology



Win Semiconductor is also adopting a similar approach, starting with a HEMT wafer with a HBT and e/d pHEMT device optimised separately on the same wafer using etch stops (Exhibit 6-5).

Strategy Analytics forecasts that BiFET / BiHEMT structures will supplant conventional HBT structures for the production of GaAs PAs in cellular handsets and other end markets. BiFET/BiHEMT structures will be produced on MOCVD GaAs epitaxial substrates and have the potential to displace conventional AlGaAs HBT and InGaP HBT structures (Exhibit 6-6).

Exhibit 6-5 Win Semiconductor BiHEMT Process

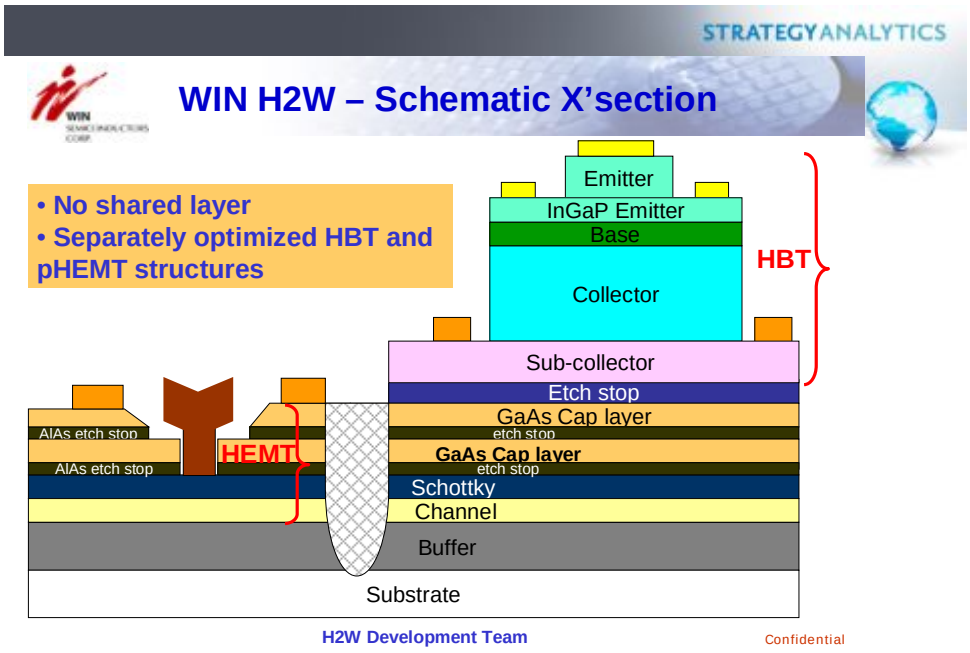
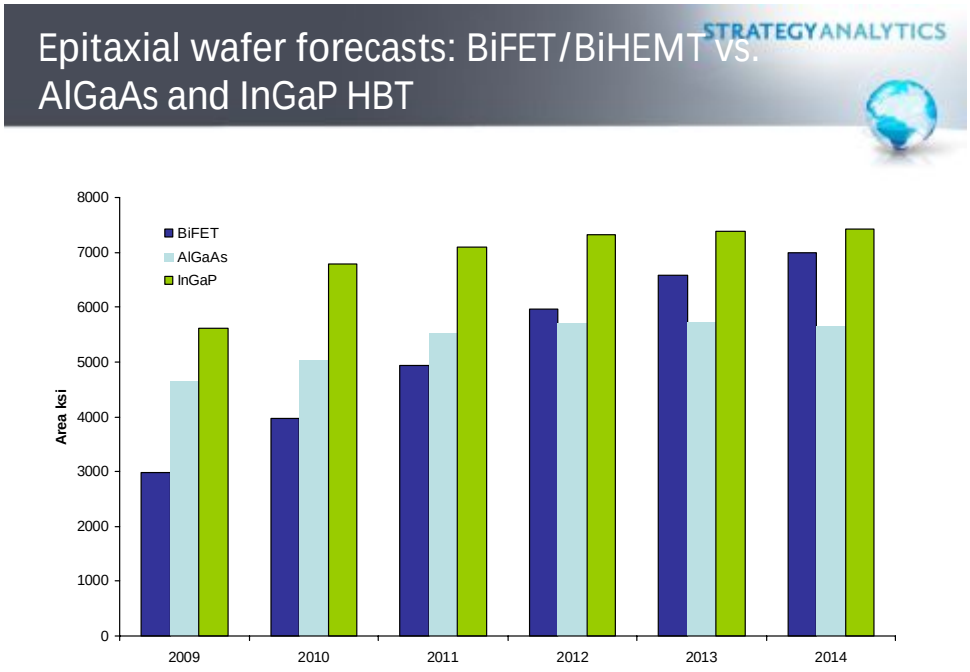


Exhibit 6-6 BiFET/BiHEMT vs. Conventional HBT



A comparison of some basic physical properties of GaN with other common semiconductor device materials is shown below.

Exhibit 6-7 GaAs vs. other semiconductor technologies

	Si	GaAs	InP	SiGe	SiC	GaN
Lattice constant (Å)	5.4	5.7	5.9	5.5	3.1	3.2
Saturation velocity (cm/s)	1×10^7	0.8×10^7	2.2×10^7	---	2×10^7	2.5×10^7
e^- mobility (cm^2/Vs)	1350	8000	10000	3000	900	1500
E_g bandgap (eV)	1.1	1.4	1.3	0.7-1.1	3.3 (4H)	3.4
F_t (GHz) FET	20	150	300	50	20	150
Power density (W/mm)	0.2	0.5	---	0.3	10	>30
Thermal conductivity (W/cmK)	1.5	0.5	---	---	4.9	~2.0
Emission wavelength (µm)	N/A	0.6-0.9	1.0-1.5	N/A	N/A	0.4

In RF applications, GaAs primarily faces competition from components manufactured using silicon LDMOS as well as emerging GaN processes and, to a lesser degree, SiC. Exhibit 6-8 provides an overview of the strengths and weaknesses of the main technology candidates.

Emerging wireless platforms are increasingly required to support multiple frequencies, power levels and standards, combined with shorter product development times, while simultaneously achieving significant reductions in power consumption. GaAs technology offers a balance of capabilities across these areas, outperforming silicon while also being a robust and cost effective manufacturing technology when compared to GaN or SiC (Exhibit 6-9).

Exhibit 6-8 Comparison of RF Semiconductor Technologies

Comparison of GaAs for infrastructure applications

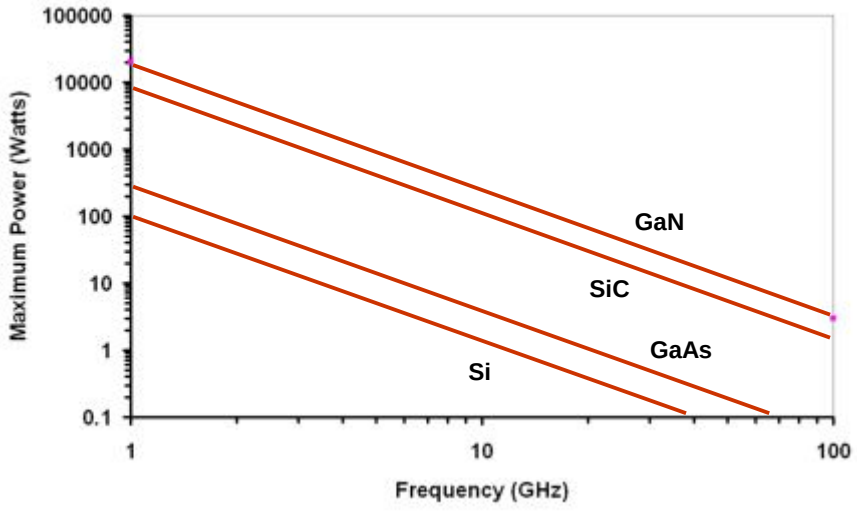
STRATEGYANALYTICS

	Advantages	Challenges
• Si LDMOS	• High gain, high efficiency, linear performance. • Good thermal properties • Volume manufacturing • Reliability • Market momentum	• Performance capability beyond 3.5GHz • Requirement for active cooling • Very high efficiency performance
• 14-17V GaAs	• Niche application • Linear performance • Efficiency • Volume manufacturing	• Conventional systems based around 26-28V
• 26V GaAs	• Fits with conventional base station design • Improved performance over Si LDMOS • Mature manufacturing base	• Potential memory effect issues • Backoff linearity compared to LDMOS • Ft similar to LDMOS
• GaN	• High voltage • High frequency • High temperature • High impedance level • Compatibility with high efficiency architecture	• Material quality/defect density • Reliability • Cost • Linearity requirements demand pre-distortion
• SiC	• High Voltage • High power • High temperature	• MESFET structure • Performance > 5GHz? • Overall performance not competitive with LDMOS or GaAs • Limited commercial development • Cost

Exhibit 6-9 Power vs. Frequency Capabilites

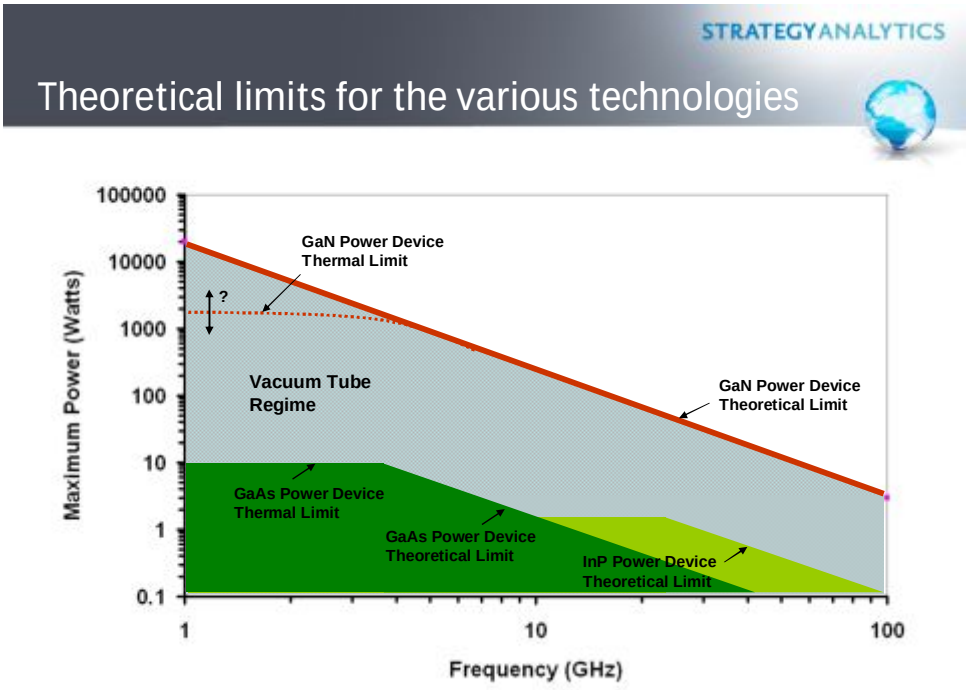
GaAs vs. Existing Semiconductor Materials

STRATEGYANALYTICS



GaAs is able to compete against emerging technologies such as InP and GaN in terms of both power and frequency capabilities and only really runs out of steam when the technology is compared against the theoretical limitations of vacuum tube technology. This is where GaN devices in particular will have specific advantages.

Exhibit 6-10 Theoretical Limits for GaAs vs. GaN and InP

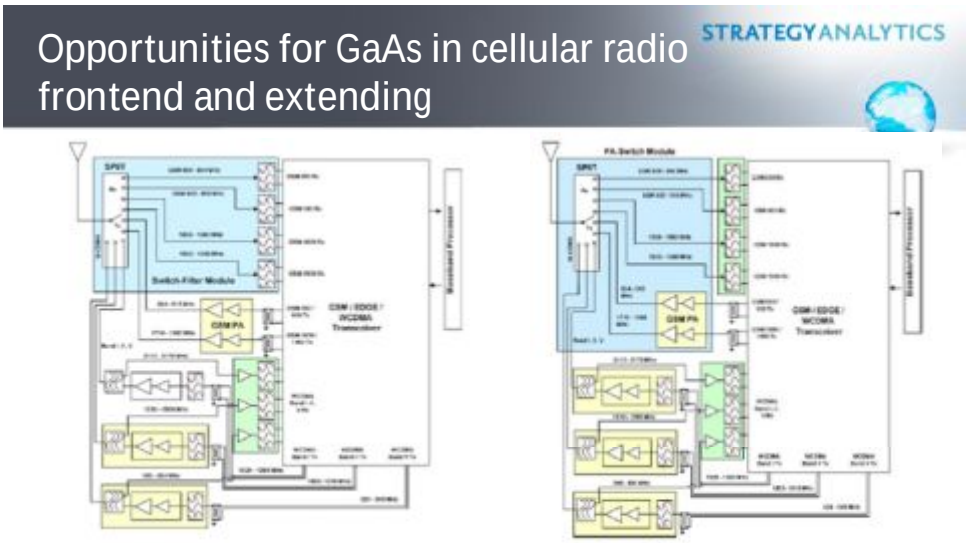


7 Wireless Consumer and Other GaAs Markets

7.1 Cellular and Wi-Fi

End-applications in the wireless communications segment will continue to represent the main markets for GaAs MMICs and the cellular handset market remains the driving force for the continued growth in demand. There will be a mix of approaches used in the cellular handset front-end, but we forecast that GaAs will continue to dominate the PA function.

Exhibit 7-1 Cellular Radio Frontend Architectures



Source: RFWC (RF and Wireless Components) Service

- GaAs is dominant technology for PA function and also used for switches
- Increasing GaAs content driven by
  - Multiple bands
  - New features, Wi-Fi, GPS
- CMOS PAs competing with GaAs in low-end GPRS handsets
- SiGe could emerge as a viable alternative to GaAs

The market for handsets will continue to grow and will be supplemented by increasing use of cellular radio technologies in other devices such as notebook computers, and for machine-to-machine (M2M) applications (Exhibit 7-2).

While there will be competition from Si CMOS and LDMOS, Strategy Analytics forecasts that GaAs will continue to dominate as the requirements in this market continue to evolve with migration from 2G to 3G to 4G technologies (Exhibit 7-3).

Exhibit 7-2 Cellular Terminal Shipments

Handsets Maturing, Growth is in PC Data Applications

STRATEGYANALYTICS

- Notebooks, netbooks, M2M and grey market make up more than 15 percent of production, and this is increasing

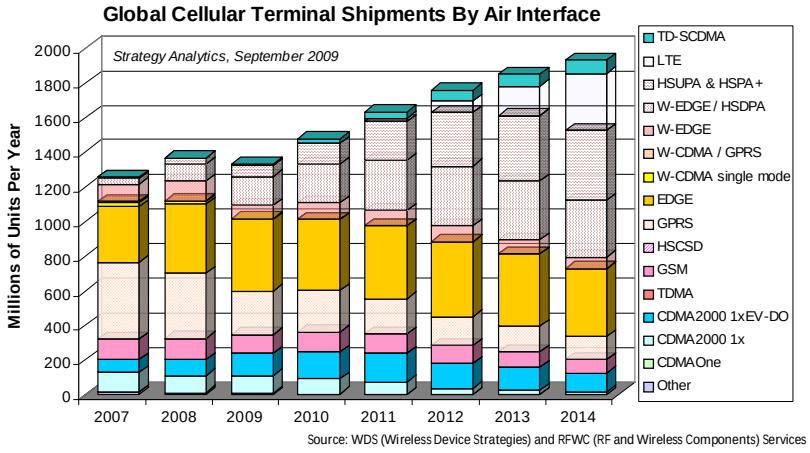
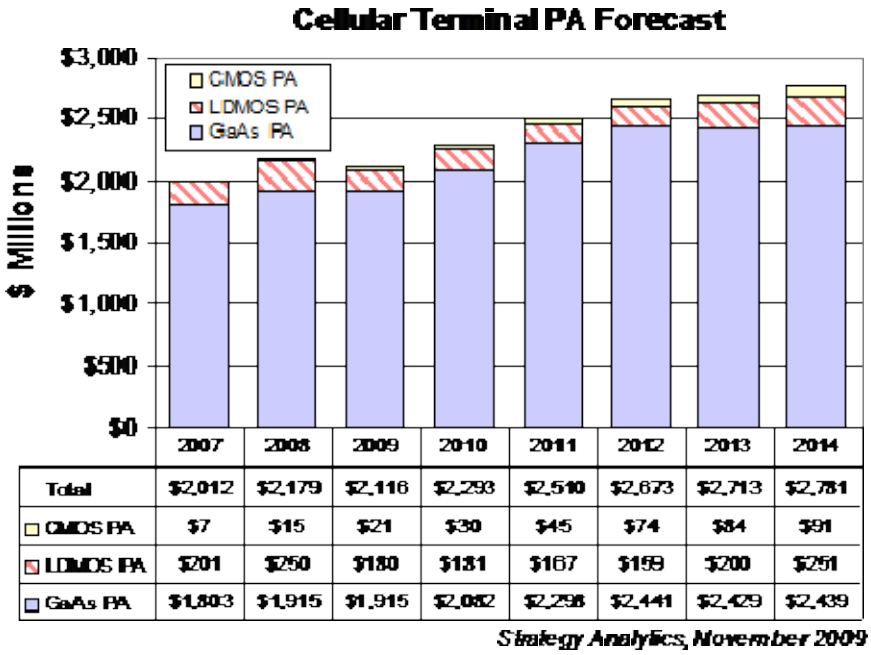
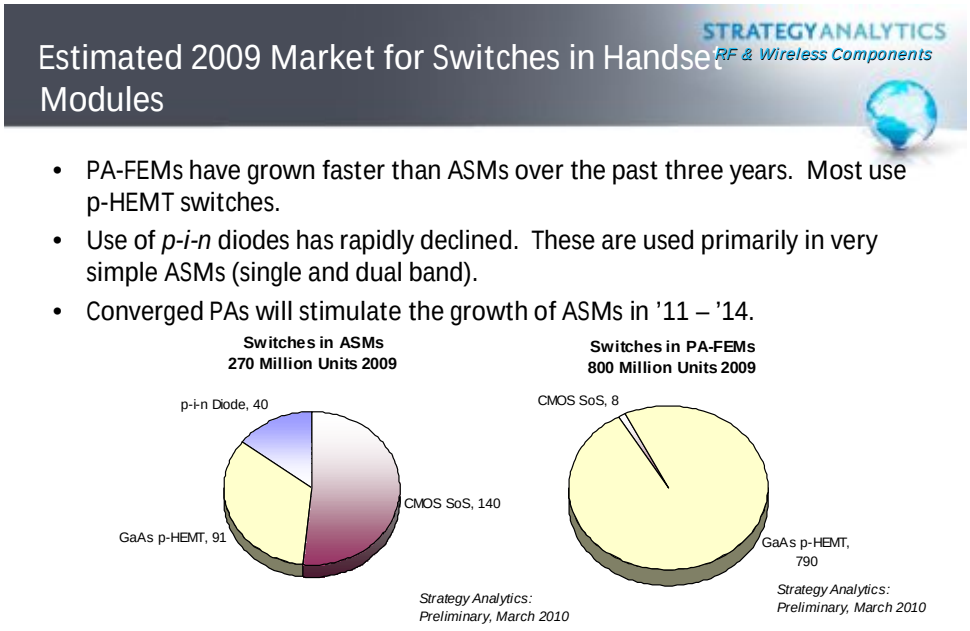


Exhibit 7-3 Cellular PA Forecast by Process Technology



GaAs pHEMTs will also continue to be used for switching applications for PA-switch modules, where GaAs IDMs will use their internal capabilities.

Exhibit 7-4 Cellular Switch Market Segmentation by Technology



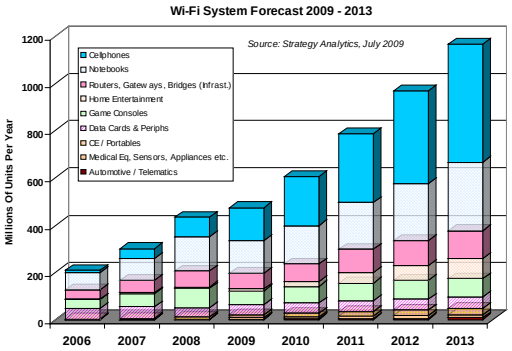
Note: Estimates from Sept. '09 Cellular Component Forecast, RFWC, to be confirmed and adjusted through primary research for calendar '09 and H1 '10, to be conducted in Q2 '10..

The Wi-Fi market is also seeing strong growth with new applications supporting existing usage in notebook computers. There will be increasing implementation of Wi-Fi in cellular handsets and an emerging market for Wi-Fi-enabled consumer devices and home networks to stream content around the home (Exhibit 7-5).

Switches and power amplifiers will represent the main opportunities for GaAs devices in the WLAN market. However, SiGe solutions will be a much stronger contender, with the penetration of SiGe-based PAs and PA-FEMs growing from about 30% of the PA market in 2008 to greater than 50% by 2014 (Exhibit 7-6).

Exhibit 7-5 Wi-FI System Shipments

WLAN Continues to Outperform Other Wireless Markets



*Home Entertainment includes: Digital media extenders, DVD / DVR / Blu-Ray players, HDTVs etc.

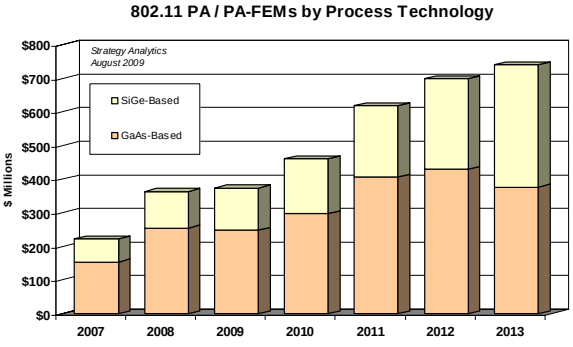
Source: RFWC (RF and Wireless Components) Service; see http://www.strategyanalytics.com/default.aspx?mod=NavigationHeader&a0=90&a1=0

- About 435 million Wi-Fi enabled systems shipped in 2008, including the often undercounted China market;
- SA projects 9.2 percent growth from '08 to '09 in unit shipments, historically low for Wi-Fi;
- Growing penetration in cellphones and new applications is offsetting softness in notebook PC market in '09;
- Wi-Fi in home entertainment systems will emerge as the third largest segment in unit terms by 2013*.

Exhibit 7-6 Wi-Fi PA Market Trends by Process Technology

PAs by Process Tech: SiGe Reaching Equality With GaAs

- SiGe Semi now shipping more than half of its 5 GHz WLAN PAs in SiGe;
- GaAs performance advantages in many cases now countered by improved SiGe performance, integration advances (e.g. dual band) and cost advantages;
- As Wi-Fi volumes continue to grow, SiGe will continue to erode GaAs share;
- Balance could tip to SiGe in 2013 (scenario shown below from SA's forecast model).

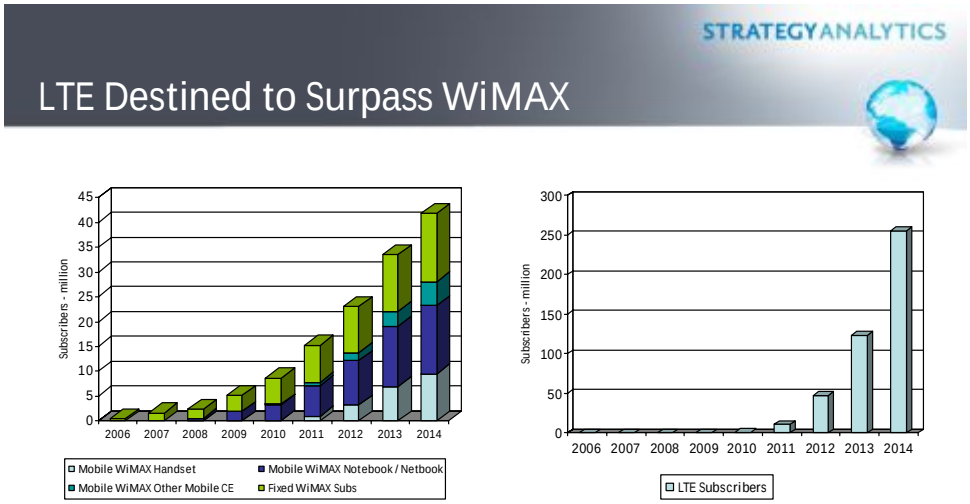


Source: RFWC (RF and Wireless Components) Service; see http://www.strategyanalytics.com/default.aspx?mod=NavigationHeader&a0=90&a1=0

7.2 WiMAX vs. LTE

Strategy Analytics' RFWC (RF and Wireless Components) service updated forecast predicts a continued upwards trend for WiMAX subscribers which will translate to around 42 million global subscribers in 2014 as markets in North America grow alongside demand from other emerging markets. The forecast assumes that fixed wireless subscribers growth will be supplemented by increasing use of WiMAX in mobile applications. Despite this early lead, LTE is expected to overtake WiMAX, leveraging the installed cellular handset base of users and infrastructure.

Exhibit 7-7 WiMAX vs. LTE Subscriber Base



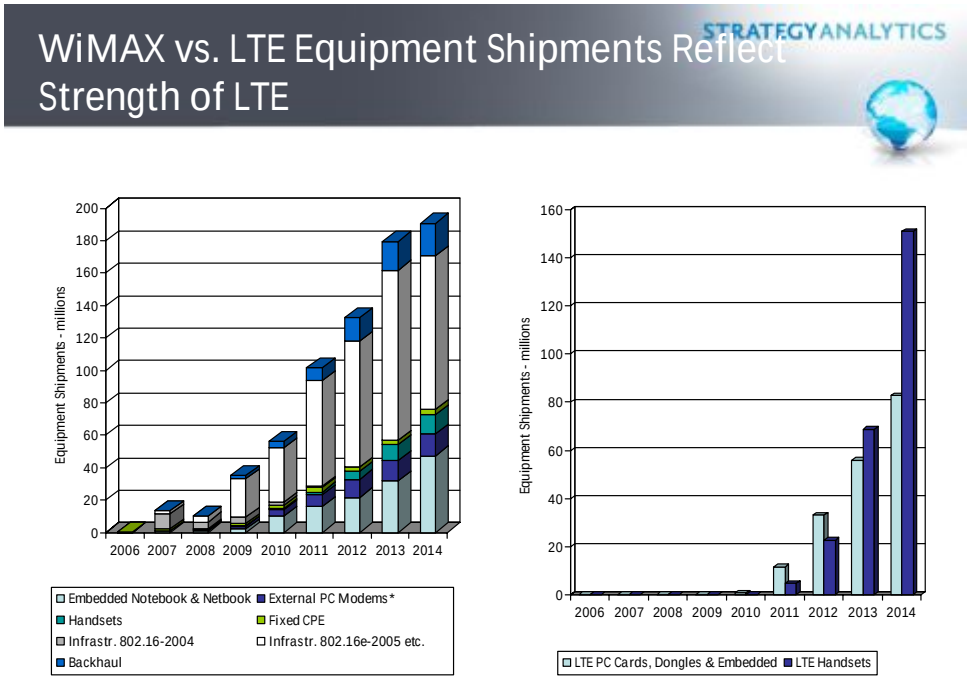
Source: RFWC (RF and Wireless Components) Service; see http://www.strategyanalytics.com/default.aspx?mod=NavigationHeader&a0=90&a1=0

- WiMAX has an early lead, but LTE is gathering momentum for 2010 launch and 2013 – 2014 ramp;
- LTE will leverage the installed base of 2.5G & 3G infrastructure;
- WiMAX will ultimately make up about 15 percent of wireless broadband, LTE the other 85 percent (subscribers & equipment shipments)

This will translate into a rather fragmented market for WiMAX, with equipment shipments a mix of both fixed broadband equipment as well as mobile equipment. In contrast, the implementation of LTE equipment will focus exclusively on mobility with USB dongles and PC cards being joined very quickly by next generation handsets (Exhibit 7-8).

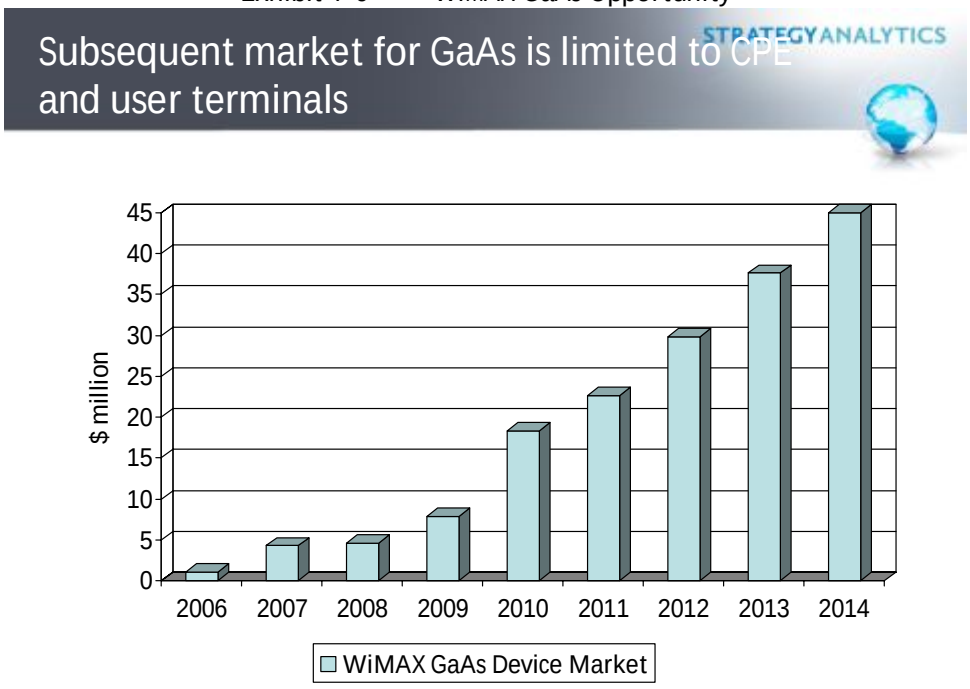
The GaAs opportunity from WiMAX will likewise be limited to CPE (customer premises equipment) and mobile devices, restricting the overall opportunity to just $45 million in 2014 (Exhibit 7-9).

Exhibit 7-8 WiMAX vs. LTE Equipment Shipments



Source: RFWC (RF and Wireless Components) Service; see
http://www.strategyanalytics.com/default.aspx?mod=NavigationHeader&a0=90&a1=0

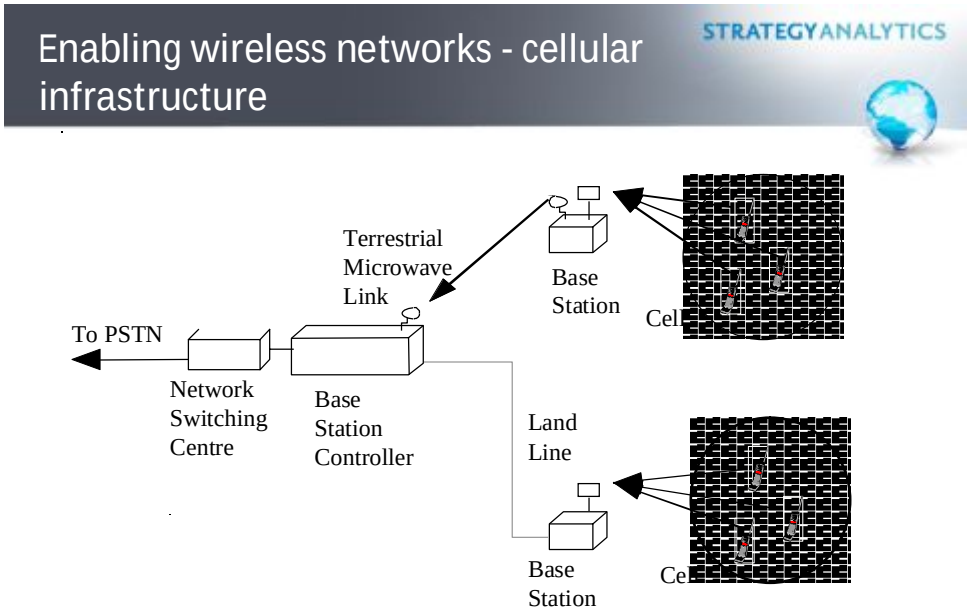
Exhibit 7-9 WiMAX GaAs Opportunity



7.3 Cellular Infrastructure

The cellular radio infrastructure consists of "cells" within which a number of mobile phone subscribers are able to make and receive calls via the BTS (Base Transceiver Station) or base station that serves that cell. Communication from the base station to the BSC is via microwave or millimeter-wave link. Millimeter wave links are also used to tie in micro or pico-cells.

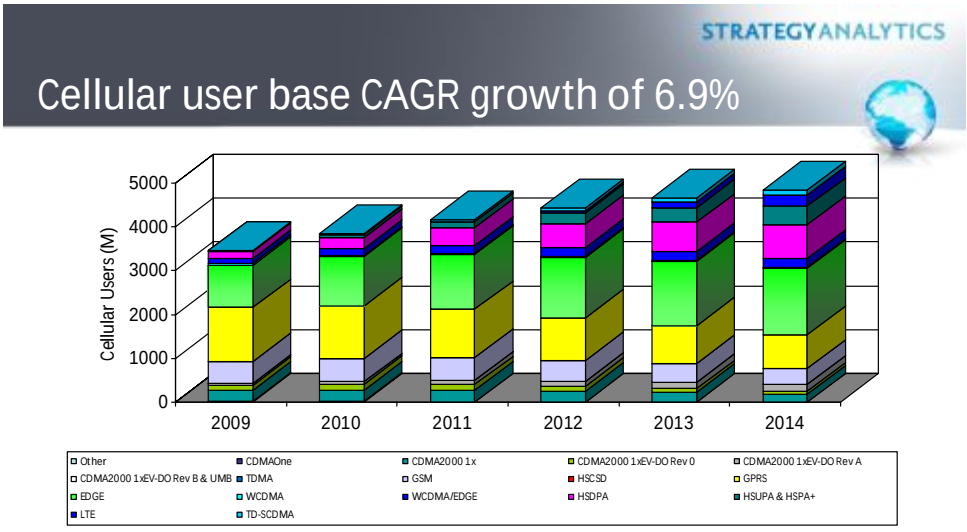
Exhibit 7-10 Typical Cellular Infrastructure Layout



Strategy Analytics' WES (Wireless Enterprise Service) estimates that the number of individual cellular users (discounting multiple subscriptions) reached 3.5 billion at the end of 2009 and will climb to over 6.6 billion by 2014 (Exhibit 7-11).

This translated into an installed base of macro and micro base stations 4.8 million. Annual shipments slowed down and declined slightly year-on-year to 575 thousand units as operators in certain markets held back on investment in light of economic uncertainties (Exhibit 7-12).

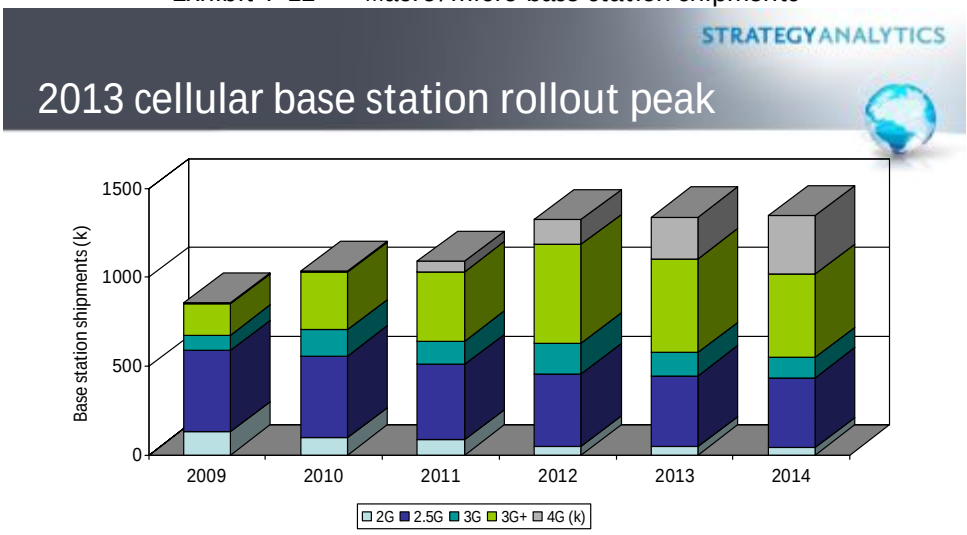
Exhibit 7-11 Cellular User Base



Source: WNS, *Worldwide Cellular User Forecasts, 2010-2015*, published Mar 2010

- Emerging markets drive growth in EDGE users
- EDGE/GPRS/GSM still accounts for 55% of global user base in 2014
- 3G and 4G users growing rapidly

Exhibit 7-12 Macro/micro base station shipments

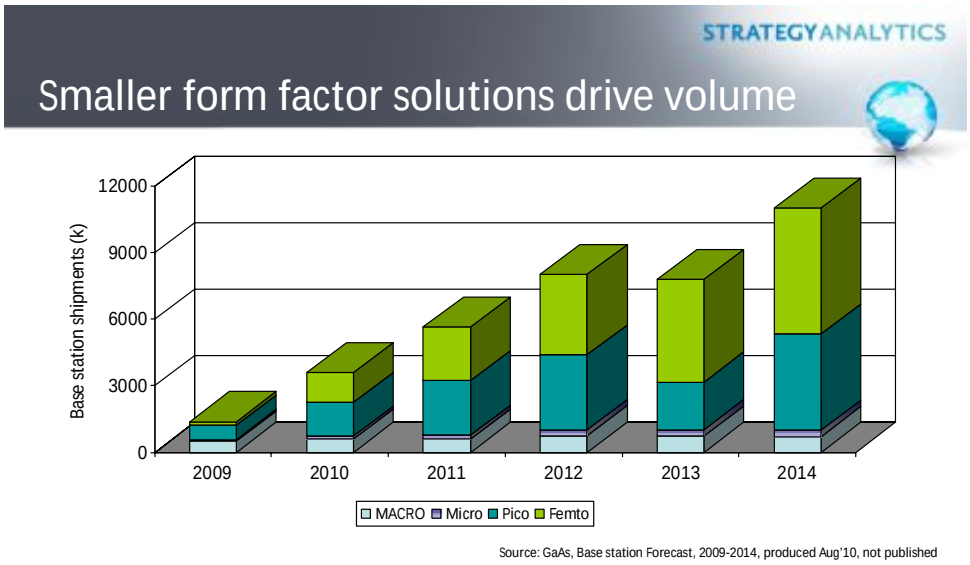


Source: GaAs, Base station Forecast, 2009-2014, produced Aug'10, not published

- 3G+ and 4G markets will drive growth for macro and micro base station rollout
  - Accounting for 59% of base station shipments in 2014
- Some continued rollout of legacy infrastructure in emerging markets
  - Primarily comprised of PA module upgrades

There is also a potential opportunity from the emerging femtocell/picocell base station market used to provide additional in-building coverage in the 3G market for both office buildings and retail parks as well extended coverage in the home. Strategy Analytics forecasts the femtocell shipments remain at an early stage of deployment, with shipments reaching 1.3 million units in 2010. Early rollout of these smaller form factor base stations suggests that GaAs-based PAs will be used at power outputs favoring MMIC technologies.

Exhibit 7-13 Total Base Station Market Rollout

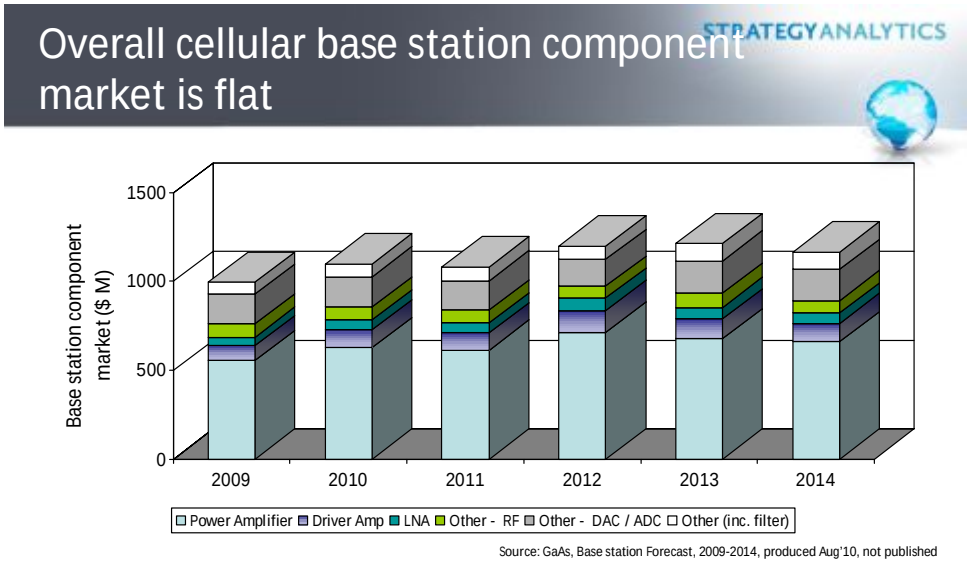


Source: GaAs, Base station Forecast, 2009-2014, produced Aug'10, not published

- Higher frequencies ~ smaller cell sizes
  - Smaller form factors required to cover gaps
- Value-add solution
  - Also allows operators to offload capacity from macro networks

Si LDMOS will remain the dominant semiconductor technology for the cellular base station PA market with the use of GaAs discretes for wireless infrastructure only representing 14% of the total market in 2009. We are forecasting that the introduction of high voltage GaAs solutions for next generation infrastructure applications that place a greater emphasis on linear performance and efficiencies as opposed to saturated power capabilities will allow this penetration to increase to 18% through 2014 (Exhibit 7-14 and Exhibit 7-15).

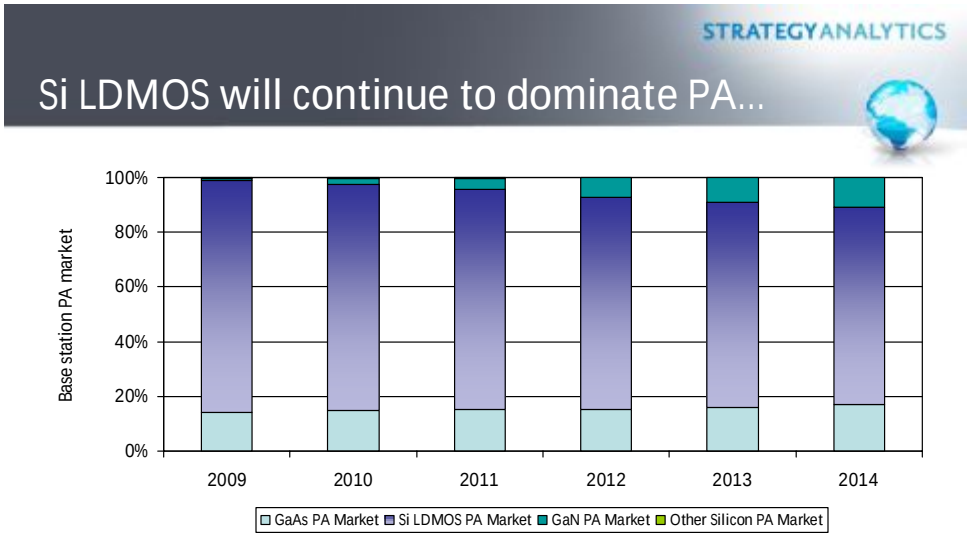
Exhibit 7-14 Overall Cellular Base Station Component Market



Source: GaAs, Base station Forecast, 2009-2014, produced Aug'10, not published

- Overall market showing growth of around 3%
  - Growth opportunities in emerging markets 3G+ and 4G
- Opportunities for GaAs technology
  - HV, femtocells

Exhibit 7-15 Cellular Base Station PA Market

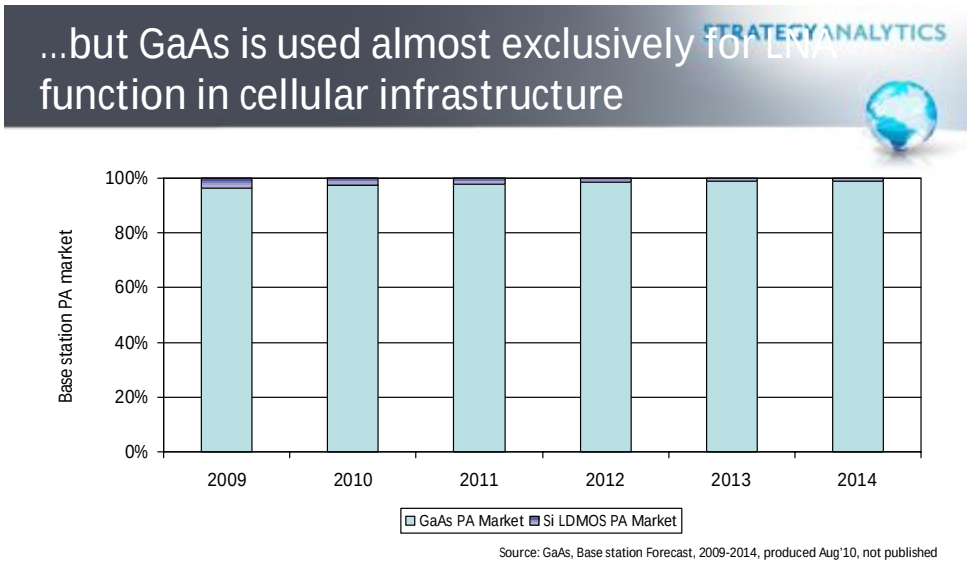


Source: GaAs, Base station Forecast, 2009-2014, produced Aug'10, not published

- Si LDMOS technology continues to improve, dominates ~$661m market in 2014
  - Dominating traditional sockets
- Opportunity for GaAs and GaN from emerging platforms
  - "Green" marketing

The LNA function constitutes the main demand for GaAs MMICs from cellular base stations. GaAs MMICs used in the driver function will also provide a market, although the driver function is typically linked with the process technology used for the PA, which is dominated by silicon LDMOS.

Exhibit 7-16 Cellular Base Station LNA Market



- Market demand for GaAs growing (~$60 million market in 2014)
  - GaAs LNAs used in base stations
  - Tower mounted antennas
  - Repeaters
- Discrete devices now being supplanted by MMICs

7.4 Millimeter-wave Radio

GaAs MMICs areused extensively for millimetre-wave radios, combining both high frequency, high performance for the transmitter with capabilities on the receive side including low noise performance (Exhibit 7-17).

Strategy Analytics estimates that just point-to-point radio shipments were flat in 2009 as the impact of global economics resulted in reduced investment. Strategy Analytics latest forecast assumes that the point-to-point radio shipments will increase at a compound annual average growth rate of 9% through 2014, from 1.1 million units in 2009 to 1.8 million in 2010 (Exhibit 7-18).

Exhibit 7-17 Millimeter-wave Radio Block Diagram

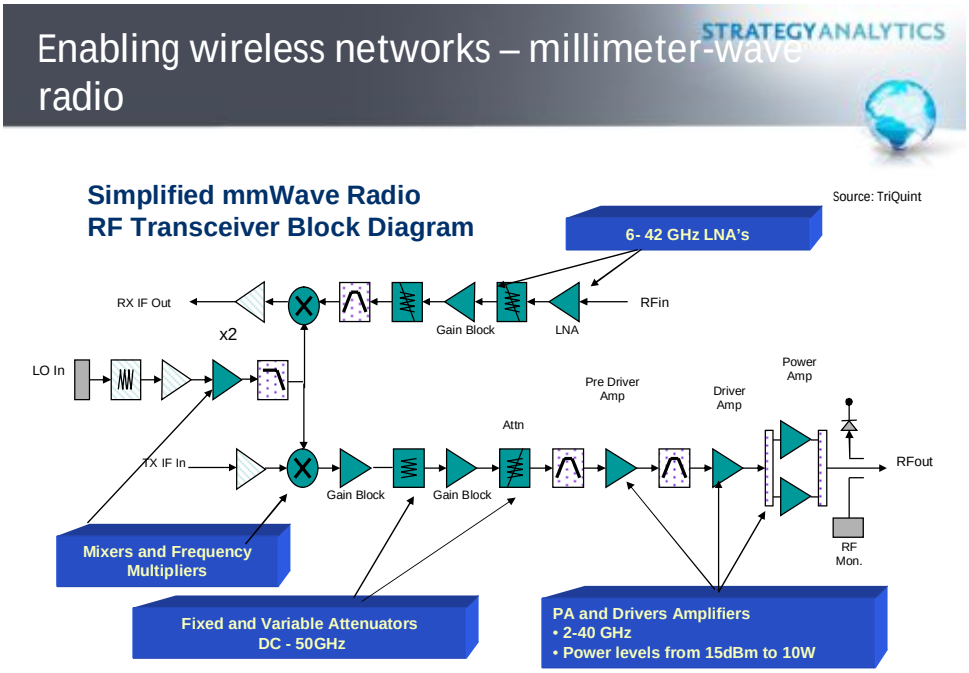
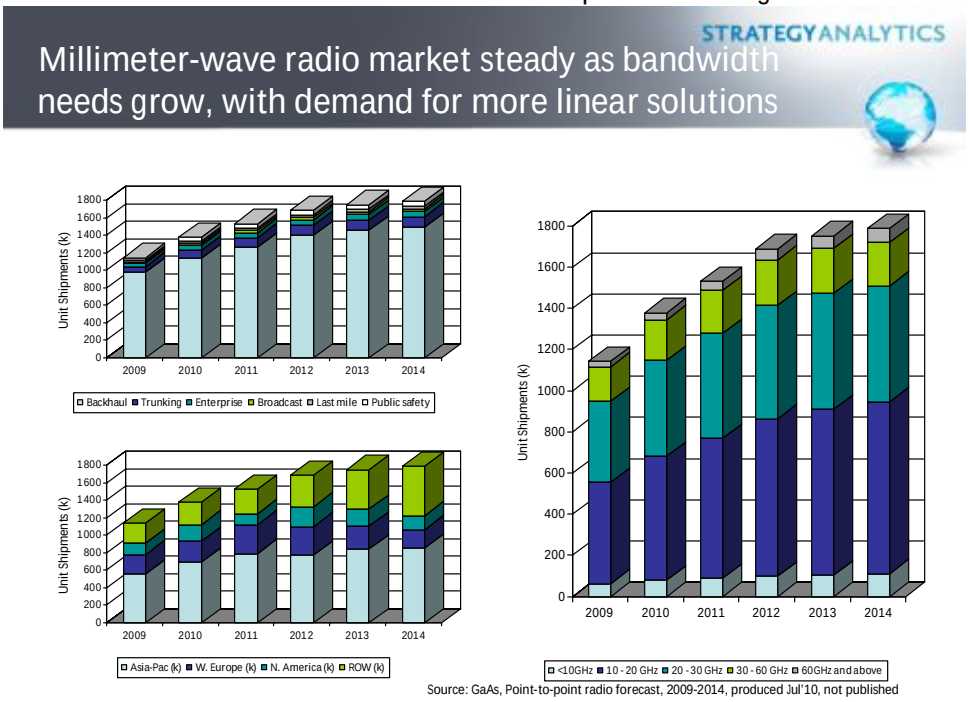


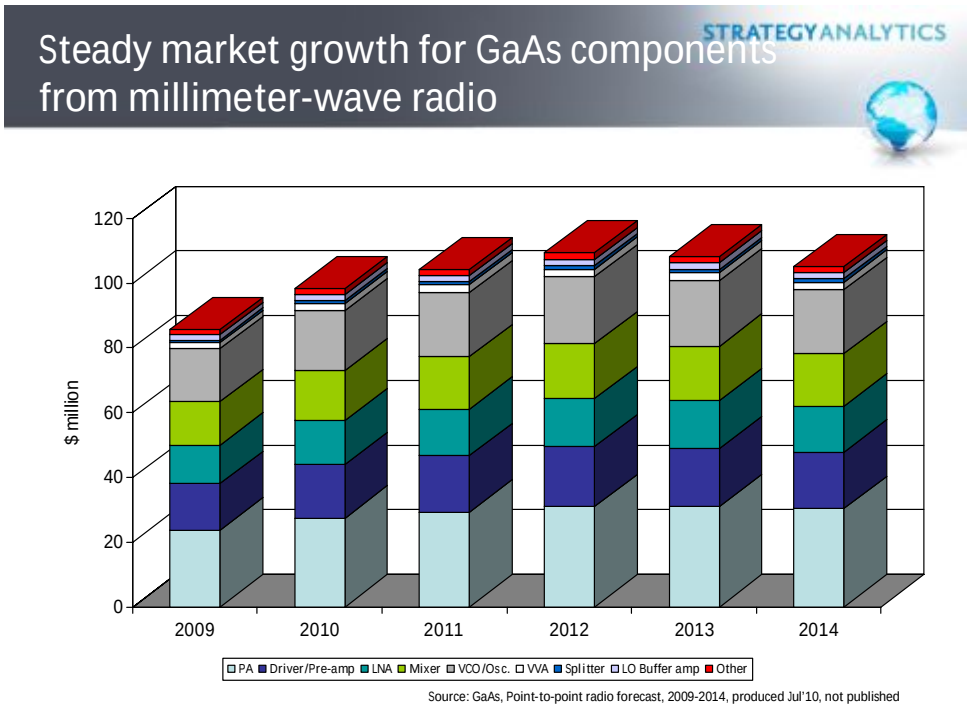
Exhibit 7-18 Millimeter-wave Radio Shipments and Segmentation



Source: GaAs, Point-to-point radio forecast, 2009-2014, produced Jul'10, not published

GaAs will continue to the dominant technology and future ASP declines will be tempered by device suppliers offering linear products with an emphasis on multi-chip packaging and integration. Subsequently, we forecast that GaAs device demand will increase from $81.4 million in 2009 to $99.6 million in 2014, a CAAGR of 4%.

Exhibit 7-19 GaAs Device Demand from Millimeter-wave Radio



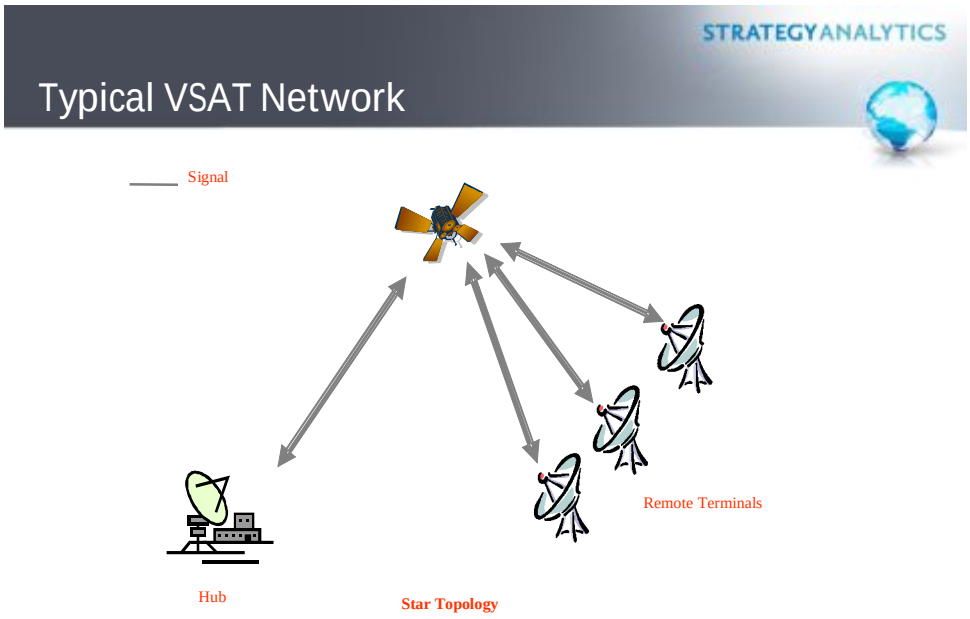
Source: GaAs, Point-to-point radio forecast, 2009-2014, produced Jul'10, not published

7.5 Satcom/VSAT markets

A VSAT (Very Small Aperture Terminal) network is a one or two-way communication system that uses satellites to provide voice, data and video connections, typically over large geographical areas. The network consists of a satellite, a remote terminal and a hub or earth station with an antenna less than 3m in diameter (most are in the .75-1.2m).

The traditional VSAT topology is a star network. In the star configuration, the communication originates at the transmitting remote terminal, goes to the network operations center or hub, via the satellite, where the signal is re-transmitted to the satellite and then to the receiving remote terminal. This type of communication is known as "double-hop". The hub provides the central routing and switching functions of the network between the satellite and remote terminals as well as command and control of the satellite itself (Exhibit 7-20).

Exhibit 7-20 Typical VSAT Network Topology

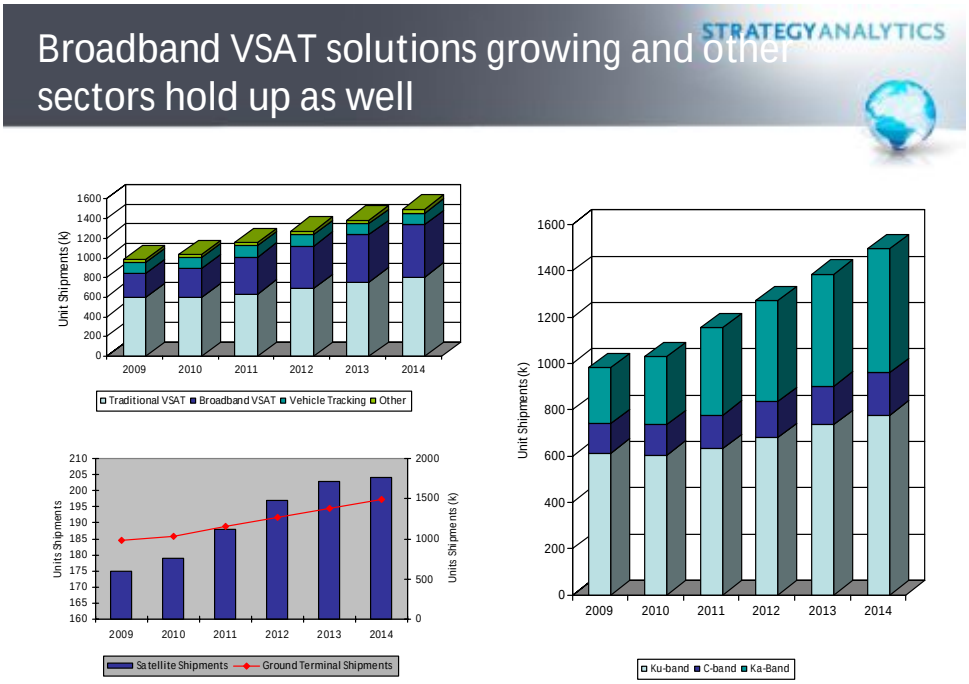


The majority of VSAT shipments both currently and for the foreseeable future will be dominated by "traditional" VSAT shipments. The "traditional" VSAT market comprises the connection of remote terminals in a heart-and-spoke satellite-based communications network used by retailers and financial institutions. There is also significant interest in broadband VSAT terminals called the "consumer-market" (Exhibit 7-21).

The market opportunity for GaAs comes from both the ground terminals and space segment of the market. MMIC demand from this sector will be derived primarily from ground terminals. Overall, the MMIC market for satellite communications and satellite systems will grow from $49.1 million in 2009 to $65.3 million in 2014, a CAAGR of 6%.

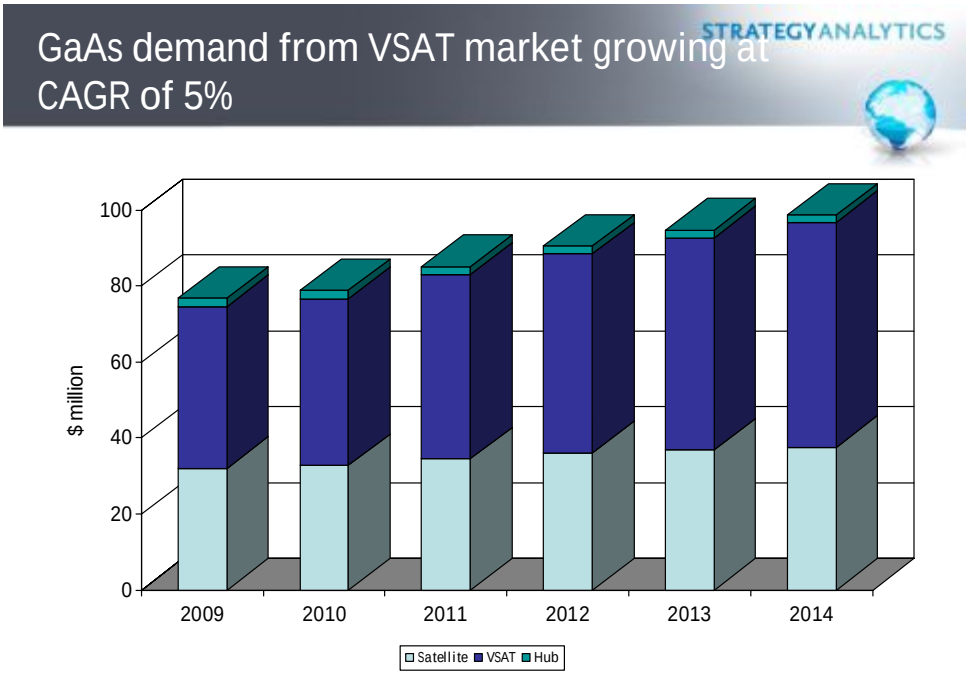
While TWTs represent the primary technology used for power amplifiers in satellite systems, the increasing use of phased arrays, used for both SAR and for directional beam antennas, require multiple solid state power amplifiers, which typically use discrete power amplifiers. We expect the demand for discrete GaAs FETs from satellite communications and space-based systems to grow at a CAAGR of 3% through 2014, from $27.75 million in 2009 to $32.5 million in 2014 (Exhibit 7-22).

Exhibit 7-21 Satcom/VSAT System Shipments and Segmentation



Source: GaAs, Satcom/VSAT forecast, 2009-2014, produced Aug'10, not published

Exhibit 7-22 GaAs Device Demand from Satcom/VSAT

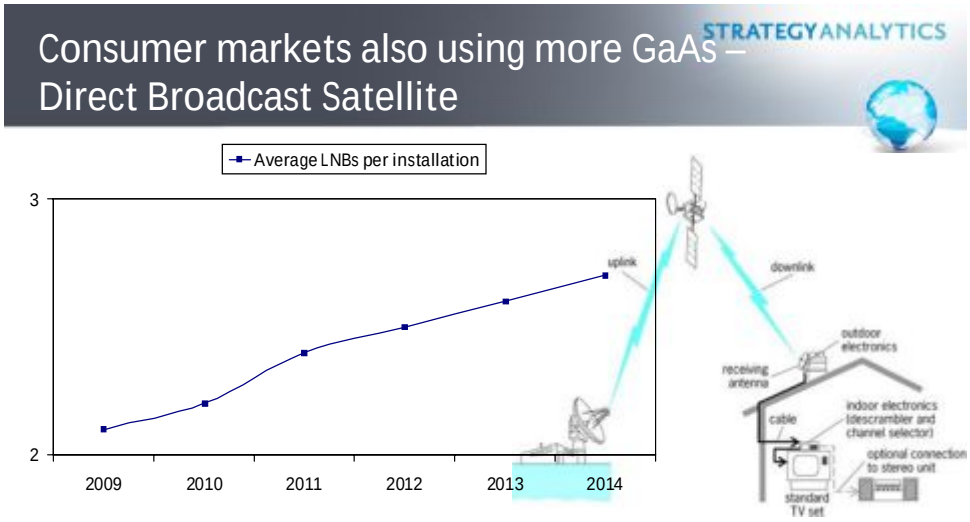


Source: GaAs, Satcom/VSAT forecast, 2009-2014, produced Aug'10, not published

7.6 DBS (Direct broadcast satellite)

DBS LNBs are the main application for discrete FETs. Almost all LNAs are fabricated using one or two discrete HEMTs, followed by a discrete HEMT or GaAs MESFET. While the market faces severe ASP pressures, the move towards interactive and PVR services increases the number of LNBs per installation and is helping to drive volume demand for discrete LNAs from this market.

Exhibit 7-23 Average number of LNBs/Installation

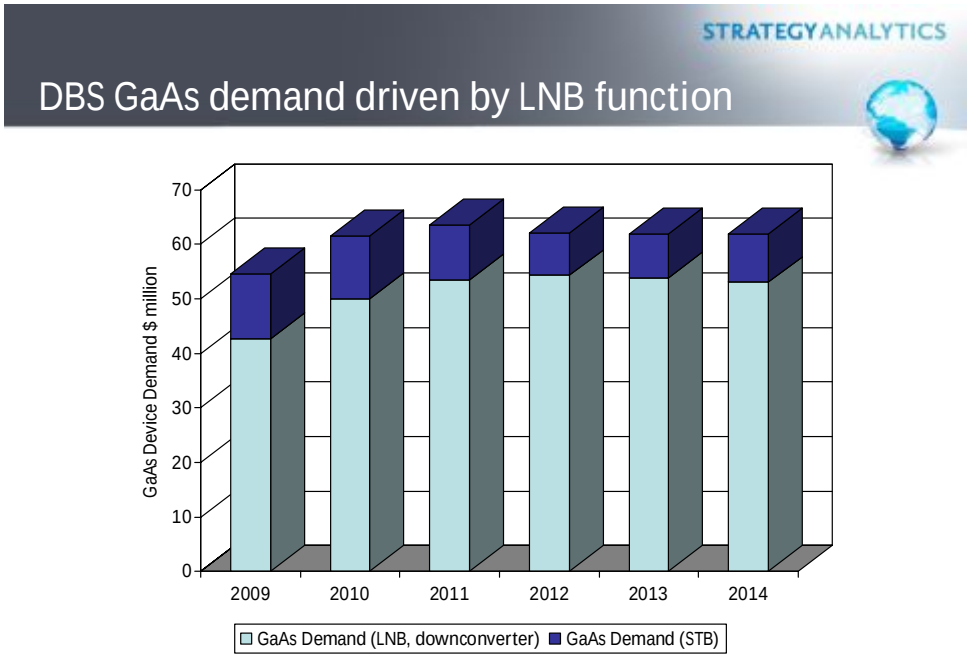


Source: GaAs, derived from *DBS forecast update*, preliminary update Q1 2010, not published
Source: http://encyclopedia2.thefreedictionary.com/_/viewer.aspx?path=mgh_cee&name=Direct-broadcasting-satellite-system.jpg

- Number of LNBs per installation increasing
  - PVR functionality
  - Interactivity

It is expected that for STB solutions, silicon devices will play the dominant role and while the implementation of the tuner/IF function has often required one or two discrete GaAs FETs, the trends towards using integrated solutions will marginalize this opportunity (Exhibit 7-24)

Exhibit 7-24 GaAs Device Demand from DBS



Source: GaAs, DBS Market Forecast 2010-2014, produced Aug'10, not published

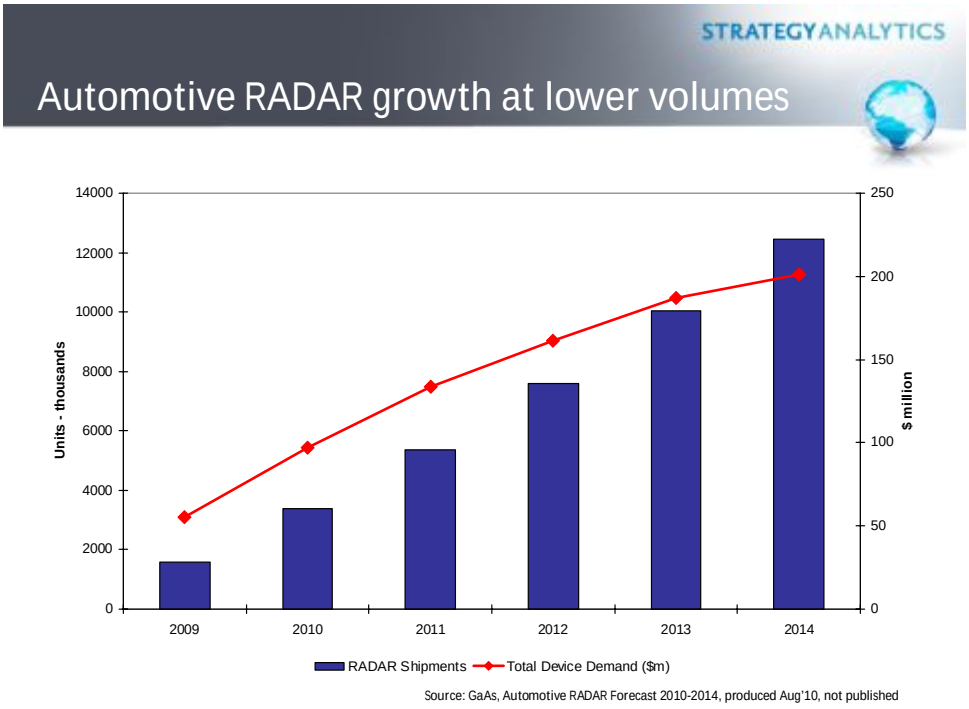
7.7 Automotive (long and short-range sensing/radar)

While the economic downturn impacted car production volumes, the effect on higher-end vehicles that are the early users of safety systems incorporating radar and other technologies was limited and Strategy Analytics estimates that overall auto RADAR shipment grew 65% in 2009 to reach 1.7 million units.

The implementation of RADAR systems as part of the safety features in a car is gaining traction. Strategy Analytics believes this emphasis on safety will eventually lead to mandatory implementation of safety features such as tire pressure monitoring, lane departure and collision avoidance. We envisage future cars hosting a multiplicity of technologies with RADAR being an integral part of the solution.

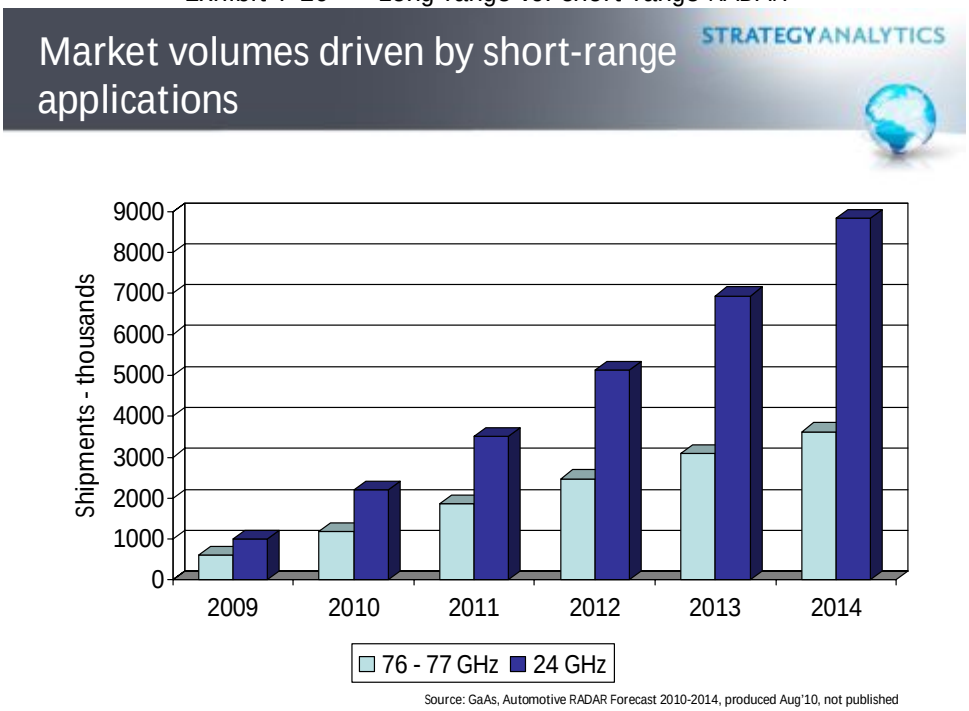
Shipments are forecast to grow at a CAAGR of 51% to reach 12.5 million units by 2014. The total automotive RADAR market will be split between long-range and short range applications with short range applications accounting for over 70% by 2014. Short range systems will be used to offer a range of features including parking and distance warning, but blindspot monitoring features will become the dominant system type by 2014 (Exhibit 7-25 and Exhibit 7-26).

Exhibit 7-25 Automotive Radar Volumes and Device Demand



Source: GaAs, Automotive RADAR Forecast 2010-2014, produced Aug'10, not published

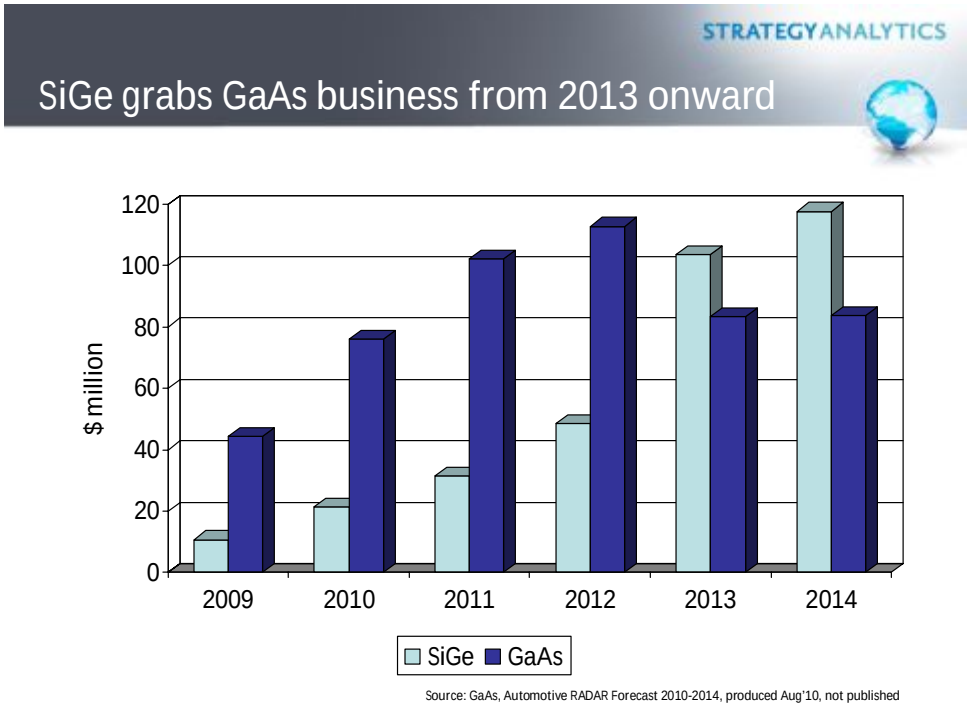
Exhibit 7-26 Long-range vs. Short-range RADAR



Source: GaAs, Automotive RADAR Forecast 2010-2014, produced Aug'10, not published

While GaAs technology has had an early lead and has considerable momentum in the market, Strategy Analytics forecasts that the GaAs-based systems will face increasing competition from SiGe with European manufacturers leading the charge. There is also the potential impact of regional markets mandating the use of narrowband technologies which will allow SiGe technology to be a much more viable option. Despite this competition, we do not expect GaAs-based systems to be phased out completely as design cycles in the automotive industry typically run over three to four years.

Exhibit 7-27 SiGe vs. GaAs in Automotive Radar



Source: GaAs, Automotive RADAR Forecast 2010-2014, produced Aug'10, not published

7.8 Other emerging opportunities

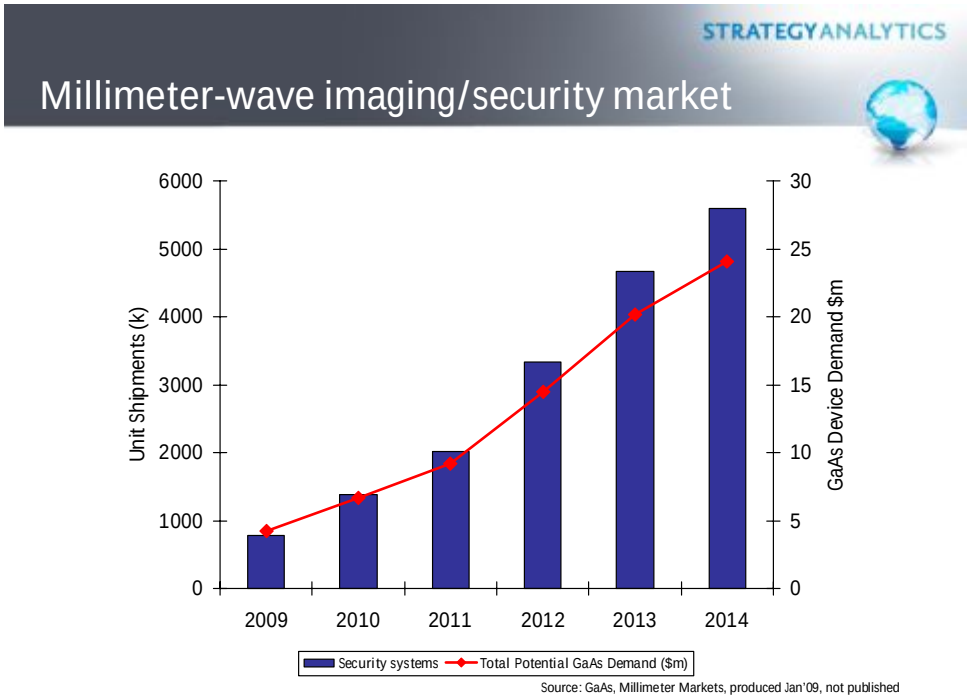
Other emerging opportunities include the use of GaAs for millimetre-wave imaging systems that can be used to replace traditional metal detectors at airports and other locations. Early deployment is estimated at no more than 200 units, but a there has been a lot of trials in the field with UK and US airports, while Schipol Airport in Amsterdam has 15 units in operation.

Smiths and L3 are reportedly the early leaders in the market. Smiths initially deployed systems based around 94GHz InP LNA receivers, used in conjunction with detector diodes. This involved a vertical mechanical scan with around 1000 receivers placed horizontally. The L3 system was an active scanning system that employed 24GHz frequencies.

Other suppliers of millimetre-wave imaging systems have included MIllivision, Trex-Sagl, Brijot and GE. No standardised systems have been developed, but companies active in the market have to consider potential ITAR consideration when using 94GHz tecnologies, while the 24GHz is unlicensed and therefore not liable to similar restrictions.

It is not clear what final technologies will be used, but based on unit shipments reaching around 5.6 thousand over the next few years, there is a potential early market of around $24 million for GaAs and/or other compound semiconductor technologies.

Exhibit 7-28 Millimeter-wave Security Imaging Market



Source: GaAs, Millimeter Markets, produced Jan'09, not published

Another potential emerging opportunity could develop from the growing impetus behind deployment of smart grids which are defined as an environment of applications, sensors, and controls that using automation and communication through embedded technologies, standards and systems to enable understanding of how a utility is operating and allow consumers and providers alike the capability to manage and control utilization and maintain reliable, affordable and environmentally responsible energy and water. Key benefits include:

- Reduced electricity/gas/water usage
- Better customer understanding of energy use, e.g. benefits of off-peak rates (known as dynamic tariffs)

- Less volatile demand patterns should allow utilities to supply a steadier flow of energy, or "load-shift", with a lower peak supply required

According to the Brattle Group: a 5% drop in peak demand nationally [US] would eliminate the need for installing and running some 625 power plants, annual savings of approximately $3BN, as well as environmental benefits.

There are a variety of technologies that can be used for implementation of the smart grid, including:

- Cellular CPE making inroads into conventional AMR with lower radio chipset & module prices
- Fixed Wireless: ISM CPE + pole mounted cellular concentrators moving to cellular CPE modules
- Mobile & Handheld: ISM CPE read by vehicle or handheld readers -- labor intensive
- PLC popular in Europe, economical only in urban settings
- Dial In / Dial Out: Telephone. Expensive infrastructure and installation

The implementation of smart grids on a wireless, e.g. cellular platform would suit GaAs technology best with GaAs being used to realize front-end modules, amplifiers, switches and LNAs. This would be around a broad range of frequencies including 450 MHz, 900MHz and 2400MHz.

In the US, deployment of smart meters has begun, driven by a US stimulus of $4.5 billion through the US Reinvestment and Recovery Act (Oct 2009). Estimates place deployment of smart meters for gas and electric utilities at around 14 milion.

In Europe, the approach is not as cohesive with different countries adopting different timescales. However, there are broad EU directives in place that require 80% of European electricity meters to be updated with "smart" equivalents by 2020 (100% by 2022). This represents an estimated 181 million units.

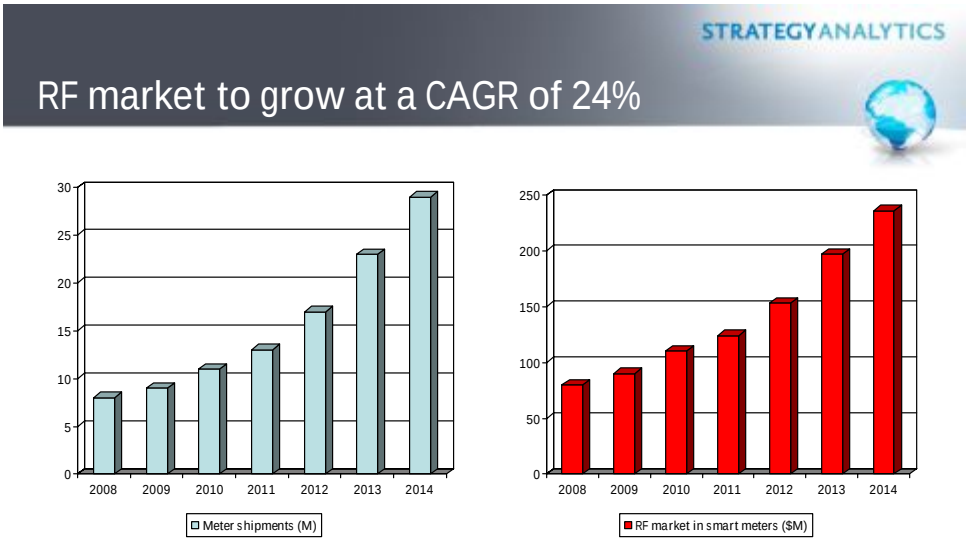
- In Italy, smart meters were distributed to the entire Enel customer base (27M) in 2000-2005.
- In the UK, all homes are to be supplied with "smart" energy meters (includes both gas and electricity) by 2020. Roll-out phase is expected to begin in 2012. Requires 46M units
- Spain: Roll-out phase: Jan 2008-Dec 2018 (mandatory for 24M residential customers). Specifications still awaited

- Sweden: nationwide roll-out almost completed for monthly meter reading. Uses variety of early meter technology, some of which is not considered "smart" but merely "remote"

Strategy Analytics RFWC service estimates that there were 20 million AMR system shipments in 2010 (including parking meter applications). Given a potential base of 600 million gas and electricity meters alone, in the US and EU, and a global market overall of almost 2.7 billion, there is significant growth potential from this market.

GaAs companies already active in this market include Skyworks and RFMD and Strategy Analytics projects a potential that could approach $236 million by 2014.

Exhibit 7-29 Potential Smart Meter RF Market Opportunity



Source: GaAs, Smart Meter Market 2008 - 204, preliminary research Q1 2010, not published

- Anticipates ramp of installations from 2013 onwards
- Assumes 2010 BOM ASP of $10, ASP declining 5% pa.
- EU + NA market, electric/gas utilities only

8 GaAs Foundry Market Trends and Outlook

The emergence of a GaAs foundry industry started on the back of the 1999-2000 boom with companies in Asia looking to emulate the model successfully developed by silicon foundries such as TSMC. Prior to this development, the provision of GaAs foundry services was only offered by a limited number of companies with TriQuint being the most prolific. In Asia, a number of companies emerged offering foundry services;

- AWSC
- GCTC
- Knowledge-On
- Suntek
- WIN Semiconductor

However Strategy Analytics noted at the time that it would be unfeasible for all the companies to remain in operation and that a number of conditions needed to be fulfilled to ensure survival. These conditions would be linked directly to the depth of investor pockets, as the foundry model dictates that companies offer a range of process technologies, around a strong manufacturing based and supported moving forwards by a well defined roadmap.

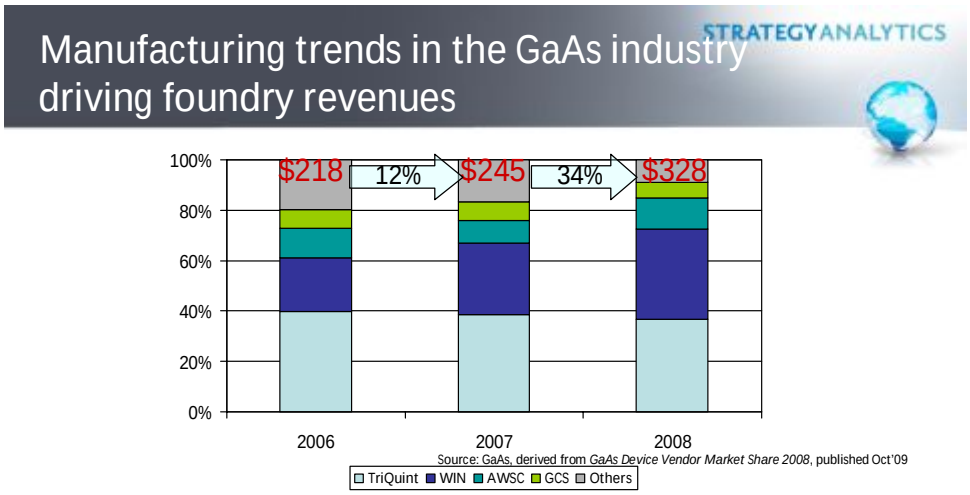
The situation in 2009/2010 validated the Strategy Analytics prediction that only a few pure-play foundries would survive, with only Win Semiconductor and AWSC remaining in the Asian region.

These companies have managed to survive by fulfilling the above highlighted conditions, developing core relationships and being able to take advantage of manufacturing trends in the GaAs industry as a whole.

While the GaAs industry has traditionally been focused around an IDM model, there was been a steady emergence of companies such as Mimix Broadband (now merged with M/A-COM Technology) and Hittite that adopted a fabless approach to realise flexibility in manufacturing, higher margins and faster time-to-market. These fabless companies have been increasingly joined by more traditional GaAs device manufacturers looking to adopt “hybrid” manufacturing models that entail continued use of internal resources, while also leveraging outsourcing to maintain volume output. Skyworks was the early leader with this type of approach, working with AWSC while also maintaining two fabrication facilities in the US. Other companies that have adopted this approach more recently include Anadigics, Avago Technologies and Freescale (though the latter’s fabrication facilities are now focused on backend processing).

These manufacturing trends have allowed the GaAs industry to grow from $218 million in 2006 to $328 million in 2008. TriQuint has maintained an overall lead in the market, but the growing strength of pure-play foundries is best reflected by the growing strength of Win Semiconductor. Indeed, Win Semiconductor is now firmly established as the world's largest pure-play GaAs foundry, while TriQuint also maintains activities as an IDM serving both commercial and defense markets.

Exhibit 8-1 GaAs Foundry Market Growth 2006-2008



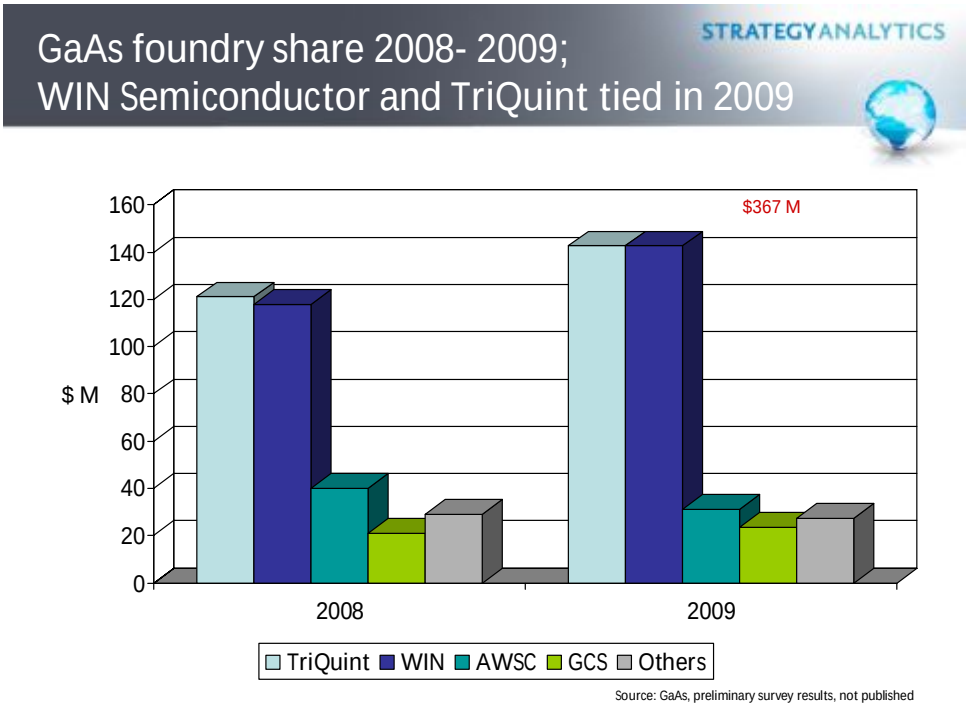
- Outsourced manufacturing offers flexibility, higher margins and faster time-to-market
  - Avago Technologies
  - Freescale
  - Hittite
  - Mimix Broadband
  - Renesas
  - Skyworks
  - US Monolithics

Moving forwards, the foundry companies will serve an increasingly important role in providing cost effective solutions based around GaAs, rather than Silicon, especially for lower volume markets and will also provide companies access to leading edge technologies such as optical lithography for millimetre-wave processes and integration capabilities through BiHEMT process technologies.

In 2009, TriQuint and Win Semiconductor maintained their positioning as market leaders, with the market continuing to grow to an estimated $367 million overall (Exhibit 8-2).

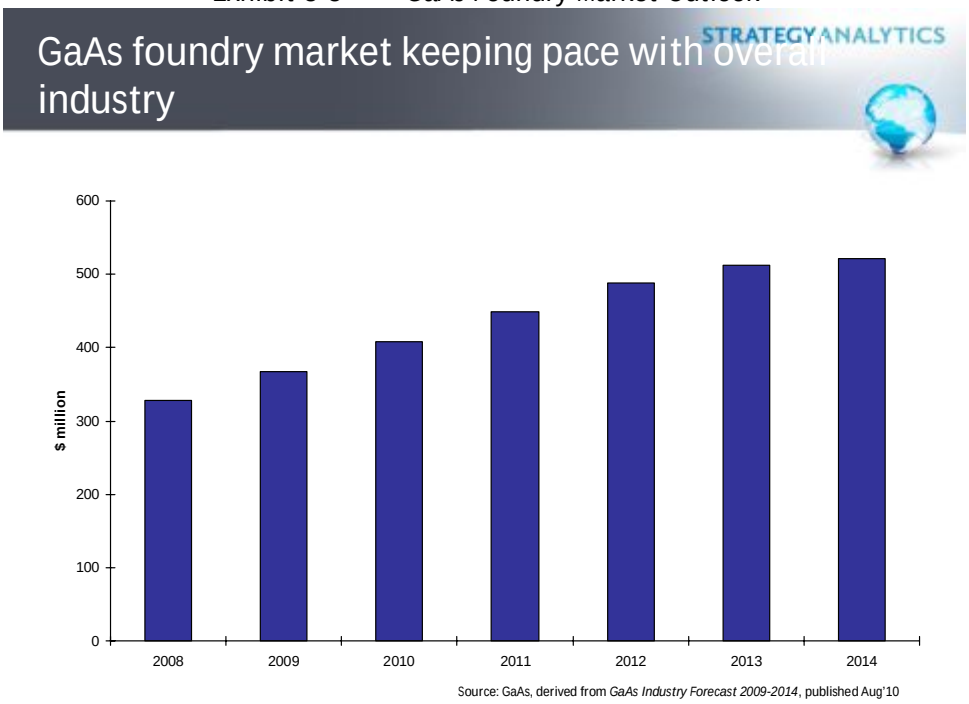
Moving forwards the market for GaAs foundry services will continue to show upwards growth revenues approaching $500 million by 2014 (Exhibit 8-3).

Exhibit 8-2 GaAs Foundry Share 2008-2009



Source: GaAs, preliminary survey results, not published

Exhibit 8-3 GaAs Foundry Market Outlook

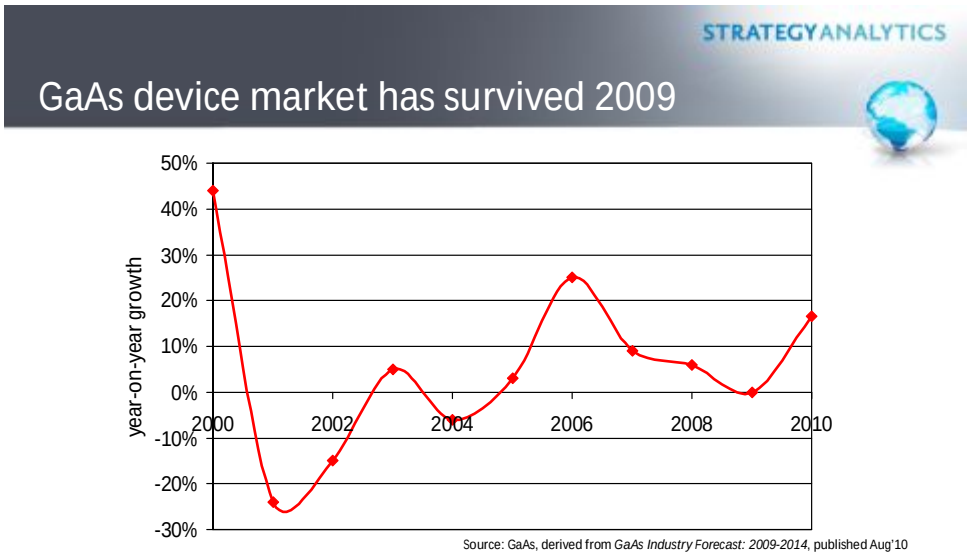


Source: GaAs, derived from *GaAs Industry Forecast 2009-2014*, published Aug'10

9 GaAs Industry Forecast 2010-2015

Despite macroeconomic trends still in flux at the end of 2009, the market for GaAs devices showed a strong recovery towards the end of the year as a result of trends in the wireless handset markets. Despite a recession, GaAs industry revenues managed to escape a drop in 2009, with a strong performance in the second half of the year translating to year-on-year revenues remaining flat at $3.7 billion versus the previously predicted 5% decline (see section 3, Exhibit 3-3).

Exhibit 9-1 Actual 2009 Performance vs. 2001



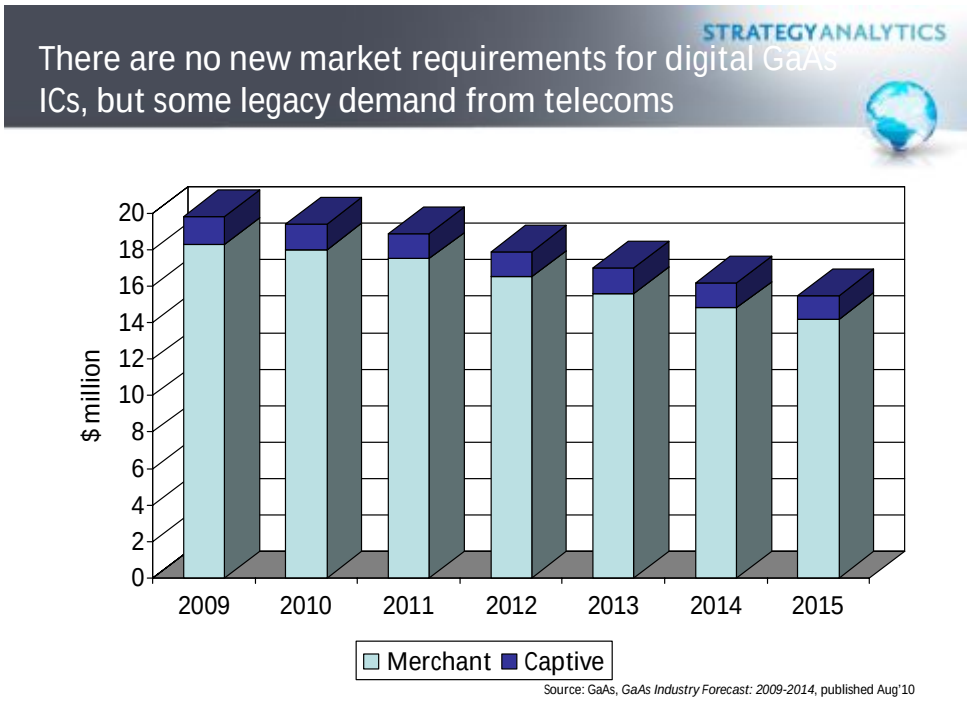
Source: GaAs, derived from *GaAs Industry Forecast: 2009-2014*, published Aug'10

- Better performance than predicted!
  - Strong recovery driven by smartphone sector allowed GaAs industry to maintain revenues and suffer a decline
  - 2010 now expected to show 17% year-on-year growth

Following a mild resurgence in demand for digital GaAs ICs, largely centered in the telecoms and datacoms market sectors for 10Gb and above markets, the market for digital GaAs ICs continued on its negative trajectory in 2009 and will show negative growth through 2015 (Exhibit 9-2).

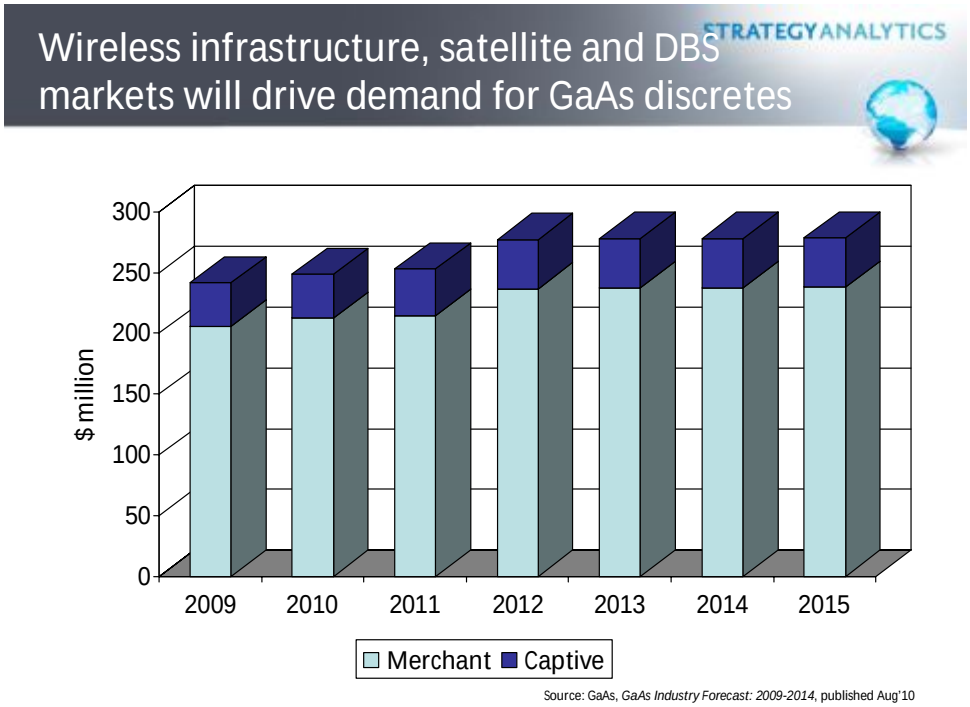
Meanwhile, wireless infrastructure, satellite and DBS markets will drive demand for GaAs discretes, but overall volumes and hence the total available market will continue to be substantially lower compared to the market for MMIC-based solutions. In areas requiring high power, high frequency capable discrete solutions, this segment will also start to see increased competition from emerging technologies, most notably GaN (Exhibit 9-3).

Exhibit 9-2 Digital GaAs IC Market (Merchant vs. Captive): 2009–2015



Source: GaAs, *GaAs Industry Forecast: 2009-2014*, published Aug'10

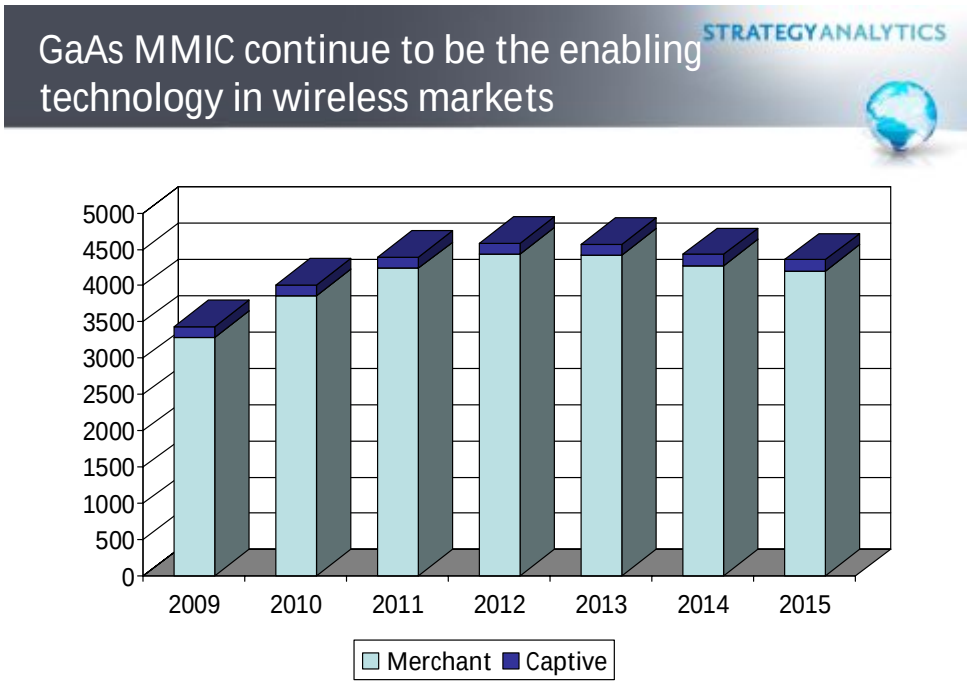
Exhibit 9-3 Discrete GaAs FET Market: 2009-2015



Source: GaAs, *GaAs Industry Forecast: 2009-2014*, published Aug'10

A strong recovery towards the end of 2009 enabled the worldwide GaAs MMIC market to avoid a decline with revenues essentially being maintained at 2008 levels. The overall 2009 market was estimated at $3433.7 million and is forecast to grow at a 2009-2015 CAAGR (Compound Annual Average Growth Rate) of 4% to reach $4355.0 million by 2015. GaAs will continue to be the enabling technology in cellular handsets, and will benefit particularly from increasing GaAs device content and the stronger than average volume growth in the smartphone category.

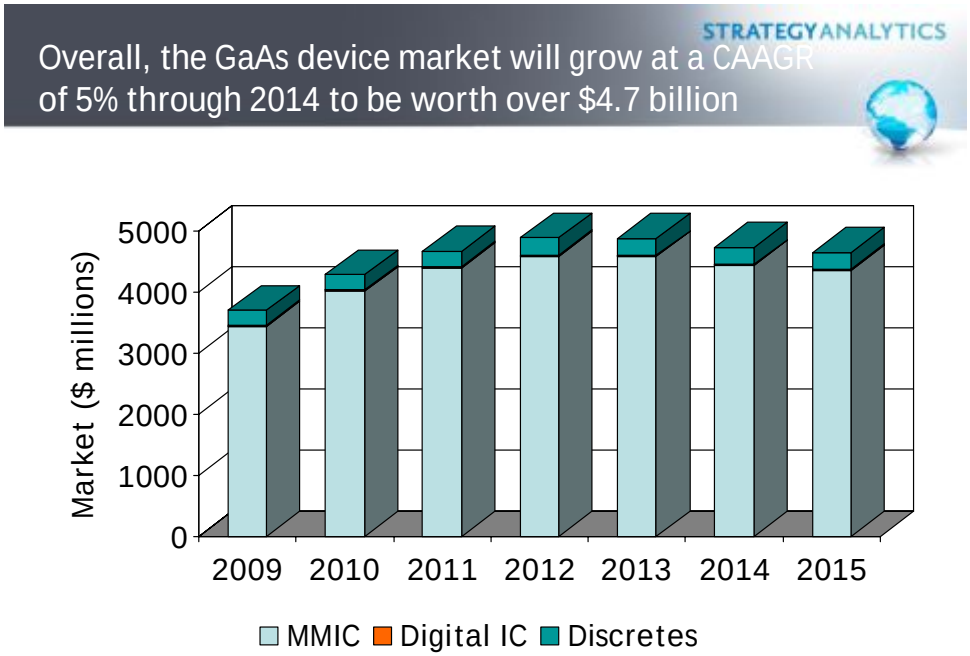
Exhibit 9-4 GaAs MMIC Market (Merchant vs. Captive): 2009-2015



Source: GaAs, *GaAs Industry Forecast: 2009-2014*, published Aug'10

Importantly, for the GaAs industry as a whole, while other sectors will see increased competition from silicon technologies, GaAs technology will maintain its position as the enabling technology for next generation cellular handsets. Overall, the GaAs device market will grow at a 2009-2015 CAAGR (compound annual average growth rate) of 4% through 2015 to be worth $4648.9 million (Exhibit 9-5).

Exhibit 9-5 GaAs Industry Forecast 2009-2015



Source: GaAs, *GaAs Industry Forecast: 2009-2014*, published Aug'10

10 Conclusions

- GaAs market grew 6% year-on-year in 2008, but industry hit a wall in the fourth quarter.
- Strategy Analytics forecast GaAs device market would survive 2009 and this has been borne out by industry performance
- GaAs remains a key enabling technology…
  - At the forefront of wireless markets
  - Enabling next generation networks
  - Delivering digital content to the consumer
  - Automotive
- …but will face increasing competition from silicon technologies
- GaAs device market will be worth $4.7 billion, growing at a CAGR of 4% through 2015
- The corresponding market for GaAs (bulk and epitaxial substrates will be worth $747 million in 2014.

Учебное пособие

Азиф Анвар

ОРГАНИЗАЦИЯ И ЭКОЛОГИЯ ПРОИЗВОДСТВА, ЛОГИСТИКА И МАРКЕТИНГ

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