As the compound semiconductor industry matures, the question arises as to whether it going through the same transitions that the silicon industry experienced. In particular, does the cell-phone-induced swing from undersupply to overcapacity in the GaAs RF IC industry mean that it is emulating the PC-driven cyclical of the silicon industry? If so, what other trends may be expected to follow?

GaAs RFICs: from under-supply to over-capacity

Since late last year - and until at least mid-2001 - it looks like the GaAs RFIC market is in the midst of a slowdown. This has been induced by faster-than-expected growth in sales of mobile phones in early 2000 leading to raised expectations for the rest of 2000 and 2001, only for the growth not to be sustained. This is reminiscent of the boom-and-bust cycles in the silicon industry, but how close are the similarities?

Cyclicality

For many years the silicon industry has been a cyclical industry. Through 1995, demand for DRAM memory chips for computers far exceeded global fab supply capacity. The shortage of DRAMs led, unusually, to prices actually rising, and hence record revenues for silicon manufacturers.

Emboldened by market research forecasts predicting continued demand and a doubling of semiconductor revenues from US$150bn to over US$300bn by 2000, silicon manufacturers went on a spending spree of building huge, new state-of-the-art fabs (an example being Siemens' fateful decision in August 1995 to build a DRAM fab in North Tyneside, UK), despite several DRAM manufacturers all aiming for a 20% market share.

Also, many new companies entered the industry and started up production in record time, such as Taiwan's Nan-Ya (founded by Formosa Plastics) and Powerchip (with processes and engineering expertise transferred from Japan's Mitsubishi).

Then, in early 1996, the DRAM market swung from under-supply to over-capacity and the price of DRAMs plummeted. Not only were revenues slashed, but silicon manufacturers were left with either half-built fab shells or - worse still - fabs that cost millions of dollars a month to run (though perhaps only 50-60% utilised) and full of maybe US$1bn worth of unwanted leading-edge processing equipment rapidly becoming obsolete.

After a slight recovery in 1997, the Asia Financial Crisis and a subsequent drop in demand for PC-dominated electronic goods made the downturn in 1998 the worst in the silicon industry's history. This led to major restructuring, both of companies (with Siemens forced by autumn '98 to sacrifice its UK fab and spin off its chip business as Infineon Technologies) and of the industry as a whole. Even after a slow recovery in 1999 and 40% growth in 2000, revenues were "only" about US$220bn rather than the forecast US$300bn.

The trend to foundry

These circumstances contributed to a big change in the industry - the transition to foundry-driven manufacturing as integrated device manufacturers such as Motorola were forced to cut costs and outsource to the likes of Taiwan's TSMC and UMC as well as Singapore's Chartered Semiconductor (the world's three biggest "pure play" foundries, with TSMC now having overtaken Intel as the largest manufacturer in terms of wafer starts - over 4m 8" wafers per year - if not in revenues).

Not only had cash-rich Taiwan been relatively insulated from the effects of the Asian Financial Crisis, but it was the only region to deliberately target foundry manufacturing (with UMC announcing in 1995 its intention to transition to purely foundry manufacturing) and show growth in semiconductor revenues through 1998.

Most GaAs RF IC suppliers expect a return to growth in second-half 2001, boosted by the shift from 2G to 2.5G (GPRS) and 3G wireless services.
Parallels in compounds

Over the last year or so there have been parallels in the compound semiconductor industry in the advent of both an inventory correction and "pure-play" foundries, though - as usual with compounds (following the CMOS-based silicon industry on the maturation curve) - compressed in timescale and more complex in application (with devices based on MESFET, HBT and pHEMT transistors competing for many applications).

The closest parallel to the PC-driven commodity DRAM silicon chip is perhaps the GaAs RF IC for power amplifiers in mobile phones.

Firstly, as the consumer cell-phone market matures, then - if the market for GaAs RF IC becomes more dependent on it - it too could become cyclical.

After 65% growth in the global cell-phone market from 1998's 170m to 1999's 280m, the forecast for 2000 was for 400m. However, after stronger-than-expected demand in early 2000, RF ICs were in short supply and prices rose. Forecasts for 2000 rose to 175 500m, and GaAs IC manufacturers scrambled to add fab capacity. But in late 2000 a relative slowing of sales made the increased forecast seem highly optimistic, especially when final sales were nearer the original forecast of 400m.

Likewise, in 1999 many forecast handset sales of 650m in 2001, but this has since been cut to 550m (and perhaps nearer to 500m - see page 4). Similar to the DRAM-induced downturns in the PC-dominated silicon industry, cell-phone makers are now correcting for excess inventory of components. This has led to sharp cut-backs in orders of GaAs RF ICs and epitwafers, which are now starting to show in a drop in quarterly sales for many suppliers (despite booming broadband demand) due mostly to RF ICs (see page 6).

For Q4/2000, sales were down on the previous quarter by 40% for ANADIGICS (due to "overall communications market conditions and inventory corrections at certain customers") and over 20% for RF Micro Devices (which received fewer-than-expected orders and expects revenues this quarter down 10%, since some OEMs have cancelled or delayed introductions of new models).

Kopin expects Q1/2001 sales down 40-50%, due to "excess inventories and forecast revisions by handset OEMs".

Celeritek has seen a "several order cancellations" and expects sales about 12% down on the last quarter and a loss in first-half 2001.

Alpha says "a build-up of inventory at contract manufacturers and distributors, primarily among digital set-top box customers and second-tier handset OEMs, resulted in orders being scaled back".

Most GaAs RF IC suppliers only expect a return to growth in second-half 2001, boosted by the shift from 2G to 2.5G and 3G wireless services. Indeed, some RF IC suppliers are now delaying fab expansions and even have under-utilised excess capacity in fabs recently either converted from 4" to 6" GaAs (with Motorola said to have cut 6" throughput from thousands of wafers per week to just hundreds) or from 6" silicon to 6" GaAs (unfortunately the case again for the former Fujitsu DRAM fab in Newton Aycliffe, UK after it was bought by Filtronic - see page 7).

Greater diversification

However, one advantage of the compound industry over silicon is that it is already extremely diversified (both in device types and materials).

Individual GaAs IC manufacturers that have been heavily dependent on a few handset manufacturing customers (e.g. ANADIGICS on Ericsson and RFMD on Nokia) have therefore - in response to the wireless slowdown - made efforts over second-half 2000 to diversify their customer base, develop more highly integrated multi-chip module technology (see page 5) and expand the broadband IC side of their businesses to match the booming demand, as well as acquiring opto manufacturing capabilities (such as merchant epitwaffer supplier Picogiga acquiring Modulight).

In contrast, manufacturers which are already diversified for other GaAs IC applications such as broadband or materials process technologies such as SiGe and silicon are still showing healthy growth (with Vitesse's sales 20% up in Q4/2000).

By comparison, silicon manufacturers such as the high-volume, low-margin DRAM-focused companies in Korea and Japan were affected severely over a long period while they tried to develop other products (less so Infineon, which already had a more diversified portfolio including SRAM memory chips and ASICs and, of course, GaAs).

Foundry

However, GaAs IC capacity is still being added by some companies, especially several new device and foundry suppliers coming on-line in Taiwan (see last issue, page 8), which are targeting high-volume, low-cost products.
One advantage that the compound industry has over silicon is that it is extremely diversified—both in terms of device types and materials.

Apart from the established Hexawave (Taiwan's first GaAs foundry, founded in 1991), these include:
- Advanced Wireless Semiconductor Corp (which started a 4" fab in early 2000 and soon won a second-source foundry supply deal with Conexant);
- WIN Semiconductor Corp (which opened its 6" foundry last September, targeting manufacture of 100,000 6" wafers a year in four years' time);
- Global Communication Technology (a 6" foundry set up in late 2000, backed by the USA's GCS);
- South Epitaxy;
- Suntek Compound Semiconductor Corp (being established with shareholders including Mitsubishi Electric and Taiwan's Procomp Informatics); and
- Transcom Inc (which plans to more than double production at its 3" and 4" fab from 15,000 wafers a year by 2002).

Outlook
It remains to be seen how long the current slowdown in GaAs RF IC demand will last (first-half 2001 or longer), how many Taiwanese GaAs foundries can be sustained and how many may not be viable long-term (with start-up G-Advance already being put on ice even after fab ground-breaking last Autumn by shareholders which included silicon chip manufacturer Nan-Ya).

However, as the silicon industry proved in its 1998 downturn, despite current over-capacity, foundries can make gains. As well as major handset makers like Ericsson cutting costs by outsourcing to Electronic Manufacturing Service providers (not only Flextronic but also Taiwan's GVC and Arima - see page 4), they are also looking to reduce costs during a downturn through sourcing cheaper components from high-volume, low-cost suppliers; while during an upturn, when integrated device manufacturers are under-capacity, they are looking to second-source.

It would therefore be no surprise if the compound industry did not go through a silicon-like transition in becoming foundry-led, particularly if the large silicon foundries—which are just starting to get into epi processing of compounds (with TSMC licensing SiGe technology from Conexant, page 13, and UMC rumoured to be doing something similar)—decide to get more directly involved in GaAs.

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