Compound Semiconductor Technologies

Published in III-Vs REVIEW THE ADVANCED SEMICONDUCTOR MAGAZINE JAN/FEB 2003

Outsourcing comes of age?

Any commentator watching the events unfolding in the optical component industry would agree that the industry is rapidly coming to terms with the realities of over expansion and overcapacity. As the large vertically integrated telecomms system providers scramble to exit the component marketplace, lessons of the silicon IC industry are helping to shape the new order.

The shift from a vertically integrated silicon industry to the horizontal fabless model of today took 40 years to achieve (see figure 1). Current evidence suggests that the compound semiconductor industry is set to mimic this trend in a fraction of the timescale. After only ~10 years in existence, the industry already has a sophisticated supply chain with sectors that are dominated by an outsource mentality.

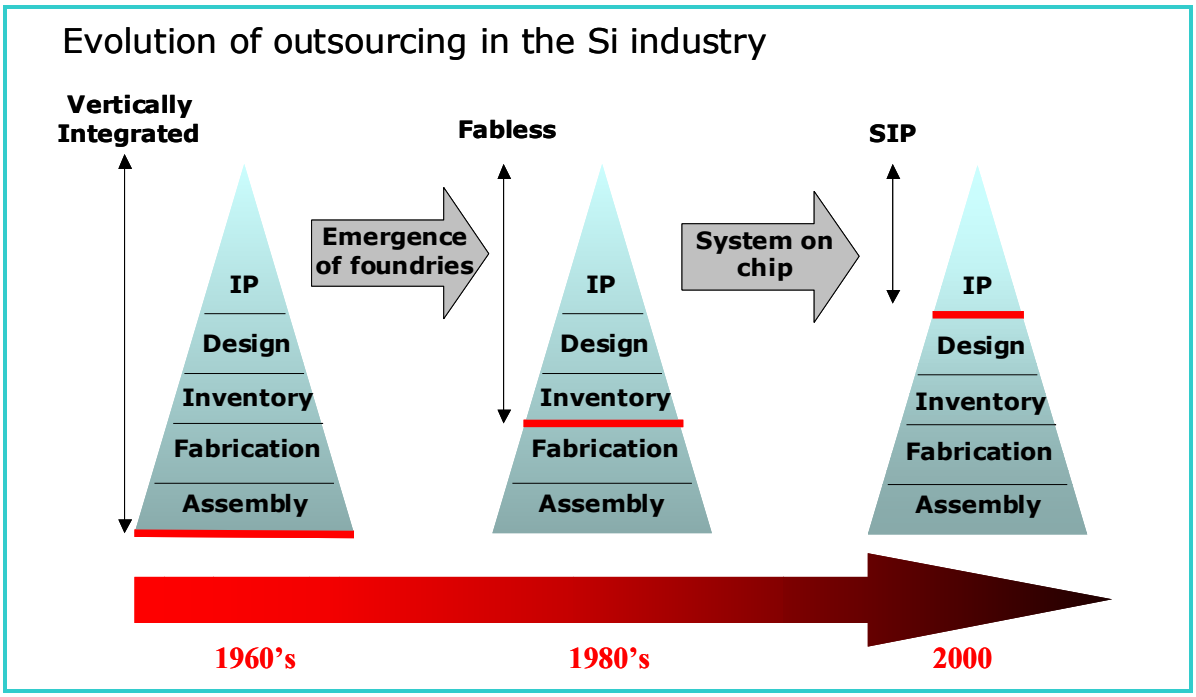

Figure 1: The evolution of outsourcing in the Si industry

Industry acceptance

The use of external substrate supply was the first accepted phase in the outsourcing of the optical component supply chain. This trend progressed with the external supply of epi-wafers. The industry recognised early on that the overheads associated with running a growth facility and the level of expertise required meant huge economies of scale could be realised with dedicated epi-foundries. The rise in the numbers of pure-play epitaxy foundries over the last five years is testament to widespread adoption of this practice in the industry. Outsourcing has made early inroads at the other extremity of the development route in the component packaging phase. This has been driven by the recognition in the telecomms market that packaging issues are becoming ever more complex in the drive to reduce fibre coupling losses and improve thermal characteristics and stability at the module level.

Recently there has been a definite trend in the fragmentation of back end wafer processing functions. Options are emerging for the use of external specialist back-end fabrication expertise. Labour intensive activities such as wafer thinning, scribe and cleave are relatively straight-forward to outsource given the generic nature and standardisation of the equipment used. It also makes economic sense to consider using specialist external optical coating services, but for different reasons. This area is highly specialised, with significant engineering input necessary for successful coating design and implementation. The capacity required to fully utilise a modern dielectric coating facility is often well beyond the requirements of a start-up venture with limited, high value add product portfolios.

This trend is set to continue with erosion of the vertically integrated model from many directions. As photonic solutions move away from discrete devices towards 'optical system on a chip' there will be an increased emphasis on the design effort required. If the current downturn continues for the foreseeable future, the concept of fables photonic design houses will become an increasingly attractive proposition as a cost effective route for new product development.

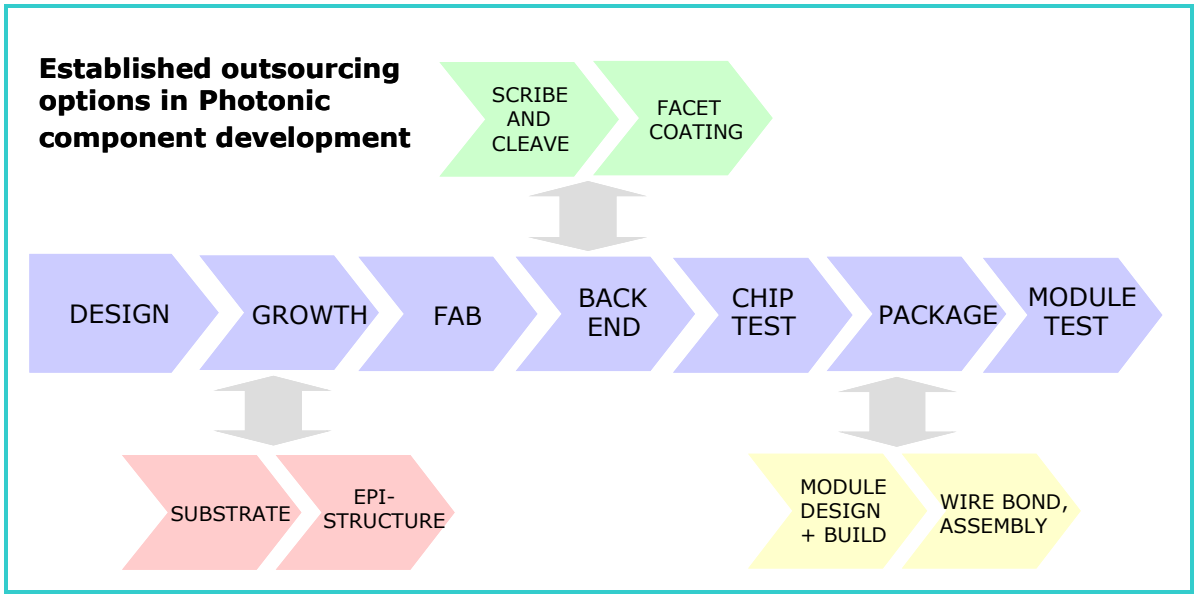

Figure 2: Established outsourcing options in Photonics component development

Pros and cons of the outsource business model

The decision to outsource any aspect of a business is a finely balanced trade-off between cost and long-term liabilities versus flexibility and IP protection. In the current climate of capital expenditure freeze and uncertain investment return, an especially robust business plan is required to warrant investment for in-house fabrication facilities for photonic component start-ups. The perceived advantages of maintaining in-house capability are indisputable:

- Complete control of job scheduling.
- IP and proprietary knowledge protection.
- Better control of critical supply chain dependencies.
- Flexibility of customisation.
- Added tangible value.

But these advantages come at a high price. Typical set-up fabrication costs can run to millions of $ and a commissioning timescale of < 6-12 months is difficult to achieve with all but the most modest facilities. The depth and breadth of engineering expertise required for the current generation of photonic devices is ever increasing. Attracting and maintaining a sufficient expertise in device design, wafer growth, fabrication, test and characterization and packaging is becoming impossible for all but the largest vertically integrated operations.

The days of valuing photonic companies by the head count of PhDs and the fab acreage are now well behind us. The current market in secondhand fabrication equipment is proof of how quickly a 'tangible asset' can become a worthless liability. Questions should be asked as to how many of the recently departed start-ups could have taken their IP to market for a fraction of the price by following a fabless model and levering off well developed process libraries.

For start-up ventures the benefits of outsourcing may be more profound; the capital investment required to even progress to a proof of concept stage may be prohibitive and only achieved with a significant degree of external resource. The argument for established component manufacturers is that outsourcing presents a mechanism for ring-fencing technical and financial risks, freeing up capital for core activity expansion. In a rapidly changing market the ability to change the direction of product development programs is a valuable asset, and this can be best achieved with the minimal internal angst via effective supply chain management.

Combining outsource expertise - developing a robust supply chain

It's a natural progression for specialist foundries to seek to constantly extend their capabilities beyond their current market space. Not only does it produce higher value add offerings to the existing customer base, but allows the foundry to differentiate itself from the competition. Since by their very nature, outsource foundries recognize the value of using external non-core expertise, an obvious route for achieving this is via partnership.

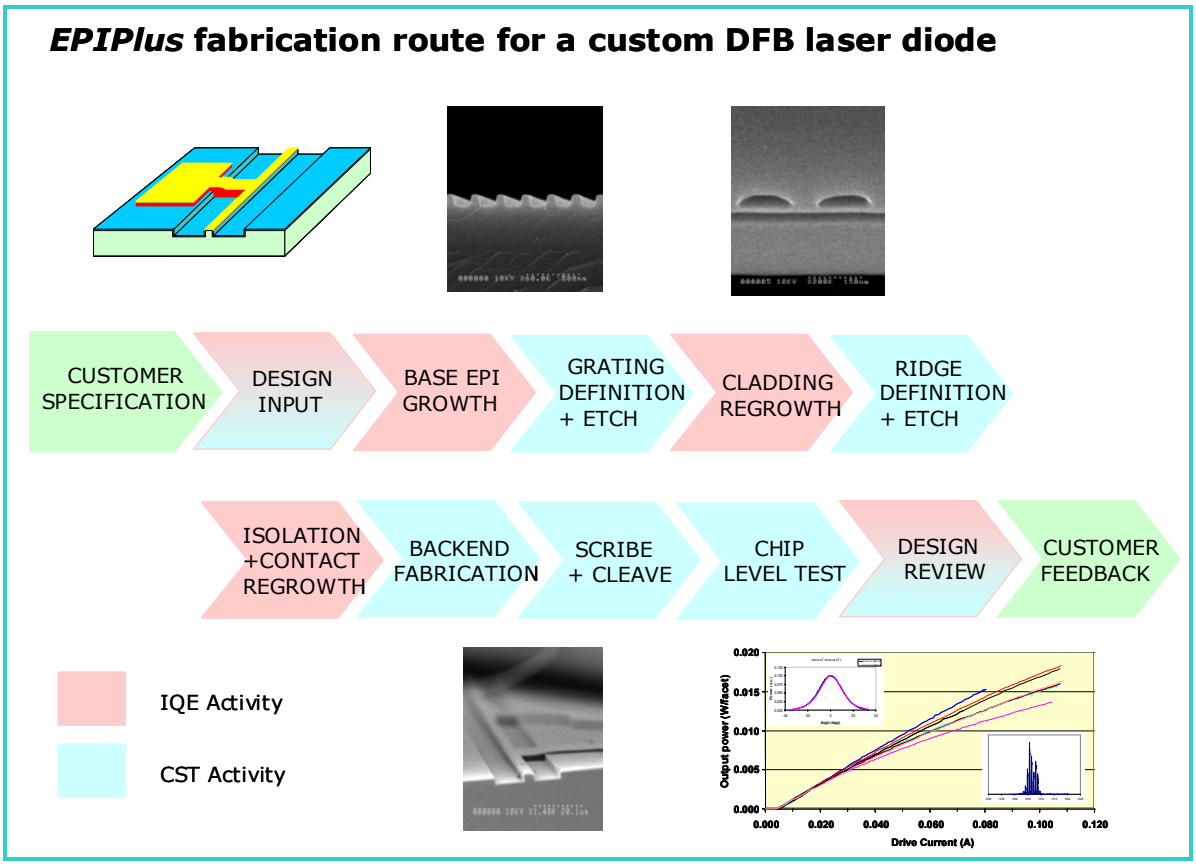

Figure 3: EPIPlus fabrication route for a custom DFB laser diode

CST Global have exercised this business model in partnership with IQE plc. CST's device fabrication and test expertise complements IQE's epitaxial design and growth expertise to satisfy the market needs for a combined foundry service. The partnership is underpinned by the concept of 'EpiPlus' products- complex multistage epitaxy products that can be supplied in partially fabricated or complete device formats.

The relationship is more than an understanding to work preferentially with each other. In order to bring viable offerings to the outsource market, a program of joint process development has been underway for the past 6 months. This has resulted in the development of a library of new 'EpiPlus' fabrication routes for a variety of devices including laser diodes and detectors. An example of the process flow for an EpiPlus DFB laser diode is illustrated in figure 3.

Subject to the placement of an appropriate NDA, a three-way discussion occurs at the design phase of the device after the receipt of a customer driven specification. This ensures all aspects of the device process flow are considered from the outset. On agreement of the device design, CST and IQE decide and manage the scheduling of their respective process tasks to satisfy the customers expectations. Good working relationships and a history of product development collaboration softens the subcontractor interface between IQE and CST. This removes the customer's need for individual sub-contractor management and reduces misunderstandings that occur at traditional outsource interfaces in the supply chain. Test and characterisation data is shared between the two partners at all levels to detect and eliminate potential

process problems at the stage they occur. Base knowledge of each other's processes aides the interpretation of such data.

The EpiPlus model retains a flexibility of allowing the customer to exit or enter the process flow at multiple points. Thus it allows high value add external expertise to complement existing internal capability. This advantage can be levered in several ways:

- to produce the most cost effective route to market;
- to produce the most rapid route to market;
- to protect proprietary processing techniques from external scrutiny.

Customer access to the process libraries of both partners allows a large degree of customization of the product. As an example, for the DFB described above, standard options include:

- custom epi and grating design;
- holographic or e-beam grating definition;
- dry or wet etch processing;
- polyimide processing for high speed applications;
- custom metallisation;
- specific facet coating design;
- wafer, bar or chip format delivery;
- Ridge Wave Guide and Buried Heterostructure device options;

There are also benefits to be realised for the individual foundry businesses in forming such a relationship. IQE benefits by the close coupling of device level feedback to shorten the timescales for epitaxial process development. This results in improved product quality, reduced qualification timescales and the assurance of device level testing from fully processed wafers. CST benefits from reduced engineering development costs and a better understanding of the epi-related device issues.

The future of outsourcing in an optoelectronic world

The EpiPlus model is an example of the increasing sophistication of the outsource offering to the marketplace, but there are still many issues to be addressed to produce a fully robust outsource model that will be successful in the compound semiconductor industry.

A mentality is needed that will aim for seamless R+D pull through to manufacture. This necessitates an industry-wide adoption of robust quality standards – the combination of compound semiconductor engineering expertise with manufacturing best practice from the established industries such as silicon.

Whilst Telcordia and JEDEC standards have been widely adopted for discrete telecomms components, there is little provision made for emerging integrated photonic devices and few standards exist for consumer optoelectronic devices. The situation is particularly bad in component packaging where, until recently, the lack of basic assembly standards has been compounded by variations in package footprint and material. This has impeded advances in assembly automation and ultimately the realisation of outsource cost benefits.

The number of specialist outsource foundries will continue to increase in the short term as more component companies seek to increase fab utilisation when volume product sales fail to materialise. Although this may be good news for the industry in the long term, as more outsource options become available, there will be steep learning curves to be climbed in the standardisation of the whole supply chain.

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