ASPIC and Packaging solutions for demanding industrial applications, an overview

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In the last few decades there is a broad oriented rising awareness with regard to photonics as an enabling technology. The applications of photonics as an enabling technology are extremely broad and will keep on growing rapidly. Photonics is being regarded not only as supplemental but also as a base technology platform similar to what electronics has become nowadays. Integrated electronics is already globally used in billions of applications and its functionality is still increasing according to Moore's law. With similarity Integrated Photonics has emerged as the generic photonic development platform for many future applications. Certainly not to replace electronics but to provide an enormous surplus in capabilities for an extremely wide range of applications.

Application Specific Photonic Integrated Circuits

An Application Specific Photonic Integrated Circuit (ASPIC) is an optical chip designed for a rather dedicated purpose. As similar to electronics ASPICs allows a variety of solutions all based on a small set of components. And unlike integrated electronics where silicon is the dominant material, APICS have been fabricated on different material platforms having each of them providing advantages and limitations depending on the functions to be integrated. For instance, Silica has desirable properties for passive components like Arrayed Waveguide Gratings (AWGs) while GaAs or InP allow direct integration of active components, i.e. lights sources, detectors, etc.

Although the fabrication process is similar to integrated electronics, there is no dominant device like the transistor. The range of photonic functions include low loss interconnect waveguides, power splitters, optical amplifiers, optical modulators, filters, lasers, detectors, etc.

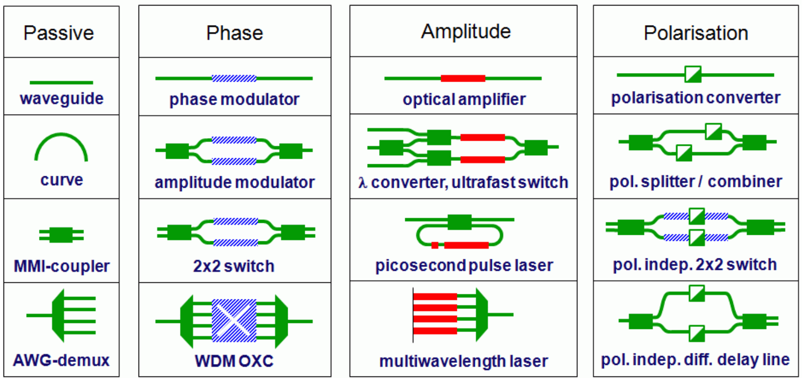


Figure 1 : Example of the functionalities that can be realized in a generic integration technology that supports four basic building blocks: Passive Waveguide Devices (PWD), (Optical) Phase Modulators (PHM), Semiconductor Optical Amplifiers (SOA) and Polarization Convertors. (Courtesy of PARADIGM)

The versatile ability to replace traditional assemblies of multiple discrete optical or micro-optical components by a single small sized chip, makes ASPICs highly favorable for next generation optical systems for benefits like cost reduction, functionality aggregation and standardization of specifications and processes. And certainly, this broad applicable versatility requires this standardization need to preserve compatibility between the development platforms allowing to integrate the best of worlds to provide the best possible solution available. In that respect valuable lessons in platform material selection for ASPICs are repeatedly discussed which ultimately will determine the success of the ASPICs industry. For instance several successes have been achieved in both InP-based and silicon-based systems. As cost and performance may currently prove silicon-based devices preferable, it is certainly the capability of having both passive and active functions combined that proves InP more worthwhile depending on the required system functionality. Moreover, the integration of both electronic circuits with photonics circuits, i.e. hybrid systems, will most likely lead to more applicable development platforms yet to be invented.

ASPIC technology may just as well be moving towards a paradigm shift once it establish a state where the complexity of optical systems will no longer be a major determining factor in optical system development. And this shift may very well cause an unpredictably large growth of applications and their markets in the next decades.

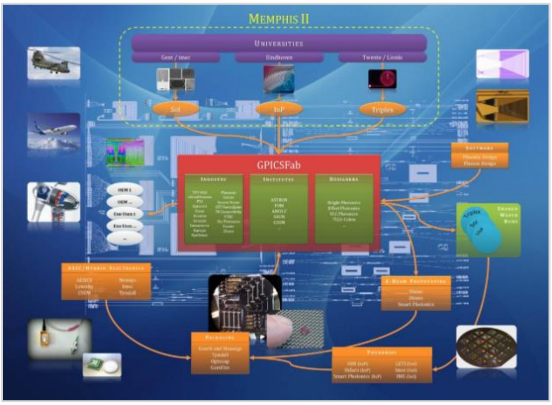
As data- and telecommunication needs have been the major driver for some time, other applications fields appear to gain increasing necessity for smaller sized, more affordable and repeatable and reliable performance devices just as well. An example of another rapidly growing application area is for instance optical sensing. Sensing is and shall always be an integral part of a large variety applications in its most wide perspective and remains expressing the need for an increasing improvement of sensing devices. Photonic Integrated Circuit technology will play a major role is this transition of current conventional systems into next generation optics based systems throughout major technology market segments like Aerospace, Automotive, Medical and Robotics, Civil, etc.

For many small and medium enterprises the rising awareness for these needs not only revealed the current ASPIC value chain and its promising capabilities but just as important its shortcomings. Bringing ASPICs to the market requires extensive development steps and associated logistics. Starting from an product idea to having a series production of ASPIC based devices involves sufficient product and technology knowledge, value assessment, sophisticated photonics integrated system design, chip manufacturing in the foundries, chip testing and prototyping, chip packaging, device integration and interfacing, series production development, and finally implementation. As the ASPIC technology is in the process of coming loose from its academic roots, some important aspects of the value chain need to be improved or developed in order to get to a valuable supply chain transition.

Generic Photonics Integrated Circuits Fabrication (GPICSFab)

The need for SME's to improve time to market for ASPIC based system is imperative. The current availability of resources like foundries, designers, packagers, still needs maturing for several reasons. Although the first complex PIC's started to be published in the late 80's and despite the similarities in chip development complexity, there still remains a significant difference in research and development methodology. The development of ASPICs is obviously very dedicated and focused to its application. As a result there are almost as many technology customizations as applications, often quite similar but different enough to prevent sufficient standardization and subsequently easy transfer from one design to the other. Although a growing trend in the market is tangible, due to this fragmentation current markets are still too small to justify extensive development into a low cost industrial volume manufacturing process, making chip fabrication practically out of reach for many SME's.

It is precisely this fundamental technology versatility which allows an enormous spread of possibilities that needs the required standardization in order to supply a lateral supported ASPIC technology. Subsequently, the ASPIC value chain appears to illustrate a certain reluctance when it comes to the development of not only follow up processes like packaging and integration but also in the design and prototyping processes of ASPICs.



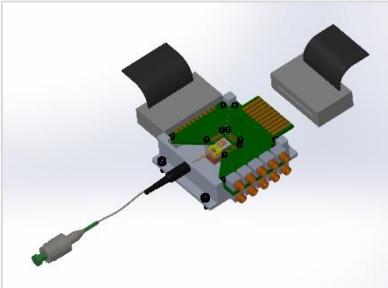
As a result of this imminent need the consortium GPICSFab – initiated from the industry – was founded that facilitates a Lean and Asset-Light manufacturing and logistics infrastructure to accelerate the introduction of integrated photonic functionalities.

Its mission is to accelerate the introduction of ASPIC functionalities for Integrated Device Manufacturers (IDM) and Original Equipment Manufacturers (OEM) by means of facilitating production and logistics infrastructure using minimal in-house resources and optimizing outsourcing possibilities.

GPICSFab is convinced that the generic fabrication approach will cause a revolution in micro and nano-photonics, just like it did in microelectronics thirty years ago. In Europe, three integration technology platforms are actively introducing the generic foundry concept for the major integration technologies in photonics: JePPIX for InP-based monolithic integration, ePIXfab for silicon photonics and TriPleX for low-loss dielectric waveguide technology. GPICSFab concerns itself by selecting and offering those parts of these development platforms which are ready for product development today and offers them to the marketplace.

Given the tremendous impact of photonics as enabling technology for further expansion of high-performance telecom networks, the availability of dedicated PICs will enable the development and efficient implementation of advanced systems and instrumentation for a multitude of applications. To maximize its reach GPICSFab aims to collaborate with national and international partners and programs like Memphis II, IOP Photonic Devices and IPC HTSM Photonics, to secure state-of-the-art and world leading photonics integration competences.

GPICSFab provides access to a suite of quality manufacturing and logistics solutions. Instead of having a general ability to subscribe to a Multi Project Wafer run once a year, the initiative of GPICSFab now offers SME's accessible and even hybrid options to subscribe to Shared Wafer Runs multiples times a year. This increase in availability of best-in-class methods for volume production will boost speed and reduce costs for the development of ASPIC based systems considerably. With regard to that, one of the important achievements of GPICSFab so far is establishing an agenda for Shared Wafer Runs with an interval period of 3 to 4 months which significantly exceeds current affordable availability of MPWs.



Another important achievement by GPICSFab in the process of standardization, is the development of a generic package for ASPICs. Packaging is one of the most important steps in bringing ASPICs to the market for which no generic volume process has been established yet. Although photonic packaging researchers have been working on a range of technologies for application across a number of key industry sectors, including telecommunications, medical devices, biotechnology and consumer electronics, many of these research activities are still being performed through industry collaborations with the expectance of growth as photonics becomes the technology of choice for an increasing range of applications.

Conclusion

Photonic Integrated Circuits represent a disruptive technology break-through that promises the delivery of immediate benefits and significant future development opportunities. To accomplish this important steps need to be taken with regard to standardization and further value chain development. GPICSFab is a good example of an industrial initiative to close a gap between technology and markets and to increase Time to Market.

References

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