Industry Perspective:

Could Photonics Boom Again via Fabless Start-ups?

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Although the photonics industry is again growing steadily, it has not recovered to the levels experienced during the boom time at the turn of the century. Much speculation and analysis has been done to determine the root causes behind the massive downturn. Whatever the causes, one thing is certain: the manufacturing models employed by the industry at the peak of the bubble were not sustainable. Overhead costs of the fabrication and packaging of photonic devices have been identified as substantial obstacles to reducing product cost structures. A chief disadvantage for photonics is that it has not yet benefited from the economy of scale enjoyed by the silicon-based electronics industry. Albeit intuitive, arguments as to what prevents photonics from benefiting from the economy of scale have not yet been fully explored. I aim to use this space in the Newsletter to initiate a discussion within the LEOS community about the topic.

Conventional wisdom, as discussed in relevant meetings and forums, suggests that photonics manufacturing should use a model similar to that on which silicon thrives. Such a model should include the development of standard processes for a variety of devices, analogous to the CMOS model. Photonic circuits would then be implemented through outsourcing to central fabrication foundries. In this model, innovation rests largely in the circuit architecture domain, which can be carried out in fabless companies with substantially reduced overhead.

Before debating the issue, it is instructive to bear in mind that photonics contract manufacturing existed in some form at the height of the photonics and optical telecommunications bubble. Even today, contract manufacturing is being used by many photonics companies. For example, on January 15th, 2007, Global Communication Semiconductors (GCS), Inc. of California and Xponent Photonics, Inc. signed a foundry service agreement whereby GCS will utilize its proprietary laser and photodiode processes to manufacture Xponent products. Therefore, contract manufacturing for photonics is not a new idea. So why look in this direction if it was tried and tested during the peak of the bubble and did not help avoid the downturn?

One often-overlooked argument may shed some light on the reason why contract manufacturing has not worked for photonics while it did for electronics. Photonics does not yet have an established technological route for fabricating integrated circuits. As such, some aspects of the silicon model do not have photonics counterparts. For example, a photonic circuit that includes lasers, modulators, amplifiers, and arrayed waveguide gratings will not allow many variations in device layout. Instead, it is the intricate structure of each component that defines its performance.

The topic of central fabrication foundries was discussed in November 2005 during a forum held by the Optoelectronics Industry Development Association (OIDA). This forum was the first serious post-downturn attempt to identify a route for photonics contract manufacturing. Out of this gathering of more than 70 participants emerged the thought that contract fabrication facilities alone are not sufficient to enable photonics manufacturing with low overhead. Participants concluded that the silicon-style foundry model probably would not work for photonics. Devices made in silicon VLSI foundries look nothing like those made in the photonics domain. Silicon wafers do not require the growth of quantum confined structures like quantum wells, wires, and dots. Moreover, manufacturers of photonic devices have various techniques by which doping profiles, carrier lifetimes, etch stop layers and numerous other processes are controlled. A minority of these processes are standardized. Further, no single device in photonics has a standard structure used by multiple manufacturers.

A key to the success of any model is the minimum demand that will warrant its economic viability. The demand for photonic components does not remotely resemble that for silicon VLSI chips. On the other hand, if you make components cheap enough, more applications will be able to afford them.

Many other challenges should be considered when scrutinizing fabless models for the photonics industry. Standardization of device design, extent of monolithic integration, integration of hybrid materials, and market demand are all points that could be included. By doing so, some device research in companies, research institutes, government labs, and academia could be steered to address the obstacles identified.

With profits still elusive, substantial research and development is rare among photonics companies. Consequently, initiatives towards standardization are scarcely being supported. Nevertheless, two initiatives have recently begun in the US and Canada that aim toward general-purpose foundries for compound semiconductors. The Photonics Technology Access Program (PTAP) is organized through OIDA and the photonics fabrication service is organized through CMC Microelectronics. Details of both programs are provided in the sidebars to this article.

European groups have also addressed the issue. The ePIXnet program, led by IMEC-Ghent University, is funded by the European Union and is a Network of Excellence to prepare Europe for a fabless industry model with a mix of academic and industrial partners. The strategy of the network is to start at the research level, where it offers foundry-like services for joint research. Industrial backing for these plans is growing quickly because of consensus in Europe that this approach seems to be an optimum route forward.

OIDA championed the InP foundry concept in the US in 2005 and has identified PTAP as the most feasible first step in that direction. Although it does not include any central fabrication facilities, the PTAP program may achieve some milestones towards the InP foundry aim by grouping academic and industrial partners around a critical mass of technologies. This program may lead to a standard or multi-source agreement on the device and technology levels. Another benefit of the program is that it provides a much needed research effort for the devices currently produced by the surviving photonics companies, whose extremely tight budgets rarely allow extensive R&D efforts with critical

Detail Box I: The Photonics Technology Access Program (PTAP)

PTAP is funded by the National Science Foundation (NSF) and the Defense Advanced Research Projects Agency (DARPA), and is managed by OIDA. PTAP provides academic researchers with pre-commercial photonic devices. The premise behind the program is that if researchers had to wait until devices were commercially available, by the time they performed their experiments and published, the results would be one generation behind the then-current technology. By providing access to pre-commercial devices, PTAP cuts the latency, publications are more relevant, and students get to learn on state-of-the-art devices.

The Optoelectronics Industry Development Association (OIDA) is a Washington DC-based, not-for-profit association that serves as the nexus for vision, transformation, and growth of the optoelectronics industry. OIDA advances the competitiveness of its members by focusing on the business of technology, not just technology itself. OIDA members include the leading providers of optoelectronic components and systems enabled by optoelectronics, as well as universities and research institutions. OIDA provides roadmaps, reports, and market data for the optoelectronics industry, serves as the voice of industry to government and academia, acts as liaison with other optoelectronic industry associations worldwide, and provides a network for the exchange of ideas and information within the optoelectronics community.

PTAP allocates devices to academic researchers based on brief proposals that are competitively evaluated. Alternatively, researchers may also request devices and pay for them with their own funds. PTAP compensates industry for the devices that they supply to the program. PTAP deals only with pre-commercial devices that a supplier may be sampling to prospective customers, but is not yet selling in the open market. They also include commercially available devices that are screened for particular performance parameters that lie outside the guaranteed range – the "golden devices." The term device encompasses materials, specialized processing, components, modules, and subsystems within in its scope.

A Prototype may embody the Provider's proprietary intellectual property. Recipient agrees not to reverse engineer or allow anyone else to reverse engineer Prototypes provided by PTAP.

The Recipient is provided the Prototype strictly for use by students and employees within Recipient's organization. Recipient agrees not to sell, lease, transfer, exchange for value, or give away the Prototype to any person or entity that is not controlled by Recipient's research organization.

PTAP encourages researchers who obtain photonic prototypes through the program to publish their research results. The only constraints are that articles acknowledge PTAP and the sponsors as the provider of the prototype, and that the device manufacturer's name not be disclosed without the manufacturer's prior written permission. The latter requirement arises because the pre-commercial devices may reveal details of business strategy, or may be different from those eventually offered on the market.

The transactions are simple arrangements with no contracts, but instead, with a signed statement by both parties agreeing to follow the published recipient and provider guidelines. The proposals are short and the program encourages student authors. The program considers the writing process a valuable teaching tool.

PTAP looks for places where it can make the most difference and leverage government funds. For example, PTAP has paid for specialty fiber draws and now makes excess material available to other researchers for independent or follow-on projects. It also has arranged for vendors to supply devices without lids – a tricky proposition because of the associated intellectual property issues. To accomplish such transactions, PTAP facilitates non-disclosure agreements between researchers and vendors, but does not enter into such relationships with the vendors.

mass. An educational component is also pursued by PTAP, which provides substantial benefits to the participants.

The program led by CMC is centered on a physical photonics foundry. CMC has established a strategic partnership with the Ottawa-based Canadian Photonics Fabrication Centre (CPFC) of the National Research Council Canada. The fabrication service enables university clients to prototype a broad range of device structures and technologies using industrial-class processes, while leveraging the expertise of an on-site optoelectronics design engineer who helps them to optimize their designs. As it is chiefly geared towards the academic community, it caters to a broad range of device structures and technologies. While the focus has not been on centrally standardized designs of photonic components, the service provides academic researchers with the ideal opportunity and vehicle for such development. The program is used by all the Canadian players in the photonics field, and although it is in its infancy, it is quickly gaining momentum. As researchers who benefit from the service generate new and important insight into photonic device design and fabrication, CMC and the CPFC are uniquely positioned to influence and drive standardization efforts in the development of photonic devices. This work includes issues related to fabrication and processing, and perhaps more importantly, challenges related to device structure and design to achieve a specific functionality. For example, can we design a universal wafer structure that accommodates most photonic functional devices that are of interest? I recognize this question has partially been addressed before in different articles and could be explored more fully in a special edition of the IEEE Journal of Selected Topics in Quantum Electronics. However, I am hoping this article will stimulate some thought-provoking discussion and debate in labs across our community. I welcome any insights or ideas you may have on this topic. Please direct them to the author Amr Helmy at a.helmy@utoronto.ca or the editor Krishnan Parameswaran at krp@psicorp.com. There are plans to publish the discussion on the LEOS Web portal. More information about this forum will be posted in the Newsletter and on the web page soon.

Detail Box II: CMC Microsystems

CMC Microsystems is a national, non-profit corporation that provides university researchers with industry-caliber design resources, access to state-of-the-art manufacturing technologies, and support services for microsystems research and development.

CMC offers products and services that include microelectronics, micromechanics, microfluidics, embedded software, and recently photonics/optoelectronics.

A comprehensive suite of photonics products and services is available to university researchers through its partnership with the Canadian Photonics Fabrication Centre (CPFC) of the National Research Council Canada (NRCC).

About CPFC: Fully operational in 2005, CPFC is a national technology centre offering a comprehensive suite of industrial grade foundry services in both III-V semiconductor (GaAs and InP) and silicon-based materials for organizations interested in developing leading-edge photonic devices. CPFC has been designed and equipped to facilitate innovation in all areas of photonics applications, including telecommunications, health, energy, the environment, defense, and security.

With a total budget of $43 million allocated in August 2002, the CPFC embarked on an aggressive program to provide Canada with a capability that bridges the gap between Canada's photonics research and development community and its high technology industry.

This partnership started in 2005 and provides the following benefits:

- Enables university researchers to effectively prototype optoelectronics and photonics devices using industrial-class processes.
- CMC manages the interface between the CPFC and university researchers for the delivery of photonic and optoelectronic prototyping services to researchers
- A CMC optoelectronics engineer is located onsite at CPFC to provide a single point of contact for the researchers.
- The mandate of this engineer is to enable the successful use of photonics prototyping services delivered through this partnership, in support of university research and development.
- CPFC works with start-ups, small and medium-sized companies, large corporations, government laboratories, and academia to provide prototyping and production runs of photonic devices & photonic integrated circuits.

Access to industrial-grade fabrication is a critical part of the comprehensive suite of photonics products and services provided by CMC. Other offerings include:

- Design tools: layout tool with photonic element library and design rule checking
- Photonics/optoelectronics packaging
- Photonics Test: Access to a broad range of test equipment, including capability for testing unpackaged devices.

Graduate students and professors at Canadian universities who are registered clients of CMC are eligible to access these services through CMC. These services may only be used for academic research or teaching purposes at a Canadian educational institution.

Access to fabrication resources through CMC is a competitive, peer-reviewed process with 2-3 application rounds per year. Applicants submit a short application form, describing the fabrication resources requested and addressing the fabrication allocation criteria. To ensure the best possible use of resources available for prototype fabrication, requests for these resources are reviewed by an external committee of experts.

Designs that are granted fabrication resources in this process receive sizable discounts (on the order of 80%) on standard manufacturing prices. Clients also have the option of paying the non-discounted price in order to bypass the peer review process.
