State of the Datacom Industry

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1.1.1 Abstract

The datacom industry has evolved over the past three decades into a strong growing segment of fiber optic communications. Photonics technology within the datacom industry has grown significantly in performance during this period.

1.1.2 Introduction

The datacom industry has evolved over the past three decades into a strong growing segment of fiber optic communications. Photonics technology within the datacom industry has grown significantly in performance during this period. There has been a gradual trend of datacom photonics technology penetrating traditional areas that telecommunications photonics once owned, especially transponders and transceivers for short haul line-side applications. There have been some key inflection points over the last two decades where datacom has really taken hold in the community:

1) VCSELs
2) Photonic integration
3) Parallel solutions and embedded cables
4) Photonics foundry
5) Consumer-based products
6) Growing market

1.1.3 Inflection points

There have been some key inflection points for the rise of the datacom industry over the last few decades:

1) VCSEL: Since the advent of the VCSEL, a key component in datacom photonics technology, it is now estimated that over 200M semiconductor VCSEL lasers have been manufactured for product. The VCSEL is one of those lucky devices with almost perfect timing, with 1Gbps performance, low power, low threshold, circular output beam, and limited competition from AlGaAs edge emitting lasers at 850nm in the late 1980s. Since then, the VCSEL has become the work horse of the datacom industry. The large manufacturing volumes have allowed this device to penetrate not only datacom-based products, but consumer-based mass market opportunities such as the optical mouse for personal computers. These markets have driven down the cost structure of the VCSEL to competitive levels with the edge emitting laser.
2) Photonic integration: Photonic integration has tried to follow silicon integrated circuit (IC) integration over the past three decades will little success. Only in the

last few years has significant progress been made in the components level photonics community for datacom. The majority of photonic integration solutions have resorted to hybrid approaches rather than the traditional monolithic approach. Monolithic approaches in photonics are challenging, especially if both electronic and photonic devices are considered. In fact, over the last two decades, the original term optoelectronic integrated circuit (OEIC) has been replaced by photonic integrated circuit (PIC). Although early silicon work in photonics progressed slowly during the 1980s and 1990s, the vast amount of research went into III-V compound semiconductors, with particular emphasis in Indium Phosphide (InP). A number of commercially successful PICs have been produced in InP, including electro-absorption modulators (EML) and distributed feedback (DFB) emitter-based circuits. Over the past decade, research into silicon photonics has accelerated quickly, with many publications of silicon based modulators, waveguides, detectors, and other passive components. Full silicon photonics monolithic integration with silicon complementary metal oxide semiconductor (CMOS) is now approaching product maturity in a number of areas. The focus has been on utilizing traditional CMOS fabrication plants, firmware, libraries, and process flows.

3) Parallel solutions and embedded cables: Parallel interconnects for datacom began appearing in the 1980s with pioneering work by HP, Siemens, and Motorola. All these solutions utilized the VCSEL as a key emitter to drive the $/Gbps metric to levels below $10 for the first time in the industry. Today, parallel fiber optics is becoming a key enabler for very short haul interconnects in datacom, whether the cable medium is one fiber (wavelength multiplexing) or a plurality of fibers (spatial multiplexing). In fact, multiplexing is one technology that was the natural home of very high performance telecom photonic solutions. Over the past decade, the datacom industry has been utilizing multiplexing technology far more quickly than anyone expected. Already, electrical cables with embedded fiber optics (active optical cables) are including passive photonic multiplexers inside the embedded transceivers for added functionality and cost performance. Volumes are expected to increase dramatically over the next decade as these high technology cables begin to penetrate consumer mass markets.
4) Photonics foundry: This inflection point has not occurred for the datacom industry as of yet, even though a small number of manufacturers are providing foundry capabilities around the world. The concept of a photonics foundry is simple: it alleviates the multitude of platforms of photonic components into a few, rather like the NMOS and PMOS that converged to CMOS in the silicon IC industry in the 1980s. The question is whether semiconductor components such as VCSELs, laser diodes, photodetectors, etc., can converge to a few platforms from the 10s and 100s of platforms today.
5) Datacom consumer-based products: Although this is not necessarily a technology inflection point, it does represent the maturity of the segment for volume products and manufacturing techniques. So far, VCSELs and CD lasers have attained mass market volume status, but more complex varieties such as DFBs have not. The active optical cable offers one interesting opportunity to take photonics into very high volume to alleviate potential display choking issues from the low

compression high definition display portals such as television in the home. Current trends in high performance cabling indicate 10Gbps data rates will be needed which would allow data centers to take advantage of lower cost photonics in servers and switches.

6) Growing market: The transceiver market represents the strongest segment in the optical components business over the forecast period, growing to $4.5 billion by 2020 (OIDA 2009). The transceiver market consists of three major segments: coarse wavelength division multiplexing (CWDM)/dense wavelength division multiplexing (DWDM), Ethernet and Fibre Channel, and SONET/SDH. The strongest revenue growth in 2008 was achieved by SONET/SDH transceivers, as networks increased their use of line-side technology in existing applications. Excellent examples of this are the OC-192 hot-pluggable grid-based transceivers with fixed wavelength capabilities. The SONET/SDH transceivers market grew 11.6% in 2008 over 2007, and is expected to maintain moderate growth over the forecast period with a 2009-2020 CAGR of 6%. The technology will experience a steady growth, from $400 million in 2004 to $1 billion in 2020. Ethernet and Fibre Channel transceivers experienced another year of strong growth in 2008, 10.3% over 2007, with revenue of nearly $1.1 billion. The outlook for Ethernet and Fibre Channel transceivers is also very strong, with revenue surpassing $2.1 billion by 2020. The market will have grown nearly four times during the forecast period, from just over $500 million in 2004 to over $2 billion in 2020. The last segment, CWDM/DWDM transceivers, experienced a slower year in 2008 with a growth of 11.5% over 2007. This was due to an increase in competition from the other segments of the transceiver market. By 2020, 10Gbps transceivers are expected to own over 51.4% of the segment share and will have revenue over $1.2 billion. The volume of lower-speed transceivers will grow significantly through declined ASPs; however, the revenue generated from these transceivers will not match the higher-speed counterparts over the forecast period. New high performance transceivers such as 40Gbps and 100Gbps will be part of a portfolio of transceiver products from the majority of manufacturers in 2020.