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Extended Abstract

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Packaging of photonic ICs

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Europe is at the threshold of a technological revolution - the application of the power of light to solve our greatest global challenges. As a fast, compact, energy efficient and therefore sustainable option, photonic integrated chips (PIC's) have been developed initially to solve challenges in the power consumption and speed requirements for telecommunications and datacenters. However, it is expected that will tap into world markets like 5G, military, medical, sensors for strain, and gas detection and LIDAR. Volume manufacturing of PIC's is rapidly becoming widespread available through foundries that have evolving process design kits with more extensive building blocks in their libraries. Success depends on the possibility of assembling the chips in large quantities for the various markets. Up to now these have all been labor-intensive production steps, the high cost of which has posed a barrier to largescale introduction. The keynote will address topics like: State of the art in the packaging field, automation assembly requirements, cost drivers, why hybrid integration is sometimes inevitable, do's and dont's when designing chips for assembly.

It has been almost a decade since the introduction of the iPhone, a device that so successfully blended sleek hardware with an intuitive user interface that it effectively jump-started a global shift in the way we now communicate, socialize, manage our lives and fundamentally interact. Today, smartphones and countless other devices allow us to capture, create and communicate enormous amounts of content. The explosion in data, storage and information distribution is driving extraordinary growth in internet traffic and cloud services. The sidebar entitled, "Trends driving data center growth," provides an appreciation for the incredible increase in data generation and its continued growth through 2020. To process and manage the unabated growth in data traffic, silicon photonics will be used to define new data center architectures. This article discusses the impact that silicon photonics will have on data center technology trends, and on the next-generation microelectronic packaging developments that address optical-toelectrical interconnection as photon and electron conversion moves to the level of the package and microelectronic (logic) chip. Data center dynamics.

The large-scale restructuring of data centers is one of the most dynamic transformations taking place in information technology. The need to re-architect the data center is being propelled by the staggering surge in shared and stored data along with an increasing demand to effectively interpret the tremendous amounts of content being generated. In addition to the huge growth in data traffic, the infrastructure supporting the Internet of Everything (IoE) will emphasize realtime responsiveness between people and/or objects. The next wave in data processing and data traffic management will require the ability to support cloud computing, cognitive computing and big data analysis along with the necessary speed and capacity to deliver a timely response. Optics have traditionally been employed to transmit data over long distances because light can carry c o n s i d e r a b l y m o r e i n f o r m a t i o n content (bits) at faster speeds. Optical transmission becomes more energy efficient as compared to electronic alternatives when the transmission length and bandwidth increase. As the need for higher data transfer speeds at greater baud rate and lower power levels intensifies, the trend is for optics to move closer to the die. Optoelectronic interconnect is now being designed to interface directly to the processor, application specific integrated circuit (ASIC) or field programmable gate array (FPGA) to support switching, transceiver, signal conditioning, and multiplexer/ demultiplexer (Mux/ Demux) applications. Figure 1 shows a forecast for silicon photonics adoption through 2025 with data centers dominating initial growth. Silicon photonics are also being developed to support applications as diverse as high-performance computing and optical sensors. The data center need for speed and capacity. Figure 2 illustrates forecasted data center traffic by 2019. One of the more notable trends is that almost three-quarters of all data center traffic will originate from within the data center. The recognition of this statistic, compounded b y t h e e n o r m o u s increase in data traffic, has significantly altered the approach to data center design. Besides upgrading optical cabling, links and other interconnections, the legacy data center, comprised of many off-the-shelf components, is in the process of a complete overhaul that is leading to significant growth and change in how transmit, receive, and switching functions are handled, especially in terms of nextgeneration Ethernet speeds. In addition, as 5G ramps, high-speed interconnect between data centers and small cells will also come into play. These roadmaps will fuel multi-fiber waveguide-to-chip interconnect solutions, laser development, and the application of advanced multi-chip packaging within the segment. The high-end or "Hyperscale" data center is massive in both size and scalability.

Bottom Note: *This work is partly presented at International Conference on Applied Physics & Laser, Optics and Photonics , April 15-16, 2019, Frankfurt, Germany*