IEEE LEOS 2004 Summer Topicals Meeting:

Optical Interconnects and VLSI Photonics

June 28-30, 2004

Optical communications in the long-haul and local area networks have proven extremely successful. The next arena where optics and optical interconnections will make an even greater impact is "within a box" where optics has the potential to solve the electronic bandwidth problem at the backplane, inter-chip and intra-chip levels. In fact, the electrical interconnections among chips typically operate at only a fraction of the internal computational bandwidth. The advancement of processor speed has been following Moore's Law closely. With the ITRS (International Technology Roadmap for Semiconductors) projection of on-chip clock speed goes beyond 10 GHz by 2008, the limitation imposed upon Cu/Low K interconnection will encounter a serious bottleneck. See Figure 1. Optical interconnect due its unique capability in transmitting optically encoded signals to provide the back-end packaging community with an attractive choice. However, silicon, the main building block of ICs, has an indirect band gap and therefore can not come up with a laser using silicon single crystal. Namely, the light sources for the realization of optical interconnect can never be silicon based to cover the modulation speed of 10 GHz and beyond. Direct modulation using laser diode and indirect modulation using laser diode and external modulator are two options to provide the modulation schemes for optical interconnect. In the context of back end packaging, these two approaches represent different levels of challenges. Implementation of a modulation scheme without complicating the packaging and reliability issues will be the winner. Figure 2 shows one of the most interesting integration scheme presented by the Optical Interconnect Research Group of the University of Texas. It separates the optical from the electrical interconnection layers by inserting thin film (10 um thick) VCSEL and photodetector arrays together with the optical waveguide layer. Electrical to optical and optical to electrical signal conversions are realized using vias. Such an approach makes the microelectronic back end packaging much easier to handle. However, accurately and reliably inserting the VCSELs and phtodetectors are the key to make such optoelectronic BEP architecture acceptable for microelectronics and computer industries

The primary goals of the 2004 IEEE summer topical meeting on Optical Interconnects and VLSI Photonics are to address the aforementioned issues by gathering leading investigators in our community to establish the road map that will bring the benefits of introducing optics into chip-scale interconnections, and to demonstrate the use of these technologies in next-generation advanced information processing systems, such as those expected to be used in high definition TV, fiber to the homes (FTTHs), real-time synthetic aperture radar imaging, target recognition, and medical image processing. All will require large aggregate communication and computing bandwidths. Since most of these systems are assembled from multiprocessor, memory, and special-purpose digital signal processing chips, the ideal aggregate bandwidths between them should be on the order of hundreds of Gbits/sec in order to handle the traffic. Two invited speakers from SEMATECH (Ken Monnig) and Sanmina SCI (Franz Gisin) provided potential limitations to be encountered by wire interconnections on chip level and board level, respectively. These papers helped to direct optical interconnect research in a meaningful direction.

A panel discussion was conducted during one evening of the conference. Dave Miller, Alan Willner, G. K. Chang, Jeff Kash and Ray Chen (moderator) are the panelists. A lengthy discussion was made on two major subjects. And they are: 1.When the optical communications for last mile and downward to FTTHs will be coming. And 2. What role optical interconnects can play to upgrade the interconnect for next generation silicon CMOS technology. It was commonly agreed among the panelists that optical interconnection definitely helps the upgrade of last mile networks including fiber FTTHs. The bandwidth increase of each individual and the cost reduction to install FTTHs will be the two key factors. The high definition TV channel will require 50Mbits/s which is well beyond current cable modem or DSL service. For example, a user with a cable modem or DSL service averagely downloads 200 MB/day. A full bandwidth HDTV movie would have the same networking traffic in only 32 seconds! (50 Mbits/s × 32 seconds = 200 Mbytes × 8 bits/byte). It is widely agreed that the requirement of such bandwidth increase will be coming before 2010. As far as the role of optical interconnection in the Si CMOS environment, inter-chip interconnection bandwidth, such as processor-to-memory, can be significantly increased using optics. Again, based on the ITRS projection, 2010 might be the turning point for the insertion of optical interconnection in the photonic VLSI. None of the panelists think that in the foreseeable future intra-chip interconnection will be replaced by optics. The panel also shared a market projection chart showing the view of Nortel and Rohm Haas in the future communications/interconnection market.

As the chairman of the conference, I would like to thank all the committee members, session chairs, invited speakers, regular paper authors

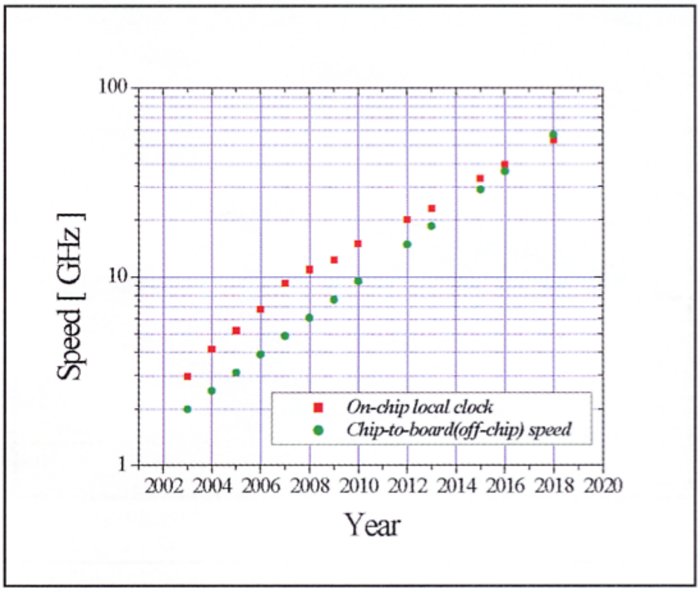

FIG.1. ITRS 2003 Road Map for Interconnect

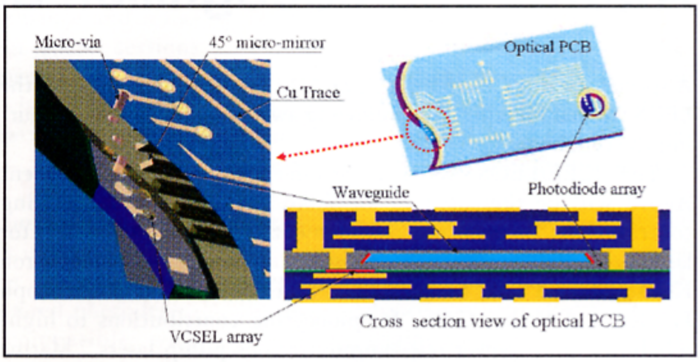

FIG.2. Fully Embedded Board Level Optical Interconnection to bridge the back end packaging (BEP) gap between optical and electronic interconnection layers. All optical components including VCSELs and photodetectors are fully embedded to ensure the compatability in the BEP.

and the IEEE/LEOS staff members. It was the efforts and teamwork of all that make it a successful conference in a cool summer in San Diego.

Ray Chen received his BS degree in Physics from the National Tsing-Hua University in 1980 in Taiwan and his MS degree in physics in 1983 and his PhD degree in Electrical Engineering in 1988, both from the University of California. He is the Temple Foundation Endowed Professor (1998-) in the Department of Electrical and Computer Engineering at the University of Texas, Austin. He joined UT Austin as a faculty to start optical interconnect research program in the ECE Department in 1992. Prior to his UT's professorship, Chen was working as a research scientist, manager and director of the Department of Electrooptic Engineering in Physical Corporation in Torrance, California from 1988 to 1992.

Chen also served as the CTO/founder and chairman of the board of Radiant Photonics from 2000 to 2001 where he raised 18 million dollars A-Round funding to commercialize polymer-based photonic devices. His research group has been rewarded with more than 60 research grants and contracts from such sponsors as DOD, NSF, DOE, NASA, the State of Texas, and private industry. The research topics are focused on two main subjects: 1. Polymer-based guided-wave optical interconnection and packaging, and 2. True time delay (TTD) wide band phased array antenna (PAA). Experiences garnered through these programs in polymeric material processing and device integration are pivotal elements for the research work reported herein.

Chen's group at UT Austin has reported its research findings in more than 350 published papers including over 40 invited papers. He holds 12 issued patents. He has chaired or been a program-committee member for more than 50 domestic and international conferences organized by IEEE, SPIE (The International Society of Optical Engineering), OSA, and PSC. He has served as a consultant for various federal agencies and private companies and delivered numerous invited talks to professional societies. Dr. Chen is a Fellow of IEEE, OSA and SPIE. He was the recipient of the 1987 UC Regent's dissertation fellowship and of 2000 UT Engineering Foundation Faculty Award for his contributions in research, teaching and services. Back to his undergraduate years in National Tsing-Hua University, he received the national championship of national debate contest in Taiwan in 1979.

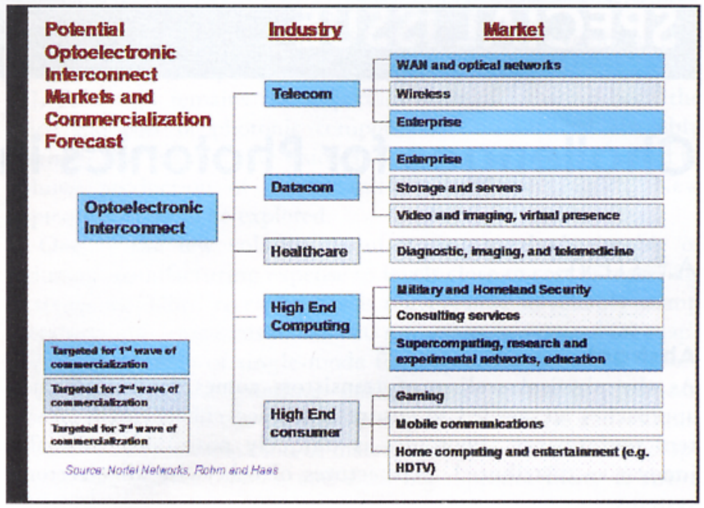

FIG.3. Future Market Projection for Optoelectronic Interconnection.