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Toward Optical Communications in SoCs

Recent advances in computation have led to important improvements in chip design and manufacture. As speed and shared-data requirements continue to increase, microelectronic technologies are approaching their physical limits. Researchers have been looking for solutions to this interconnection bottleneck for several years. One of the most promising solutions is the use of light rather than electrical signals as an information carrier.

In the past few years, several optical devices for inter- and intrachip communication have been developed. These components have important advantages over their electronic counterparts, making optical interconnects (OIs) an attractive technology. These advantages include high-speed propagation of light, smaller dimensions thanks to the design flexibility of optical channels, higher bandwidth due to wavelength division multiplexing, and a reduction in crosstalk noise and signal loss.

Thanks to these advances, various optical components to generate, transport, and detect light in SoCs have been developed. Although an OI can consist of several components, depending on its particular application, three of these components are always present: an optical transmitter, a channel, and a photodetector. Several devices can perform these tasks. Along with well-known and widespread semiconductor sources (such as LEDs and vertical-cavity surface-emitting lasers), micro- and nanocavities, either electric or metallic, and Raman lasers have been integrated as optical sources on chips. Although optical fibers are well-known optical channels, new devices are necessary to reduce the space requirements and signal losses.

Given these constraints, a wide range of waveguides made of silicon or polymers, as well as those that use scattering features (as with plasmonic waveguides), have appeared. These new waveguides present several advantages over electric wires, and they're independent of RLC impedances.

In addition, free-space configurations have appeared, with interesting characteristics that can make 3D integration possible. Beyond the challenge of developing optical sources for SoCs, there are also challenges in designing high-sensitivity photodetectors with low-power signals or high-speed detection. Fortunately, the new designs of germanium and surface plasmon polariton (SPP)-based photodetectors comply with these requirements. The manufacture and integration techniques to produce these devices are critical because these techniques must be CMOS compatible. These optical links are also used for more complex systems such as networks on chips (NoCs), in which crosstalk noise is an important consideration as a result of these systems' complex signal routing. Recently, several hybrid NoCs, combining an electrical and an optical network, have been developed, drastically improving power consumption and bandwidth compared to fully electrical networks.

Although some complete devices have already been described in the literature, there is still a long way to go before fully commercial devices can be realized. One of the major limitations that current optical technologies have not yet overcome is the integration of optical components in the chip. Also, strong limitations regarding cost and power consumption are the main reasons why optical inter- and intrachip communications still belong to the near future rather than to the present.

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- "An FPGA-Based Framework for Technology-Aware Prototyping of Multicore Embedded Architectures," by P. Meloni et al.
- "An Analyzable Memory Controller for Hard Real-Time CMPs," by M. Paolleri et al.
- "Efficient Software Synthesis for Dynamic Single Appearance Scheduling of Synchronous Dataflow," by W. Liu et al.
- "Hardware Resource Virtualization for Dynamically Partially Reconfigurable Systems," by H. Chun-Hsian et al.
- "Evaluation of Dynamic Profiling Methodologies for Optimization of Sensor Networks," by A. Shenoy et al.

Upcoming Conferences (Bill Joyner, william.joyner@src.org)	
CODES+ISSS	Scottsdale, Arizona, 24-29 Oct. 2010
ICCAD	San Jose, California, 7-11 Nov. 2010
ASP-DAC	Yokohama, Japan, 25-28 Jan. 2011
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