EPIC: Building the Perfect Chip

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Three years ago a team from Bell Labs took on a very daunting challenge – put an optical networking system on a commercially manufactured silicon chip, load it with a smorgasbord of sophisticated opto-electronic devices in a combination that's never been done before, and make it easy to mass produce.

The project is part of a U.S. DARPA-funded program (Defense Advanced Research Project Agency) to develop technologies and design tools necessary to fabricate an application specific, electronic-photonic integrated circuit (EPIC). This program is led by BAE Systems in partnership with MIT, Applied Wave Research, and Bell Labs, through Alcatel-Lucent's LGS subsidiary.

"Modern communication systems are built using both photonic and electronic components, each with their own technology platforms based on different materials. The vision is to put photonics and electronics on a tiny silicon chip where the strengths of both technologies can be realized on a high volume, low cost manufacturing platform," explained Sanjay Patel, Bell Labs Integrated Photonics.

CMOS (complementary metal oxide semiconductor), fabrication is the platform on which today's electronics industry is based. Recently, CMOS fabrication passed a feature-size milestone where the level of control in integrated circuit manufacturing is precise enough to support the demanding requirements of photonics. The timing is right to take advantage of the commercial mass production infrastructure and put optical networking onto silicon.

“The EPIC project achieved the critical first step in building the foundation for this new breed of devices,” said Alice White, vice president, Enabling Physical Technologies Research at Alcatel-Lucent’s Bell Labs. “We’ve applied our core competency in optics and expertise in chip design and telecommunications technology towards realizing the full potential of silicon-based optical networking by not only creating circuits that can carry optical signals, but providing the control to modify those signals, which is a much more sophisticated process.”

This research will enable telecom providers to move from using specialized and large optical networking devices to a new generation of low cost, mass produced silicon chips that combine electronics and photonics in a single chip - opening the door to new optical networking architectures that could usher in new sorts of broadband deployments and applications. Possible new applications include low-cost, mass deployment of fiber to the home; truly meshed optical networks that cleanly switch optical signals between different transmission formats; and the deployment of optical networking into places unapproachable by today’s optical networking devices such as over short-runs or in confined spaces.

A wide variety of photonic components are being developed on the silicon platform under the EPIC program to complement the existing suite of electronic components already available in the marketplace. These include all the basic building blocks of any modern optical communication system: optical filters to provide signal processing in the optical domain; electro-optic modulators to convert electrical signals to the optical domain; optical filters to provide signal processing in the optical domain; and detectors to convert optical signals back to the electrical domain.

One of the first achievements of the EPIC project is a highly versatile guided-wave (tunable) optical filter made entirely in a standard CMOS

manufacturing line, upon which was demonstrated a novel optical equalizer. This achievement, announced at the 2007 OFC/NFOEC conference, is a critical first step toward the ultimate goal of seamless integration of photonics and electronics on the CMOS platform.

The tunable optical equalizer uses a novel architecture to correct distortion from bandwidth limitations in the signal, allowing for superior performance with minimal control requirements. It also counteracts another form of distortion in a signal, called dispersion. “Self-correction” of distortion could significantly improve the speed, cost and performance of next-generation optical and high-speed data networks.

“The success we have achieved thus far bodes well for the full EPIC capability envisioned by DARPA as well as for novel and potentially lower cost components for commercial optical systems,” said Patel.

Source: Bell Labs