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The Enlightened Chip

By Ken Gilleo PhD
ET-Trends LLC

Traveling sure seems to be getting easier, faster and cheaper these days, and that's good news. So many people are whizzing around at the speed of light, and with few complaints about airport security. Getting from here to there faster makes the globalized world go round faster. Hold on! Does this sound like a *wishful-thinking far-in-the-future* scenario? It may, but it's accurate today when you travel the Internet Highway. No matter how you get onto that main line - the long haul, your messages, files and pictures travel via photon messengers - the most efficient medium possible. The data-laden photons race along glass optical fiber links that traverse the entire world as underground and submarine cabling. But why photons instead of electrons? Photons, traveling through a single thin glass fiber at the speed of light, can carry about 1-million times more information than electrons using copper wire. Nothing beats the photon for bandwidth and the reasons are due to the fundamental differences of charged electrons vs. neutral photons. Remarkably, hundreds, or even thousands, of different wavelengths can independently travel through the same thin (9-μ) fiber. So why not use photons to link computer chips and circuit boards?

Actually, many groups have been working on solutions for light-linking electronic chips but the challenges for a cost-effective solution are substantial. Recently, Intel and the University of California - Santa Barbara (UCSB), came up with the last tool for a potent "Photonic Toolkit" that could enable light linking of silicon chips, eliminating the copper "bottlenecking". The technology was dubbed "Silicon Photonics" and it purports to provide a means for economically fabricating a modulating laser onto a silicon chip. The laser will send vast amounts of data into and out of a CPU without wires. There's a lot more to this than just adding a laser, but it does appear that all the blocks of technology are now ready to be combined into a photonic chip system.

The final breakthrough, in a series of many, resulted when the team built the world's first electrically powered Hybrid Silicon Laser using standard silicon manufacturing processes. These researchers were able to marry light-emitting Indium Phosphide (IP) to silicon (Si). The IP and Si layers were combined by wafer-level bonding. Since silicon is transparent to the wavelengths used, it can be fabricated with light-manipulating capabilities using channels, waveguides, prisms, splitters and frequency-separating diffraction gratings. MEMS fabrication methods could also be used to produce optical structures in silicon. Application of voltage to the IP laser structure produces infrared "light" that travels through the silicon waveguide to create a laser beam that can drive other silicon photonic devices.

This system could enable low-cost terabit-level optical data pipes inside of future computers. The technology also has the capability of handling different wavelengths so that wave division multiplexing (WDM) could be used to combine and separate data

streams. WDM is a key technology used for the Internet to boost capacity; 1000 different wavelengths give an incredible 1000 times boost in bandwidth.

While we watch this technology unfold, this is the right time to think about its impact on packaging, circuitry and assembly. How will the data beams be transmitted? There are two choices, through the air, called free-space, or through optical channels. Perhaps both methods will be used. It is likely that a photonic-capable PCB will need optical pathways, or at least be able to handle optical fiber connections. Fortunately, developers and designers have been working on this idea for many years and a number of concepts have emerged. One idea is to send the data beam downward from the chip to an embedded prism, or 45^{o} reflector, and then through a light channel as shown in Figure 1. The beam must then route upward to link to another chip. There are many ways of creating photon paths but it's too early to know the outcome. But as the sun rises on the bright world of *photonic data transfer*, new materials and designs will be needed that open up new opportunities. Concurrently, the photonic Internet in our Net-centric world, will gradually replace copper wire links with wireless and fiber-to-the-home (FTTH). The photonic computer chip might be directly connected to the Internet by fiber for incredible speeds making trips even faster and cheaper - and hopefully, friendlier. In the meantime, CircuiTree will keep the light on for you.

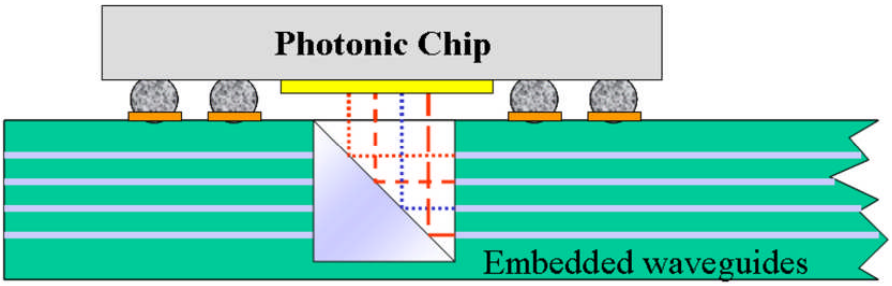

Figure 1