By Ken Gilleo

Search for a New Device Could Catalyze a Circuit Board Revolution

The printed circuit board has not fundamentally changed in its century of existence. While PCB making has improved, we still place copper patterns on dielectric substrate. The conductor patterning process has evolved from cutting strips of metal, to printing, and finally to photoimaging, but for the most part, we're still stringing copper wires. This works, so maybe there's nothing wrong with doing things the same old way. After all, the semiconductor industry has been "chiseling" away at silicon for half a century and keeping up with Moore's Law. Why should anything change? We can keep making electronics smaller, faster, cheaper for another century, right? But could the end be near? Will we witness the demise of silicon in the next decade or two, or is this heresy from the Nano-nerds? Let's say that silicon goes back to being just rocks—what would happen to circuitry?

Industry roadmaps are indeed predicting the end of silicon-based electronics and entry into a brave new world: "the post CMOS era." Our electronics industry is based on the electron and its negative charge, as the term implies. Various electron-based mechanisms have served us well for over a century if we include vacuum electronics launched in the late 1800s. Are we ready to retire silicon and maybe even the electron during the 21st century?

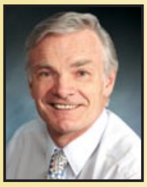
Some savvy technologists are not only predicting the end of silicon's dominance; they foresee a paradigm shift in the fundamental mechanisms used for logic and memory chips. Many potential methods for performing logic and storing data are available, including some that could boost density a thousand fold or more. Several could eliminate waste heat and provide ultra-efficient chips in the future. ITRS Roadmaps [http://public.itrs.net/] include spin, phase change, multi-pole orientation, mechanical position (nanoscale), polarity, orbital symmetry, magnetic flux quanta, molecular configuration, and quantum state as alternative device mechanisms. With so many possibilities to consider, a new "switch" is possible during the next 20 years. But even if electron charge devices continue far into this century, there's still a good chance that Nanoelectronics will let us transcend beyond silicon semiconductors. Many futurists are betting on some form of carbon structure, especially carbon nanotubes (CNT) and nanowires (NW). Considerable progress has been made in just a few years and we already have CNT transistors in the lab and processes for selectively forming these structures. There's also a group looking into biologically inspired architectures and we can't rule out bio-based chips in the future. Work also continues on a photonic computer and remaining problems could be solved in the next decade. To be sure, all of these areas have hurdles to overcome, but there appear to be few "show stoppers."

The device-to-circuit connection method could also change. Since we use electrons as the messenger and energy source, electrical pathways have become the standard, primarily made up of copper pathways, and solder junctions. But there are other ways of coupling electronics such as capacitance, inductance, and light; a photonic computer chip would utilize light for data transfer. So while we've used solid metal links for the first century of electronics, we could move to some form of "contactless," or even wireless technology, just as we're doing in communications today.

Assuming success with one or more of these emerging technologies, what will happen to the traditional copper-epoxy PCB? Will we still etch or plate copper in 2026? Will we still be soldering photonic or carbon-based devices? The next few years should give us more insight into the most likely technologies, but the 21st century will probably shed silicon and solder, and even copper PCBs.

There are other scenarios. We could retain copper and add embedded active devices. We could also add coupling zones to permit new devices to transfer data by wireless methods, including light. Future devices would be placed close to the coupling zone to enable ultra-high I/O connections. Embedded switches could allow the PCB to be programmed. Today, several silicon devices are programmable (FPGA, ASIC, EPROM), so a future PCB may be programmed for specific applications. Maybe the future circuit will behave like a network that enables devices to selectively link. And if future technology uses photons, then circuits would probably use light pipes instead of copper. Just consider the extraordinary bandwidth of a beam of light; about 1-million times greater than a copper wire. Since our modern metro Internet links are fiber loops around cities, the PCB might adopt this concept with devices mounted along the "light ring." Each addressable device would capture data, perform functions and send out the result. The incredible bandwidth of light would remove any need for multilayer conduits. Additional bandwidth would involve adding wavelengths (Wave Division Multiplexing; WDM), just like we do on the Internet.

The PCB of the future may not contain copper or any other metal. Even the shape could change. A round PCB would make sense for a fiber, or light pipe loop, where signals traveled in both directions. How do you make round boards without a lot of scrap? Saw them from a cylinder of material just as we do with wafers. Say goodbye to minerals and metal and hello to circuits unusual. ◻



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