MIKE BUETOW

Let There Be Light

WHEN John Bardeen and Walter Brattain produced their first transistor in December 1947, it was almost certainly a light emitter but at such a low level as to be undetectable. The field later developed around manipulating electrons rather than light.

Fifty-seven years later, Bardeen's first student, Nick Holonyak Jr., has teamed with Milton Feng, the maker of the world's fastest transistor, to conceive a light-emitting transistor (LET) that could revolutionize electronics. The pair, professors at the University of Illinois at Urbana-Champaign, have invented an LET that could make the transistor the fundamental element in optoelectronics as well as in electronics. The scientists reported their discovery in the Jan. 5 issue of *Applied Physics Letters*.

"We have demonstrated light emission from the base layer of a heterojunction bipolar transistor, and showed that the light intensity can be controlled by varying the base current," said Holonyak in a press release. In English, what this suggests is a way to replace electrical wiring on a PCB with optical interconnects and photons – which operate much faster. Applications include flat-screen TVs, computers and other visual displays; the technology eliminates the need to have separate LEDs and transistors to control them in the screens.

A transistor usually has two ports: one for input and one for output. The new device has three: an input, an electrical output and an optical output. "This means that we can interconnect optical and electrical signals for display or communication purposes," said Feng.

Even better, it can be built, albeit differently than conventional silicon devices. A U of I graduate student fabricated LET samples last year, using indium gallium phosphide and gallium arsenide, rather than the typical silicon and germanium.

While the inventors' names might not be familiar, they should be. Holonyak developed the first practical LED and the first semiconductor laser to operate in the visible spectrum, which led to broad use in CD and DVD players and fiber-optic communications. Feng last year developed the world's fastest bipolar transistor – a startling 509 GHz.

So far, the researchers have demonstrated the modulation of light emission in phase with a base current in transistors operating at a frequency of 1 MHz. They are wholly confident of hitting much higher speeds.

"At such speeds, optical interconnects could replace electrical wiring between electronic components on a circuit board," Feng said. "This work could be the beginning of an era in which photons are directed around a chip in much the same fashion as electrons have been maneuvered on conventional chips."

They acknowledge that their work is still "in the early stage" and all the possible uses have yet to be determined. "But," says Holonyak, "a light-emitting transistor opens up a rich domain of integrated circuitry and high-speed signal processing that involves both electrical signals and optical signals."

Also in January, another interesting new packaging concept was put forth by Joe Fjelstad. Fjelstad, cofounder of SiliconPipe, a Silicon Valley IP firm, envisions routing I/Os from the top of IC packages. Low-speed signals such as power and ground would be routed through the bottom side, while high-speed signals would be routed through the top, point to point, from IC to IC, by means of a flex circuit.

Doing so would eliminate noise discontinuities and changes in direction that sap signal strength and integrity, says Fjelstad. Furthermore, it would make better use of the multi-GHz speeds that ICs are capable of, he says, and testing would be possible using full parametrics at real speed because the I/Os are accessible.

Fjelstad's concept conjures up images of MCM technology. It also seems doable using conventional technologies. Taken together, these ideas may signal we're on the cusp of serious breakthroughs in speed.

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EDITOR IN CHIEF: Mike Buetow, 617-327-4702, mbuetow@upmediagroup.com

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EDITORIAL OFFICE: 2018 Powers Ferry Rd., Suite 600, Atlanta, GA 30339, 678-589-8800, fax 678-589-8850

INTERNET: www.pcdandm.com

PRODUCTION

MANAGING EDITOR: Katherine Haddox, khaddox@upmediagroup.com

ADVERTISING PRODUCTION MANAGER: Jenny Darby, 678-589-8854, jdarby@upmediagroup.com

PRODUCTION MANAGER: Javier Longoria, jlongoria@upmediagroup.com

WEB DEVELOPMENT MANAGER: Teresa Gentry, tgentry@upmediagroup.com

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EUROPE: Star Media Services, Tim Anstee, Steve Regnier, +44 (0) 1732 366 555, fax +44 (0) 1732 366 052, sales@starmediaservices.co.uk

ASIA (EXCEPT KOREA): Jan Vardaman, jvardaman@upmediagroup.com, 512-372-8887, fax 512-372-8889

KOREA: Young Media Inc., +82 2 756 4819, ymedia@chollian.net

PRINT REPRINTS: Stella Valdez, FosteReprints, 916-983-6562, fax 916-983-6762, svaldez@fostereprints.com

ELECTRONIC REPRINTS: pcdm_reprints@upmediagroup.com

REPRINTS PRIOR TO MARCH 2002: Karen Jacobs, 516-562-7030, 800-682-4972 ext. 7030, kjacobs@cmp.com

LIST RENTAL: Rubin Response, 847-619-9800, fax 847-619-0149

CIRCULATION

DIRECTOR OF AUDIENCE DEVELOPMENT: Jennifer Schuler

CIRCULATION/SUBSCRIPTION INQUIRIES/ADDRESS CHANGES: jschuler@upmediagroup.com, fax 918-496-9465

UP MEDIA GROUP, INC.

PRESIDENT: Pete Waddell

MARKETING MANAGER: Ronda Faries, 678-589-8827 rfaries@upmediagroup.com

CONTROLLER: Michael Douglas

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