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THE 30TH ANNIVERSARY OF THE INTEGRATED CIRCUIT

Thirty Who Made A Difference

under Tarui's direction. They were to work together for four years.

Sharp and other pioneers in the use of ICs were excluded because MITI felt VLSI circuits would be very difficult to make and the high price would make them impractical for calculators.

Tarui's idea was to get the researchers to work on "basic and common" technologies. "You know," he points out, "even in Japan it is very difficult to get competing companies to really work together, so by limiting our research to basic and common technologies, we could develop something useful for each company. So the companies cooperated and we got some very good people."

There was another reason for cooperation. "At the time," Tarui recalls, "we had no confidence that we could compete or succeed. So executives at the various companies were very cooperative."

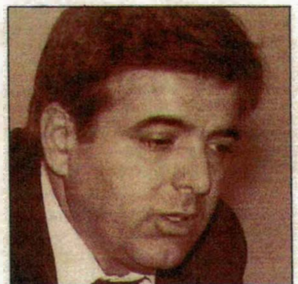
Tarui formed six groups, three to focus on lithography and one each to focus on crystals, processing and evaluation. These groups were led by Masatoshi Migitaka of Hitachi, Tadashi Nakamura of Fujitsu, Yoshiyuki Takeishi of Toshiba, Takashi Iizuka of MITI's Electrotechnical Lab, Taiji Oku of Mitsubishi and Akira Kawaji of NEC.

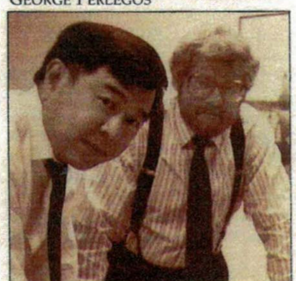
Equipment manufacturers, like Nikon (Nippon Kogaku), Canon, Anelva and JEOL, played an important role, too. Shojiro Yoshida of Nikon, working with the VLSI researchers and other Nikon engineers, developed the Nikon stepper. MITI provided money to Nikon and others to develop equipment that would be required for VLSI circuits.

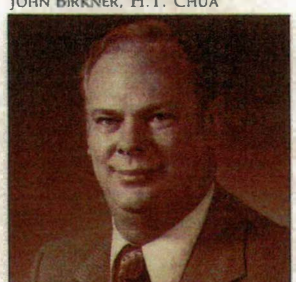
The dramatic developments in VLSI can trace their ancestry to dramatic achievements in isolation—achievements like Peltzer's Isoplanar, Richman's Coplamos and Murphy's buried collector. But Short's dielectric isolation, though it chewed up real estate, continued as a powerful technique, especially as embodied in Radiation's PROM.

Radiation's PROM represented an important leap ahead, as it enabled engineers to tailor a ROM to their own needs without requiring expensive masks that could be amortized only over relatively long production runs. But the PROM did have a drawback. Once programmed for one application, it could not be used for another.

That problem was solved at Intel in 1972, when Dov Frohman developed the ultraviolet-eraseable PROM (UV-PROM or EPROM). One could erase its contents by exposing the chip through a quartz window on the surface of the package to ultraviolet light. Then one could program the chip anew.


George Perlegos


John Birkner, H.T. Chua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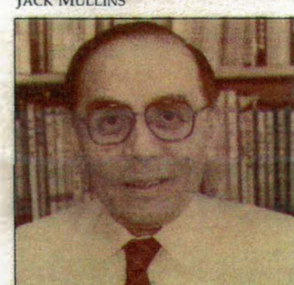
Yasuo Tarui

GEORGE PERLEGOS

Dov Frohman's EPROM was an extremely significant product, though it was curbed by limited memory—only 2 kilobits—and by being a p-channel part. The man who took that device further, George Perlegos, spent six years going for his doctorate at Stanford, and left school with "only" an MSEE because he ran out of funds in 1978.

But he started working long before he finished his schooling. He worked at American Microsystems from mid-1972 to early 1974, then joined Intel, where he stayed until February 1981, concurrently spending part of the time (1978 and '79) teaching at Santa Clara University and part of the time (to 1978) studying at Stanford.

He made some important contributions at Intel. First, in 1974, based on Frohman's work and work on stacked gates and channel injection by Yasuo Tarui, he developed the first n-channel EPROM, an 8k part, the 2708. He also made the first 5-V EPROM, the 2716. All earlier EPROMs and most of the earlier memory devices required three voltages.

Then, in 1978, Perlegos made the first commercial electrically erasecable PROM, the 2816, that didn't suffer from density limitations, as did earlier MNOS EEPROMs. This made it possible, for the first time, to erase and reprogram a large PROM in circuit, even remotely via modem or radio signal, and without time-consuming ultraviolet exposure, and without the need for a quartz window on the package.

The MNOS EEPROM, which had been developed in the 1960s at Westinghouse, was limited to rather small PROMs in the region of about 2k, while the Perlegos device paved the way for 1-Mbit EEPROMs, which Atmel expects to announce by year-end.

Perlegos' EEPROM required developing a thin-oxide technology—with oxide layers as thin as 100 angstroms—as it involved a tunneling phenomenon. While the EPROM would enjoy a much broader market and was a mainstream product, his EEPROM offered specialized capabilities that had not been available earlier.

In 1981, Perlegos left Intel to become a founder of Seeq Technology. He left in October 1984 to become chairman, president and chief executive officer of Atmel Corp., a manufacturer of high-speed non-volatile memories and logic devices.

JOHN BIRKNER, H.T. CHUA

Harris, Intel and others made great progress in programmable and re-programmable memory. But memory isn't everything. There's also logic. One man who made the big breakthrough in programmable logic was John Birkner, who has a 1971 MSEE from the University of Akron.

Birkner worked at Goodyear Aerospace, Philco Ford and Computer Automation before he joined Monolithic Memories Inc., a leader in PROMs, in 1975. MMI was looking into field-programmable logic devices that would be significantly better than those on the market from Signetics and those that Intersil almost brought to the market.

Birkner and H.T. Chua, a design engineer at MMI, developed a device they called, at first, a field-programmable logic array. The FPLA was later called Programmable Array Logic and it came in a 20-pin, 300-mil DIP, when earlier devices required a 600-mil DIP with 28 pins. The PAL was fast—with 35-ns propagation delay that was later improved to 30. Earlier devices had 80-ns propagation delay.

The Birkner/Chua PAL wasn't revolutionary, but it stormed the market, acquiring licensees like National Semiconductor, Texas Instruments and Advanced Micro Devices because it added features that others lacked. One significant feature was the use of programmable I/O pins. Earlier programmable logic devices had committed I/O pins. A user who needed three input pins and 12 output pins, for example, could not use a device that had eight input and eight output pins. The new PAL eliminated that problem, thereby helping customers and semiconductor vendors reduce inventory.

Birkner and Chua did something else to make their product a leader: They made their PAL easy to use. They offered a development tool, the PAL assembler, and they wrote a handbook with many applications examples.

Birkner left Monolithic Memories in July 1986; Chua left in July 1987, just before the company's acquisition by Advanced Micro Devices; and Andy Chan, a close associate at MMI, joined the pair in January 1988. They are all peers at Peer Research, a company they started on February 16, 1988, the first day of the Year of the Dragon—a symbol of good fortune.