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Intel, Motorola and Advanced Micro Devices Enlist 3 DOE Labs to Develop New Computer Chip

Fifty years ago, young physicists at Bell Laboratories jabbed two electrodes into a sliver of germanium and discovered that the power gain of this semiconductor was almost 100 times stronger than the voltage going in. The physicists—John Bardeen, Walter Brattain and William Shockley—had invented the transistor, which garnered them the Nobel Prize in 1956 and opened the way to the telecommunications revolution and the information age.

On 11 September, three major US semiconductor companies—Intel, Motorola and Advanced Micro Devices (AMD)—announced that they were joining forces with three Department of Energy laboratories—Lawrence Livermore, Sandia and Lawrence Berkeley—to reduce the size and increase the processing power of the early transistors many thousands of

The touchstone for the industry is called Moore's Law, after Gordon Moore, cofounder of Intel and now its chairman emeritus. Moore's Law holds that every two years the number of transistors drawn on chips doubles, even as the size of the chip stays the same. By and large, the industry has kept to that pace.

Intel officials are confident that by the year 2011 the microprocessor will contain 1 billion transistors, operating at more than 10 gigahertz and delivering 100 000 millions of instructions per second (MIPS).

EUV lithography for microprocessors was devised at Sandia in Livermore, California. The source of EUV light is based on a plasma created when a laser is focused on a beam of xenon gas clusters expanding at supersonic speeds. Patented by Sandia in

tel officials came up with a novel plan to initiate a limited-liability partnership and sell stakes in it to other firms in the industry over time. So far, only Motorola and AMD have joined in. The new venture is called EUV, the same as the acronym for the technology it hopes to use, and LLC, for limited-liability company, was added to the name.

"Whoever controls the intellectual property will have a significant competitive advantage," says Sander H. Wilson, an Intel manager who also is the business director for EUV LLC. The venture is the largest investment by private industry in a DOE research program.

Energy Secretary Federico Peña told us during a telephone interview that without the money from the companies, his agency would have eliminated many of the jobs now held by

The Incredible Shrinking Transistor

Year: Microprocessor	Number of transistors
1971: 4004	2300
1974: 8080	6000
1978: 8086	29 000
1982: 80286	134 000
1985: Intel 386	275 000
1989: Intel 486	1.2 million
1993: Pentium processor	3.2 million
1995: Pentium pro	5.5 million
1997: Pentium 2	7.5 million

The number of transistors that can fit in a single microprocessor has increased at a phenomenal rate as the size of the transistor shrinks. Today's chip has more than 3000 times as many transistors squeezed onto it than did the 4004 chip made in 1971. New techniques could produce a microprocessor that contains about 1 billion transistors, over 100 times the current number in the Pentium 2.

Source: Intel

times. The companies will put up \$250 million in the next three years for an advanced lithography research project targeted at increasing computer chip capabilities for the 21st century. The advanced technology, called extreme ultraviolet (EUV) lithography, will allow semiconductor makers to etch circuit lines less than 0.1 micron wide, thereby enabling microprocessors to become 100 times faster and to store 1000 times more information than is currently possible.

Most chips made today possess features that are 0.35 microns in width. A few days before the announcement, Intel introduced its first chips using 0.25-micron technology. By shrinking the dimensions of circuit elements, chip makers can cram more transistors onto a chip.

1996, the EUV light source has already created proof-of-principle microelectronics devices with lines and spaces as fine as 0.15 microns. But developing manufacturing technology at this level is something else again. By about 2007, if Moore is right, it may be possible to make chips with features measuring about 0.10 microns. It's a risky venture, transforming a promising idea from the research lab into a practical technique, Moore admits.

Since the early 1990s, DOE's weapons labs have spent around \$25 million on R&D in advanced lithography. In September, DOE, under increasing budget pressures, cut off funding for such work. Intel executives first tried to convince other chipmakers to share the costs of an EUV consortium. When those companies proved reluctant, In-

scientists and engineers at the defense laboratories. Indeed, much of the new company's capitalization will be used to keep former weapons researchers on the payroll. "We consider this a proper and prudent move for the department," said Peña, "because we think the new technology will provide chips for the supercomputers we will need in the next century to simulate nuclear weapons tests."

The three national labs have been designated a virtual national laboratory. EUV LLC, for its part, has received the blessing of government and industry organizations such as the Defense Advanced Research Projects Agency, the US Semiconductor Industry Association, Sematech, Integrated Solutions, Northrup Grumman, Tinsley Laboratories and TRW. Also con-

tributing support to the new company are such semiconductor equipment manufacturers as Nikon, Silicon Valley Group, Ultratech Steppers and ASM Lithography, a subsidiary of Philips of The Netherlands. Intel executives say it is critical to involve these companies, which are already engaged in lithography, to ensure that the new technology could be quickly placed in commercial use under license to the equipment makers.

However, not everyone in the industry agrees that extreme ultraviolet is the way to go. IBM, for instance, has invested 25 years and countless dollars in x-ray technology. Bell Labs, the research arm of Lucent Technologies, is exploring an approach it calls Scalpel, based on using electron beams to

etch the circuit patterns on silicon wafers (see page 61 of this issue). A few Japanese companies are dabbling in other technologies.

Foreign participation in EUV LLC is likely to be a politically charged issue. Wilson hopes to short-circuit this problem by requiring that foreign companies licensing the technology put it to use only in the US for two years before taking it home. "We can't have only US companies benefit," he said, "but we can try to provide an opportunity that doesn't disadvantage chip makers in our own country."

Moore is a true believer in EUV lithography. "We hope through these research efforts to invent the future once again," he said.

IRWIN GOODWIN

Peña Vows to Speed Up Lab Reforms In Wake of Political Sharpshooting

Admitting that "we have not made sufficient progress on laboratory management reforms," Energy Secretary Federico Peña pledged to speed up the recommendations of two advisory panels and to prepare a "roadmap" for the department's R&D programs that includes a strategy for taking on such big science facilities as light sources, accelerators and neutron sources over the next 15 to 20 years.

Peña made his commitment to "management excellence" before his Secretary of Energy Advisory Board (SEAB) on 3 September, in his first meeting with the group since his Senate confirmation in March. "I know that some of you are somewhat frustrated by [the slow pace of introducing management reforms], but this is changing," he promised. "I will not tolerate lax management that jeopardizes the environment, health or human safety. And I expect our managers to squeeze every penny out of their budgets that doesn't contribute to helping us fulfill our missions, whether it's scientific research or cleaning up the environment."

Since taking the top job at DOE in May, Peña has made aggressive decisions to deal with environmental and safety troubles at Brookhaven National Laboratory, Los Alamos National Laboratory and the Hanford site in Washington state. He ordered better training of laboratory staff and improved communication with local officials, the press and the public when an accident or other emergency occurs.

He was particularly vexed by the situation at Brookhaven, where lab officials still don't know the source of

elevated levels of tritium that were detected in groundwater. After examining the suspected sources, lab officials said the tritium definitely did not come from the High Flux Beam Reactor (HFBR). But when a tritium leak was found in the HFBR's spent fuel storage tank in December, it was weeks before the leak was revealed to local authorities. More recently, a review of Brookhaven's environmental problems conducted by the lab, New York's Suffolk County, DOE and the US Environmental Protection Agency turned up another tritium leak under a second, smaller reactor that is used for medical research. The review, completed in early September, also identified 21 "significant" findings, including a 1972 spill of 100 gallons of oil and 90 gallons of a toxic chemical, trichloroethane. In the wake of the latest report, Senator Alfonse D'Amato and Representative Michael Forbes, both New York Republicans up for reelection next year, issued a statement in which they said the findings vindicated their belief that the lab "has been a dumpsite of indifference." D'Amato introduced a one-line bill in the Senate calling for the permanent shutdown of HFBR and told colleagues he would try to add it to the energy and water appropriations bill for fiscal 1998.

The three former members of the House of Representatives and two former governors who serve on SEAB expressed sympathy for Peña's political problems, but urged him to move forward rapidly with management reforms. So, too, did the head of the Laboratory Operations Board, a committee of 19 nongovernment executives and senior department officials, that

was created after a 1995 report by a task force headed by Robert Galvin, former chairman and CEO of Motorola. The Galvin report concluded that barring their emancipation from DOE, the labs should be more focused on their respective missions, cut their operating costs and eliminate many wasteful administrative functions.

In its report to Peña, completed in January but issued at the SEAB meeting, the Laboratory Operations Board, led by John McTague, vice president for technical affairs at Ford Motor Co, said DOE needs "a more rapid rate of progress" and noted a loss of momentum following the departure of Hazel O'Leary as the department's secretary. A separate independent review of the nuclear weapons labs was completed in January by the Institute for Defense Analyses (IDA) but not formally presented to Peña until August. Recommendations in the IDA review, known as the "120-day report," call for streamlining lab management and establishing clearer lines of authority between the labs and DOE program offices in Washington and in the field—much like the conclusions of the report by the operations board. The secretary has already notified Congress that the department will soon decide on whether to significantly realign the reporting functions for the Albuquerque and Nevada operations offices.

Peña told SEAB that he "agreed . . . that there are too many people in the DOE management system, that there are unclear lines of authority and diffuse responsibility" and that this had led to "inefficiencies that hurt the performance of the laboratories." He said that Ernest Moniz, an MIT physicist who has been nominated by President Clinton to be the department's under secretary, will take the lead role of pushing lab reform just as soon as he is confirmed by the Senate. Peña has instructed the department's R&D council, chaired by Martha Krebs, who heads all energy research programs, to take on a study of research facilities. The council, a group of top energy research managers, also will seek ways of reducing red tape at the laboratories. The goal, said Peña, is to "let researchers spend more time on research and less time on paperwork."

Peña wants the council to come back in 90 days with a plan to foster exchanges of scientists with universities and industry. He has promised SEAB that he will develop a strategic plan that will make the department's civilian research program the equal of the nuclear weapons stockpile stewardship program.

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