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PRIMARION BRIDGES ANALOG/DIGITAL DIVIDE

Silicon Interposer Quiets High-Frequency Chips

By Keith Diefendorff {2/21/00-03}

A group of ex-Intel executives from Tempe (Ariz.) has collected $13 million in venture funds, including an undisclosed amount from Intel Capital (Intel's $8 billion venture fund), to form Primarion. According to Bill Pohlman, chairman and chief technical officer, Primarion's goal in life is to close the growing chasm between digital microprocessors and the outside analog world. Primarion sees the gap growing to crisis proportions as processors plunge headlong into the deep submicron regions.

Once upon a time, when processors ran at 5 V and 100 MHz, life was simple. Interfacing a microprocessor to a system was not much more difficult than selecting parts from a data book and wiring them up. Over the years, however, digital ICs have come a long way. Primarion predicts that as processors move to 0.15- and 0.13-micron processes, and reach gigahertz speeds and sub-1-volt operation, the problems of electrical noise, clock skew, bus speed, and soft errors will increase exponentially, creating a data-integrity crisis. The impending crisis will affect high-performance systems first but will quickly spread to DSPs, ASICs, and embedded systems.

Data-integrity problems arise in microprocessors primarily from the inability to deliver clean, stable power to all circuits (see *MPR 12/27/99-03*, "Processors Put Pressure on Packages"). At gigahertz switching speeds, there is nothing even approximating an ideal power supply. In practice, power is delivered to a microprocessor through a complex network of parasitic impedances. Because of these impedances, when the floating-point unit, for example, adds two numbers that cause many bits to change, the switching transistors can rob current from adjacent units rather than taking it from the external power source, as intended. This effect creates electrical noise on chip. To make matters worse, as power-supply voltages drop with each new process generation, so does the noise margin of the gates. The result of these two effects is a seriously reduced signal-to-noise ratio and thus a statistically higher bit-error rate.

Primarion is not the first company to recognize the impending crisis. Primarion is, however, the first to come up with an aggressive plan to fix it. Its proposal is to break the on-chip power grid into small, independent sections. The microprocessor is then C4 bonded to a silicon interposer chip containing high-speed, low-impedance power regulators for each section of the processor. With this arrangement, the power sources to the various processing units are isolated from each other, which prevents switching transistors in one unit from generating noise in the next. With clean power supplied to each processing unit, the data integrity of the signals is greatly enhanced. Using this technique, Primarion believes it can speed the analog-power response to digital-signal transitions by a factor of 100, while creating a hundredfold reduction in system noise. In addition, Primarion will use the interposer to distribute a skew-free clock signal to all parts of the microprocessor. The net result could allow processor speed increases of up to 50%.

The trick behind the technology, which Primarion calls active signal-integrity architecture (ASIA), is the interposer and its circuits. Building high-speed power supplies capable of delivering 100 A to 1-V 1-GHz processors calls for a circuit

technology far different than that used in standard digital or analog CMOS devices. To do the job, Primarion will use a radical new silicon-based technology that exploits heterojunction bipolar transistors (HBTs), which are particularly good for building fast, low-impedance power supplies. Even though the new company already has 10 patent applications filed to protect its technology, it is not yet ready to reveal exactly how it works.

The company is also not ready to disclose the mechanics of mounting processors to silicon interposers or mounting the interposers to a package substrate or motherboard. One difficulty will be getting signals off the microprocessor and through or around the interposer chip substrate; although some work has been done on etching vias through silicon substrates, the technology has never appeared in a commercially successful part. But, at this point, Primarion's technology is still in the research stage, presumably to address just such problems. The company says it plans to have a proof-of-concept demonstration by October of this year and to be shipping product one year later. Within five years, Primarion expects its technology to be widely deployed in high-volume products such as PCs.

Because the technology will initially be expensive, and because it will be needed most urgently by high-end systems, Primarion intends to deploy the technology first in servers, workstations, and Internet-infrastructure devices. The company believes, however, that the cost will come down rapidly, and it is just a matter of time before PC and other microprocessor-based systems will face the same problems and need its technology. Primarion knows of no other way to solve the problems it is addressing, which, if true, would put the company in the catbird seat.

The company says it has several big-name partners currently working with it to define ASIA technology, which consists of design rules for building compliant microprocessors, a system-requirements specification for using the technology, and, of course, the bipolar interposer technology itself. Primarion plans to make its money selling interposer chips, which it will build in its bipolar fabrication facility in Tempe. Since each microprocessor will require a unique interposer design, Primarion could have its work cut out designing and manufacturing chips.

Although the company acknowledges that its technology will be expensive, for high-end systems this expense may not be an issue. If the technology solves the problem, then its value will be high and server OEMs will pay a lot. Furthermore, the technology might actually save cost at the system level. A quiet source of power will allow the frequency-bin distribution of microprocessors to be shifted upward, increasing top speed and lowering the cost of midrange parts.

While a claim of two orders of magnitude improvement in anything normally pegs the MDR skepticism meter, it looks as if Primarion may be on to something. Whether it can engineer a practical system at reasonable cost remains to be proved, but the company founders have considerable experience in related technologies and intimate knowledge of the issues Intel is facing for its future microprocessors, so it definitely deserves a close watch. ◇