On the Forefront

E. Jan Vardaman

Is SiP Haunted by the MCM Ghost?

Thanks to cellphones, stacked-die packages are ringing up gains.

Remember Mosaic Systems? How about Midway, Polylithics, Advanced Packaging Systems, UniStructure, Alcoa's thin film production line, ISA, Polycon, Texas Instruments' multichip module foundry, nChip or MicroModule Systems? These companies or divisions were all at one time in the MCM foundry business. And all are now on tombstones in the MCM cemetery, having ceased business operations. Exit MCM; enter system-in-package (SiP). What are the differences in these packages and why is success predicted for SiP?

Historically, MCMs were large substrates – ceramic, thin film, laminate or some combination – with tens of bare dice mounted with flip chip, TAB or wire-bond interconnect. While the high performance market became a reality for some products, its size in terms of volume and dollar value never attained once-great expectations. Instead, a new type of multichip package (MCP) evolved. This package typically featured a few bare integrated circuits on a relatively inexpensive substrate. While many applications, such as notebook computers and portable products made by Japanese companies, used MCPs, the volumes were limited to niche applications. Toshiba's digital cellphone was introduced with an MCM consisting of five chips wire-bonded to a laminate substrate. Oki Electric marketed a credit card-size PC containing a multichip BGA package. NEC's PC-9821 notebook computer contained multiple chips in a 33 x 33 mm BGA with 196 balls on the package. (A graphics controller and memory device were flip-chip-mounted to one side of the BGA substrate, while packaged SRAMs and VRAMs were mounted on the other. The eight-layer substrate used build-up board technology.) Why did these applications fail to become mainstream? For many applications, silicon integration resulted in a single-chip solution less expensive than MCM or MCP. The availability of known-good die (KGD) at an acceptable price was an issue for other applications. Also, semiconductor makers often cited module design and testing as issues that prevented widespread adoption.

What's different between today's SiP and stacked-die packages vs. MCMs or MCPs of the past? A volume driver.

The introduction of SiP stemmed from the need to incorporate greater functionality in smaller spaces (similar to the driver for MCPs). Stacked-die packages containing logic devices are one form of SiP and continue to see double-digit growth. Hundreds of millions of stacked-die packages containing just memory shipped last year and may be considered MCPs. Most mobile phones use at least one stacked-die package; some use two. Japanese companies, including Matsushita (Panasonic), Mitsubishi, NEC, Sharp, Sony and Toshiba, have shipped mobile phones with stacked-die packages for years. Early packages contained SRAM and flash only, but will increasingly contain logic devices. Stacked-die packages can also be found in phones manufactured by Chinese companies including Konka and Ningo Bird.

NEC shipped its first SiP in 3G mobile phone models in 2001, with a package that contained a microcomputer unit and one SRAM.[1] SiPs are also found in PDAs, digital cameras and camcorders, laptop computers and other portable products. Sony's DCR-IP220 contains a stacked package with logic and 128M SDRAM in a 240-pad array style. The Sony Cyber-Shot digital camera (DSC-F77) also comes with stacked packages.

What is different between today's SiP and stacked-die packages and MCMs or MCPs of the past? At conferences 10 years ago participants regularly lamented the lack of a volume driver to enable MCM technology and reduce cost. Enter mobile phones. With the short

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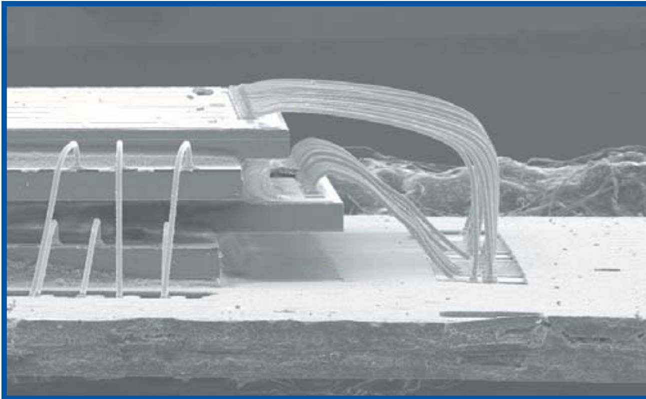
More in Less: Intel's four-die stacked package.

product design times and production cycles, waiting for a single chip solution is not an option, even if it could be provided. Repair was often a concern for expensive MCMs of the past. When tests indicate a defective part with stacked flash and SRAM memory packages, it is cost-effective to throw away the package. High dice yields and the use of good dice make even this less likely. KGD is still an issue for many companies, but some packages are stackable and can be tested along with bare dice. Module design and test capabilities have also improved. While new problems such as die thinning (75 µm or less) and handling of the fragile thinned dice have emerged, new developments are enabling solutions to mechanical problems.

Mobile phones have emerged as the technology driver for many of today's packaging developments. SiP and stacked-die package shipments continue to grow and the number of die inside each package is increasing. Stacked-die packages containing both memory and logic are expected to see major expansion.[2] The growth in stacked packages is driven by the need to incorporate greater functionality into smaller areas – a historical driver of the old MCPs. Most stacked-die packages used in the past few years contained two dice – typically flash and some form of RAM, but three, four, five and six dice packages have recently moved into production. Logic and memory combinations are increasing as KGD and logistics issues are being resolved. Perhaps the MCM was just ahead of its time.

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References

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