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New Bubble-Memory Packaging Cuts Board Space and Manufacturing Costs

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Low-profile 4-Mb bubble-memory package is interchangeable with 1-Mb types and also lets printed-circuit boards be spaced on 0.6-in. centers

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□ Designing a second-generation product gives an engineering team the chance to put in all the improvements they realized were needed after the first design was formalized. The new 7114 4-megabit magnetic-bubble memory from Intel makes the most of this opportunity in terms of its ease of both use and manufacturing.

Despite the quadrupled bit density, the 7114's leaded package is smaller in all three dimensions than the leadless package of its 1-Mb predecessor, the 7110. It occupies less space on a printed-circuit board and has a lower profile—low enough for the boards carrying it to fit into adjacent rather than alternate slots in standard card cages. Moreover, chip and package are far easier and cheaper to assemble.

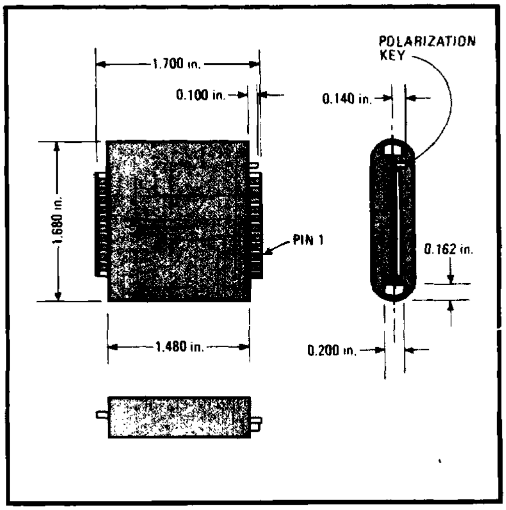
Nor is that convenience compromised by a lack of compatibility with the 7110. The pinouts are the same, and the pin spacings sufficiently similar to make it simple to upgrade from the 7110 to 7114. Also, the support circuits essential to the control of each bubble memory are either identical or so alike as to be interchangeable.

More specifically, the first-generation 1-Mb bubble device is a 520-by-620-mil chip in a leadless package that needs a socket; the assemblage has a footprint of 2.20 by 1.825 in. (Fig. 1) and an overall height of 0.430 in.

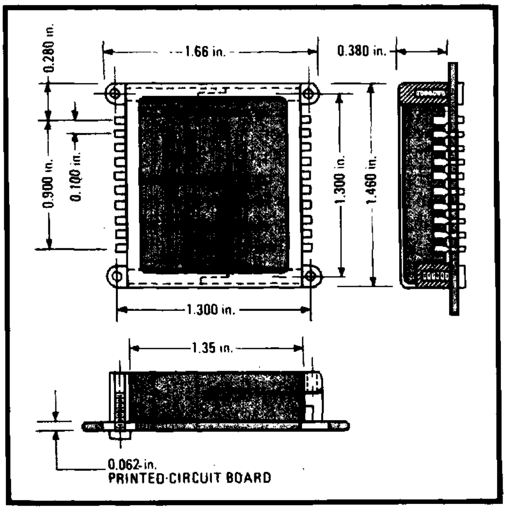
In contrast, the 4-Mb chip and a forthcoming 1-Mb device are smaller—580 by 500 mils—and their leaded "thin-C" dual in-line package has a footprint of only 1.66 by 1.46 in. (Fig. 2). Also, its height is now only 0.375 in., so that when inserted either directly into a pc board or in a zero-profile socket, it leaves ample clearance for the 0.6-in. card spacing normal in commercial card cages.

Design goals

Without scaling down device geometries, it would have been impossible to fit a garnet chip containing four times as many bubble domains into a package of the same size, let alone a smaller one. Thus the first order of business was at least to halve device geometries in both dimen-



1. Leadless. The leadless package of this first-generation 1-megabit magnetic-bubble memory has a footprint of 2.20 by 1.825 inches and an overall height of 0.430 in. when socketed. Thus boards cannot be spaced the standard 0.6 in. apart.



2. Thin and leaded. Despite its 4-Mb capacity, this bubble chip fits in a leaded package with only a 1.66-by-1.46 in. footprint and 0.375-in. profile. Cards carrying these packages or using zero-profile sockets for them can be set into a card cage with the standard 0.6-in. spacing.

sions. The production application of X-ray lithography, in fact, yields 4-Mb bubble chips that are smaller than the 1-Mb one in the current 7110 leadless package.

In addition to different die dimensions, the smaller package required smaller magnets and coils with different dimensions to help control the flow of magnetic bubbles on the garnet chip. A program for designing models of coil size and shape was therefore developed and run on an IBM Personal Computer.

Either the 1- or 4-Mb scaled-down bubble device could have been placed in the same package as the original 1-Mb memory if that had been desired. Instead, it was decided not to settle for the existing package but to produce a new one that, while compatible with the 7110, would be more useful to the engineer—namely, by being smaller and allowing standard pc board spacing. Equally important, if not more so, was the decision to make the production process more efficient and cost-effective.

Nevertheless, there were to be no compromises in the stiff specifications for durability, magnetic shielding, and temperature range. In essence, the design goal was for the new package to be at least as good as the first in some aspects and better in others.

A thinsy

One major concern in moving to a new package is its effect on users who are already producing systems containing the first-generation version and who plan to continue manufacturing while introducing the later one. Unless pinout and spacings are absolutely identical, the transition to a new package cannot be totally painless.

However, in this case, maintaining the identical spacings both within and between the two rows of pins would eliminate any benefit gained by a smaller package. Thus, the decision was to keep the 7114's pinout and adjacent pin spacings the same as on the leadless 7110 package. Only the separation between the two rows of pins has been made smaller on the new memories.

As a result those engineers now manufacturing equipment using the previous 7110 model can lay out their pc boards in such a manner as to accommodate either the first-generation package or, with a minimal amount of revision, the new one. The trick is to elongate and drill the pin trace pads on the board for two holes per pin, as shown in Fig 3. For new layouts, this scheme should be used from the very start. Existing system boards can be modified this way with little effort. If board-level diagnostic and maintenance operations require the use of sockets for the packages, the pc-board holes should be dimensioned for the zero-profile–socket contacts, such as Augat Holtite types. Otherwise, the advantage of the 0.6-in. board spacing will be lost.

Attacking manufacturing costs

In many ways, making magnetic-bubble chips is similar to making integrated circuits, but there are significant differences—for instance, semiconductors do not need wire coils. Therefore, it is reasonable to assume that the major manufacturing cost factors in the one process will not be the same for the other.

In the original 7110, the garnet bubble chip is first die-bonded to a ceramic substrate and then wire-bonded to conductors metalized onto the ceramic. Next, the field and drive coils are put in place around the garnet chip, and all the components are potted using a liquid epoxy compound. Both the use of ceramic and the potting process contribute heavily to memory cost.

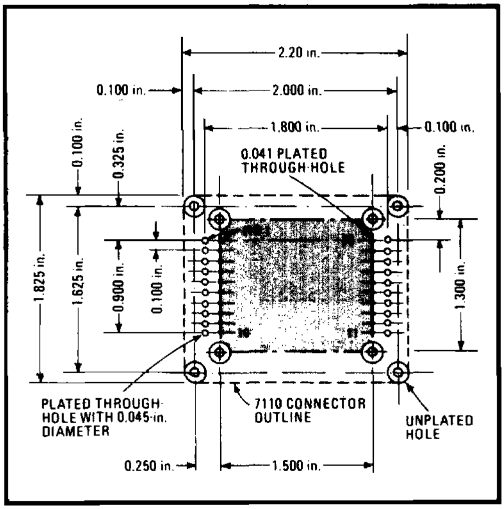
The 7114 package design is more economical on both counts. For the ceramic substrate, the design team substituted a special pc-board material that is thinner, lighter in weight, and lower-cost.

Next, the designers tackled the problem of potting the chip, substrate, and coil combination. Packages containing ICs often employ transfer molding of a thermoset epoxy compound. But when applied to the bubble assembly, the high pressures involved in this process—about 500 to 1,000 pounds per square inch—routinely deformed the bubble memory's wire coils and degraded their electrical performance unacceptably.

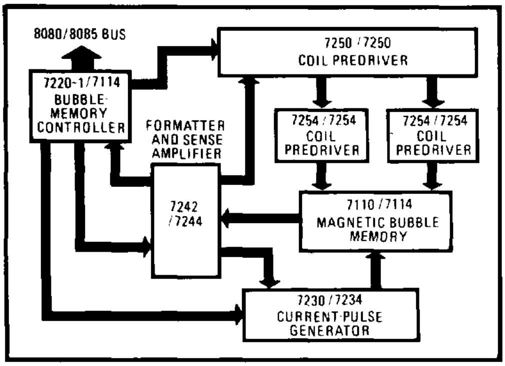
Indeed, for the 7110, manual potting had seemed unavoidable, even though production personnel spent an average of 1 hour on each bubble assemblage, first placing it in a mold, then pouring in liquid epoxy, placing it in a high-temperature oven to cure, removing the mold from the oven, and finally extracting the assembly.

Nonetheless, for the 7114 a fast alternative was found in the liquid injection-molding process used by some manufacturers for high-voltage insulators. Unlike transfer molding, it employs only low pressure, in the region of 15 psi, and it speeds up the potting process to more than 50 devices per hour.

Thus by replacing the ceramic substrate with pc-board material and by substituting liquid injection molding for the manual pouring of a potting compound, the package engineering team had a very favorable impact on the cost and throughput of manufacturing. An added advantage is that, with the ceramic removed, the possibility of chip-



3. Four for one. If this pc board layout is followed, it is possible to plug either a socketed 7110, a leaded 4-Mb, or a leaded 1-Mb bubble-memory package into this hole pattern. The socketed 7110 goes into the outer set of holes, while the newer packages fit the inner set.



4. Upgrade. Along with the bubble chip, all the other ICs of the 1- and 4-Mb memory systems are mechanically and electrically interchangeable so far as the pc board layout is concerned. The diagram shows the chip set for a 4-Mb system in color and the 1-Mb system in black.

ping the exposed edges has been reduced. The table on this page summarizes the packaging and manufacturing aspects of the new and old bubble package methods.

There is always the danger that improving one aspect of a product may inadvertently degrade another. In this case, however, that has not been the result. For example, the original 7110 package was designed to offer protection from external magnetic fields to a level of 20 oersteds. Furthermore, the 7110 is specified to operate over a standard temperature range of 0° to 75°C.

In each case, the new package offers the same or better specifications than the leadless package. In terms of mechanical reliability, both the leadless and leaded package meet and exceed all vibration and shock test limits specified in MIL-STD-883. The leaded package precludes many mechanical problems since it does not depend on a leadless package socket for interfacing with the board.

One for one

The original 1-Mb bubble memory was developed along with a set of support ICs that handled all of its complex timing and drive functions and made its interface with a microprocessor bus indistinguishable from that of any *bona fide* peripheral semiconductor. Considerable engineering effort was applied to make these support circuits interchangeable.

Consequently, any support chip works with any bubble memory. This is in marked contrast to otherwise similar devices that need matched sets of support components.

Intel's 7114 4-Mb device uses the same architecture as the 7110, but now has eight identical sections (called octants) instead of four, and each section is enlarged to store double the number of bubbles it does in the current 7110. The result is a fourfold increase in capacity. However, all of the same pins are brought out in the same order on both bubble memories. Thus the pinout is identical and allows for the use of the same new package for both the new 1-Mb and 4-Mb devices.

Those support ICs that are not affected by the increased capacity, such as the coil predriver (7250) and drivers (7254), are used with either memory.

FIRST VERSUS SECOND GENERATION MAGNETIC BUBBLE MEMORIES

[illegible]	[illegible]	[illegible]	[illegible]
Memory (Mb)	1	1	4
Die size (in.)	0.620 by 0.520	0.580 by 0.500	0.580 by 0.500
Substrate material	ceramic	printed-circuit board	printed circuit board
Potting technique	liquid epoxy by hand	liquid injection molding	liquid injection molding

Those support ICs that have been designed in conjunction with the new memory are the same size and have the same pinouts as their counterparts in the 7110 1-Mb subsystems. What has changed is some of the programmable parameters and the descriptions of their associated registers. These are all involved with the new bubble-memory controller chip—the IC that interfaces the microprocessor bus with the 4-Mb memory.

Examining the effect of these changes in upgrading from a 7110 1-Mb to a 7114 4-Mb package reveals that the modifications are really minimal—the new support ICs can be designed into the same board layouts as their 1-Mb cousins. Users will have only to make some modifications in their software to handle minor differences in addressing and configuration initialization.

Intel's bubble-memory system therefore can have the same configuration whether working with 1-Mb or 4-Mb devices. A single bubble-memory controller acts as the interface between the microprocssor bus and one or more bubble storage subsystems.

The 7224 controller for the 4-Mb bubble-memory device is housed in a standard 40-pin, dual in-line package and takes up about 2 by 0.5 in. on a board. A single controller operates up to eight storage subsystems for a maximum capacity of 4 megabytes.

Each bubble-memory subsystem contains a monolithic formatter and sense amplifier in a standard 20-pin DIP; a current-pulse-generator chip in a 22-pin DIP; a coil-predriver chip in a 16-pin DIP; a pair of quad V-groove MOS driver chips, each in a 14-pin DIP; and of course the bubble device itself. One subsystem takes up less than 3 by 4 in., and a 4-megabyte board of eight of them plus a a controller could be constrained to 6.75 by 12 in.

Obviously, boards laid out for the 7110 1-Mb memory and its support family would be approximately the same size for one fourth the amount of memory. However, in a card cage with a standard 0.6-in. spacing, boards built using the original leadless packages could not be stacked in adjacent slots.

Converting from the earlier 7110 1-Mb to a 4-Mb system essentially requires modifications to the pin pads of the 7110's leadless package. The 7220-1 bubble-memory controller is the same size and has the same pinout as the 7224. The same is true for the 7242 formatter and sense amplifier and its 7244 replacement, as well as for the 7230 current-pulse generator and its 7234 substitute. Figure 4 shows how an identical board can support either a 7114 4-Mb or a leaded or leadless 7110 1-Mb system.

Space limitations, interface details, and other such criteria will typically dictate the actual board layout. □