Amorphous semiconductors Part I

Nonvolatile and reprogramable, the read-mostly memory is here

Integrated arrays combine amorphous and crystalline technologies; new memories could help realize promise of microprograming

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☐ Both the read-only and random access varieties of semiconductor memories leave something to be desired in many applications. RAMs' volatility allows data stored to disappear if power fails. On the other hand, ROMs' inflexibility commits them to data that cannot be changed.

A new kind of integrated circuit, the "read-mostly memory," avoids these problems. An integrated array of amorphous and crystalline semiconductor devices available in sample quantities, the RMM can be programed, read, and reprogramed repeatedly. And once programed, the RMM retains data unless it's intentionally altered. The RMM, therefore, doesn't need the data storage on card, tape, or disk required to back up a RAM if power fails. And the same RMM can be used even if the program must be changed; there's no need for the time-consuming and expensive process of making new masks and fabricating a new IC, nor is it necessary to substitute an electrically programable but fixed type circuit.

Microprograming—a computer technique in which a programer can at will change an operational code or sequence—probably will emerge as the most important application for these devices. The great promise of the microprograming concept has yet to be fully realized—even though the idea originated almost 20 years ago—because of the difficulty and cost of changing the contents of microprogram stores with available memory devices.

Several fertile areas exist where the read-mostly memory's special property of electrically alterable, nonvolatile data storage could be usefully applied:

- Airborne computers, which often require a different set of data for a particular mission or operational situation.
- Industrial control systems, in which "canned cycles" —stored instructions—must occasionally be altered for new tooling, instrumentation, or test procedures.
- General purpose computers in which, even though storage of fixed data is required, it is still desirable to make changes in the data during the design phase.

Physically, the new 256-bit RMM's organization is a 16-by-16 matrix of amorphous semiconductor cells, which must be isolated from each other by integrated silicon p-n junction diodes, as shown on opposite page, to prevent spurious paths in the array. The 122-by-131-mil chip size gives a packing density comparable to that of bipolar or MOS techniques, and should improve with fabricating experience. The chip is enclosed in a 40-lead ceramic dual in-line package.

Each cell in the memory consists of an Ovonic amorphous semiconductor device and an isolating diode in series on a silicon substrate, as shown opposite. The Ovonic structure itself consists of a film of amorphous semiconductor material between two molybdenum electrodes. Many such cells—series combinations of Ovonic devices and silicon diodes—are arrayed over the silicon chip, with each cell addressable by an x-y grid, as shown on opposite page, below. The cell behaves like a nonvolatile bistable resistor with an on-to-off resistance ratio of about 10^3.

Without the series diodes, a few adjacent Ovonic devices in the on (low resistance) state might make the Ovonic device being interrogated appear to be on when it's really off. The resistance of the adjacent on cells would shunt the off resistance. With the diodes, however, the back resistance of the diodes added to the on resistance of the adjacent cells prevents this ambiguity.

Despite some superficial resemblances, the amorphous semiconductor memory is quite a different animal from the electrically alterable, fusable type of memory recently introduced by such companies as Radiation Inc., Motorola Semiconductor, and the Solid State Scientific Corp. Although both types can be programed in the same way, the fusable type's program can't be changed, whereas the amorphous semiconductor RMM can be reprogramed repeatedly.

Changing the memory cell from a high-resistance (disordered) to a low-resistance (ordered) state and vice versa—that is, programing—is done by applying a pulse of a certain voltage, current, and duration. The cell can then be interrogated, or read, without changing its state by applying a constant current and measuring the voltage to determine whether the Ovonic device is in its high or low resistance state.