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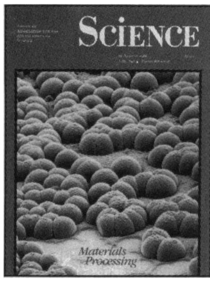

COVER Polycrystalline diamond balls grown at high supersaturation using combined hot filament and microwave plasma-assisted deposition. The source gas was 1.5% methane in hydrogen at 10 torr. The diameter of the balls is approximately 18 micrometers. See page 913. [Scanning electron microphoto is courtesy of Thomas Anthony, General Electric Corp., Schenectady, NY]

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Products & Materials

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High-Tech Materials Processing

The pace of research and development of high-tech materials continues to be impressive. Four articles in this issue provide a glimpse of the progress being achieved in microelectronic devices, artificial diamonds, and high-temperature superconductors. All of the articles deal with technologies having potential for large economic impacts. This is particularly true of the microelectronics involved in the $400-billion information-processing industry.

In the past, advances in microelectronics were a major contributor to the 20 to 30 percent annual reduction in the cost of computing that has characterized the last three decades. During that time, the number of circuits per chip increased from 1 to 100,000. Today chips contain as many as 10^6 memory bits. A group of authors from IBM tell us that straight ahead progress is expected for at least the next decade. Their article suggests how the trend to more circuits per chip will be achieved. For the immediate future, new additional photon beam–controlled processes will be used with more process steps and ever more finely patterned lateral dimensions and smaller vertical dimensions. The optical lithography currently practiced with resolutions down to about 1 micrometer will be extended to about 1/3-micrometer resolution, which the authors state will be sufficient to fabricate 100-megabit DRAM memory chips (5000 typewritten pages of text per chip).

Means of producing much more finely structured chips have already been explored. They involve use of electron beams that can be focused into spots a few angstroms in diameter. A chip has been produced containing circuits of field effect transistors with gates as short as 70 nanometers. The dimensions correspond to densities that will allow 1 billion memory bits per chip in the future. Improvements arising from tinier lateral dimensions will be supplemented by shortening vertical dimensions through epitaxial growth of thin layers. Excellent equipment for monitoring the structure of such chips is available in the form of the scanning electron microscope and the scanning tunneling microscope.

The other three articles on processing describe developments that are in early stages. Using ion beams 10^5 times more intense than those employed in doping semiconductors, White and Short have demonstrated the feasibility of creating mesotaxial growth of conducting layers within silicon semiconductors. When a beam of 200–kiloelectron volt cobalt ions strikes silicon crystals, the cobalt atoms come to rest at a range of distances from the surface. However, annealing the chip at 1000°C results in a migration of cobalt atoms against the concentration gradient to form a thin, single-crystal layer of $CoSi_2$ within both (111) and (100) silicon. An insulating layer of SiO_2 within silicon has been formed by a similar technique employing a beam of oxygen ions.

The formation of diamonds and diamondlike hydrocarbons at ambient pressure is described by Angus and Hayman. Because of the superior properties of diamonds, these products will have substantial practical applications. Diamonds grown on a substrate held at about 900°C from a vapor containing active small hydrocarbons and atomic hydrogen show the hardness and thermal conductivity of natural diamonds. Diamondlike hydrocarbons are formed when 50– to 200–electron volt hydrocarbon ions hit a substrate. The films formed, which can have a hardness approaching that of diamonds, may contain 20 to 30 atomic percent hydrogen and may be deposited on large areas at rates as high as 80 micrometers per hour. Their permeability to organic solvents and inorganic acids is extremely low. When the films are annealed at 400°C, they become more diamondlike in their electrical conductivity.

The fourth article, by Murphy and colleagues, reviews processing techniques for the $Ba_2YCu_3O_7$ high-temperature superconductor. The authors point out that attaining a high critical temperature is only one requirement. It is relatively easy to produce material that exhibits some magnetic field exclusion and zero resistance at temperatures above the boiling point of liquid nitrogen (77 K). But no one has yet produced material that has a large critical current and is in a form suitable for most desirable applications. The authors describe various synthetic processes and progress in producing desired shapes such as films and wires. However, they concluded, "The eventual use of the new superconductors may require new processing techniques as innovative as the discovery of the materials themselves."

—PHILIP H. ABELSON