# A National Facility for Making Submicron Structures

Microfabrication is the term used to denote making structures having characteristic features with dimensions of the order of 1 micrometer (micron). Although primarily the province of the semiconductor industry, microfabrication is not confined to microelectronic integrated circuits. Research on ultraminiature electronic, magnetic, optical, and superconducting devices is under way in numerous laboratories. But research in university laboratories is inhibited by an unfortunate inverse relationship that exists between the size of such devices and the cost of the equipment needed to make them.

To help alleviate the predicament of academic investigators, the National Science Foundation (NSF) is making a $5-million grant to Cornell University to establish a National Research and Resource Facility for Submicron Structures.

Officials at NSF emphasize that the facility is in no way intended to duplicate the capabilities of semiconductor manufacturers or to compete with them—a hopeless task, given the respective resources. There will be, for example, no attempt to make large batches of devices, an ability which is crucial to commercial success. Instead, activity is to focus on the fundamental problems of making structures with dimensions of less than 1 micron, problems whose solution could have an impact on commercial device-makers a decade or more in the future. And the structures need not be applicable to the electronics industry at all. According to Jay Harris of NSF, one hope is that the facility will enable investigators in various disciplines to first conceive and then build unique entities, such as ultraminiature probes for measuring ion concentrations within living cells.

Apart from integrated circuits, areas already identified where long-term research could benefit from a national facility for microfabrication include:

▶ Integrated Optics. Future optical communications systems using lasers and optical fibers to transmit voice, video, and digital data within cities and across long distances may use optical circuits that have features comparable in size to those of microelectronic circuits. Called integrated optics, such circuits would consist of a miniature laser and various waveguide-like structures that guide, reflect, transmit, and switch light of the proper frequency from one part of the circuit to another. It may also be possible to form composite optical signals from light of different frequencies (multiplexing), just as is done now in electronic signal processing. The dimensional tolerances in integrated optics are much finer than in integrated circuits because light is so easily scattered by irregularities in the optical circuit.

▶ Superconductors. One class of superconducting device consists of thin films in a special configuration called a Josephson junction. Such devices are already used to measure minute electrical voltages and very weak magnetic fields and to detect infrared radiation. One day they may serve as logic or memory elements in digital computers because they can operate much faster and can run on much less power than present semiconductor elements. Depending on the type of device, junction widths can be from 0.002 to 0.2 micron.

▶ Magnetic Bubbles. Magnetic bubbles are cylindrical domains in a magnetized film whose direction of magnetization is perpendicular to the film. Depending upon the orientation of an applied magnetic field, the magnetization can be "up" or "down," and the bubbles can therefore act as memory elements for computers. There is considerable interest in reducing the size of the bubbles from the present 6 microns to about 1 micron, necessitating arrays of bubbles having features with minimum dimensions of about 0.25 micron.

▶ Surface Acoustic Wave Devices. These structures convert microwave electrical signals to lattice vibrations that propagate along the surface of a piezoelectric crystal, such as quartz. The different characteristics of the electrical signal and the surface wave permit electrical engineers to design a variety of special devices for processing microwave signals, such as discriminating the true reflected wave from spurious waves in radar systems. At present, the upper limit on the frequency is set by the dimensions of the metal stripes on the piezoelectric that are used to launch and detect the surface wave and by the perfection of the crystal surface itself.

▶ Microfabrication Technology. Much of the future technology for making submicron structures will depend on the use of electron beams and x-rays to delineate the features of the structure. Numerous problems exist in making electron guns that can emit an intense beam of electrons into a narrow spot, in designing electromagnetic lenses to focus the electron beam, and in developing the sensitive polymers needed to rapidly respond to electron or x-ray beams. Further processing then transfers the pattern generated in the polymer to the structure that is being built.

The microfabrication facility will reside in a new wing added to the Elecrical Engineering department at Cornell, and its organization is planned to follow a format common to most large centers. There will be a policy committee composed of three persons from Cornell and four from outside to establish overall policy and to advise NSF. A program committee, largely composed of users of the facility from outside Cornell, will oversee day-to-day operations and select projects from among proposals submitted by prospective users. There will also be a professional staff to operate the facility, which will be headed by a director not yet selected. (Acting director is Joseph Ballantyne of Cornell.) The facility is conceived to be a "hands on" laboratory, not a "job shop," and visiting researchers will not be able to expect the staff to do more than provide guidance on the use of the available equipment.

Among the equipment that the facility will have are a computerized electron beam pattern generator and a system for molecular beam epitaxy. In the latter process, beams of atoms in an ultrahigh vacuum system are directed toward a substrate in such a way that a single crystal with controlled composition is built up, one atomic layer at a time. The facility will also have conventional crystal growing, materials processing, and diagnostic equipment. Among the latter will be a scanning transmission electron microscope, an instrument that combines the high resolution of transmission microscopes with the capacity to obtain certain additional information that the scanning feature provides.

Of the $5 million committed to the project so far, $2 million is slated to be spent the first year, with $750,000 available for each of the next 4 years. This level of support was at the low end of the range of figures suggested, at workshops held by NSF last year, as being large enough to have a perceptible impact on the state of the art. Officials at NSF now think the figure is adequate in part because, they hope, many visiting researchers will be partially supported by other sources. In any case, it seems that the trend toward the establishment of centralized facilities in many fields, driven by the realization that no one researcher can afford the ever increasing cost of needed equipment, is continuing apace.

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