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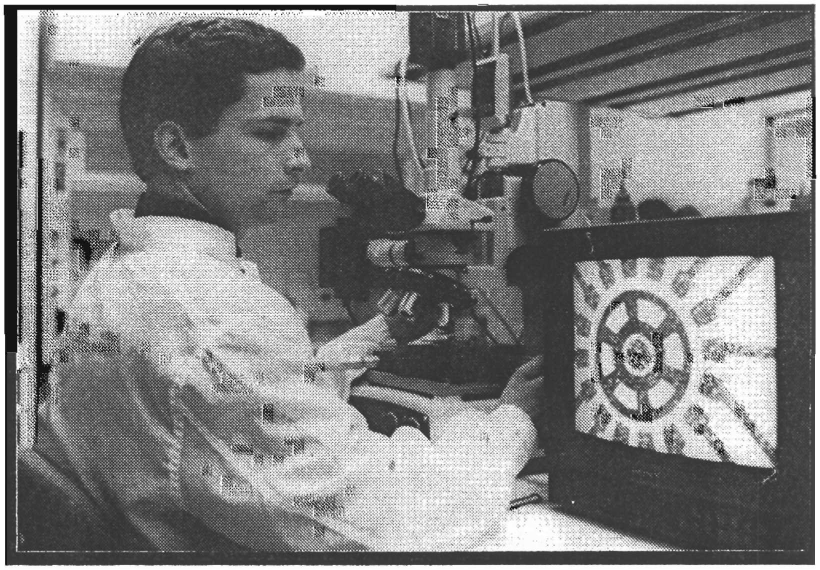
THE COMMON MAN'S MICROMACHINE? RESEARCHERS CUT THE COST OF TINY GEARS AND MOTORS BY USING STANDARD EQUIPMENT

The ability to fabricate microscopic motors, gears and other components has permitted the development of "micromachines" small enough to operate on the surface of a microchip -- or even inside the human body. But manufacturing the tiny metal parts that will be needed to make many of the micromechanical systems practical requires costly equipment now available only at a few large laboratories.



Graduate Student Bruno Frazier studies components for a micromachined motor with an optical microscope. The components were produced using a new technique. (Color Slide/B&W Available)

Now, a group of scientists at the Georgia Institute of Technology has developed a new technique it believes will allow many more laboratories to share in development of the tiny machines. Based on microscopic plastic molds and conventional electroplating methods available at most microelectronic fabrication facilities, the technique could reduce the cost of manufacturing the components from various metals.

"We are trying to make this technology available to anyone who has a clean room," explained Dr. Mark G. Allen, assistant professor of electrical engineering. "We are trying to find the middle ground between the relatively expensive structures being made in a few laboratories and the thinner structures that have been produced with conventional processing equipment."

Using microfabrication and clean room facilities at Georgia Tech's Joseph M. Pettit Microelectronics

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Research Center, the group is fabricating components for use in variable-capacitance motor structures 300 microns in diameter and 50 microns thick. Motor components made of copper and nickel have been fabricated so far.

The process relies on photosensitive polyimide, a polymer plastic material commonly used for packaging microchips. Using conventional microelectronic lithographic techniques, the Georgia Tech group places patterns of motors, gears or others components onto the polyimide, then chemically etches out tiny cavities.

The cavities then serve as molds, which are filled with copper or nickel using standard electroplating technology. After the metal components are formed, the polyimide mold is carefully etched away, leaving a finished micromachine. Because the photolithographic process creates straight edges in the polyimide, the technique produces well-defined components, Allen said.

"The technology of combining polyimide and electroplating is well developed from the point of view of electronic packaging," he noted. "We are taking proven technology and applying it to micromachining."

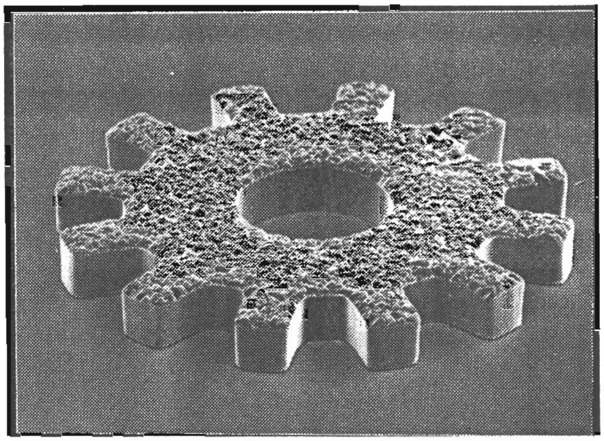
Early micromachines were made of silicon using technology common to the microelectronics industry. But because they were just a few microns thick, these "pancake" micromotors were able to generate barely enough power to overcome friction.

Scientists realized that if micromachines were to generate enough torque to do useful work, they would have to be fabricated in more substantial thicknesses.

To do that, scientists developed a technique using X-ray synchrotron radiation, which allowed the production of components that were many times as thick as they were wide. Such components were sturdy enough to be practical, and could generate useful amounts of torque. But since synchrotron equipment is not widely available, micromachine research based on this technique was limited to the few institutions having access to that equipment.

Allen and Graduate Student Bruno Frazier have produced parts with aspect ratios as high as eight to one. While that is not as good as parts produced through the synchrotron technology, Allen believes the thinner parts will still be brawny enough for many applications -- and inexpensive enough for many researchers to use.

"The idea is to be able to make these gear and micromotor structures using processes that are available to many," he added. "We are borrowing from the electronic packaging industry, where people typically do build up relatively large structures. And we don't have to bring any strange or new materials into the clean room environment."



Scanning electron microscope picture shows copper microgear approximately 300 microns in diameter by 50 microns thick.

Allen sees some initial applications in positioners that would operate on the surface of a microchip. Such positioners, he suggested, could be used as a stage for a scanning tunneling electron microscope, or as a platform for positioning lasers to fiber optic cable.

Also participating in the work were Jonathan W. Babb and Dr. David G. Taylor. Details of the process will be presented to the American Society of Mechanical Engineers (ASME) Symposium on Micromechanical Systems in Atlanta later this year.

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