

# Lensless Lithography

Scientists at IBM have used a pliable, light-coupling mask placed directly on a silicon surface to form structures as fine as 100 nm, an achievement that may well herald a new era in the fabrication of microcircuits on silicon wafers.

The mask, called a "light stamp" by its developers at IBM's Zurich Research Laboratory in Switzerland, is made from a rubbery plastic that conforms closely to a silicon wafer even when there are variations in the height of the wafer surface.

Protruding features on the light stamp form the pattern that is to be transferred to the silicon wafer. When light passes through the stamp, the protrusions shift the light to a shorter wavelength and guide the intensified light to the substrate. Other areas block or reflect

light so it does not reach the substrate. The intensified light, confined in the well-defined channels of the stamp, produces patterns with sharp boundaries on the light-activated photoresist material on the wafer surface.

After its exposure to light, the photoresist material is etched away to create the desired circuit patterns. Because the light does not have to be focused through precision lenses, the microcontact process does not suffer from the diffraction or size limits of the optical-lithography technique now used to create microcircuits on silicon. The light stamp requires only direct exposure to high-intensity light at 248 nm to form 100-nm structures. The silicon master molds used to form the light stamps are made by a combination of electron-beam writing and reactive ion etching. To fabricate a light stamp, polydimethylsiloxane is cast on the master mold and then peeled away after curing.

Previous work on high-resolution contact lithography made use of chrome-on-glass masks. Because glass masks are rigid, uniform contact over a large area is difficult to achieve. The pliable light stamp, on the other hand, makes uniform contact over the entire wafer surface. IBM researchers are expecting that each stamp will last for about 1,000 substrate impressions.

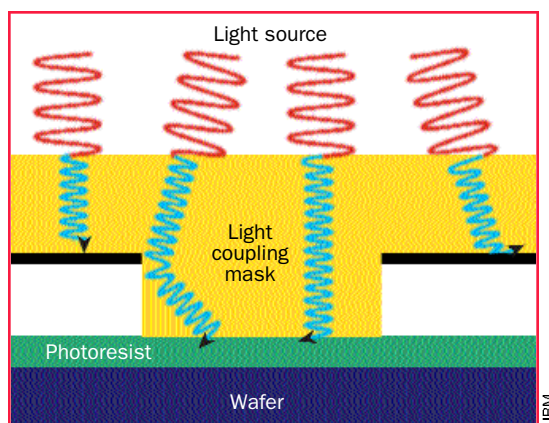
Today's microelectronic devices are made with several layers of circuits and connecting

wires. Each layer is formed by repeating the conventional photolithographic process, which requires dozens of steps that must be precisely aligned with one another. IBM researchers hope to make the light-stamp technique suitable for multiple-step lithography. One approach fuses stamps on quartz plates, which then

can be accurately aligned.

IBM has set up a team to adapt the microcontact process to manufacturing environments. In addition to its use for fabricating circuits on silicon chips, the light-stamp spacing method can be applied to the manufacture of patterned optical devices such as filters, gratings, and polarizers.

In a variation of the technique, called microcontact printing, the stamp is "inked" with a reactant or other material, which then is transferred directly to a surface by a printing process. Microcontact printing may have important application in the fabrication of light-emitting-diode displays, biosensors, and molecular electronic devices. IBM is also working on high-resolution nanocontact printing, nanoembossing, contact fabrication of nanowires, and contact processes for microfluidics and for aligning biological molecules in space and connecting them.



**Light from a conventional source, shortened in wavelength, is blocked in areas not in contact with the stamp and produces sharp patterns where the stamp is in contact.**

## — Update —

In 1995, Cornell University's Johnson Graduate School of Management began a 12-month option (TMO) for students with a graduate science or engineering degree who want to acquire an MBA in one year instead of the usual two (see *The Industrial Physicist*, 6/96, pp. 32-34). A total of 87 students have received MBAs on the TMO track, and the class of 1999, which began this summer, numbers 41. The current class, the largest yet, consists of about equal numbers of people with master's degrees and Ph.D.'s, along with a few M.D.'s. In 1996, about three-quarters of the students entering the TMO track held a master's degree, and one-quarter had a Ph.D. Cornell reports an increasing number of inquiries from companies interested in sponsoring their own employees for the 12-month course.

Carthage College (Kenosha, WI) has created one of the first undergraduate minor programs in the United States that integrates business entrepreneurship, science, and technology. The program, called ScienceWorks, was launched four years ago with financial support from Carthage alumnus Donald D. Hedberg. It is directed by Douglas Arion, professor of physics, who previously served as manager of the applied physics and engineering division of Science Applications International Corp., a large science and technology consulting firm.

ScienceWorks' entrepreneurial business program provides course work in fiscal management, marketing, regulatory issues, and business practices. Seminars are led by experienced business professionals, and students spend one summer as an intern with a company. Seniors in the program prepare a comprehensive business plan for a realistic business project, and process patent, trademark, and incorporation papers.

Stanford University has begun offering its first completely on-line graduate-degree program, a master's in electrical engineering. Admission and completion requirements are the same as for on-campus students. Harvard and Wharton business schools are developing on-line business courses with Pensare, Inc. (Los Altos, CA). □