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In Situ Technologies for Semiconductor Patterning

In situ processing methods simplify fabrication of semiconductor devices and, furthermore, eliminate exposure of surfaces to air, liquids, or human operators. The principal methods for *in situ* patterning of semiconductors are reviewed. Two methods, laser-direct writing and excimer-laser projection, appear to be promising candidates for advanced semiconductor fabrication. Ion-beam techniques will have important special applications.

In situ processing of microelectronics may permit the fabrication of semiconductor devices by dramatically simpler and more precise methods than those of current technology [1]. These processing methods are based on new and potentially revolutionary nonlithographic technologies, and rely heavily on the still developing area of beam-controlled techniques for microfabrication.

The underlying principle of *in situ* processing is the replacement of the current indirect semiconductor patterning process of photoresist pattern-transfer sequences with direct-photon-, electron-, and ion-beam-controlled techniques that produce microscopic reactions on the semiconductor. This approach, in principle, eliminates the usual solvent and air exposure, which degrade critical electronic surfaces in resist processing.

In the most advanced application, an electronic device could be completely processed within a single vacuum chamber, in a manner similar to molecular-beam epitaxy technology. A second application, already partly realized, is real-time fabrication (again without photoresists), using "closed-loop" construction, of highly precise microdevices. This approach streamlines conception, design, and fabrication sequences and allows more efficient realization of new device ideas. Current fabrication technology is ponderously slow and inordinately expensive for prototyping, and therefore impedes the development of new device and circuit designs. To address these limitations, *in situ* processing combines existing and future beam technologies with compatible nonbeam methods — to achieve total vacuum and/or real-time fabrication.

New semiconductor patterning technologies offer possibilities ranging from development of a 0.25-μm optical lithography to an entirely nonlithographic laser-direct-writing technology for post-fabrication (final-step) processing and circuit prototyping. The former could provide a simpler, faster, and less expensive alternative to x-ray, electron, or ion-beam lithography for next-generation VLSI. The latter could be used for high-accuracy trimming, wafer-scale integration, and interactive circuit design.

Studies of laser-controlled microchemical reactions for deposition, etching, and doping of electronic materials began in the early 1980s. Since that time, an increasing number of research groups have become interested and an increasing breadth for these processing methods has been demonstrated. A variety of technology targets have been identified.

Beam patterning is probably the most critical area of development for the new technology. The principal alternatives to classical lithography are focused-beam-writing methods, for low-volume operations where turnaround time or process localization is at a premium, and *in situ* flood-beam printing methods for high-volume production. Because the applications and the critical issues are quite different, we consider these two classes of methods separately.

Focused-Beam-Writing Methods

The most mature of the beam-writing methods, in terms of instrumentation, is electron-beam technology. A source and/or space-charge-limited flux of 10^{18} quanta/cm^2 s can be readily delivered to a substrate. Commercial scanning-electron-beam instruments can achieve <10-nm spot sizes, can register to about 50-nm precision over large fields, and can scan at multiple-MHz pixel rates. A particular strength of this technology is the sophistication of the software control that has been developed for lithography. Although research [2,3] in direct processing (deposition) extends from the 1950s, applications are limited by the small particle momentum and low cross sections of gas-, adsorbed-, and solid-phase reactions. Therefore, reactive electron-beam processes generally cannot utilize the high scan rates that are achievable.

The constraint of cross sections is generally greater at the typical high energy (20 to 100 keV) of most electron-beam columns. Current research [4,5] has begun to stress lower-energy primary beams and reactions stimulated by secondary electrons, where cross sections are much greater. At the moment applications of electron-beam reactions remain in the research environment.

An alternative direct-writing technology, based on surface reactions stimulated with UV/visible lasers [6,7], has been vigorously developed since the late 1970s. An almost arbitrarily high quantum flux (>10^{24} quanta/cm^2 s) can be achieved. Spot sizes are limited by diffraction to ~0.5 μm, although nonlinear reactions permit practical writing of features less than 0.25 μm. Intense research activity over the last five years has led to the demonstration of a large variety of deposition, etching, and doping reactions.

Laser-direct writing employs a scanned micrometer or submicrometer reaction for serial, but real-time, modification of electronic structures. Although a conceptually radical departure from planar fabrication technology, direct writing is intended as a new tool to enhance this existing technology. Such *in situ* writing offers solutions to some perenially awkward problems for lithography.

Commercial instrumentation, however, lags laboratory systems significantly. Although laser-writing instrumentation has been demonstrated to be capable of matching or exceeding [8] electron-beam technology in pixel rate, the registration and imaging capabilities of optical systems are fundamentally more limited. This disadvantage is offset, for reasons to be discussed below, by reaction speed, because good laser reactions are many orders of magnitude faster than alternative beam-writing techniques. A few applications are now in manufacturing practice, with several others in early stages of commercialization. Table 1 lists several of these applications.

A third alternative, focused-ion-beam technology, shares many of the properties of electron-beam technology, and, in part because of this, instrumentation has been developed very rapidly. Achievable fluxes with bright sources (*eg*, Ga^+, Si^{++}) are ~10^{18} quanta/cm^2 s in 200-to-50-nm-diameter spots. The greater momentum of ions relative to electrons provides greater substrate/chemical activity. In addition, direct-write ion implantation is an attractive potential application. Many articles describe the status of this technology [9].

Focused-ion-beam deposition has been applied commercially to photomask repair. In addition, several laboratories have attached focused ion beams (FIB) to molecular-beam epitaxy systems to achieve *in situ* three-dimensional patterning.

Molecular-Flux-Limited Rate

Efficient beam-writing reactions operating in the gas phase are often limited, not by the arrival rate of beam quanta, but by the molecular flux of reactants onto and away from the surface in the vapor. This molecular flux depends on ambient pressure and, at high pressures, on the size of the reaction volume. A simple treatment considering diffusive transport of reactants is given in Ref. 6. Figure 1 shows the steady-state rate calculated for a reaction efficiency of 0.1 (one out of ten incident molecules react at the

Table 1. Representative Laser-Direct-Write Applications and Processes

Application	*Process*	*Reference*
Gate-Array Structuring	p^+-polysilicon deposition by 488-nm pyrolysis of SiH_4/B_2H_6	7(b)
Patterned Etch of Si	488-nm-driven photochemical thermal etch by Cl_2	7(c)
Mask Repair	Cd deposition by 257-nm photolysis of $Cd(CH_3)_2$; Cr deposition by pyrolysis of $Cr(CO)_6$	7(d), 7(e)
Patterned Etch of Al	Thermally driven etch by $HNO_3/H_3PO_4/K_2Cr_2O_7$ solution	7(f)
Two-Level IC Metallization	Pyrolytic W deposition from WF_6, ablative via formation	7(g)
Microwave Circuit Tuning	Pyrolytic W deposition from WF_6, ablative via formation	7(h)
Nonplanar Self-Developed Lithography for Hybrid Interconnect	Cl_2 etch of amorphous Si layer	7(i)

surface) and for various beam spot sizes. At large (1000-μm) spot size, boundary-layer effects become dominant, restricting reactant arrival and departure rates. The size of the reaction zone limits rate enhancement, which smaller zones experience with increasing pressure (*ie*, above a few Torr). This is also the usual pressure/rate limit of large-area reactions in conventional processing.

At smaller, *eg*, 1-μm beam size, rates increase nearly linearly with pressure to pressures of several atmospheres. This full enhancement is realizable in laser deposition, where pressure scaling frequently permits rate enhancements of 10^3 over conventional large-area chemical vapor deposition in the same chemical systems. Pressure scaling in electron-beam and ion-beam systems is restricted by the requirement of high vacuum at the beam source. Nonetheless, with differential vacuum pumping and localized injection of the reactant, it has been possible to reach effective molecular pressures of ~1 Torr at the reaction zone for focused-ion-beam deposition. This distinction is important in locating the strategic areas of application of the two technologies.

Comparison of Focused-Ion-Beam and Focused-Laser Technologies

At this time, the principal writing alternatives for *in situ* processing are the focused-ion-beam and laser-direct-write technologies. Key characteristics of each are listed in Table 2. The FIB has advantages in the sophistication of instrumentation and in resolution, both of which carry over for processing operations and also for imaging and registration. Laser technology has advantages in quantum energy (2 to 7 eV), which is close to typical chemical-

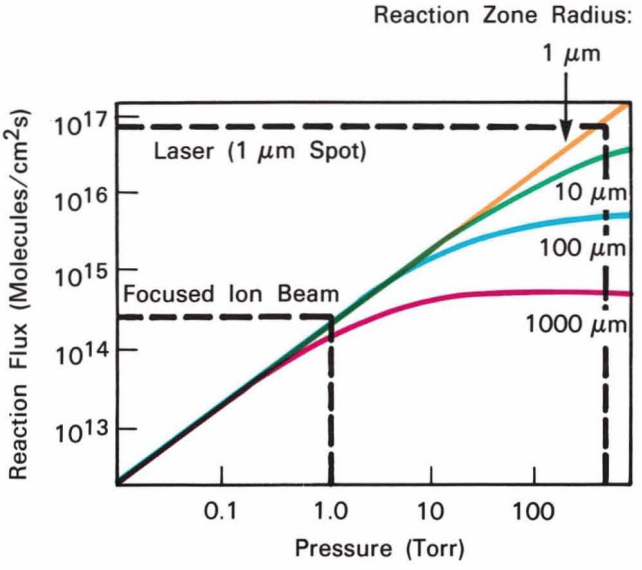

Fig. 1 – Results of a general analysis of process rate limitations for focused-beam microchemical techniques in the high-rate mass-transport-limited regime. The modeling (from Ref. 6) takes into account mass transport limitations by gas-phase diffusion. The transport limit is calculated for 1,000-μm, 100-μm, 10-μm and 1-μm beam diameters and a 0.1 surface-reaction efficiency. In all cases, boundary-layer effects pin rates as reactions are scaled to higher pressure. However, smaller beam diameters permit scaling to much higher rates. Focused-ion-beam (FIB) reactions are limited currently to ~1-Torr effective pressures by the efficiency of differential pumping schemes. Laser reactions are limited to about one atmosphere in current reaction cell designs.

bond strengths (permitting chemical selectivity), and in the magnitude of the beam flux that can be delivered in a relatively small spot. The greatest advantage of the laser is probably the transparency of (high-pressure) gases to photons, which permits process diversity and speed.

In practice, both technologies have carved out different niches. Figure 2 illustrates the overlap in microchemical processing. Limitations in throughput prevent both technologies, in their simple forms, from economic mass production of silicon chips. However, nonlinear and monolayer surface-modification reactions could extend the use of both technologies. Laser-writing techniques may enter a regime of limited-purpose mass chip production after considerable development. The likely areas of application for direct-writing techniques are device research, mask repair, trimming, prototyping, and packaging of high-density digital and optoelectronic systems. Both laser and ion-beam methods are likely to be used for circuit surgery (*ie*, debugging and analysis). As noted first at the Optoelectronics Joint Research Laboratory [10], FIB have a natural synergy with molecular-beam epitaxy machines.

Table 2. Beam Characteristics for Writing Applications

(I) Focused Ion Beam	*(II) Laser Beam (Photomechanical)*
Resolution: ~0.05 μm	Resolution: 0.2-1 μm
Quantum: 30-200 keV	Quantum: 2-7 eV
Flux: ~10^{18} quanta/cm^2 s	Flux: ~10^{24} - 10^{27} quanta/cm^2 s
Special Strengths	Special Strengths
Sophisticated Scanning	Selective Photochemistry
Large Particle Momentum	High Speed
Functions	Functions
Implantation	Deposition
Etching, Deposition	Etching
Imaging and Registration	Shallow Doping

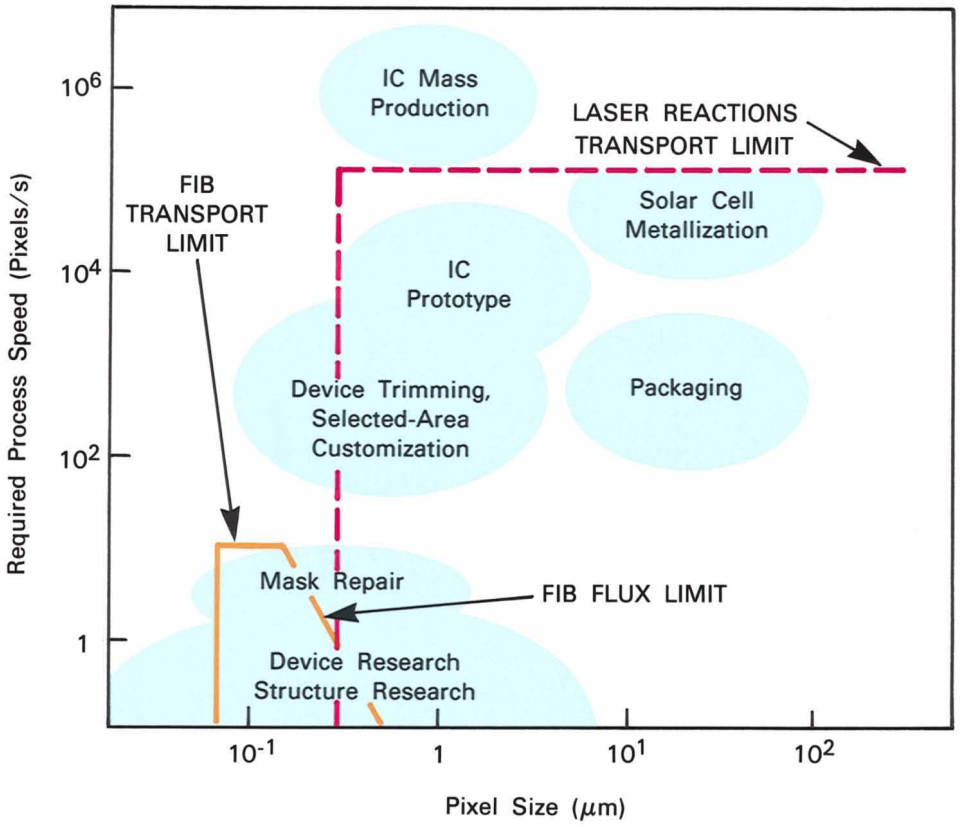

Fig. 2 – Current focused-beam microchemical processing applications in electronics, classified by required resolution and pixel-writing rate. The blue line circumscribes the region currently addressed by FIB; the red line marks a similar region addressed by focused lasers. The molecular-reaction flux limit in each case is indicated. A falloff in pixel rate at large pixel size for FIB processing results from the finite total beam flux available from liquid-metal ion sources. FIB technology has important resolution advantages but is limited by the effects illustrated in Fig. 1 to lower process rates. Both technologies are potentially extendable, by a factor of three to five, to smaller pixel size using nonlinear reactions (already demonstrated for focused lasers). And by using surface-modification processes, FIB and focused-laser technologies can be extended upward in rate by several orders of magnitude.

Printing Technologies

Pattern printing methods employ either extended-field-of-view projection techniques or proximity masks. These printing methods have been applied by using photons, ions, and electrons in all conceivable combinations. At the moment, the most vigorously developed — and also the most suitable for *in situ* processing — are optical projection and (for high resolution) ion-beam proximity/projection techniques. Ions are favored over electrons (among other reasons) for having very little proximity effect; the more limited lateral range of the ion exposure leads to sharper features.

Optical projection technology will become vastly more capable of *in situ* processing when deep-UV excimer lasers, which offer resolution and depth-of-field advantages, are incorporated as radiation sources [11]. The configuration originally used in Lincoln Laboratory experiments is shown in Fig. 3. Deep-UV (193- or 157-nm) light pulses, 20 ns in duration, illuminate a nearly conventional photomask that is imaged at reduction onto the wafer. A typical fluence at the wafer is ~30 to 300 mJ/cm^2 (1-to-10-MW/cm^2 peak intensity). This fluence is sufficient to induce many forms of nonlinear solid or solid/vapor reactions including, for example, ablation of thin films from the wafer. As shown in Fig. 4, extraordinarily high resolution (the highest of any optical printing technique) can be achieved. Theoretical throughputs equal those of current mass-production methods, but instrumentation and supporting alignment/overlay technologies to exploit the resolution remain to be developed.

Excimer-laser projection is intended as a new lithography for mass production. The far-UV or vacuum-UV output of a small excimer laser is used in a geometry similar to that of a conventional reduction stepper. Excimer projection is potentially important both as a novel resist and as a resistless patterning technology. A variety of new reactions based on interfacial chemistry, defect injection, or solid transformations are induced in extended-area

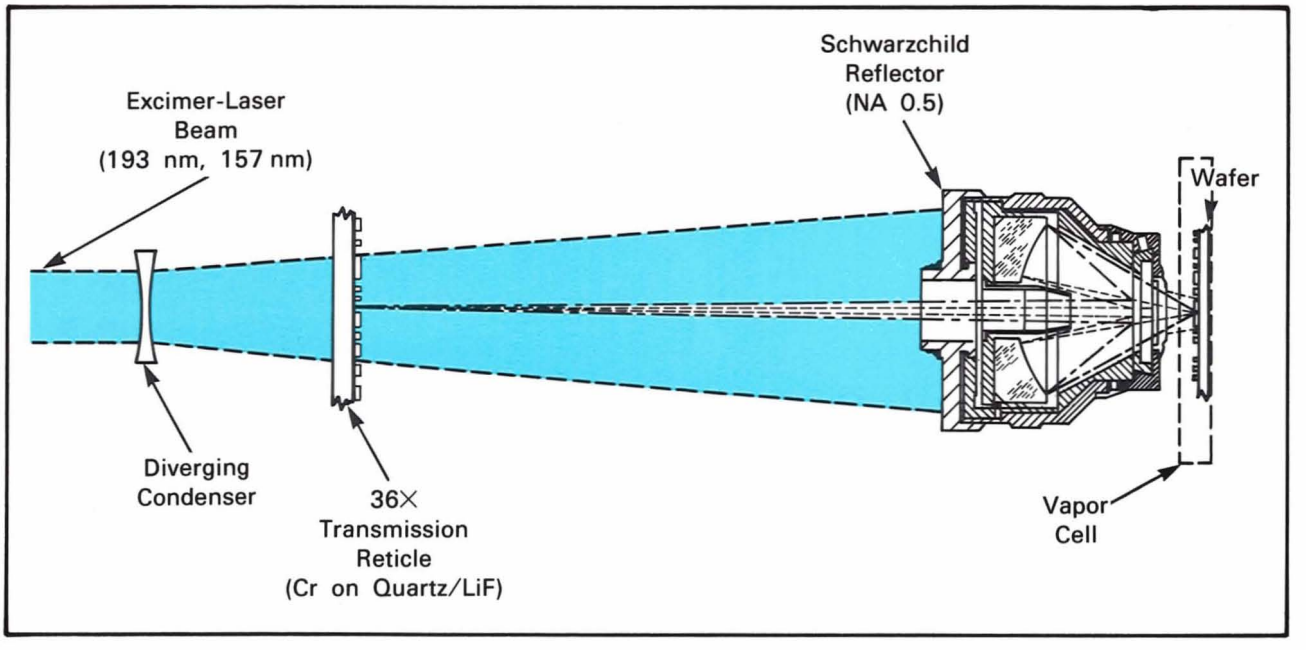

Fig. 3 – Configuration for the original submicrometer-resolution excimer-projection printing experiments (Ref. 11). Pulsed 193-nm or 157-nm light from an excimer laser illuminates a transmission mask in much the same geometry as optical step-and-repeat machines. Reflective optics are used to reduce the image of the reticle onto the wafer. The wafer is mounted in a vapor cell to control the ambient environment.

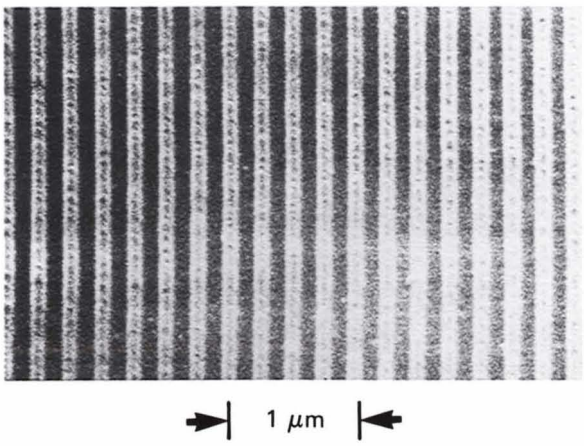

Fig. 4 – Scanning-electron micrograph of 0.13-μm lines and spaces in diamond-like carbon resist on GaAs. The 150-nm-thick resist was deposited in a radio-frequency plasma in butane gas at 10-mTorr pressure, in a geometry similar to that of a reactive-ion-etching system. Exposure was in air, with one 193-nm excimer-laser pulse; the fluence was about 0.13 J/cm². The fluence is near threshold for ablation, and its effect is blistering of the carbon, which permits subsequent transfer into the GaAs substrate by reactive ion etching. The unexposed carbon serves as the etch mask.

patterns. It is anticipated that, based on its potential resolution, speed, and cost of implementation, this technology could become a viable 0.25-μm production technology. Although less radical a departure in philosophy from current methods, the surface interactions used for excimer processing are often more radically new than direct-writing reactions.

An alternative printing technology with yet higher resolution is the masked-ion-beam method [12-14]. As with optical projection technology, the theoretical throughput of the masked-ion-beam technology is sufficient for mass production. The configuration and a typical result are indicated in Fig. 5. A collimated flux of accelerated (50-to-100-keV) ions (for example, protons) are directed through a stencil [12,13] or channeling [14] mask onto a substrate. The source is typically a conventional ion implanter, which will deliver a 10^{13}-to-10^{14}-cm^{-2} dose, acceptable for driving many reactive processes in a few seconds or less. A significant advantage for *in situ* processing, relative to other high-resolution (*eg*, x-ray) methods, is the allowance of a large (>100-μm) mask/wafer gap without loss of linewidth control. As with x-ray lithography, practical mask technology is an active and important area of research. Recently, efforts to develop a reduction ion-projection technology employing stencil masks have increased [15]. This technology could relax aspects of the thermal-loading and mask-fabrication (feature size) constraints of masked-ion-beam methods and could allow macroscopic separation of the mask and wafer.

Processing Issues

Laser-direct patterning methods for deposition, etching, and doping of different electronic materials are currently available for more than 100 different surface reactions. For direct writing these have been reviewed recently [6]; many techniques based on photochemical or thermal reactions in vapors or liquids have been developed. A linewidth of 0.2 μm, well below the Rayleigh limit, can be achieved in well-controlled reactions [16].

The available methods developed are summarized in Fig. 6, which locates generic classes of laser techniques as they now stand with regard to rates and induced local temperature. Since virtually all surface reactions are accelerated by heating, the trade-off between rate requirements and maximum temperature often determines the choice of method for an application. The photochemical methods on the left side of the figure, for example, are better for processing membranes or fragile semiconductor substrates; the speed of higher-temperature thermal methods on the right makes them preferable for less sensitive applications.

Steady-state rates for laser reactions are far higher than they are for the closely related traditional counterparts [6]. For example, pyrolytic silicon chemical vapor deposition (CVD), which in a traditional furnace typically has a maximum useful rate of less than 10^{-2} μm/s, produced excellent electronic-grade poly-Si at a rate greater than 10^{2} μm/s in laser-direct writing [6]. For this reason, laser-direct writing has been applied to such applications as circuit

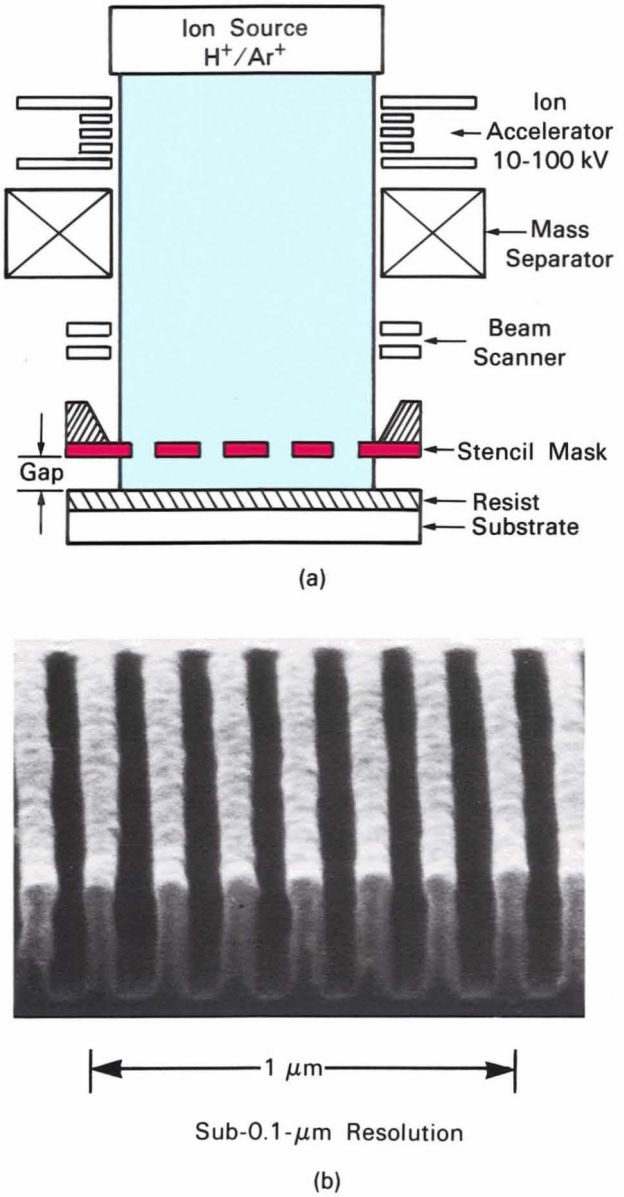

Fig. 5 – (a) Schematic representation of the Lincoln Laboratory masked-ion-beam lithography exposure station. A beam of ions (H^+ or Ar^+) of about 20 to 100 keV is generated and mass-selected by an electromagnet. A set of scanning plates is used to rock the beam angle when needed. The ion flux has a beam divergence of less than 0.5 mrad and a current density of 0.2 μA/cm², with a better than 99% uniformity over 1 in². The stencil mask has transmission holes in a 1-μm-thick SiN_x membrane and is separated from the sample by an intervening spacer to form a gap ranging from 25 to 300 μm. (b) Scanning-electron micrograph of 80-nm lines and spaces exposed in 300 nm of polymethylmethacrylate (PMMA). A 50-keV proton beam and a total dose of 2×10^{13} ions/cm² were used with a 1-μm-thick SiN_x stencil mask at a 25-μm gap. The exposure time was 10 s, followed by 30-s development in a 40% methyl-isobutyl ketone/60% isopropyl-alcohol solution.

prototyping, mask repair, and *in situ* design or trimming.

For projection microchemistry, which uses a short-pulse excimer source rather than the continuous-wave laser sources of direct writing, reactions are just beginning to be developed [17]. Some of the methods of direct writing should be immediately transferable.

Among the most useful near-term processes for projection microchemistry may be reactions based on solid transformations in thin films, which are illustrated by the Al/O cermet system in Fig. 7. In this process, a thin film, typically about 100 nm thick, of a metastable Al/O composite is deposited by evaporation of Al under a controlled oxygen ambient. The film is exposed to single 20-ns ArF-laser pulses, which renders it dry- or wet-developable. The high sensitivity and contrast of such rugged etch-resistant films permits efficient patterning and gives a resolution of less than 0.5 μm [17]. Thus the great strength of excimer microchemical methods may be in lithography-like technologies, which are likely to be relatively straightforward extensions of current optical projection techniques.

Excimer Projection with and without Resists

The advantages of excimer lasers for more or less traditional resist exposure have been discussed [18]. Now, however, new inorganic resist and resistless processes are under development.

Apart from the implicit attractiveness of a short wavelength and an easily obtained high-UV flux, excimer projection offers two key capabilities. One is very high contrast ($\gtrsim$10), because it is not limited to the relatively narrow confines of traditional organic resists. And related to this property is the second key property, sensitivity enhancement (*ie*, positive nonreciprocity), which accompanies high-dose-rate exposure in many microchemical reactive systems [17].

Many systems undergo orders of magnitude-sensitivity enhancements (reduced required total dose) as the dose rate is increased by

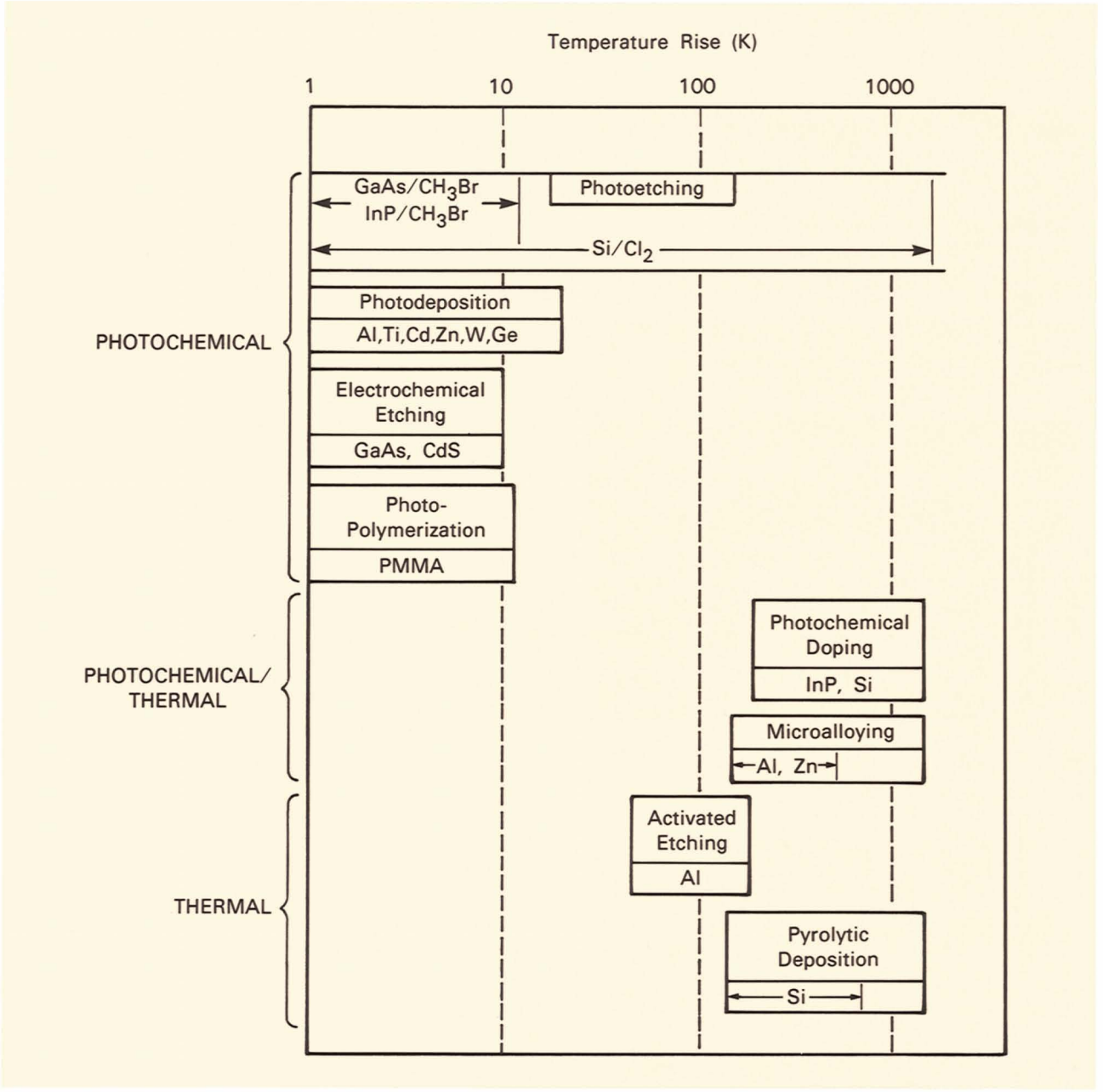

Fig. 6 — Classification of laser-induced microreactions by their induced surface temperature rise. The photochemical reactions operate at very low temperatures; the thermal processes offer much higher reaction rates.

increasing the incident pulse energy. Single-pulse exposure, an advantage for exposure-tool design simplicity, can be obtained in many systems. An example of 0.4-μm lines and spaces in 1.5-μm-thick polymethylmethacrylate (PMMA), obtained with ArF projection, is shown in Fig. 8.

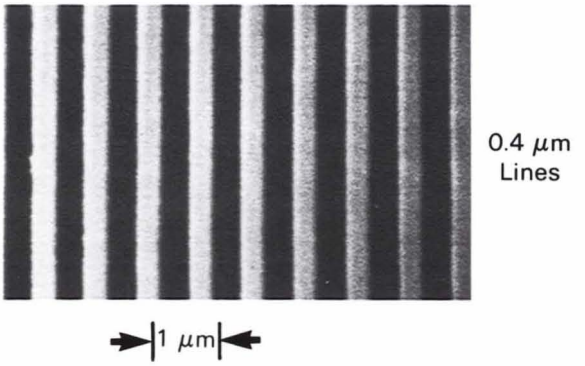

Fig. 8 — Projection patterning of an organic bilayer. A 140-nm-thick film of AZ 1350 J, which served as the imaging layer, was ablated in one pulse (80 mJ/cm ^{2}) of 193-nm radiation. The underlying planarizing layer was 1.5-μm-thick PMMA. Following patterning of the imaging layer, the PMMA was exposed to UV-lamp flood illumination and the exposed areas were wet-developed. The photograph is a scanning-electron micrograph of 0.4-μm lines and spaces. Some damage is done to the fragile structure by the heavy electron dose used in scanning-electron microscopy.

Circuit Prototyping by Microchemical Direct Writing

The long lead time required to create masks and to process ICs conventionally makes interactive modification of circuits in a test environment a desirable capability. A series of laser-microchemical techniques was developed for restructuring a semicustom integrated circuit under test [7a]. Two such laser-activated processes, one for local aluminum etching, the other for poly-Si deposition, were used in the initial application. The first process (used to eliminate existing connections) is a chemical etching process, which is thermally activated by a tightly focused laser beam. The second process (used to add connections to the existing circuit) is laser-activated CVD of boron-doped poly-Si.

Using these two tools, a designer can debug and optimize a circuit after conventional fabrication. Many tasks can be performed that previously required multiple passes at design or computer simulation. Circuits can be modified with design corrections, they can be optimized for performance, redundant sections can be added or deleted to improve yield, problem sections can be isolated and connected to bonding pads for testing, and, ultimately, small quantities of semicustom circuits can be created without masks or conventional processing. The approach used to demonstrate these

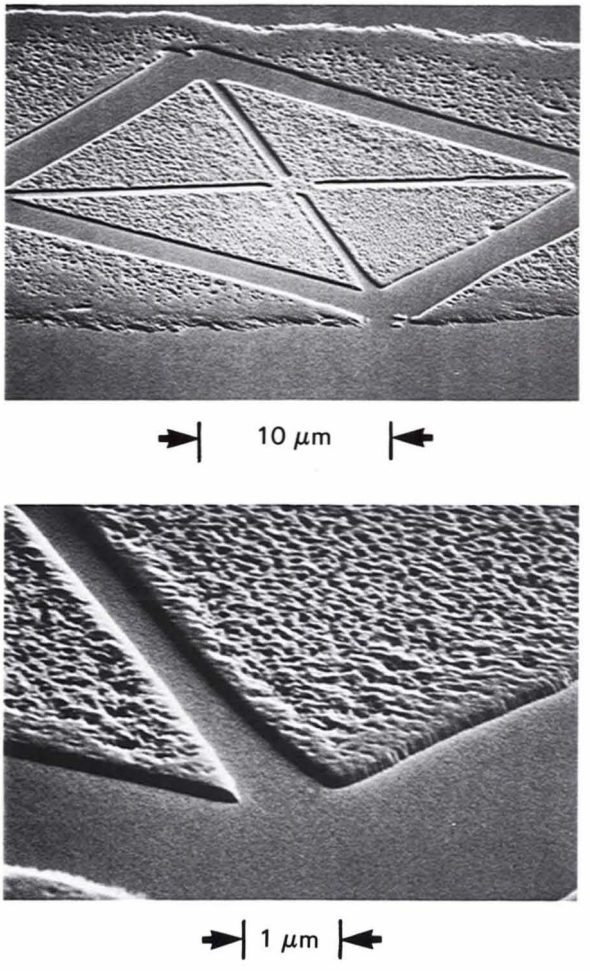

Fig. 7 — Scanning-electron micrographs demonstrating the excellent submicrometer resolution obtainable by projection patterning of an Al/O cermet film at 193 nm. One 120-mJ/cm^2 pulse was used to induce solid-state transformations in the 30-nm-thick film. Development was performed by wet etching in nitric acid/phosphoric acid followed by reactive ion etching in CHF_3.

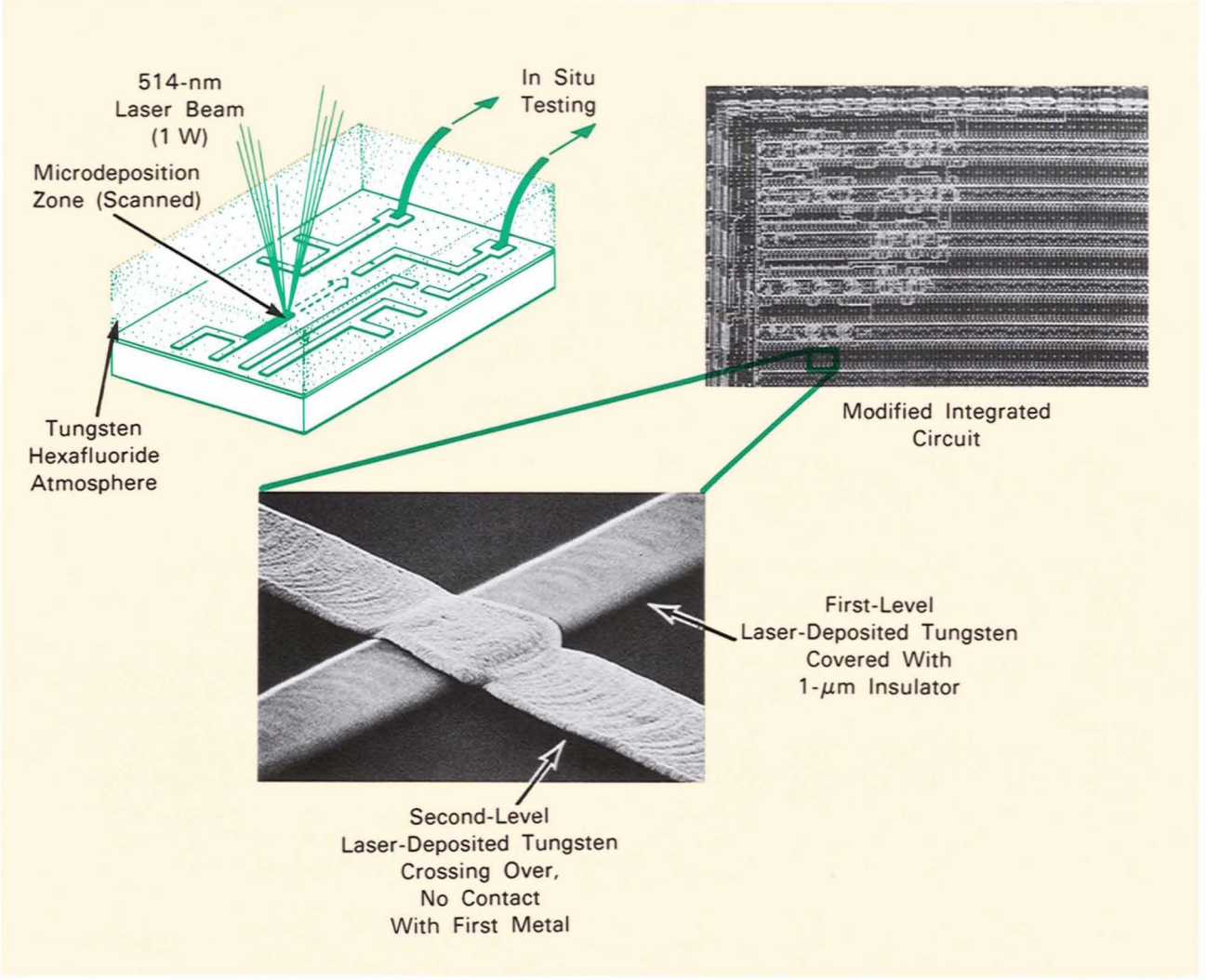

Fig. 9 — The laser-direct-writing process applied to silicon integrated circuits. A focused laser spot causes a local chemical vapor deposition (CVD) reaction, which, as the spot is scanned across the chip, defines a metal interconnection line. New processes also permit multiple-level restructuring of circuits.

advantages for prototyping of CMOS gate arrays is shown in Fig. 9. Greater detail can be found in Refs. 7a and 7g.

Mask Repair by Photodeposition

In the last several years, techniques have been developed for the repair of opaque and, more importantly, clear defects in optical photomasks by direct-write etching and deposition [7d]. These methods are now well-established as laboratory techniques and in a commercial product available from Quantronix (Smithtown, NY). Figure 10 illustrates the recent extension of similar methods to repair pinholes in x-ray masks.

UV-laser photodeposition of lead was adapted to the repair of clear defects in fully fabricated polyimide-membrane x-ray masks [19]. The spatial resolution of the process was explored with conventional x-ray exposures and was found to be adequate for one-step repair of 1-μm defects, with good edge definition and without damage to the fragile mask membrane. Smaller features should be possible by combining photodeposition and an ion-milling step that uses an FIB, a process developed by Micrion (Beverly, MA).

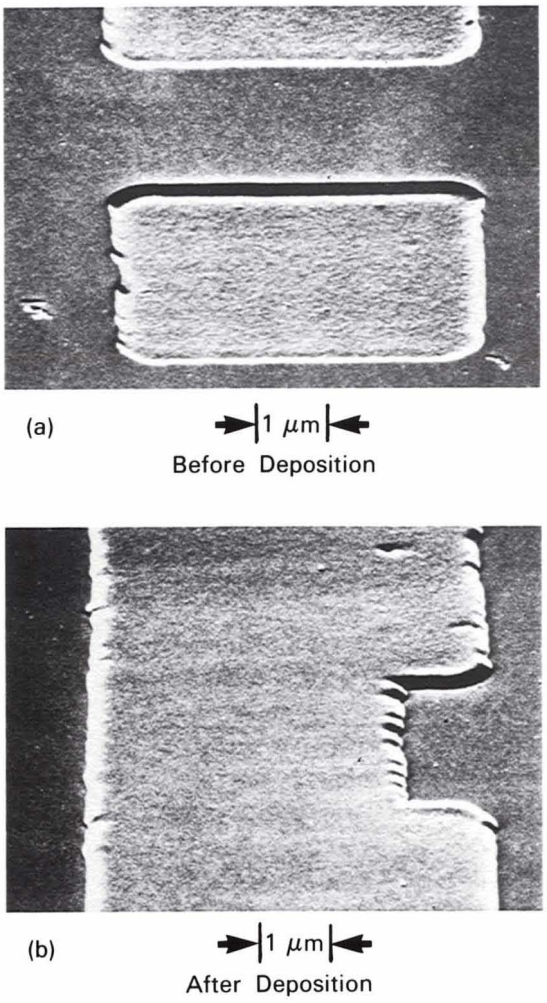

Fig. 10 — Repair of an x-ray photomask by laser photodeposition, a typical application of laser photochemical technology. For this figure, a 257-nm frequency-doubled Ar^+ laser deposited lead by photolysis of adsorbed tetramethyl lead. X-ray exposures before (a) and after (b) repair are shown. The mask substrate is a 1-μm-thick polyimide membrane.

In Situ Optimization and Trimming by Microchemical Writing

Recently, direct-writing techniques have been designed for the optimization of expensive discrete devices used in radar, microwave, or optical-signal-processing applications. Because of substrate-to-substrate variation, process variability, and limits to the precision of simulation, such devices are typically incompletely optimized with multistep processing. To obtain higher performance, direct-writing techniques have used physical ablation to trim, for example, poly-Si resistors on analog circuits and devices [20]. The increased resolution and greater range of material processing of microchemical techniques have greatly increased the precision of these operations. *In situ* optimization of fragile substrates is also now possible.

Figure 11 illustrates one such example: the *in situ* trimming of a reflective-array compressor on lithium niobate. To avoid perturbation of device operation during trimming, the phase and amplitude performance of the device must be adjusted in a subtle manner. This process is designed around low-temperature photochemical etching of Mo using Cl_2 vapor.

Wafer-Scale Integration

Several groups, including researchers at Lincoln Laboratory and Lawrence Livermore Laboratories, are developing laser-microchemical procedures for wafer-scale integration [21]. Laser-microchemical techniques may offer great processing versatility for interconnection of complex systems. Therefore, the techniques illustrated in Fig. 9 are being adapted to wafer-scale integration applications. In addition, a fast direct-deposition linking process has been developed for high-density circuit structuring.

Recent Lincoln Laboratory work has demonstrated wafer-scale systems with complexities of 10^4 and 10^5 programmed switches, by laser [22] and electron-beam [23] switching methods, respectively. Work is in progress to combine these two beam technologies in more complex wafer-scale systems.

Conclusions

Patterning is one of the key strategic issues for *in situ* processing. This field of research is evolving rapidly and much progress is anticipated in the next few years. We have pointed out the strengths, stemming from fundamental considerations, of FIB for high resolution and of lasers for high processing

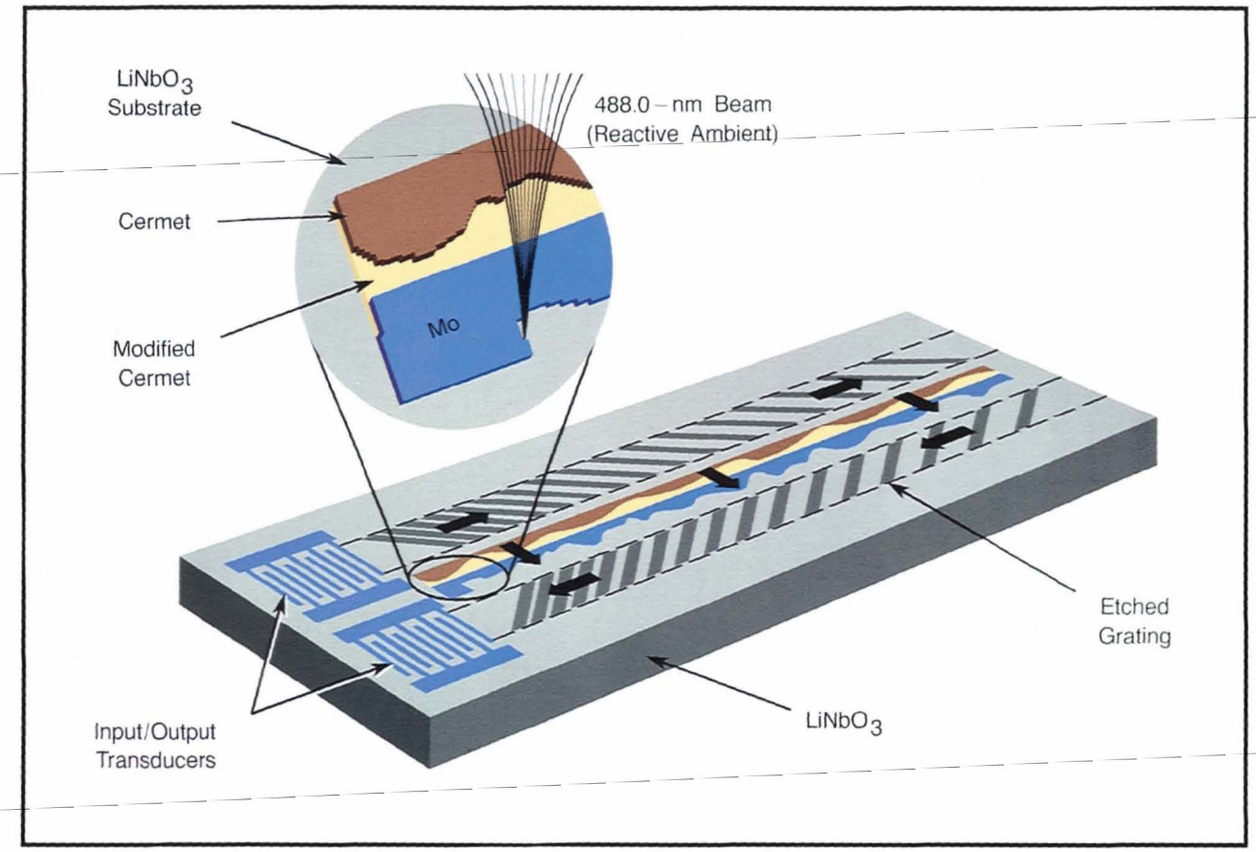

Fig. 11 — In situ *trimming of a reflective array compressor. A laser-activated Cl_2 etch of Mo thin films finely tailors the phase and amplitude response of the device over a large bandwidth. The etching process provides a feature resolution of 0.25 μm, affording extremely precise control of device performance.*

rates. Whether resolution or processing rate is the more dominant concern depends on the specific beam-writing application.

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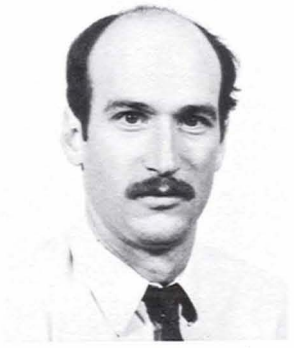

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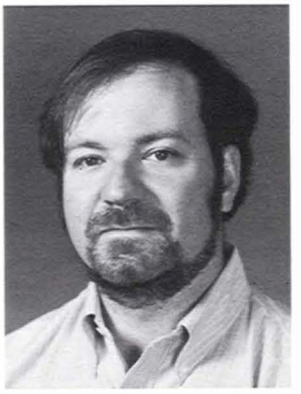

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