LASER PROCESSING CUTS WIDER SWATH

New applications in semiconductor processing and microanalysis developed in past few years excite seminar at materials meeting

By Norman Alster

Lasers, most often valued for their thermal properties, are finding increasingly sophisticated applications in semiconductor processing because of their unique photochemical and optical properties. At the recent Materials Research Society meeting in Boston, 39 papers were presented in a new symposium on the use of lasers in photochemical processing and optical microanalysis. Especially promising were reports on laser photodeposition of thin-film insulators, laser direct etching on gallium arsenide, and the use of lasers for analyzing the submicrometer areas of device materials.

"This is a field that has really taken off in the last year or two," reports Richard M. Osgood, professor of electrical engineering at New York's Columbia University and symposium chairman. "Virtually none of these applications were being looked at a couple of years ago. And in some cases, lasers are doing things that simply can't be done any other way." For instance, researchers in Lexington, Mass., at the Massachusetts Institute of Technology's Lincoln Laboratory are using Raman spectroscopic techniques to obtain submicrometer-area measurements of crystallinity, stress fields, defect density, surface morphology, and temperature in semiconductor materials.

Raman spectroscopy is based on the tendency of light to be scattered from a surface at frequencies other than that of an incident waveform. Characteristics of this inelastically scattered light vary according to the properties of the medium. Thus, laser light will show different scattering patterns depending on whether the targeted silicon medium is crystalline, amorphous, or polycrystalline. "We can take a 0.5-micron-square area and determine whether it is crystalline, amorphous, or poly. This has become increasingly important in terms of characterizing very small areas of recrystallized silicon," reports Steve Brueck, staff member at Lincoln Lab. Additionally, Brueck and his research partner, Daniel Murphy, have been able to analyze stress fields in silicon-on-sapphire and silicon-on-insulator films.

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Seeing small. Minute surface variations can also be analyzed since surfaces that have spatial structures on the order of 1,000 angstroms will enhance Raman scattering. Defect density also affects Raman scattering, with greater defect density yielding a broader spectrum of scattered light. Finally, temperature can be measured by the Stokes to anti-Stokes ratio, which is the ratio of the light scattered at frequencies lower than that of the incident waveform to light scattered at higher frequencies.

What makes the Raman measurements so valuable is their very high spatial resolution and the fact that they can be made nondestructively. "This will allow us to understand what's happening to materials during processing and to follow devices closely through fabrication steps. Such capabilities will be important both for quality control and as research tools," explains Brueck. Osgood notes that the technique is "simple and convenient and provides high spatial-resolution measurements which, as in the case of crystallinity and stress fields, cannot be achieved any other way."

One step. Even as laser diagnostics opens an entirely unique avenue to a more detailed understanding of fundamental device-material properties, laser processing techniques promise specific advantages over already well-established methods. Thus, for instance, a collaborative effort of Lincoln Lab and Columbia researchers has resulted in a laser technique for direct one-step etching on GaAs and other III-V compound crystals. Already, the laser technique has yielded diffraction gratings of 1,700 *Angstrom*.

Osgood, who reported the research, notes that laser etching is a low-power, high-speed process that boasts significant advantages over electron-beam lithography. "We don't have to put down photoresist. Ours is a one-step process. And GaAs is a highly sensitive material which can be damaged by photoresist." In addition, he says that good-quality gratings may be etched over a 1-centimeter diameter in 30 seconds, and he feels that high-resolution, low-power laser process is already a viable technique for producing the fine diffraction gratings required by integrated optical components.

Laser etching works because laser light causes holes in the GaAs crystal to migrate to the surface. The freeing of the electron holes and their migration to the surface stimulates the etching process.

In the Columbia-Lincoln Lab arrangement, GaAs (or another III-compound) crystals are immersed in an oxidizing solution. Two interfering laser beams create an interference

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pattern of alternating bright and dark regions on the crystal surface. The high-intensity light, by increasing electrochemical activity, produces the faster etching rate that defines the brighter regions. It is the difference in etch rates that yields a series of parallel grooves of alternating depths.

Meanwhile, George J. Collins, professor of electrical engineering at Colorado State University in Fort Collins, is enthusiastic about his results in depositing thin-film insulating materials. Collins and his group are using laser light to achieve photodissociation of gases and their subsequent depositions as insulators. Thus, silicon dioxide may be formed from the laser-induced photodissociation of nitrous oxide and ᵢane. Having produced highly adhesive and uniform films that exhibit low-defect density, high breakdown voltage, and conformal step coverage, Collins is satisfied that the laser-deposited films are comparable with those produced by plasma depositon.

But the laser process in addition claims certain inherent advantages. First, at 300°C it is a low-temperature process especially useful for creating interlevel dielectrics in double-metalization devices. Second, at 3,000 *Angstrom* per minute, it is significantly faster than conventional depositon.

Additionally, the laser technique allows greater control over the chemical products. Varying the wavelength used in silicon nitride deposition, for example, achieves control over how much hydrogen becomes bonded to the silicon and how much to the nitrogen.

Such capabilities are important in fine-tuning the charge-trapping and charge-retention properties of silicon nitride when used as a gate material is erasable programmable read-only memories. Yet another advantage is the absence of risk from radiation damage, a problem at times with plasma deposition.

Collins's success is already raising some eyebrows. Osgood says, "A low-temperature process with greater bond-breaking specificity - after one year, that's darn good." Another observer, Ted Kamins, project leader in the semiconductor devices labs for Hewlett-Packard Co. in Palo Alto, Calif., says that laser deposition "looks very intriguing. It certainly sounds like an attractive alternative to plasma processing since it would avoid radiation damage. It needs a lot more investigation but it looks very promising at this time for any IC application and particularly where you need a low-temperature dielectric."

BRIEFS

CRYOGENIC MATERIALS are the subject of a conference to be held Aug. 15-19 in conjunction with the Cryogenic Engineering Conference. Topical areas will include electrical, magnetic, thermal and other applied physical properties of metals, semiconductors and insulators including effects of radiation, stress, etc. The emphasis will be on work related to understanding and characterizing material behavior for low temperature applications.

The conference will be held in Colorado Springs, Colo. For more information contact the program co-chairman, K.T. Hartwig Jr., University of Wisconsin-Madison, 911 Engineering Research Building, Madison, Wis. 53706, phone (608) 263-5028, or the conference administrator, Centennial Conferences, 1215 Mapleton Avenue, Boulder, Colo. 80302.

THE AMERICAN NUCLEAR SOCIETY says a recent survey found that nine of every 10 scientists favor nuclear power generation. In its "Nuclear Report" to its members, it says the public is seriously misinformed on this point, mistakenly believing that a quarter of all scientists oppose further development of nuclear power.

"The press, its biases, and its preferred 'experts' are exposed by [Stanley] Rothman and [S. Robert] Lichtner [who did the survey], who say the scientific community does not address the public," the newsletter asserts. Rather, the relatively small percentage of anti-nuclear scientists, and even non-scientists such as Ralph Nader, monopolize the press's reporting on the issue.

THE JOURNAL OF MATERIALS EDUCATION is the new name of the former Journal of Education Modules for Materials Science and Engineering. The change was effective at the beginning of this year.

The journal-textbook hybrid will continue to provide copyright-free instructional modules, but will broaden its scope to include meeting announcements, book reviews, pedagogical papers, etc. For information write to the Managing Editor, Journal of Materials Education, 110 Materials Research Laboratory, Pennsylvania State University, University Park, Pa. 16802.

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