Journal Title: Journal of the Electrochemical Society

Volume: 131
Issue: 8
Month/Year: 1984
Pages: C311-C311

Article Author: ROCCA, JJ

Article Title: LARGE AREA ELECTRON-BEAM PROCESSING OF MICROELECTRONIC FILMS

Imprint: www.isinet.com:WoK

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Staff

Matilda Wheaton
1320 Campus Delivery
ERC B229
Fort Collins, CO 80523

Instruments, Inc., Semiconductor Process Laboratory, Dallas, TX 75265, and *G. G. Barna*, Texas Instruments, Inc., Process Automation Center, Dallas, TX 75265

A major use of the plasma process engineer's time is the tweaking of processes to meet the needs of a specific device. Advanced plasma processes typically require that many coupled parameters be adjusted to achieve the best balance among several observables. The sequential simplex algorithm offers an effective solution to the problem. The use of the simplex algorithm for process optimization is described through photoresist ash and polysilicon etch processes. Several process parameters were varied to result in processes optimized with respect to multiple observables. The tradeoffs among the observables and how they are handled in this method are discussed.

387 Optical Etch-Rate Monitoring Using Active Device Areas: Lateral Interference Effects: *P. A. Heimann*, AT&T Bell Laboratories, Murray Hill, NJ 07974

The technique of optical (laser) etch-rate monitoring detects the change in film thickness during etching by monitoring the reflectance of the film on the integrated circuit wafer. When the reflectance is monitored over a region of the wafer containing both etched and unetched areas, the results are affected by lateral interference, which is interference between the light reflected from the different regions. This lateral interference has only a minor effect when less than 30% of the region being monitored is covered by an etch-resistant layer (typical for metal-type lithography levels), but it can cause severe distortions when a larger fraction of the region is covered by the resist. For window-type lithography levels, where most of the area is covered by resist, a new technique is described which allows the etch end point to be detected. Experimental results are presented for this technique. Lateral interference can also be used to monitor etching into opaque materials, and calculations described here show good agreement with experimental results in the literature.

388 The Relationship Between Anisotropy and Etch Time: *R. W. Light** and *H. B. Bell*, Sandia National Laboratories, Div. 2141, Albuquerque, NM 87185

Directionality in plasma etching processes appears to be a complex function of many parameters making process optimization a difficult task. A clarification of this problem can be achieved by examining anisotropy as a function of etch time rather than a function of the individual system parameters. Anisotropic etching is generally obtained at long etch time in low pressure, parallel plate and hexagonal cathode systems operating at 13.56 MHz. This mechanistically significant trend is examined for Al, polysilicon, and $TaSi_2$/polysilicon etching processes. (This work performed at Sandia National Laboratories was supported by the U.S. Department of Energy under Contract no. DE-AC04-76DP00789.)

389 Oxide Contact Windows Profiling in a Single Confined Discharge Structure: *L. Peccoud, J. Arroyo, P. Lassagne*, and *M. Puech*, Laboratoire d'Electronique et de Technologie de l'Informatique, IRDI, Commissariat à l'Energie Atomique, Grenoble Cedex, France 38041

In VLSI technology, close dimensional control of features is required in CVD oxide windows opening. Furthermore, the step coverage ability of the metal interconnection needs contact windows having a sloped wall profile. A single confined discharge structure offers an alternative to solving this problem independently of the photoresist mask (nature, treatment, and profile) by controlling oxygen flow rate. Samples with patterns of 1 μ^2 showed a good aluminum step coverage, slight contact resistance, and less interface state generation than samples etched in a standard RIE mode.

390 Large Area Electron Beam Processing of Microelectronic Films: *J. J. Rocca,** *L. Thompson, D. Bishop*, and *G. J. Collins*, Dept. of Electrical Engineering, Colorado State University, Fort Collins, CO 80523

We have demonstrated the use of large area (≈100 cm^2) kilovolt electron beams to deposit and etch microelectronic thin films. Silicon nitride, silicon dioxide, and metal films have been deposited at low (50°-400°C) substrate temperatures. Dissociation of reactant gases occurs primarily in the confined planar region of the electron beam created plasma. Electron beam assisted etching of silicon dioxide films has also been achieved in a $CF_4 + O_2$ gas mixture. The electron beam area can be easily scaled using our scheme to process 10 cm diameter wafer.

391 Multilayer RIE Process in Manufacturing: *F. Martinet*, IBM France, 91102 Corbeil, Essonnes, France

Multilayer processes requiring separate "resist" layers are commonly used in the "lift-off" process and are now implemented for pattern transfer. This paper shows some aspects of the complexity of the reactive ion etching steps: reactor interaction, mask material effects, selection of the plasma parameters, and step sequence product topography in order to achieve the desired etched profile without parasitic effects. A tight RIE control with optical emission spectroscopy and electrical measurements are required to ensure the process reproducibility.

392 The Effect of Moisture on the Plasma Oxide Etch: *Y. W. Hu*, Intel Corp., Santa Clara, CA 95051

A strong correlation was found between the plasma oxide etching rate and the moisture (H_2O) content measured by the intensity of the hydrogen emission line. Data also indicated that the moisture effect is probably caused by a combined effect from both the hydrogen and the oxygen species. Using the results of this finding to explain some phenomena observed in the plasma oxide etching process are discussed.

393 Contact Hole Etching in a Load-Locked Hexagonal Reactive Ion Etching System: *S. Shanfield** and *M. Hendriks*, LFE Corp., Clinton, MA 01510

We report on process characterization of contact hole etching in a fully load-locked hexagonal RIE system. Contact holes were etched in silicon dioxide and phosphosilicate glass. The effect of process parameters on contact hole taper angle and selectivity to doped polysilicon were systematically investigated. In addition, a comparison was made of run-to-run process reproducibility with and without load-lock operation.

394 SiO_2 Etching in CHF_3 and CO_2 Using a Cylindrical Tri-Electrode Etching System: *K. Kim** and *O. Wilkinson*, ANELVA Corp., Yotsuya, Fuchu, Tokyo, 183, Japan

A high etch rate of SiO_2 on a Si wafer was achieved in a condense plasma produced by a cylindrical tri-electrode system with magnetic field. The rate reached was up to 1.5 μm/min without photoresist damage under such conditions as pressure of 500 ~ 1500 mtorr, total RF power of 2500W, flow rate of 110 cm^2/min, decreased self-bias voltage on the substrate holder, with a selectivity to photoresist OPFR-800 of 1.8-4.0 and a taper etching profile.

395 Highly Selective Dry Etching of Si_3N_4: *Y. Kawamoto,** *T. Kure*, and *N. Hashimoto*, Hitachi Ltd., Central Research Laboratory, Kokubunji, Tokyo 185, Japan, and *T. Takaichi*, Showa Denko K. K., Chemicals Research Laboratory, Ohgimachi Kawasaki-ku, Kawasaki, Kanagawa 210, Japan

The high selectivity of Si_3N_4 over both SiO_2 and Si in dry etching has been achieved, using either CH_2F_2 or CH_3F as the reaction gas in a reactive sputter etching apparatus. Moreover, the etched profile reveals anisotropy. The mechanism for high selectivity was determined from XPS analysis. It can be explained in terms of F-poor polymer formation in the gas plasma, and Si-O, Si-F, and Si-N bond strength.

396 Shaping of Profiles for SiO_2 Vias Using Postexposure-Baked Resist and RIE: *I-W. Huang,** *T. W. Bril, D. Bernard*, and *B. Westlund:* Philips Research Laboratories, Sunnyvale, CA 94088

Several factors influencing the final profile in etched P-doped SiO_2 films are investigated. They are: the pre-etch photoresist profile, the isotropic etch component in etching the photoresist, and the etch selectivity between the SiO_2 film and the photoresist. To produce uniform, 60° photoresist profiles, a postexposure bake applied to stepper-exposed photoresist was found to be very effective. Computer modeling of the taper etch process together with experimental results show that the isotropic etch rate of the photoresist enhances the taper forming process.

397 Sidewall Tapering in Reactive Ion Etching: *A. G. Nagy*, Motorola, Inc., Phoenix, AZ 85008

A sidewall tapering phenomenon in silicon dioxide reactive ion etching, akin to that seen in sputter etching, has been observed. A 70° facet forms in the photoresist mask during etching, and the downward propagation rate of this facet is more than twice the vertical etch rate of the resist. If the facet is allowed to reach the etching material during the course of the etch, it will replicate significantly into this material.

398 Geometry Independent Deep Trench Etching, Refill, and Planarization for Isolation of Merged Bipolar-CMOS Devices: *G. C. Eiden,** *J. A. Hughes*, and *P. K. Boyer*, Tektronix, Inc., Beaverton, OR 97077

An isolation process has been developed for application in merged bipolar-CMOS devices. The process consists of planarization of a dielectric-refilled trench in silicon. Details of the effects of trench dimensions on the silicon etch process, the refill character, and ease of planarization for a variety of planarization materials are discussed. Effects of the etch process parameters on Si and SiO_2 etch rates is also presented. Methods for controlling the texturing of etched Si surfaces are suggested, and results of Auger and SIMS analyses are presented.

399 An Improved Etchback Method for Bird's Head Planarization: *M. Violette,** *P. Howell*, and *J. Siulinski*, Fairchild Semiconductor, South Portland, ME 04106

The bird's heads associated with LOCOS isolation render the wafer surface nonplanar, causing defects in photolithography and contributing to poor metal step coverage. A method of bird's heads planarization has been developed using an etchback technique. Wafers are planarized with photoresist then etched in a plasma which has 1:1 selectivity of photoresist to SiO_2. Plasma etch uniformity of both layers is ±3%. The bird's head is reduced to 20% of its original height.

400 Etching of Si in Low Frequency Cl_2 Discharges: *A. J. van Roosmalen,** *A. P. M. van Arendonk*, and *H. T. Arends*, Philips Research Laboratories, 5600 JA Eindhoven, The Netherlands, and *F. Schmidt*, Valvo, Stresemannallee 101, 2 Hamburg, Germany

Dry etching of mono- and poly-Si was studied in a high-pressure, low-frequency planar reactor. Anisotropy and selectivity to SiO_2 are shown to be strongly influenced by the presence of small