USING THE GCA 4800 DSW WAFER STEPPER AS A PHOTOREPEATER FOR THE FABRICATION OF CHROME AND ALUMINUM MASKS

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ABSTRACT

Utilization of the GCA DSW 4800 as a PHOTOREPEATER enables the production of masks with flexibility, resolution, speed, and precision. A new chuck directly interchangeable with a standard GCA 100 Millimeter wafer chuck was machined for simple conversion from STEPPER to PHOTOREPEATER. Commercial Chrome plates and Quartz plates with thermally evaporated Aluminum films were coated with KTI-820, exposed, and etched. Chrome film resolved to 1 micron and the Etched Aluminum resolved to 3 microns.

INTRODUCTION

Since the formation of the Rochester Institute Of Technology (RIT) Undergraduate Microelectronic Engineering program, the majority of the masks used by the Students and Faculty have been fabricated on a Mann Type 1795 PHOTOREPEATER. Reliance on this technology has created severe limitations on geometries available lithographically to the Institute. Using the current procedures, lithography is limited to fabricate emulsion masks with a ten micron rule. The Mann Type 1795 PHOTOREPEATER uses a 10X Ultra-Micro Nikkor (Nikon) Lens with a Numerical Aperture of 0.28 and F=28 mm corrected for H-line exposu_e at 5458 Angstroms. The Lens can image over a 6.3 mm square area and is limited to one focus setting at any given exposure run [2]. The GCA DSW 4800 Stepper has a 10X G-Line lens with a numerical aperture (NA) of 0.28 corrected for 4360 Nanometers wavelength. The Ziess lens can image a 10 mm square area. The 4800 DSW is equipped with high precision stages that are monitored by a laser position transducer to meter X/Y coordinate stage positions. The system is equipped with automatic compensation for atmospheric pressure and work piece temperature is employed to insure stage accuracy. The 4800 DSW contains an automatic lens focus system which compensates for standard wafer thickness tolerances and surface irregularities. This is accomplished through the use of a photoelectric detection circuit which utilizes the wafer surface as a reference plane. The circuit controls a Z-axis drive which determines the elevation of the microreduction printer tube [1].

Utilizing the precision optical and mechanical capabilities of the GCA 4800 DSW stepper, a new process was implemented that could optically resolve geometries to 1.25 microns. The excellent flexibility of the GCA 4800 DSW software allows for the inclusion of more than one die type on a mask and variability in its location.

The primary concern of this project was to utilize the above system to develop a vertically integrated system for the production of masks, including a procedure for coating Glass or Quartz plates. An Aluminum evaporation procedure was investigated for its attractive cost and application method.

Major considerations for the conversion is the relative thickness difference between the two substrates and the conversion process between modes must occur easily. The solution was to bring the mask into the focus plane of the wafer. For the Autofocus system to accept the substrate, the system must determine the distance between the optical column and the substrate on the chuck. The optics are optimized to focus on a surface of 15 mils through 20 mils above the chuck; mask plates are 90 mils thick. The increased thickness is outside the focus tolerances of the optical column, 2.5 microns per 25 mm, and the stepper will reject the substrate.

<u>EXPERIMENT</u>

A chuck was machined, illustrated in Figure 1, to be interchangeable with the 100 mm chuck on the GCA 4800 DSW that would accomplish this task. Focus adjustments were eliminated since the surface of the mask would be in the same position as a wafer under the optical column and autofocus system. The assemblies for the wafer chuck, mask chuck, and the two superimposed are illustrated in Figures 2,3, and 4.

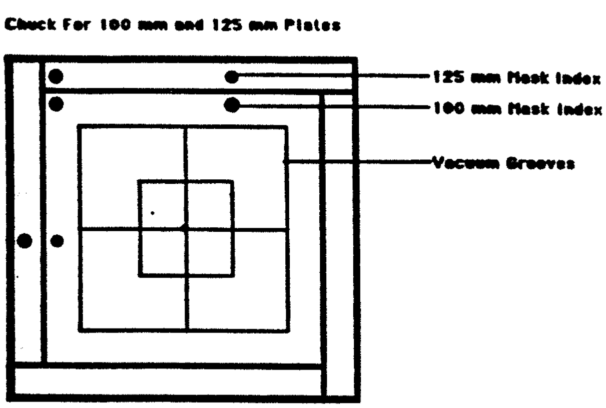

Figure 1

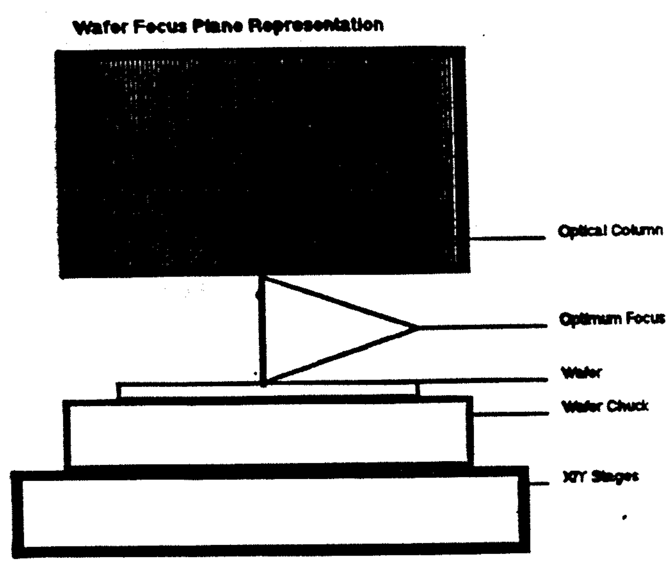

Figure 2

Ultra flat 125 mm Glass plates for Pattern Generator use, Quartz plates, and Commercial Chrome plates were obtained. The Glass plates were cleaned in a Bleach solution with a 1:1 ratio with water, cleaned in a soap solution, rinsed in DI water, and Nitrogen air dried.

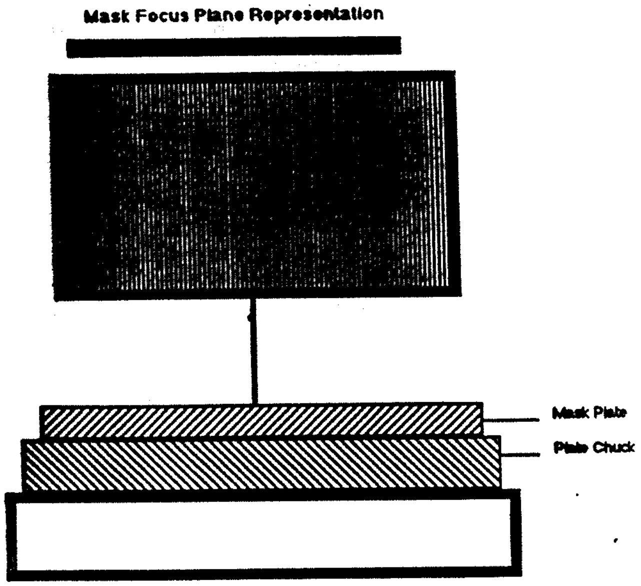

Figure 3

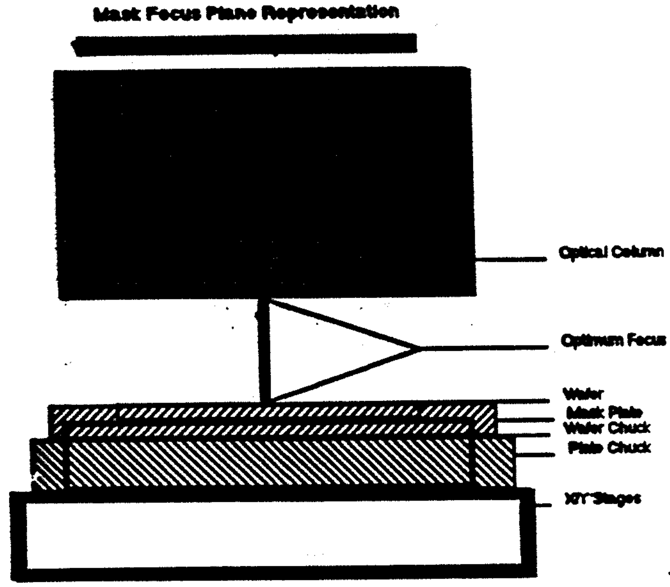

Figure 4

The Glass and Quartz plates were placed in a CVC Evaporator for both an Argon Glow Discharge clean and Aluminum evaporation. The chamber was pumped to a pressure of 2.0E-4 Torr and a variac was used to create a 45 Volt difference between the chamber and the plate holder. An Argon plasma was sustained at 8.0E-4 Torr for a 10 minute clean cycle. Two 0.6 Gram pellets of Aluminum were evaporated at a pressure of 1.0E-5 Torr. Measurements were taken using a Profilometer, thickness for one pellet was 3800 Angstroms and two pellets (after etch) produced a thickness of 4450 Angstroms.

Plates were coated with an Integrated Technology coater. A dynamic dispense of KTI 820 was executed at 50 RPM, the resist was accelerated to 4000 RPM for a 30 second spin, and resist thickness was measured utilizing a profilometer over developed resist image. The resist was pre-baked at 85 Degrees Celsius for 30 Minutes in a convection oven. To obtain relative uniformity measurements, the Nanospec program "Positive Resist on Silicon," one hundred measurements were collected at 12.5 millimeter intervals in both the X and Y directions. The numbers were normalized to the edges and a three dimensional plot was made using the PLT3D software on a VAX computer system.

A program was written in the $!!$DX1 directory of the GCA 4800 DSW STEPPER entitled ETM MASK. This program is a two pass job that allows an array of device chips to be exposed with a 10 Millimeter stepping displacement, followed by an array of test chips. This job can be altered to change stepping, allowing for multiple passes, and multiple chips to be exposed on the same substrate. The job is written for a 110 Millimeter wafer to fill the entire desired 100 Millimeter area. A second job labeled MASK1 was written for 4000 Micron square chips. This is a two pass job similar to ETM MASK.

Using the EXPO(sure) feature on the GCA 4800 DSW STEPPER, a focus exposure matrix was created to determine the optimum values of Focus and Exposure for both Chrome and Aluminum plates using the KODAK/RIT ETM MASK. Optimum focus and exposure was obtained and plates were exposed at these values. The ETM MASK was utilized for its wealth of resolution targets and line width structures for characterizations. The exposed resist was developed in KTI-934 developer mixed at a 1:1 ratio with DI Water for 30-35 seconds and postbaked for 30 Minutes at 140 Degrees Celsius in a convection oven.

Aluminum plates were etched in a solution of hot phosphoric acid/Aluminum etchant at 40 Degrees Celsius until clear. Aluminum thickness measurements were accomplished with a profilometer. The Chrome masks were etched in CYANTEK CR-4 Chromium Photomask Etchant until clear. The masks were placed in a cascade DI water rinse until resistivity was above 7 MegaOhms.

The plates were examined to determine best resolution using 45 Degree Resolution Targets, Equal Line/Space pairs, and KODAK/MANN 3600 Targets.

Resist was stripped in a TEGAL Plasmaline and with Acetone. The plates were rinsed in a DI water bath, sprayed with DI water, and blown dry with a Nitrogen gun.

RESULTS/ANALYSIS

Resist was coated and the average thickness measured by the profilometer was 6250 Angstroms after development. A three-dimensional plot of the normalized resist uniformity is pictured below in Figure 5. The contour plot shows a uniform and stable area within a four inch diameter in the center of the plate where the mask die would be exposed.

PATTERN GENERATOR grade Glass plates were initially used for the substrate material, however, it was determined that the plates were not flat enough for STEPPER use. When the plates were exposed, each plate yielded a different optimum exposure and focus. More disturbing, the focus window was extremely narrow and was inconsistent from plate to plate. Quartz/Commercial Chrome plates were substituted for the Glass plates and exposure/focus performance resembled standard wafer values. Optimum exposure and focus values were as follows: For Chrome

plates with 12% anti-reflective coating, the best exposure was 61 mj/cm-cm with a center of focus at 250 GCA units. Aluminum exposure was calculated at 48 mj/cm-cm with a center of focus at 250 GCA units.

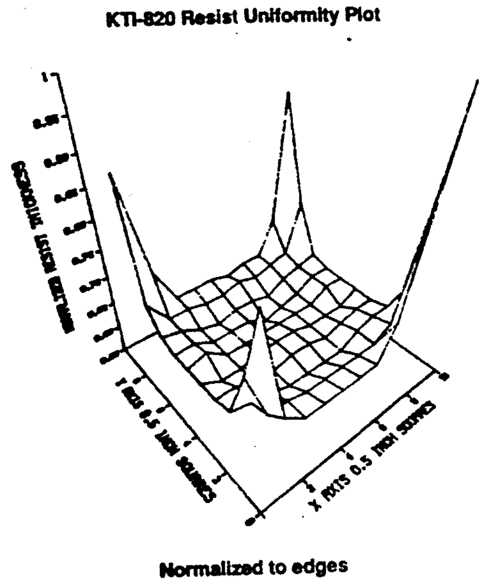

Figure 5

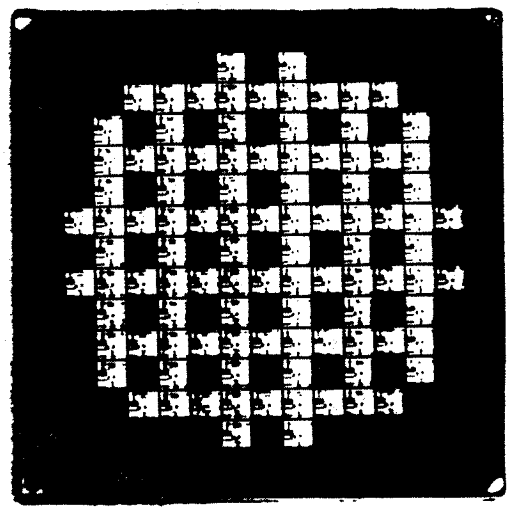

Figure 6 Completed Mask

Chrome plates were etched, clearing time was 2 to 2.5 minutes at 20-25 Degree Celsius. Aluminum Clear times were 2 to 3 Minutes at 40 Degree Celsius in Aluminum etchant.

The Chrome etching process was well behaved, while the Aluminum etching process produced limited lifting. From examinations under the microscope, the Aluminum lifting can be attributed to undercutting of the smaller structures. For 45 Degree Resolution Targets, the Chrome resolved 1.0 Microns and Aluminum resolved 3.0 microns. Examining Equal Line/Space pairs, Chrome resolved 1.2 Microns and Aluminum resolved 3.0 Microns. The KODAK/MANN 3600 Targets yielded 1.0 Microns in a Chrome film and 2.5 Microns in an Aluminum film. The differences between the two processes can be attributed to the developed Chrome etch.

When plates were post-baked, Acetone would not remove the resist. A Chrome mask was placed in the TEGAL PLASMALINE asher in an O2 Plasma; the resist was removed and the anti-reflective Chrome-Oxide layer was destroyed. A procedure without a post-bake was examined and the resist was polymerized enough to withstand the wet etch. A completed mask is illustrated in Figure 6.

CONCLUSIONS

Utilizing the GCA 4800 DSW as a Photorepeater extends the optical range available, flexibility, and control for mask making. The new mask chuck provides a simple solution for converting from STEPPER to PHOTOREPEATER without requiring any adjustments to the optical column or focus system. Aluminum can be used as a masking material and with a developed etch process produce high resolution masks. For the continuation and optimization of this investigation, the following is suggested. Develop a method for depositing Chrome material on Glass or Quartz plates. Investigate methods to produce superior uniformity in resist coatings using the 125 Millimeter coater. Develop a AZ1350J resist procedure as an alternate resist and compare the resolution of the two processes. Examine both the Chrome and Aluminum etch processes to obtain superior line width control and better uniformity. This process enables a completely vertically integrated inexpensive method for producing high resolution masks.

ACKNOWLEDGMENTS

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REFERENCES

[1] GCA Corporation/Burlington Division, GCA 4800 DSW manual, (1978/1979) GCA Corporation

[2] David Mann Company, MANN 1795 PHOTOREPEATER manual, (1969) David Mann Company

[3] David J. Elliot, Integrated Circuit Mask Technology, (1985) McGraw-Hill Inc.