ADVANCED MASK MAKING AT RIT

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ABSTRACT

This project involved the definition of the steps necessary to generate a mask or reticle for any of the three exposure tools (ie. GCA 10X G-line Stepper, Perkin Elmer Scanning Aligners, and Kasper Contact Aligners) used at RIT. Next a working process for creating chrome masks for the Perkin Elmer Scanners was developed. Using the process outlined in this paper 5 micron line widths can be repeatedly obtained.

INTRODUCTION

A method for creating accurate, high quality masks is needed to reduce minimum dimensions of devices made at RIT to below 10 microns. This can be accomplished by going to masks made of chrome instead of emulsion. Though emulsion masks have the advantage of the ease of processing and relative low cost, they unfortunately suffer from poor linewidth control and lack of durability. Emulsion films are made of small grains and its these grains that limit your resolution to approximately 10 microns. For the 10x reticles used in steppers these limits are acceptable. But for contact printing and the Perkin Elmer scanners, a one to one mask is needed with dimensions approaching three (3) microns. For this the emulsion is inadequate, therefore the need for chrome masks is obvious.

With chrome masks the resolution needs of 3 microns at RIT can be met. Chrome masks have better resolution because of its different method of imaging it. Photoresist is used to transfer the image into the chrome as compared to directly imaging the emulsion masks. A chrome system starts with a quartz plate which can be of varied size and thickness. The plates for the Perkin Elmer Model 240 Scanners are 5"X5" and 90 mils thick. Chrome is then deposited on the plate by either sputtering or evaporation techniques. Normally the thickness of the chrome is less than 2000 angstroms but not so thin as to have pinholes. The chrome is then coated with some type of photoresist. This resist is spun on very thin (between 0.3 - 0.5 microns) so as to obtain the best possible resolution. Chrome is very reflective and can degrade your image because of reflections off the surface. These problems can be minimized by using low reflective chrome or using an anti-reflective coating in combination with the photoresist. This system is then exposed with the desired pattern and developed accordingly for the resist type used. The pattern is then transferred by etching the chrome, usually with a Ceric Ammonium Nitrate solution. The resist is then stripped and the

mask carefully inspected for any pinholes or other defects.

In the VLSI industry, chrome masks and reticles are the standard. Because of the increased demand for high precision and low defect density masks optical methods for creating these masks has become inadequate. The use of electron beam lithography is now industry wide. Although the electron beam tools have excellent precision and very high resolution (on the order of 0.2 microns), there are some drawbacks. Electron beam exposure tools are very costly, usually in the millions of dollars. This expensive tool also needs strictly controlled environmental and physical conditions maintained. The housing to achieve these controls can also cost millions of dollars. Aside from the large capital cost, the electron beam imaging system is very slow. It could take many hours to expose just a single mask. These drawbacks are accepted in order to obtain the high quality masks and reticles needed in todays semiconductor industry.

This project included two parts which were as follows:

(1)First a flow chart which follows through every step of mask making for the three different exposure tools at RIT, (ie. GCA 10x Stepper, Perkin Elmer Scanning Aligners, and the Kasper Contact Aligners) was generated for both emulsion and chrome.

(2)A process was devised to create chrome masks and then used to create masks for the Perkin Elmer Scanner.

EXPERIMENT

The basic assumption is that all masks start with MANN 3000 files created with ICE[*] layout software. These files will be used by a Mann 3000 pattern generator to create a 10X reticle. Referring to Figure [1]. Processing beyond this point depends on the end result desired. This is as far as the reticles for the GCA stepper need to go because it is a 10X reduction tool. Now the image is in emulsion and it needs to be reversed because emulsion is a negative tone imaging system.(ie:It becomes opaque when light strikes it.) The photoresist is positive tone so the mask itself must be positive tone. This can be done with a simple chemical reversal process after exposure. A chrome reticle could then be created by contact printing from emulsion to the photoresist on the chrome plate.

The next alternative is to reduce the image to 1X. This is accomplished on the photorepeater. The photorepeater will step and repeat the image of the circuit across the entire photosensitive plate. This is called a mask.

[*]ICE - Integrated Circuit Editor is a CAD tool available to students at RIT through the Microelectronics Department

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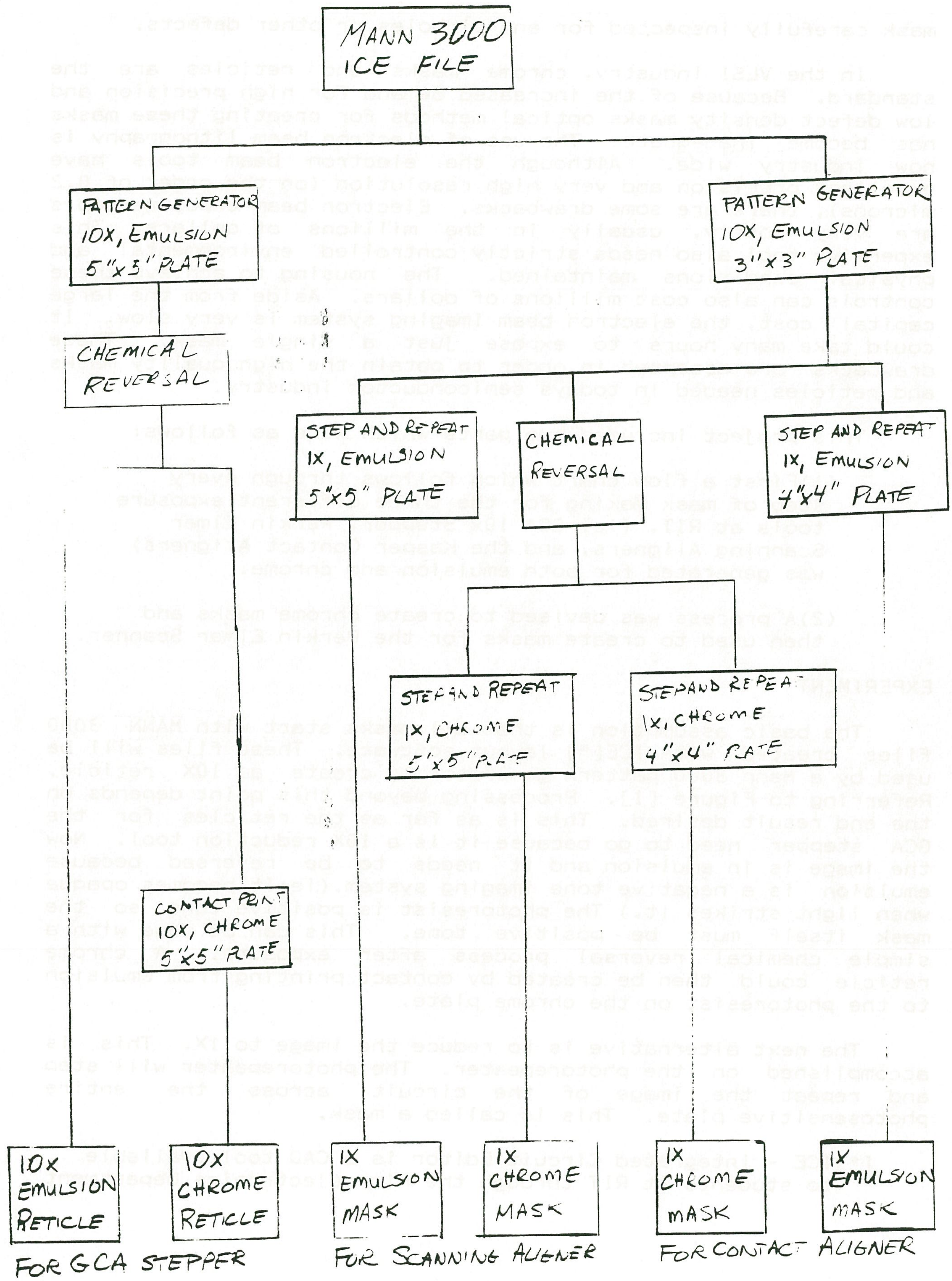

FIGURE 1. MASK MAKING FLOW CHART

To create an emulsion mask take the reticle created on the pattern generator and use it directly on the photorepeater. The negative tone of the reticle will be reversed again because of the emulsion film. After the development and fixing of the emulsion film the mask is ready to use. This process works for both the Perkin Elmer and Kasper aligners NOTE: The Kaspers use 4" plates while the Perkin Elmers use 5" plates.

Making chrome masks is slightly different. The 10X reticle is created on the pattern generator as before, but instead of normal processing the image must be reversed. This is because the photoresist on the chrome plates is positive and therefore the image must be 'turned around' before using the photorepeater. The photoresist is sensitive to UV light so the chrome masks must be exposed on Photorepeater #2 which is in Mask Making #2. This photorepeater is equipped with a mercury vapor lamp which gives of UV illumination. Expose as you would an emulsion mask.

The path that was chosen to demonstrate the chrome mask process was that for creating chrome masks for the Perkin Elmer 120 Scanning Aligner. The plates that were used were from Electronic Materials Corporation.

The plates were quartz	5"x5"x0.09"
12% reflective chrome	0.1 microns
Microposit 1450-017 positive photoresist	0.5 microns

Turn on lamp in photorepeater #2 (needs at least 20 minutes to warm up and stabilize). Next the intensity of the lamp needs to measured. Place the plate holder (without the plate in it) on the platen of the photorepeater and slide out the cover shield. Move the platen so that it is underneath the lens. Place the sensor of the IL440 radiometer on the holder underneath the lens. Be sure to use the washer with the small hole on the sensor to achieve the the best possible accuracy. The ratio of the areas of the sensor and the washer is 4.86. (ie.take the reading with the washer in place and multiply that reading by 4.86 to get the true measurement.) Open shutter manually to take the reading. Check the focus and make sure it is set for the particular holder being used.(The chart for focus and holders is in Mask Making #1 on the controller for the photorepeater). The settings for the 4" plates is well documented in a logbook for photorepeaters. The settings for the 5" plates were as follows:

Exposure spacing	0.200
Row spacing	0.200
Number of Rows	18
Exposures/Row	18
X-starting point	5
Y-starting point	5

NOTE: The controller used for the mercury lamp shutter is on top of the console.

Mount the plate in the holder.(Note: These plates are white light sensitive so all work must be done in red light.) The shutter must be timed and set by hand. The markings on the timer are meaningless.Adjust the time of exposure accordingly. After the exposure is complete, remove the plate from the platen and secure it in a light tight box. Transfer it into the wet chemical across from Photolithography area #2 in the clean room. The rest of the processing will be accomplished here.

RESULTS/DISCUSSION

The following process was found to yield linewidths of 5 microns repeatedly.

Exposure desired 35 - 40 mJ/cm2

Develop the plate in Microposit 351 positive resist developer.

Diluted (2:1) (water:developer)
Room temperature (20oC)
Time - 90 seconds
Rinse and inspect

Post bake the resist prior to etching

Bake Temperature - 90oC
Bake Time - 30 minutes

Etch the chrome plate (Ceric Ammonium Nitrate solution)

Chrome Etchant Type 1020
Etch Time - 60 seconds
Room Temperature - (20oC)
Rinse and Blow dry
Inspect

Strip the photoresist

acetone soak - 10 minute
Inspect for scumming

CONCLUSIONS/SUMMARY

A process for generating 5 micron lines on chrome has been developed. With some refinement of this problem linewidths of 3 microns could be attained.

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