STUDY OF THE CHARACTERISTICS OF DYED PHOTORESIST

Brad Campbell
5th Year Microelectronic Engineering Student
Rochester Institute of Technology

ABSTRACT

Undyed, AZ 1512,and dyed, AZ 1512-SFD, photoresist was coated on aluminum covered oxide topography. The exposure was varied from 70mJ/cm2 to 130mJ/cm2 and the 3.0um line/space pairs were measured to calculate the exposure latitude. The resist lines were examined over topography for signs of reflective notching. Results showed an increase of the exposure latitude from 9.1% to 9.9% for the dyed resist. The data was inconclusive in determining any improved control of reflective notching with the use of dyed photoresist.

INTRODUCTION

The microelectronic industry is continually striving for smaller geometries. In order to extend the practical lifetime of costly lithographic equipment, alternate methods of imaging photoresist are being examined. Antireflection coatings, multilayer resist systems, and dyed photoresist have all been used successfully to enable existing equipment to meet the required smaller dimensions. The strength of dyed photoresist is that it can be directly incorporated with little variation of an existing p ocess.

A dyed photoresist helps control notching from stray light , while at the same time increasing the exposure latitude [1],[2]. Notching is a variation in the photoresist linewidth which occurs as it passes over reflective topography. The scattered light exposes the resist as it reflected through the layer. The unwanted exposure of the photoresist results in line width variations in the region of the topography after development. The addition of the dye to the photoresist will absorb stray light[3], resulting in a reduction in reflective notching. Figure 1 shows the effects of stray light in an undyed photoresist. Dyed photoresist exhibits a greater exposure

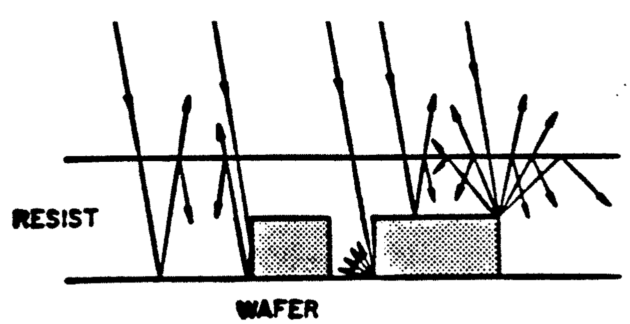


FIG 1.

latitude over the undyed material. The dye absorbs excess light which falls on the resist that would normally cause overexposure. Thus, the dye renders the resist more tolerant to small variations in exposure.

Dyed resist is not without drawbacks. Since exposure due to reflected light is removed by the dye, the dose required to expose a wafer is increased. The throughput of wafers coated with dyed resist is less than that of conventional wafers coated with undyed resist because of the increased exposure time. The other major drawback of dyed resist is an decrease in the slope of the resist sidewalls. It has been found that an increase in absorptivity of a photoresist results in a smaller side wall angle[4].

The American Hoechst corporation produces the undyed photoresist AZ 1512-SFD. The resist is a diazoquinone-novalac based system [4] with the addition of an absorbing dye. The non-bleachable dye is most sensitive to light with a wavelength of 436nm, the g-line of a mercury vapor lamp [4].

The objective of this experiment was to compare the exposure latitude of a dyed and undyed photoresist. Also examined was the ability of the dyed photoresist in controlling reflective notching.

EXPERIMENTAL

An oxide layer of 5000A was grown on 16 wafer using a wet oxygen environment. KTI820 positive photoresist was the resist layer used in patterning the Kodak Exposure Test Mask (ETM). Figure 2 shows the layout of the ETM mask which is used in evaluating photoresist images. A wet etch was used to

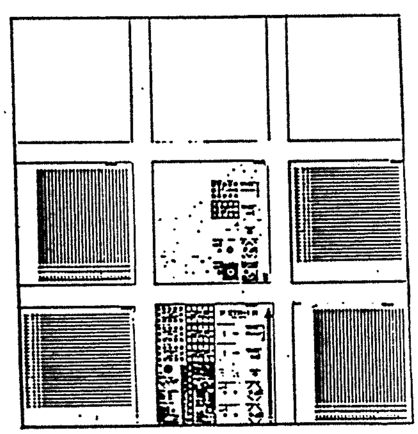


Fig 2

transfer the ETM pattern into the oxide. An aluminum layer, 2500A, was thermally evaporated on the wafers.

Five wafers were hand coated with AZ 1512 at a spin speed of 4000RPM. The wafers were prebaked on a hot plate for 45sec at 100C. A 1.1um thick layer was measured using the Nanospec. The exposure was varied from 70mJ/cm2 to 130mJ/cm2 in increments of 15mJ/cm2. The ETM mask was shifted so that the arrow on the mask aligned to the marks of the center cell in the middle row. A hand development took place for 1min in AZ312 MIF (1:1.2) developer. The 3.0um line/space pairs were measured with a stage micrometer. Linewidth verses exposure was plotted. It was determined that a variation of 0.1um from the actual value of 3.0um was acceptable. The maximum and minimum exposure which yielded acceptable linewidths was recorded. The exposure latitude was calculated using the equation:

$$\text{Exposure Latitude} = \frac{EXPmax - EXPmin}{EXPopt} \qquad (1)$$

The process was then repeated for the dyed photoresist, AZ 1512-SFD.

The region where resist lines crossed over 5000A of Aluminum coated oxide topography was used to examine notching. The 3.0um photoresist linewidth was examined visually to see if variation occurred while passing over topography. This was done for both the dyed and undyed photoresist. Photographs were taken at each exposure.

RESULTS/ANALYSIS

The results for the calculation of exposure latitude are summarized in Table 1. Figure 3 shows the plot of linewidth verses exposure for the undyed photoresist, and the plot of the dyed resist is seen in Figure 4.

The optimum exposure for the 3.0um line increased in going from the undyed to dyed photoresist. The dye in the resist absorbs the secondary light. This is light which would normally reflect off of the surface of the substrate and aid in the exposure of the resist. The exposure of the dyed resist was increased to compensate for the removal of the secondary exposure.

EXPOSURE LATITUDE
EXPRESSED AS A PERCENTAGE OF THE TOTAL RANGE

	AZ 1512	AZ 1512-SFD
EXP_{MIN}	61.25	76.25
EXP_{OPT}	64.20	80.00
EXP_{MAX}	67.10	84.20
LAT	9.1%	9.9%

Table 1

A slight increase of the exposure latitude (EL) occurred for the dyed photoresist. As calculated above, the EL is expressed as a function of the total range. The amount of variation of the exposure from the mean exposure which gives acceptable results is plus/minus half of the EL, as calculated with Equation 1. A minimal increase in the exposure latitude occurred in going from the undyed(9.1%) to dyed(9.9%) resists.

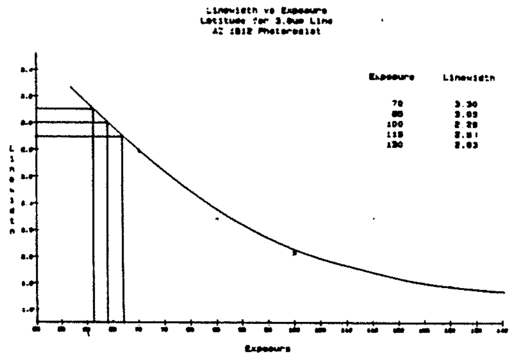


Fig 3

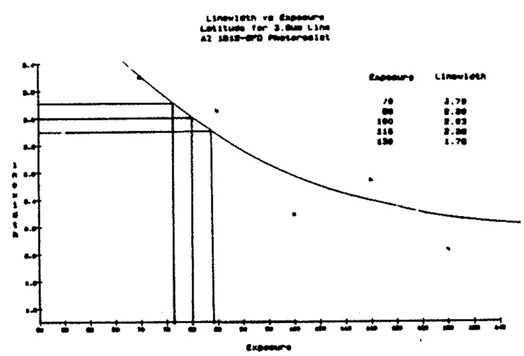
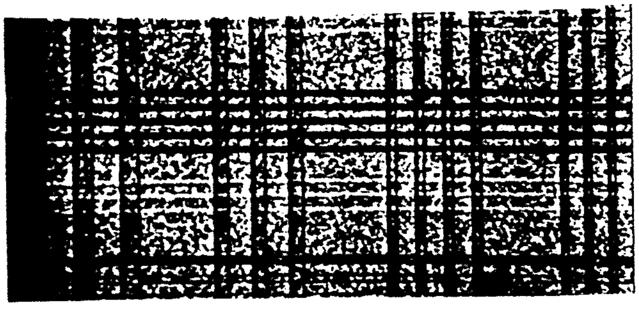


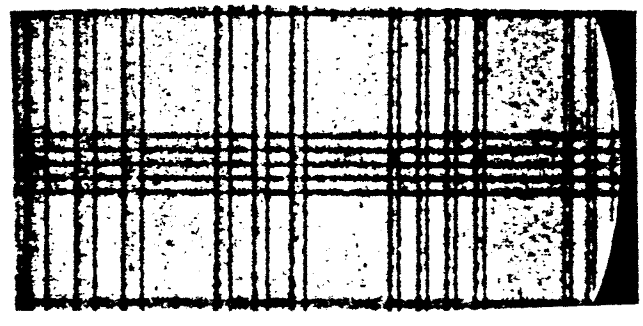
Fig 4

The photoresist lines which crossed over the topography were examined for notching. The inspection was done visually. All the wafers showed similar results with virtually no notching occurring at any exposure dose. Figures 5 and 6 shows the resist, which runs horizontally across the picture, at the maximum exposure of 130mJ/cm2. No difference could be seen between the dyed and undyed resist in the control of reflective notching.



undyed

Fig 5



dyed

Fig 6

CONCLUSIONS

The exposure that was required to produce similar line/space pairs increased going from the undyed to dyed photoresist. This results because the dye absorbs light reflected from the substrate which normally aids exposure. The exposure latitude showed an increase with the addition of the dye. The change in exposure latitude was not as large as expected. Finally, the results from the reflective notching experiment were inconclusive. No variation was seen between the dyed and undyed resist.

ACKNOWLEDGMENTS

I would like to thank Bruce Smith for the help that he gave me on this project.

REFERENCES

[1] Chris A. Mack, "Dispelling the Myths About Dyed Photoresist,"Solid State Technology,pp. 125-130, January 1988

[2] M. Bolsen, "TO Dye or Not To Dye - Some Aspects of Today's Resist Technology,"Microelec. Eng., vol3,pp. 321-328

[3] M.Watts, D. DeBruin, W. Arnold,"Experimental and Modelling Study of Reflective Notching Control Using Dyed Resist," SPE 7thPhotopolymer Conf., Ellenville 1985

[4] M. Bolsen, et al.,"One Micron Lithography Using Dyed Resist on Highly Reflective Topography,"Solid State Tech., vol. 29,no. 2,pp. 83-88(Feb. 1986)