ANALYSIS OF KTI-820 POSITIVE RESIST USING THE PERKIN ELMER DEVELOPMENT RATE MONITOR

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ABSTRACT

Experimental analysis via the Perkin Elmer Development Rate Monitor (DRM) has determined that KTI-820 resist, when exposed at 48 mJ/cm2 and developed for 30 sec in KTI-934 developer, gives optimum results. That is, 2 micron line-space pairs have been succesfully reproduced with minimal sidewall sloping.

INTRODUCTION

Computer simulation is a tool used extensively in the semiconductor industry. The analysis of photolithographic systems by such simulations has been established. The Perkin Elmer Development Rate Monitor (DRM) is a computer aided system which monitors the real-time development action of photoresist. The data obtained during the experiment is stored in a computer for later analysis. The stored data is combined with the cha acterization of the exposure tool to make predictions which would result under certain process conditions.

Since a thin film of resist is applied to a highly reflective surface, the wafer, it stands to reason that the total reflectivity of the system will vary with the resist thickness. According to Dill [1], reflectivity is a maximum for each even quarter wavelength multiple of resist thickness. Similarly, odd quarter wavelength multiple correspond to minimum reflectivity. This fact is the precursor to the fundamental principle behind the DRM, namely interferometry.

Interferometry is a term used to describe analysis based on data collected as a function of interference patterns. When monochromatic light is reflected from two parallel surfaces, the resulting beams will interfere and form a pattern. The interference pattern may be detected in the form of signal intensity versus time. In a resist system, the variation in the detected signal is a function of reflectivity due to the change in resist thickness. Figure 1 is a pictorial representation of this concept and depicts the sinusoidal nature of the signal.

Figure 2 is a more specific representation of the DRM. As shown, several points along the wafer are monitored simultaneously. There are 256 points for which development action must be monitored. The information which is collected is passed through a photodiode array and is stored in a computer data base for retrieval and subsequent analysis.

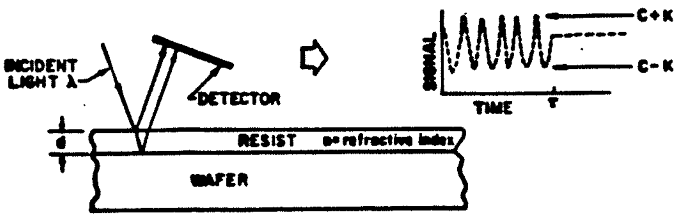

FIG 1

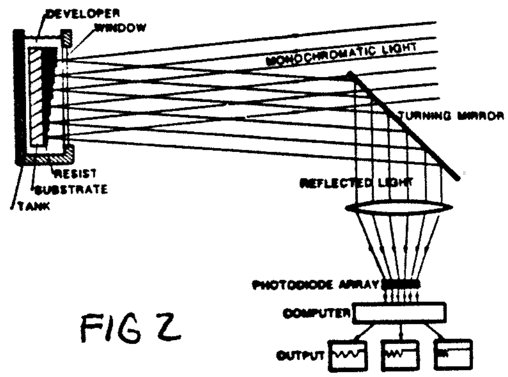

FIG 2

DREAMS software is used to address the analysis of the development process. The development of positive photoresist has been modeled as a surface-rate limited etch reaction [1]. The concentration of the inhibitor in the resist exposed to the developer is the major factor in determining etch rate. Resist and developer chemistries are also significant variables but remain constant for most analysis. Inhibitor concentration is maximum in exposed areas, corresponding the a lowest etch rate. DREAMS uses these principles to analyze development data.

DREAMS will present to the user intensity versus time data for the 256 pixels monitored. The user examines this and manually divides the information into zones which correspond to the exposures used prior to development. The computer averages the information within each zone and reduces the 256 pixels to a particular number of zones. Each zone is examined; maximum, minimum, and steady state intensity values are indicated. This information is used to generate thickness versus time plots. Such a plot gives the time to clear, Tc, for each exposure value. In addition, DREAMS creates the characteristic curve for several development times. The sensitivity,Eo, and contrast for the resist can be extracted for such a plot.

At this point, PROSIM software is used. The first step is to characterize the exposure tool with respect to light source, mask type, lens system, etc. The end result is an aerial image af the system. This is the intensity distribution of the light that actually hits the wafer surface. Such information is then combined with rate information obtained in DREAMS to make perdictions on resist performance under specified conditions

This experiment utilized DREAMS and PROSIM software to characterize the performance of KTI-820 positive resist.

EXPERIMENT

Several 3 inch wafers were coated with KTI-820 positive photoresist. The wafers were exposed using the Kasper contact printer at an exposure value of 80 mJ/cm2. This was done through a multiple transmission mask as shown in Figure 3. The 15 percent transmissions for this mask range from 1-60% thus providing values from 4 to 48 mJ/cm2. The wafers were then placed in the development tank shown in Figure 4 which was filled with KTI-934 developer. The DRM monitored the development and stored intensity versus time information for each of the 256 pixels.

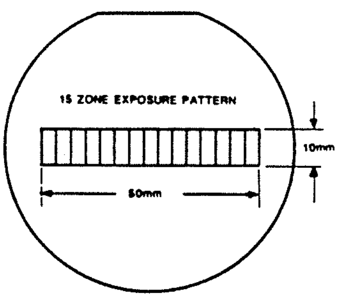

FIG 3

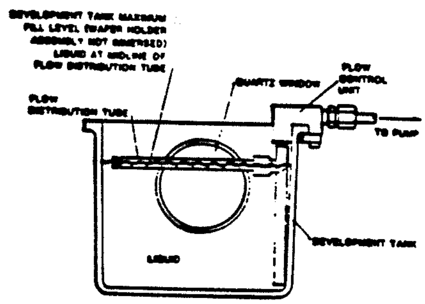

FIG 4

The raw data was examined and the 256 pixels were reduced to 15 zones. Signal versus time data for the pixels within a zone were averaged to create one plot for each exposure value. Figure 5 is the intensity versus time plot for zone 7 which was exposed to 14.4 mJ/cm2.

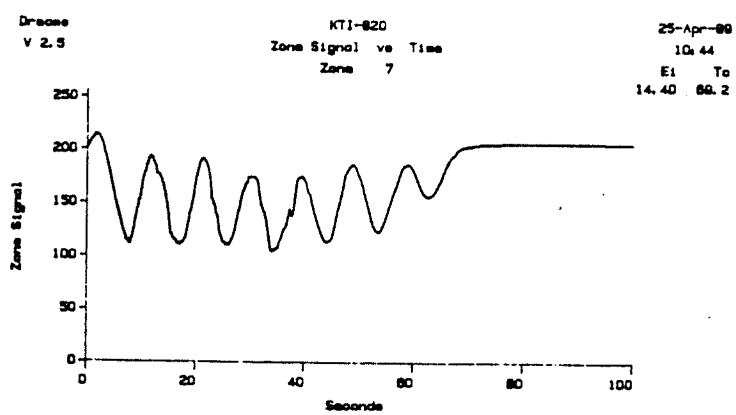

FIG 5

Analysis of the development data as well as the characterization of the exposure tool then took place using DREAMS and PROSIM. Finally, all of the information was combined to to generate resist profiles for varying exposures and development times.

RESULTS/DISCUSSION

Thickness versus time data can be found in Figure 6. Time to clear, Tc, is shown as well as original thickness for each zone. Characteristic curves were generated in Figure 7. This is a relationship of thickness with respect to log exposure for several development times. The sensitivity for each development time is tabulated.

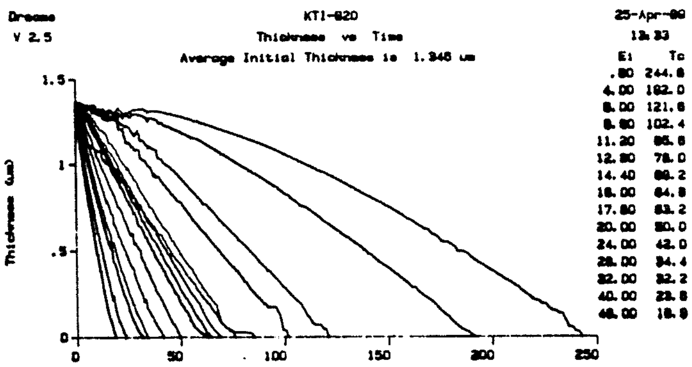

FIG 6

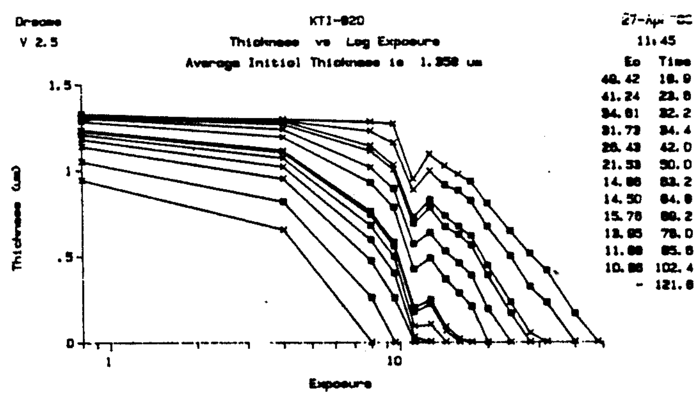

FIG 7

The Kasper contact printer was characterized for 2 micron line space pairs sighting G,H, and I lines. An intensity distribution was obtained for an 8 micron window. This can be examined in Figure 8. Once this distribution delivered through the mask was determined, it was applied to the rate information obtained earlier and several profiles were generated.

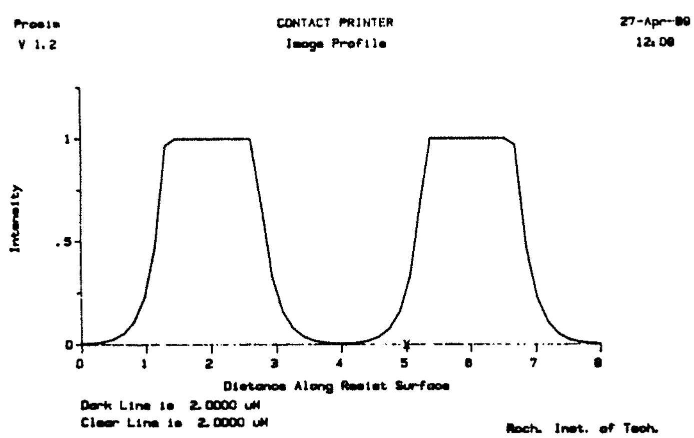

FIG 8

Figure 9 shows profiles for varying exposures at a development time of 30 seconds. The best reproduction of 2 um lines and spaces occurs for an exposure of 48 mJ/cm2. However, there is a little thickness loss and some edge rounding. In addition, the sidewalls slope at approximately 84 degrees. Figure 10 corresponds to a development time of 90 seconds. In this case, 14 mJ/cm2 provides the optimum profile. Here rounding

and thickness loss is more pronounced and sidewalls are sloping at approximately 76 degrees.

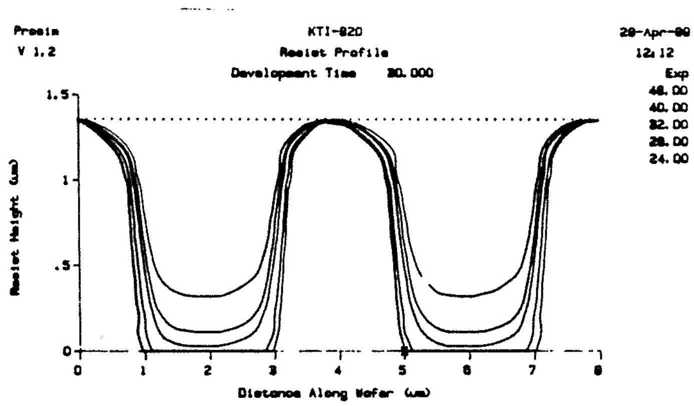

FIG9

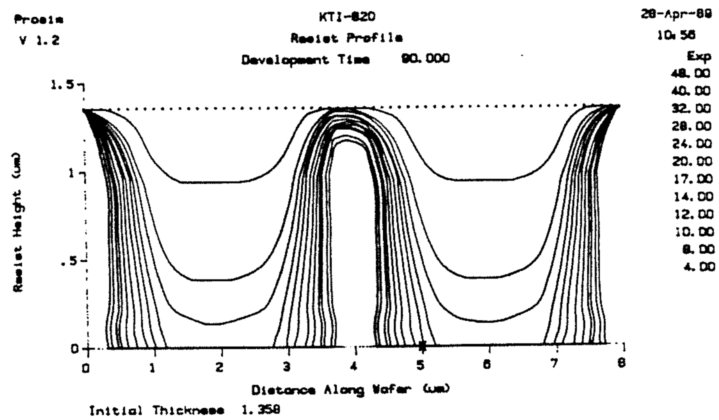

FIG 10

CONCLUSIONS

Experimental analysis demonstrated the optimum process conditions for KTI-820 resist. That data shows that an exposure value of 48 mJ/cm2 with a development time of 30 seconds will form the best series of 2 micron lines and spaces. Although less exposure with longer development time also produced the correct line and space width on the base of the image, such images have pronounced thickness loss and more sidewall sloping. Simmulations predict that For "best results" one should invoke a higher exposure value and develop for a shorter time.

ACKNOWLEDGMENTS

I would like to thank Mrs. Kathy Hesler and Mr. Bruce Smith for their help.

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