Utilization of the Hitachi S-6780 SEM For Critical Dimension Measurement

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Abstract - The necessity of being able to accurately measure sub-micron features in devices fabricated in RIT's microelectronic manufacturing facility has resulted in the acquisition of a Hitachi S-6780 CD SEM The Hitachi SEM will remove all user error, completely automate the current CD measurement procedure, and yield more accurate results. This project entails learning the operations of this model of SEM and the creation of various instruction manuals to allow this tool to become a commonly used piece of equipment at RIT. Explained will be the different kinds of files and measurement techniques the S-6780 SEM uses. Various experiments were performed and will be discussed proving the reliability and accuracy of this tool with measurement capabilities at RIT down to 0.3 um.

1. INTRODUCTION

As device critical dimension continues to rapidly decrease every year, improved methods of measurement need to be utilized. Presently RIT lacks a truly reliable method to measure our microelectronic facility's control over CD (critical dimension) size. To assist RIT in it's measurement capabilities a Hitachi S-6780 CD SEM (Scanning Electron Microscope) was acquired. Upon this tool's complete installation it has remained idle with only a select few individuals utilizing it. This small amount of usage is a direct result of time restraints of both professors and students and an overall lack of CD SEM operation knowledge.

To allow this tool to become a commonly used piece of equipment an operation manual was initially created. This manual will provide both students and faculty with instructions to run this tool. All basic commands along with many medium and some advanced operations were included.

Upon completion of the operation manual three experiments were performed with the Hitachi SEM. Each test measured a different set and size of five identical features arranged next to each other. The purpose of such experimentation was to prove the reliability and repeatability of the tool.

2. CREATION OF THE OPERATION MANUAL

To allow every person the ability to use the Hitachi S-6780 CD SEM a very descriptive operation manual was created. Included were twenty pages of a complete listing of all basic instructions along with many other advanced procedures. Three areas were focused on most heavily. These were the two files necessary for any measurement program to operate, the IDW (Identification of Wafer) and IDP (Identification of Position) files along with an automation program that incorporates these two files, the CP (Cataloged Procedure) file. Both instructions on how to create and run these files were included.

Displayed below in figure 1 is a complete listing of what is covered in the operation manual, shown is the operation manual's table of contents.

Page Number

Turning on the SEM.. 1
Loading the measurement files (IDW and IDP)......... 1
Flashing the tip.. 1
Loading the wafer... 2
Beam adjustment and Focusing............................ 2
Wafer alignment.. 4
Locating inspection points (manual)...................... 4
Locating inspection points (automatic).................. 5
Manual CD measurements.................................. 5
Automatic CD measurements............................. 6
Unloading the wafer.. 6
IDW file creation.. 7
IDP file creation... 10
CP file creation... 12
Running a CP file... 16

Figure 1: Table of Contents of the Operation Manual

3. MEASUREMENT TECHNIQUE

RIT's present method of measurement utilizes two different scanning electron microscopes and an outside measurement program called Vital-Scan. This is a rather poor system allowing for much user error and is seldom

repeatable. Unlike this current method the Hitachi S-6780 CD SEM needs no outside assistance in measuring the critical dimensions of selected features.

Vital-Scan

The Vital-Scan system is a high performance PC that is interfaced to the scanning electron microscope. This system allows the user to manually measure a line by clicking on the two edges of the feature, which is shown on the PC's monitor. According to where the user clicks, Vital-Scan will make the corresponding CD measurement. The largest problem with this system is all measurements are completely left to the user's ability to determine where the feature edge begins and ends.

Shown below in figure 2, a single resist line is measured by two different users with the Vital-Scan system. As can be seen, each user chose a different location for the beginning and the end of the feature edge, therefore resulting in two different CD measurements for on single line.

Figure 2: Resist line measured using Vital-Scan

Hitachi S-6780 CD SEM

Unlike Vital-Scan the Hitachi CD SEM needs no outside assistance to measure CD sizes. The SEM has a built in program capable of determining the location of feature edges using one of two different methods: linear approximation or threshold.

With linear approximation the base and slope lines are linearly approximated and the intersection of the linear zed line is used as a measurement point. A schematic of this is shown in figure 3

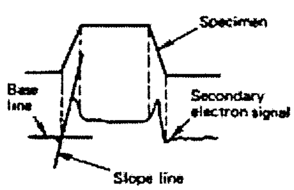

Figure 3: Linear Approximation

The second possible method, threshold, is used for examples where the feature edge is small, where the feature has good contrast. For the threshold technique the maximum and minimum signal intensities around the edges are determined and a threshold level is set up between them. The intersection of the threshold level and signal waveform is used as a measurement point. A schematic of this technique is shown in figure 4.

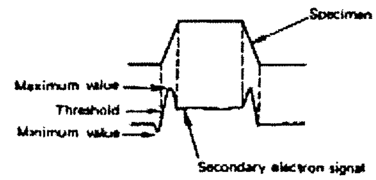

Figure 4: The threshold technique

4. EXPERIMENT

Once the operation manual was created three experiments were performed to prove the reliability and repeatability of the SEM. Three different CP files were created. This type of file stores a series of operational commands that the SEM automatically will carry out for the user.

The same wafer was used for each experiment. The wafer was coated with positive OIR 620 resist. A XLX 20 TARC (top anti reflective coating) layer was applied to the top of the resist. The wafer was then exposed using a Canon I-1 stepper, I line exposure. The Canon test reticle was used to pattern the wafer.

Each CP file would automatically align the wafer and then move to the measurement point, which was a set of five resist bars aligned in parallel next to each other. The set of five resist bars should have theoretically been identical in width and length. A drawing of the resist bars is shown in figure 5.

Figure 5: Drawing of resist bars.

The CP file would then increase magnification as to achieve a better image. It would then measure the width of each line at the exact same position. Each CP file measured a different size set of CD bars. The first experiment measured 1.0 um lines, the second experiment

measured 0.5 um lines, and the third experiment measured 0.3 um lines. For the final step of the experiment the SEM would calculate the following statistics for each set of five measurements: maximum, minimum, mean, and standard deviation.

5. ANALYSIS

Each experiment and appropriate CP file functioned correctly. In each experiment the appropriate lines were measured at the appropriate locations. The following six figures show the results of each experiment along with a SEM image of where the measurements took place.

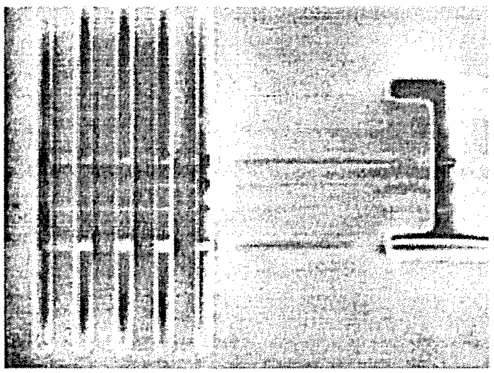

Figure 6: 1.0 um lines, magnified 20,000x

* * * * * Measure Data * * * * *
1. DATE : 01-05-02
2. IDP FILE : RESOLUTION-1
6. COMMENT : 1 UM LINES
8. VACC (KV) : 1.00
CHIP= (9, 0) , MP= 1 DATA = 0.977
CHIP= (9, 0) , MP= 2 DATA = 0.976
CHIP= (9, 0) , MP= 3 DATA = 1.013
CHIP= (9, 0) , MP= 4 DATA = 1.016
CHIP= (9, 0) , MP= 5 DATA = 1.009

MAXIMUM = 1.016
MINIMUM = 0.976
MEAN = 0.998
STDEV = 0.016

Figure 7: Measurement data for experiment #1

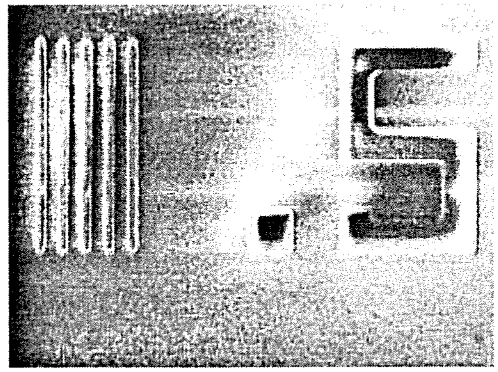

Figure 8: 0.5 um lines, magnified 20,000x

* * * * * Measure Data * * * * *
1. DATE : 01-05-02
2. IDP FILE : RESOLUTION-1
6. COMMENT : 0.5 UM LINES
8. VACC (KV) : 1.00

CHIP= (9, 0) , MP= 1 DATA = 0.486
CHIP= (9, 0) , MP= 2 DATA = 0.509
CHIP= (9, 0) , MP= 3 DATA = 0.503
CHIP= (9, 0) , MP= 4 DATA = 0.524
CHIP= (9, 0) , MP= 5 DATA = 0.492

MAXIMUM = 0.524
MINIMUM = 0.486
MEAN = 0.506
STDEV = 0.015

Figure 9: Measurement data for experiment #2

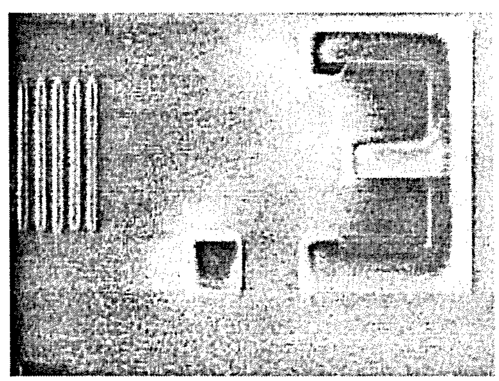

Figure 10: 0.3 um lines, magnified 50,000x

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***** Measure Data *****
1. DATE        :  01-05-02
2. IDP FILE    :  RESOLUTION-1
6. COMMENT     :  0.3 UM LINES
8. VACC (KV)   :  1.00

CHIP= ( 5, 4 ) , MP= 1   DATA = 0.309
CHIP= ( 5, 4 ) , MP= 2   DATA = 0.325
CHIP= ( 5, 4 ) , MP= 3   DATA = 0.321
CHIP= ( 5, 4 ) , MP= 4   DATA = 0.319
CHIP= ( 5, 4 ) , MP= 5   DATA = 0.312

MAXIMUM    = 0.325
MINIMUM    = 0.309
MEAN       = 0.319
STDEV      = 0.007
```

Figure 11: Measurement data for experiment #2

6. RESULTS

The statistics of each experiments results are displayed in chart 1.

Feature Size	Mean	Standard Deviation
0.3 um	0.319 um	0.007
0.5 um	0.506 um	0.015
1.0 um	0.998 um	0.016

Chart 1: Experimental results

The mean feature width of each set of five resist lines was close to their optimum value. All standard deviation calculations were relatively small remaining below .016.

Experimentally through the completion of this project RIT now has the capability to accurately measure sub-micron CDs, the reliability and accuracy of the Hitachi CD SEM has been proven over a range of feature sizes, and an easily comprehendible set of operation instructions has been created.

7. CONCLUSION

This project involved the reliability and repeatability testing of the Hitachi S-6780 CD SEM along with creating a comprehendible set of operation instructions. Through three different experiments the SEM has proven to be a viable tool and can now be utilized by anyone in the microelectronics' facility.

8. ACKNOWLEDGEMENTS

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