SETUP AND PERFORMANCE TESTING OF AUTOSORT MARK II FLATNESS ANALYSIS SYSTEM

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ABSTRACT

An Autosort Mark II wafer flatness tester was installed and initial runs and performance testing accomplished. A guide for aiding in every day use of the machine was written as well as a fortran program that performs a statistical analysis on performance data.

INTRODUCTION

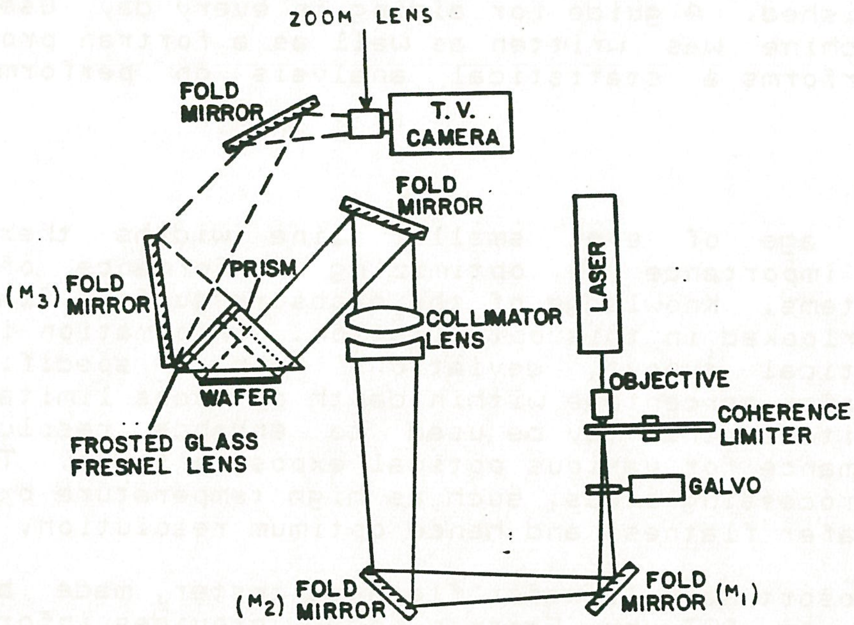
In the age of ever smaller line widths there is an increasing importance on optimizing performance of optical exposure systems. Knowledge of the exposure surface flatness can not be overlooked in this optimization. Information in regards to total vertical runout, deviations from a specified focal plane, and wafer percentage within depth of focus limitations are important criteria that may be used to enhance resolution and yield performance for various optical exposure tools. The effect of various processing steps, such as high temperature oxidations, may affect wafer flatness and hence optimum resolution.

The Autosort Mark II wafer flatness tester, made by Tropel and donated to RIT by Eastman Kodak, provides information in regards to the above tests and sorts a group of measured wafers based on one user selected criteria. Even though sorting is performed on one criteria, data for each criteria is obtained for each wafer measured.

Interferometry, the method of measuring wafer flatness, is based on the wave nature of light. When two (or more) light waves of the same wavelength are superimposed, interference results in one wave. Depending the phase difference of the waves (fractional part of a period in which the time variable of a wave has moved), the interference will be constructive, producing a light fringe, or destructive, producing a dark fringe. At the constructive extreme, the two light waves will have phases that are an integer number of wavelengths apart and the resultant wave will have an amplitude that is the sum of the individuals. At the destructive extreme, the two light waves will have phases that are 180 degrees (one half the wavelength) apart and the summed amplitude of the resultant wave will be zero. These interferences cause alternate dark and light fringes and the various phase relationships of the two light waves that fall between these extremes will produce shades of gray fringe patterns.

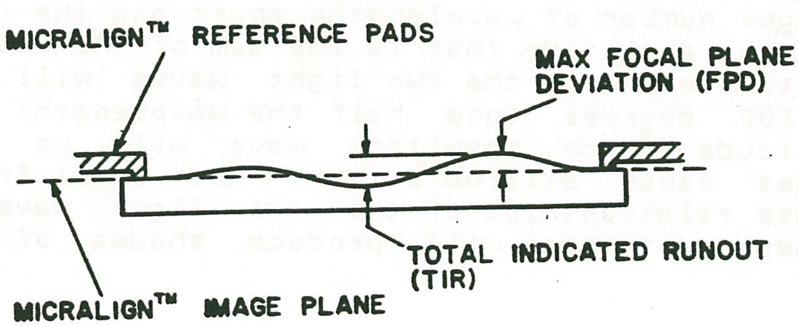
The optical path of a typical interferometer system is shown in Figure 1. The light is directed into a prism and split into two beams at the prism/air interface nearest the wafer under measurement. One beam is internally reflected while the other passes out of the prism, reflects off the wafer surface at a high angle of incidence, and again enters the prism to combine with the internally reflected signal(s). This is referred to as a grazing incidence interferometer. The resulting wave exiting the interferometer is picked up by a 32 X 32 array of pixels, integrated over space and time, and stored for computer use.

Figure 1 : AUTOSORT'S OPTICAL PATH



There are four different criteria for sorting wafers. One of them is Total Indicated Runout (TIR) and is shown in Figure 2. This is a measure of the vertical distance between the lowest and highest points on a wafers surface. The information it supplies is relative to exposure system considerations in that the depth of focus must be varied to account for all areas on a wafer. Because of this, TIR is the most used flatness criteria in the semiconductor industry today [1].

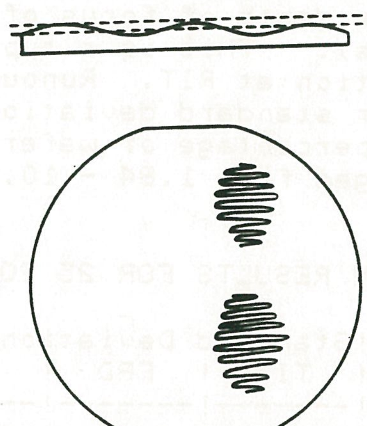
Figure 2 : TIR/FPD SORT CRITERION



A second criteria, Focal Plane Deviation (FPD), is also shown in Figure 2. This measures the largest vertical distance on a wafer surface, being negative or positive, from a specified focal plane. The focal plane is defined by the three Perkin-Elmer Alignment pad locations (Micralign reference pads in Figure 2) on the wafer perimeter, spaced at the vertices of a triangle. A subsequently needed depth of focus could be determined from this criteria.

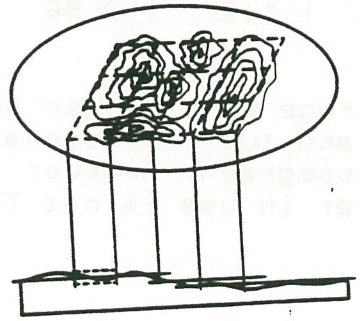
Percent of Wafer within Depth of Focus (PWI), a third criteria, is a measure of the percentage of wafer that will be within a user specified depth of focus. This is represented in Figure 3. In using projectors for exposure purposes, this criteria could determine the depth of focus limits that can be used with 100% of wafer in focus.

Figure 3 : PWI SORT CRITERION



The fourth criteria is Direct Step on Wafer (DSW) test/sort process and simulates, as shown in Figure 4, the exposure of a GCA stepper. The stepper normally refocuses for each step to be exposed on the wafer. Therefore, the Autosort will return the number of steps on the wafer that upon exposure will be 100% within the user specified depth of focus after each stepper refocusing. The number of steps on the wafer is automatically determined prior to measurement based on user entered parameters such as minimum unexposed distance from wafer flat, step size, step centering method, and wafer edge exclusion.

Figure 4 : DSW SORT CRITERION



EXPERIMENTAL

The Autosort Mark II flatness analysis system, using a collimated Helium-Neon laser (633 nm wavelength) as it's source, was brought on line. Performance testing was carried out using 15, 3", 10-20 ohm/cm2 SEH wafers which were run through the machine 25 consecutive times. During these runs, wafers were sorted according to various degrees of TIR, FPD, PWI, and DSW, but data was collected for all 4 criteria. A program was written to input performance testing results from a number of runs and output the average, standard deviation, and high and low data points for each criteria on each wafer. Autosort plots were also taken.

RESULTS / DISCUSSION

Upon calibration at each new testing session, sensitivity was within the 7.0 +/- 0.2 specified value of a calibration disk. In performance testing, a depth of focus of 1.5 microns was used (determines PWI results). This is a typical value for the GCA stepper that is in operation at RIT. Runout results for the 25 runs showed a superior standard deviation range of 0.46 - 2.61 compared to that of the percentage of wafer in focus test which standard deviation ranged from 1.84 - 10.84. A results summary is shown in table 1.

TABLE 1 : PROGRAM RESULTS FOR 25 CONSECUTIVE RUNS

Wafer	Standard Deviation (um)		
*	TIR	FPD	PWI
1	2.61	4.43	4.55
2	0.81	0.42	1.84
3	0.80	2.05	4.11
4	0.93	3.05	6.35
5	1.96	4.94	7.44
6	0.50	4.78	5.56
7	1.10	3.40	4.12
8	1.54	6.06	2.78
9	1.01	5.69	4.27
10	0.86	3.76	8.25
11	0.46	3.16	10.8
12	2.36	5.04	4.54
13	1.33	1.96	5.60
14	1.20	4.65	6.32
15	3.12	5.95	3.77
Mean	1.37	3.96	5.36

The Tektronix Storage Display use by the Autosort will give a three dimensional and two dimensional ('birds eye' view) plot of the wafer surface topography however no hard copy is currently available as the printer in use is not Tektronix compatible.

To assist a user who is unfamiliar with the machine, a guide to start procedures has been written. This is a cross between the user manual and the individual variations of RIT's machine. It will bring the user from the point of arriving at the machine through the testing of the wafers. For more technical information, he/she is referred to the published users manual [2].

Finally, some concern should be given to the actual test area. The blowers on the environmental hood, located over the machine, are in operation however water hookups need to be made for temperature control. The current temperature specifications of the room (mask making area) may prove to be adequate over time however precise temperature (and humidity) control is required for optimum accuracy and run to run conformity.

CONCLUSION

The Autosort Mark II system is now up and running and ready for further testing. Future use may include testing as to how well results of the of flatness testing can be applied toward exposure tool effectiveness. Also, the effects on wafer flatness of various processing steps such as high temperature oxidation can be examined. Eventually, the autosort CPU may be connected on line to the VAX/VMS computer system so that data does not need to be input by hand into appropriate data files for program analysis.

ACKNOWLEDGMENTS

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REFERENCES

[1] Stephen T. Pritchard: "The Autosort - An Optimization"

[2] "Autosort Users Manual", Tropel: 60 O'Conner Rd, Fairport, New York, 14450