Theory of Operation

Purpose of This Section

This section provides a general discussion of the theory and physics involved in thermal wave measurements. This discussion is intended for those who wish a more detailed understanding of the system theory. An understanding of this information is not required of the system operators.

Thermal Waves

Thermal waves are generated whenever an oscillatory or time-variant heating occurs in a material. In the TP-420 system, the periodic heating is produced by a low power pump laser focused to a spot, approximately 1 µm in diameter, at the sample surface. In a material like silicon, typical temperature increases generated at the illuminated spot are about 10 °C. For thermal wave measurements, the pump laser is modulated at 1 MHz. Since thermal waves are diffusive in nature, and thus critically damped, these 1 MHz waves propagate into materials such as silicon to a depth of 2-5 µm.

Although thermal waves are diffusive and have a short range, they do interact and scatter from thermal features. Thermal features are regions of an otherwise homogeneous material that exhibit variations, relative to their surroundings, in either the thermal conductivity or the volume specific heat. Local variations in these thermal parameters usually arise from local variations in sample composition or from the presence of impurities or lattice perturbations. Those thermal features, or sample variations, that are located at or near the surface of the sample, interact with the pump-generated thermal waves, and are thus detectable.

Theory of Operation

Modulated Reflectance Signal

In the TP-420 system, an argon pump laser generates the thermal waves while a HeNe probe laser detects them. The probe laser is focused to the same spot on the sample surface as the pump laser and measures the changes in the sample reflectivity induced by the pump laser. In most materials the modulated reflectance signal on the probe laser beam arises from a purely thermal-reflectance effect. That is, since the optical properties of most materials are dependent to some extent on the sample temperature, and since the temperature of the sample surface undergoes a periodic variation from the laser pump generated thermal waves, the reflectance of the probe laser beam experiences a corresponding modulation. By measuring the local modulated reflectance signal across the surface of the sample one can therefore obtain a measure of the sample's local inhomogeneities, impurities or lattice disruptions in a completely non-contact, non-damaging manner. The basic optical configuration of the TP-420 system is shown in Figure 3-1.

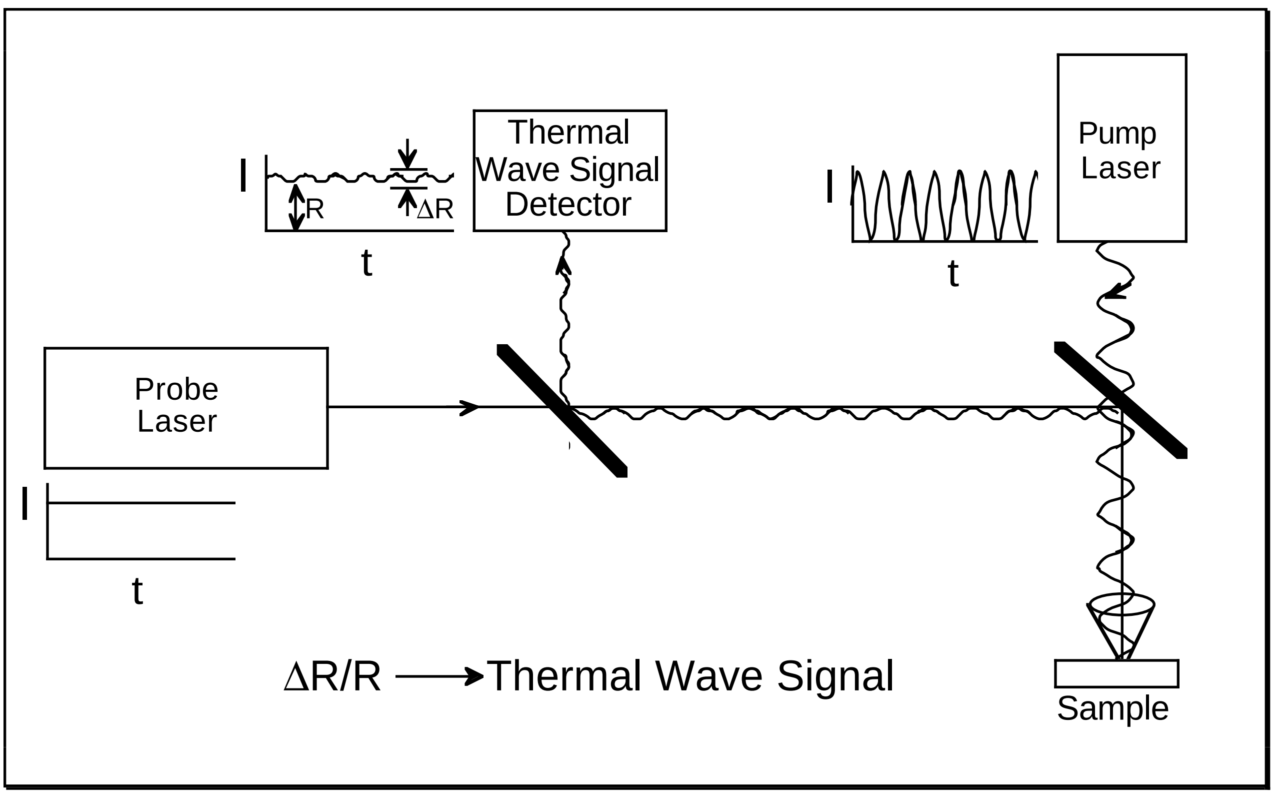

Figure 3-1. TP-420 Optical System

Theory of Operation

Semiconductors

In semiconductors, it is possible to have local variations in sample composition or lattice characteristics that have an appreciable effect on the local electronic properties while having negligible effect on the local thermal properties. Thus, a purely thermal wave technique will be insensitive to these important sample features. The TP-420 system, however, does detect these electronic features as well as the thermal features. This valuable capability comes about from the fact that the pump laser in the TP-420 system generates electron-hole plasma waves as well as thermal waves in a semiconductor such as silicon. These electron hole plasma waves are also critically damped and are sensitive to local variations in carrier mobility, ambipolar diffusivity, recombination lifetime, and so on. In addition, like the thermal waves, the plasma waves alter the reflectance of the probe laser beam. Thus the TP-420 system can detect both the electronic and the thermal features in silicon.

Ion Implant Damage

The TP-420 system has excellent sensitivity for detecting and quantifying the extent of silicon damage that arises from wafer fabrication processes such as ion implantation and dry etching. The TP-420 system thus provides a highly sensitive, non-contact method for inspecting important, but previously difficult to monitor, processes in the manufacture of integrated circuits. Furthermore, these inspections can be performed with micron-scale resolution directly on product wafers.

As the thermal and plasma waves propagate into the silicon wafer, Figure 3-2, their behavior is influenced by the presence of subsurface features. For example, if the waves were to encounter crystalline damage just beneath the surface of the silicon wafer, the propagation of both the plasma and thermal waves would be altered with a resultant change in the thermal wave signal.

Theory of Operation

Ion Implant Damage (continued)

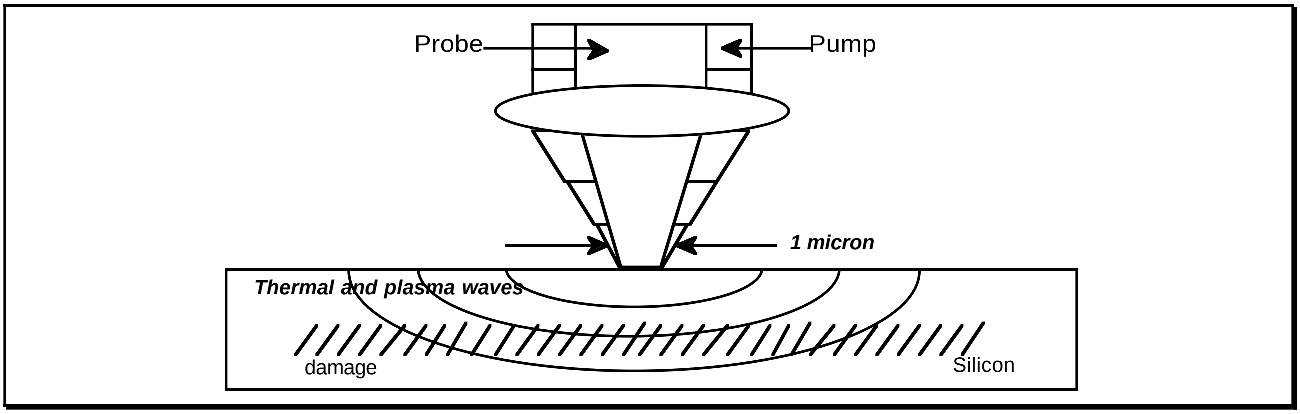

Figure 3-2. Laser Generation of Thermal Waves

Damage to the silicon crystal lattice that takes place during ion implantation increases the thermal wave signal above that of the un-implanted silicon wafer. This effect is the basis for implant monitoring with the TP-420 system. The characteristic dependence of thermal wave signal versus implant ion dose is shown in Figure 3-3. The functional dependence is smooth, monotonically increasing, and nonlinear. Other aspects and consequences of this basic functional behavior will be mentioned in following sections. Because the TP-420 derives its implant monitoring ability from the presence of lattice damage which can be removed during a thermal anneal cycle, TP-420 measurements are generally made directly following the ion implant step and prior to any anneal or other elevated temperature process step.

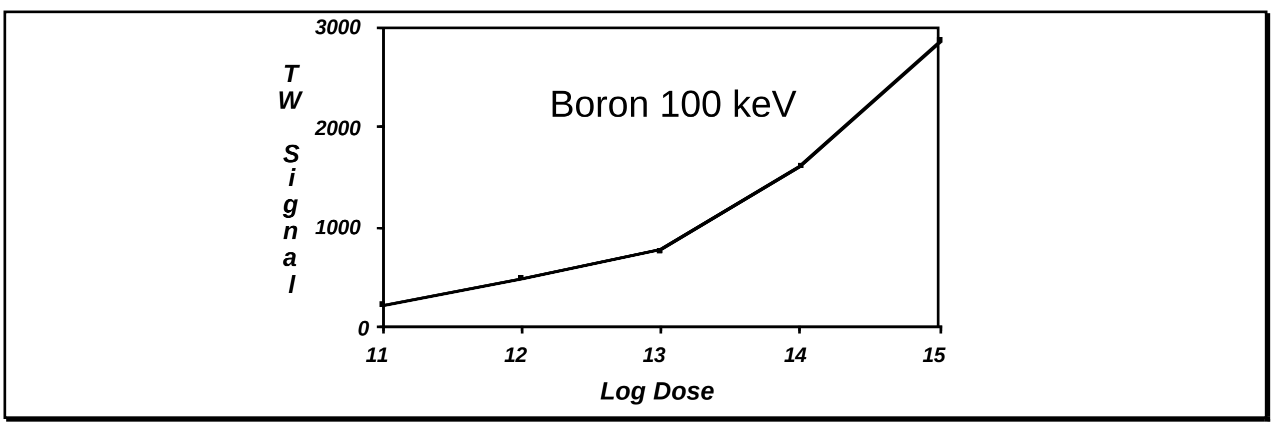

Figure 3-3. Typical TW Signal vs. Implant Dose for a Boron Implant

Measurements in Thermal Wave and Ion Dose Units

The TP-420 is designed to provide readings in either thermal wave or ion dose units. Thermal wave readings can be obtained directly without the need for prior calibration. Measurements in thermal wave units are usually quite adequate for monitoring implant reproducibility or implant uniformity. Variations in the recorded thermal wave signal can be converted into variations in implant dose by using a calibration procedure. When the TP-420 system provides measurement data in thermal wave units, the situation is analogous to that found with a four-point probe system where measurements are made in sheet resistance units and not in actual ion dose units. However, unlike the four-point probe, an increasing thermal wave signal indicates an increasing dose dependant on the dose regime. In high dose the TW signal may decrease with increasing dose.

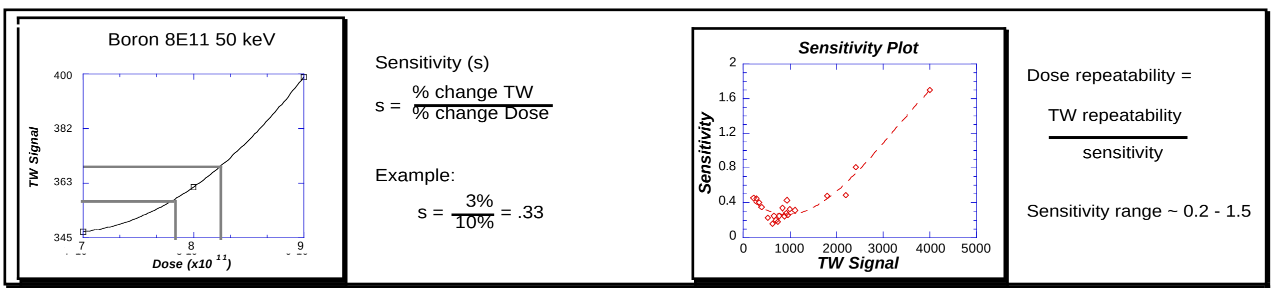

Figure 3-4. TW Signal vs Dose

The TP-420 can also provide readings in actual ion dose units by following a simple calibration procedure that uses a small number of calibration wafers implanted in a routine fashion with the user's ion implanter.

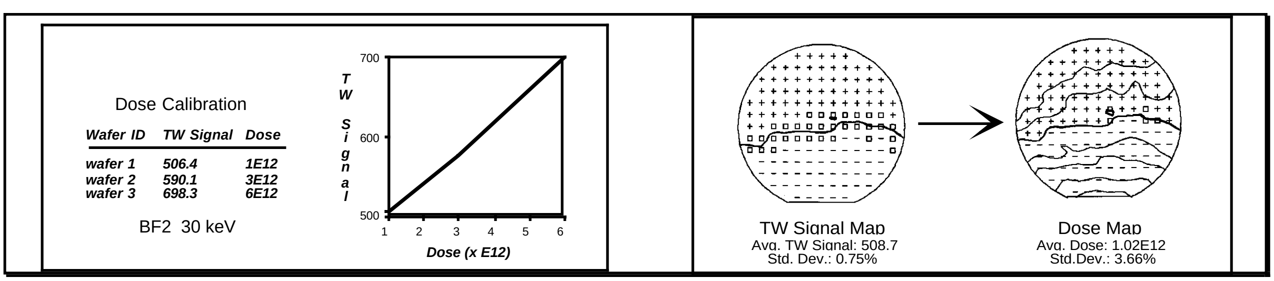

Figure 3-5. TW Signal Calibrated to Dose

Theory of Operation

Oxide Thickness Measurements on Ion Implanted Wafers

Measurement of oxide thickness and its relation to TW signal can be a complicating factor in ion implant - dose calibrations. This complication is the result of two factors: (1) the refractive index of silicon can be altered by the ion implantation process, (2) the TP-420 cannot independently measure the oxide thickness on a silicon wafer if the refractive index of the silicon is unknown.

For these reasons, special considerations are required when making measurements of oxide thickness on implanted wafers. Since the TW signal and the oxide thickness are generally interrelated by the Oxide Compensation Function, any errors made in the measurement of oxide thickness can be propagated into errors in TW signal measurements as well.

Details of the oxide measurement process during implant calibration are described below, including the following topics:

- General theory of oxide measurements
- Effect of ion implantation on silicon refractive index
- Example of an implant calibration with a changing silicon refractive index
- Film calibration

Oxide Measurement Theory

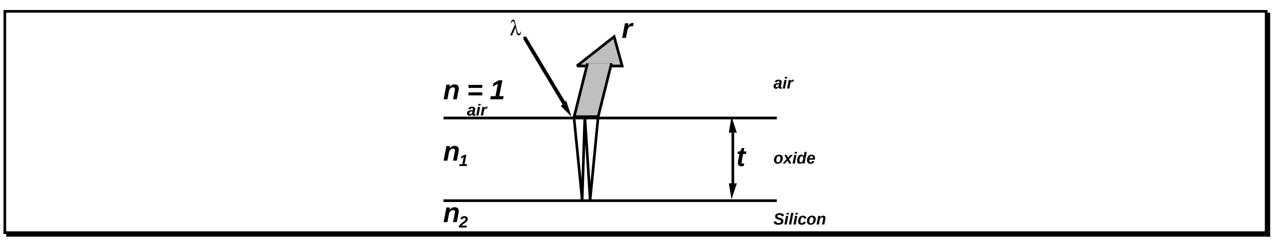

Figure 3-6. Thin Film Reflectivity

On the TP-420 system, oxide thickness measurements are made by measuring the intensity of the reflected HeNe laser beam from the surface of the wafer, shown schematically on Figure 3-6. The presence of a dielectric layer (such as oxide) on the silicon surface results in reflections from two interfaces: the beam is reflected from the air/oxide interface, and the dielectric/silicon interface. These beams return to the reflected HeNe detector. This phenomenon is known as thin-film interference.

Oxide Measurement Theory (continued)

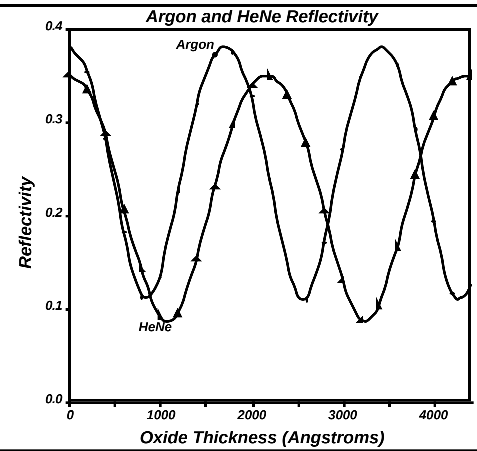

Figure 3-7. Thin Film Reflectivity Function

The relationship between reflectivity and oxide thickness is illustrated in Figure 3-7. The reflectivity is a periodic function of the oxide thickness. In order to determine the correct period of the function for determination of oxide thickness, the software uses the Argon laser (a different wavelength) as a check and also requires that the user enter a range for the oxide thickness being measured, e.g., 0-1500 Angstroms.

There are four parameters that determine the reflectivity of the silicon wafer with an oxide layer (ignoring absorption in the oxide).

Equation 1: $r = F\{ n_1, n_2, t, \lambda \}$

The complete function is shown below.

Equation 2:

$$r = \frac{r_0^2 - r_1^2 + 2r_0r_1 \cos\{4\pi n_1 t/\lambda\}}{1 + r_0^2 + r_1^2 + 2r_0r_1 \cos\{4\pi n_1 t/\lambda\}}$$

$$r_0 = \frac{n_1 - 1}{n_1 + 1}, \quad r_1 = \frac{n_2 - n_1}{n_2 + n_1}$$

and

n_1 = oxide refractive index
n_2 = silicon refractive index
t = oxide thickness
r = HeNe reflectivity from the wafer

Theory of Operation

Oxide Measurement Theory (continued)

To determine any parameters specified in Equation 1, all other parameters must be known. That is, Equation 2 can be inverted to solve for any single parameter. Since λ (lambda), n_1 (oxide) and r (HeNe reflectivity) are always known, the unknowns are generally n_2 (si), t (oxide thickness) for implanted wafers. In this case some approximations must be made.

Effects of Ion Implant on Silicon Refractive Index n(si)

The silicon crystal lattice damage created during ion implantation causes a change in the TW signal, but also has an effect on the silicon refractive index (and therefore reflectivity). The effect of damage on the silicon refractive index is much less than the effect on the TW signal, but still very important to oxide thickness measurements.

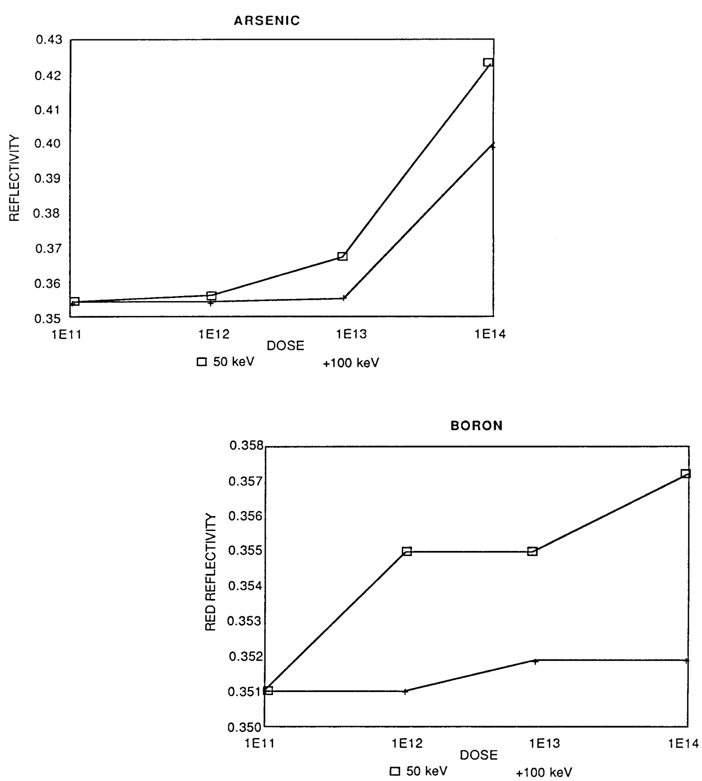

Figure 3-8. Arsenic and Boron Plots

Effects of Ion Implant on Silicon Refractive Index n(si) (continued)

Since the silicon refractive index is altered by the damage to the crystal lattice, it is affected by the dose and the energy of the implant. Figure 3-8 illustrates the variation in reflectivity created by implants of Arsenic and Boron over a range of doses and energies. This data demonstrates that for Arsenic, implant doses as low as 1E12 ions/cm^2, can change the substrate refractive index. The effect is more pronounced for low energies since the range of the ions is reduced; the damage is closer to the surface of the wafer.

When an oxidized wafer is implanted, the effect of the implant is to increase the reflectivity and reduce the apparent oxide thickness (when the actual thickness is between 0 - 1084 Angstroms).

Errors in the calculation of oxide thickness on an implanted wafer can propagate into errors in TW signal (dose) when the Oxide Compensation function is not used. The Oxide Compensation function is employed to eliminate the dependence of the TW signal on oxide thickness.

Film Calibration

As an alternative to using the empirical oxide compensation routine, the film calibration function can be used to correct for the film thickness contribution to TW signal. A film calibration can be computed in two ways: 1) by measuring a set of wafers with varying oxide thickness and a nominal dose and establishing a curve, or 2) from previously stored data by generating a scatter plot of TW signal versus oxide thickness and fitting a curve to the plot. Film calibration can be used independently or in conjunction with implant calibration.

Film calibration is a function that will compensate for changes in the TW signal caused by variation in film thickness. The TW signal responds primarily to changes in damage to the silicon crystal lattice caused by ion implantation dose. However, optical effects caused by variations in dielectric film thickness can also change the TW signal independent of dose effects.

"Oxide compensation" is a software calculation that can reduce the dependence of the TW signal on oxide variations. For certain applications, this compensation may not be accurate enough. Oxide compensation will not function properly for film types other than oxide.

Theory of Operation

Film Calibration (continued)

Film calibration involves making a series of measurements analogous to the implant dose calibration procedure that will accurately compensate for changes in film thickness over the calibration range. The film calibration can be performed in addition to, or independently of, an implant dose calibration.

An example of a film calibration would be the following: to calibrate for film thickness variations of ± 30 Angstroms about a nominal film thickness of 400 Angstroms for an implant of 2E12 ions/cm^2, the following set of wafers would be measured.

Calibration Wafer	Dose	Film Thickness
# 1	2E12 ion/cm^2	350 Angstroms
# 2	2E12	400 Angstroms
# 3	2E12	450 Angstroms

The calibration will not be valid for doses significantly different from the "nominal dose" of 2E12. When measuring an unknown wafer using the film calibration data, the TW signal for every point in the measurement is converted to a value corresponding to a "nominal" film thickness. The nominal film thickness must be defined by the user. When constructing a film calibration, the user is prompted to enter the nominal film thickness when the first wafer is measured. Or, if a dose calibration already exists, the nominal film thickness of the film calibration is defined to be the same as the nominal film thickness in the dose calibration.

The film calibration is ideally suited to be used in conjunction with dose calibrations that have a single target (i.e. target dose, ± 50% dose). If a dose calibration spans a full decade (1E12 - 1E13) it is not possible to construct a film calibration that will correct for film variations over the entire dose range.

Damage Relaxation (Decay Factor)

Damage relaxation is a phenomenon which can result in a gradual change in the measured thermal wave (TW) signal on a silicon wafer as a function of the time after implant. If measurements were made on a wafer just after implant, and then at periodic intervals, the TW signal level would slowly change until reaching an asymptotic value. The amount of change in the signal as well as the time for the signal to stabilize is dependent on the species and dose.

Measurements on the TP-420 system can be made using "Damage Relaxation Compensation". The effect of this type of measurement is to eliminate the dependence of the TW signal on time since implant.

The technique for eliminating the damage relaxation effect depends on the use of a laser to accelerate the relaxation process. When the pump beam (Argon laser) illuminates a single 1µm spot on a silicon wafer, the damage relaxation effect is accelerated so that a stable "relaxed" signal is obtained in seconds, rather than the hours or days required at room temperature. This relaxed TW signal is independent of the time elapsed since the implant was performed.

Even though the damage relaxation can be accelerated to a time-scale of seconds by use of the pump laser, this is still too slow to acquire all of the data for a measurement, such as a 137 point contour map, in this manner. The following technique is used to provide equivalent data, but in a much reduced time.

Just before (or after) the normal measurement, some additional signals are taken. The relaxed TW signal is measured in one or more locations. This data is acquired by keeping the pump laser in one place for a specified time (usually 10 seconds) and then recording the TW signal. The laser probe is moved slightly between subsequent relaxed TW measurements to ensure that each reading is completely unaffected by the previous one. As a default setting, 10 damage relaxation measurements are taken, the duration at each point is 10 seconds and the distance between points is 10 µm. All of these parameters are adjustable in the software to satisfy special or unusual situations.

Theory of Operation

Damage Relaxation (Decay Factor) (continued)

Using improved electronics, repeatability of the decay factor measurement on low-dose wafers allows collecting the relaxed (t=10) TW_{10} signals, and the unrelaxed (t=0) TW_0 signals at exactly the same location on the wafer simultaneously.

The t=0 sec (unrelaxed) and t=10 sec (relaxed) signals are combined to obtain the damage relaxation factor, referred to as the decay factor (DF).

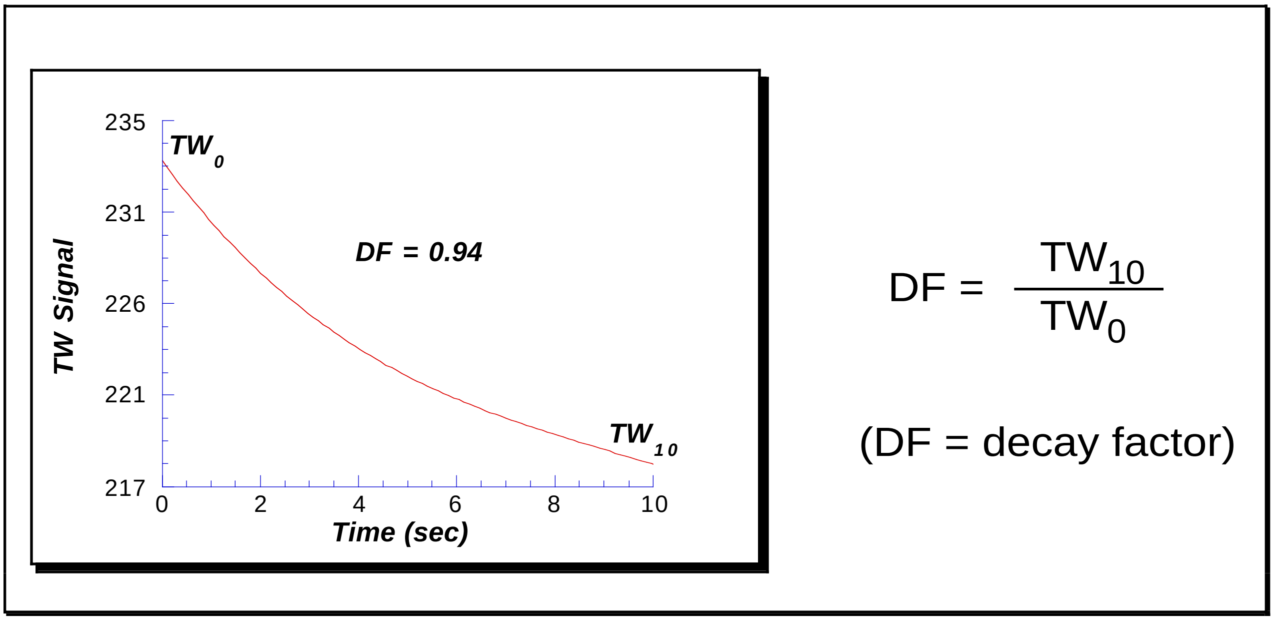

Figure 3-9. Decay Factor

The contour map or line scan data points are then taken in the normal fashion. Afterwards, the data values are multiplied by the decay factor. The result of this operation is equivalent to taking a relaxed TW signal at each data point, but in a much shorter period of time.

Reference Measurements

The TP-420 is designed with an internal reference standard to improve short term stability. The reference measurement is used to normalize the TW, and reflectivity signals. This measurement can be performed automatically, before and after each wafer measurement, or manually in the Main Menu, Operator Menu or Alternate Menu.

Silicon Calibration Wafer Measurements

The Silicon Calibration Wafer (SCW) has the same process conditions as production wafers and corrects for system drifts in TW signal due to environmental changes or aging. The SCW measurement is performed automatically at specified times, before cassette or manual measurement. A Timer option can be selected to remeasure the entire cassette at a specified interval. A pre-job file option with an associated SCW wafer can be selected that allows remeasuring before the production job file is run.

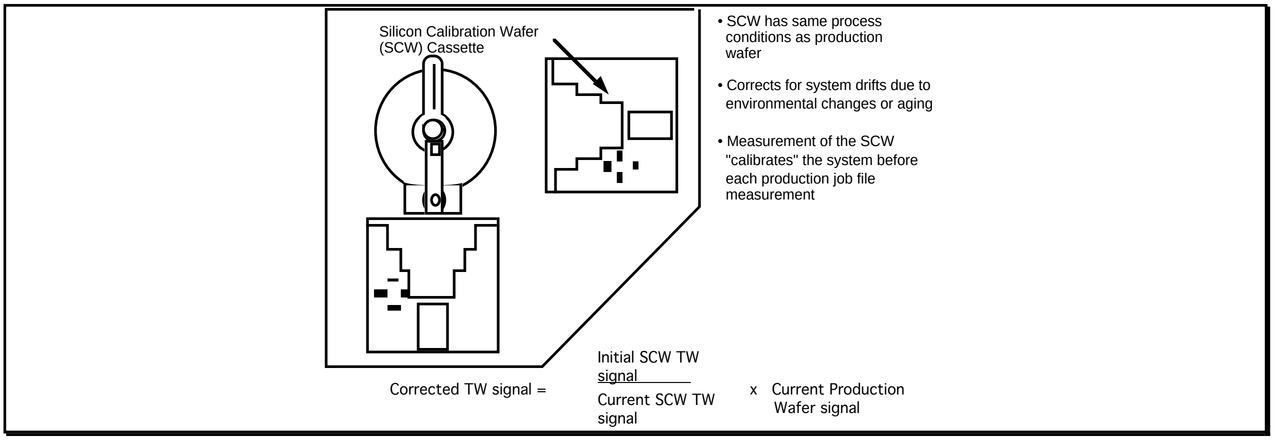

Figure 3-10. Silicon Calibration Wafer

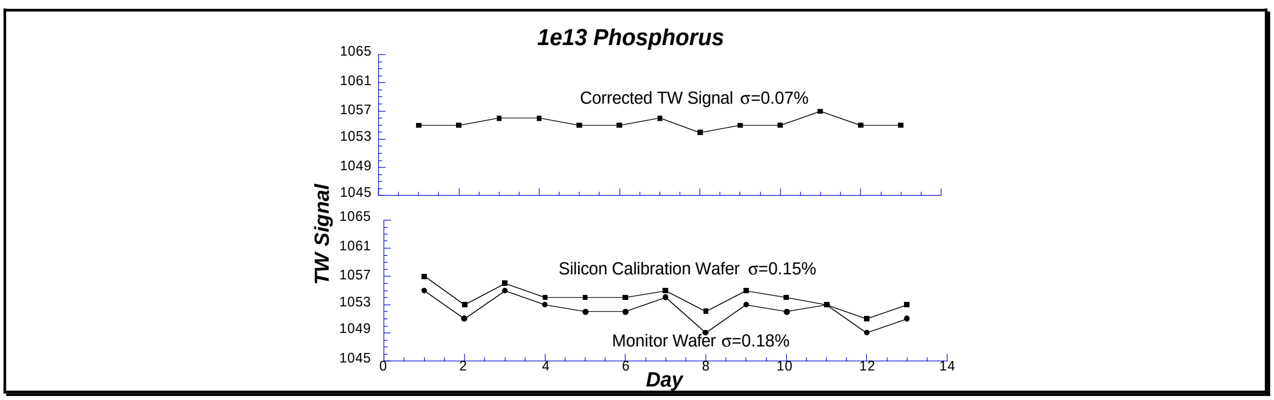

Figure 3-11. Example of SCW

Job File Chaining

Job File Chaining allows the automatic chaining of job file execution. For each job file the user may specify the next job file to be executed. Any number of job files can be run without operator intervention.

Theory of Operation

Ion Channeling

The TP-420 can readily detect the presence of ion channeling. Ion channeling usually has a negative impact on device yield and performance and thus should be avoided. In order to obtain truly accurate readings of ion dose and of implant uniformity it is recommended that wafers be implanted in a manner that minimizes the presence of ion channeling. This includes implanting at appropriate implant angles and wafer orientation and the use of oxide films. Unlike 4-point probe systems, the TP-420 can make measurements directly through an oxide layer and since an oxide layer is a most effective means for minimizing ion channeling; Therma-Wave recommends implantation through an oxide layer whenever appropriate.

Secondary Implant Parameters

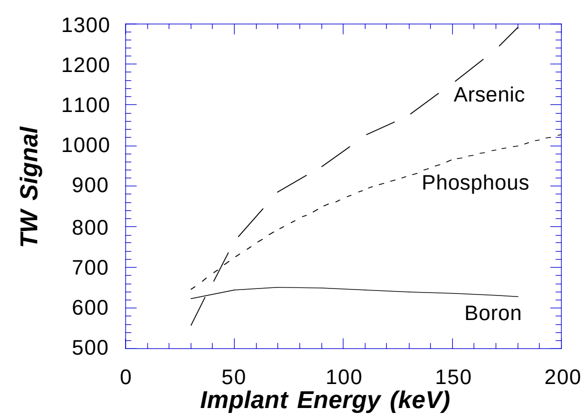

Figure 3-12. TW Signal vs Implant Energy

The thermal wave signal is primarily dependent on implanted ion dose, but is influenced to a smaller degree by other implanter parameters such as acceleration voltage, beam current and wafer temperature at high dose rates. The exact dependence of the thermal wave signal on these secondary parameters may vary from implanter to implanter. Hence, if accurate comparisons in TW signal or dose readings between wafers are required, the secondary parameters should be the same.

High Dose Software

This processing algorithm is used to compute high dose ion implant. Below is the table of species and their corresponding minimum values that defines the lower limit that high dose software can be used.

Species	Minimum Dose Value for HD
Arsenic	2.5e13
Phosphorous	1.5e14
Antimony	1.5e13
BF2	5.0e13

Table 3-1. Minimum Dose Value of High Dose

In the high dose implant range, the subsurface silicon crystal is completely damaged, producing a layer of amorphous silicon. (This is in contrast to the low dose regime, where the subsurface silicon crystal is only partially damaged.)

In the low to medium dose range the TW signal is a monotonically increasing function of dose as illustrated in the left-portion of Figure 3-13. In the high dose implant range the layer of amorphous silicon grows thicker with increasing dose. Consequently, an interference phenomenon is observed in the measured thermal wave signal and laser reflectivities, as a function of dose.

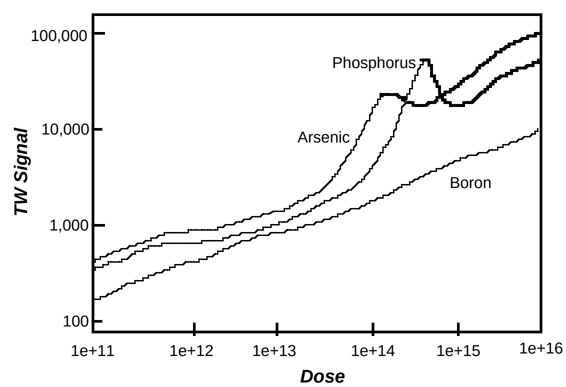

Figure 3-13. Thermal-Wave Signal vs. Dose

As a result, the measured thermal wave signal is not necessarily a monotonically increasing function of dose as in the low dose case, and may be a decreasing function of dose (illustrated in the right-portion of Figure 3-13).

Theory of Operation

High Dose Software (continued)

High Dose Model

The mathematical model used describes the relationship between dose, amorphous layer thickness, measured reflectivities, thermal wave signal, and decay that is based on the physical model shown in Figure 3-14. The model algorithms provide more accurate and repeatable measurements.

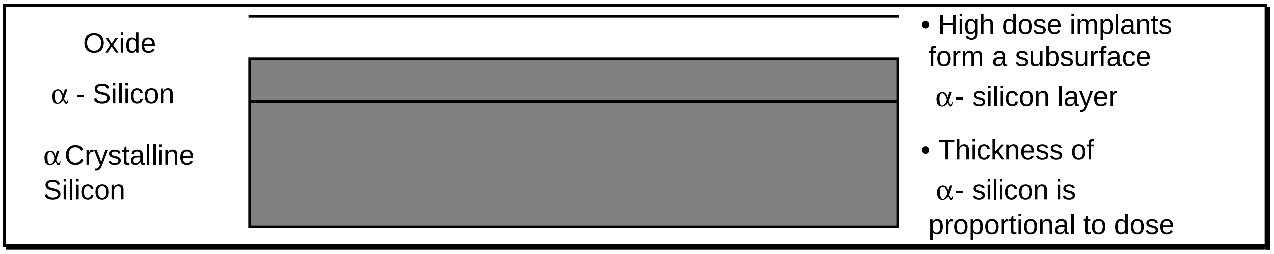

Figure 3-14. High Dose Model

High dose implants form a subsurface amorphous silicon layer. The thickness of amorphous silicon is proportional to dose.

Figure 3-15 illustrates the periodic reflectivity variation with increasing thickness (dose). Using such a multi-layer model and given a complex index of refraction in each layer for each wavelength used, it is possible to calculate the reflectivity for each laser wavelength as a function of amorphous silicon thickness.

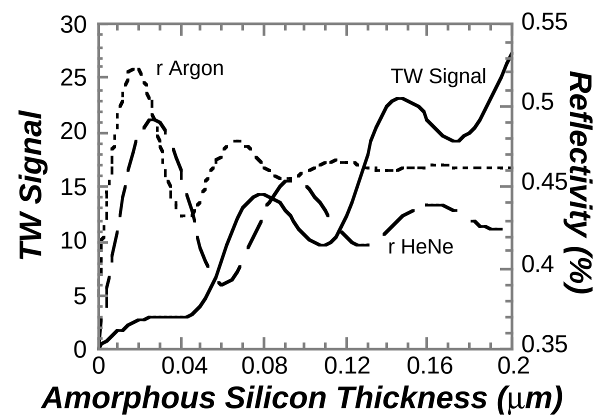

Figure 3-15. Periodic Reflectivity Variation

High Dose Software (continued)

High Dose Model Weight Factors

Four weight factors are now saved with the high dose job file:

- HeNe Reflectivity,
- Argon Reflectivity,
- TW Signal, and
- Decay

High Dose Calibrations

All dose calibrations in High Dose are performed using the new model, making calibrations more accurate and repeatable. A sample High Dose Calibration is shown in Figure 3-16.

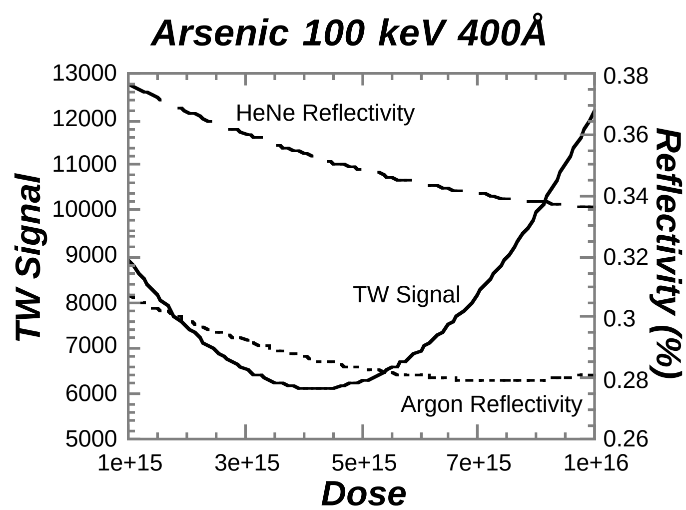

Figure 3-16. High Dose Calibration

The input to the High Dose calibration algorithm consists of the known dose and average oxide thickness of each of the calibration wafers (a minimum of four calibrations wafers is required for High Dose). The average thermal wave signal, HeNe reflectivity, Argon reflectivity, and decay are measured for each wafer. The calibration algorithm then computes the thickness of the amorphous layer relative to the known dose and oxide thickness of the calibration wafers.

Theory of Operation

High Dose Software (continued)

High Dose Calibrations (continued)

These parameters are stored in the calibration table for use in computing dose and oxide thickness values of unknown wafers.

After a calibration has been completed, dose and oxide thickness of unknowns can be computed from the measured thermal wave signal, reflectivities, and decay using the parameters determined from calibration. To calculate the dose value of an unknown wafer the measured average values of the thermal wave signal, Argon and HeNe reflectivities, and decay are input into the calibration to generate an amorphous thickness. The amorphous thickness is converted to a unique dose.

PW Auto Software

The PW Auto software allows the user to automatically find valid measurement locations on a product wafer by specifying up to 128 sites on a template. At each site the laser searches for the proper thickness of oxide. Once an area of appropriate size is located, the measurement is taken and the system moves to the next measurement location.

This section describes the theory and elements of the features unique to the construction of a PW Auto job file. The key elements to the construction of a PW Auto job file are:

- Specify Search Parameters
  This defines how the system looks for a valid region for each measurement area defined in the template.
- Create a Template
  This defines the general area(s) (stage X-Y coordinates) for measurement to be taken (up to 128 sites).
- Teach the Valid Region
  This involves teaching the system the optical characteristics of a valid implant region based on the regions reflectivity and thermal wave (TW) signal

These elements enable the system to recognize valid measurement regions on product wafers without operator assistance.

PW Auto Software (continued)

Specify Search Parameters

The search parameters define how the system searches for a valid region. The scan consists of the wafer on the stage being moved under the lasers until a region of the correct reflectivity is detected. These parameters includes the speed of the search scan, the minimum and maximum size of the search area, the distance between each scan, the length of each scan, and the number of times the system scans trying to locate a valid region. The power setting for the Argon/HeNe laser can be adjusted to prevent burning the resist during the search routine.

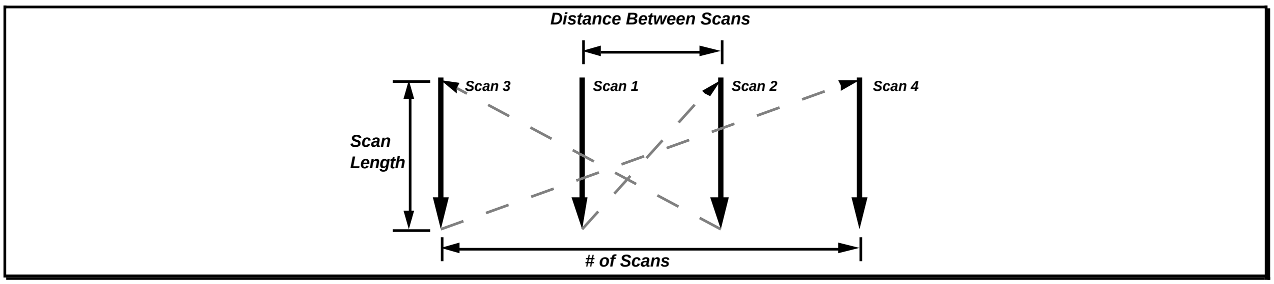

Figure 3-17. Scan Parameters

The minimum and maximum size of a valid region can be specified from 1 µm (4 µm when using edge exclusion) to <5000 µm. The maximum measurement points per region are also defined in the search parameters. This enables the user to control throughput by controlling the number of points in a large region. The points are spread evenly to fit the region to a minimum of 2 µm.

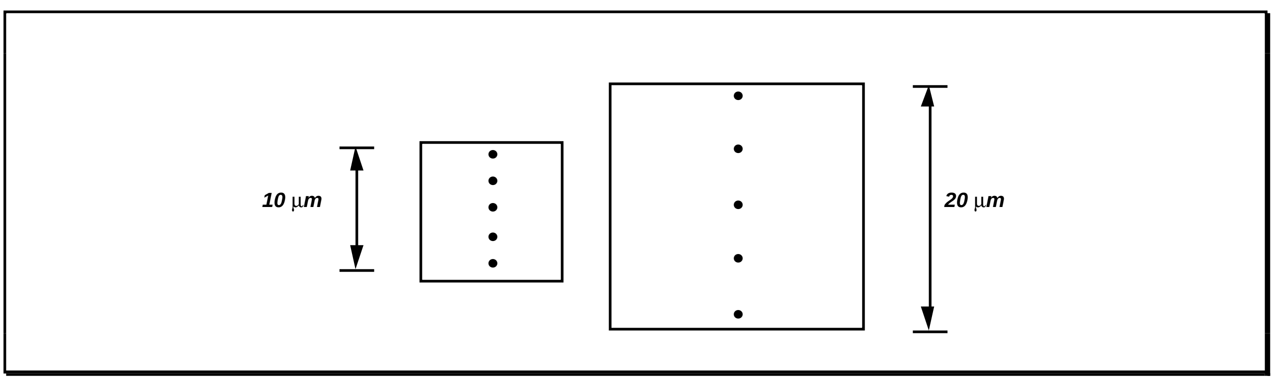

Figure 3-18. Defined Points Per Region

Theory of Operation

PW Auto Software (continued)

Specify Search Parameters (continued)

To improve the accuracy of the measurement, the angle of the search scan can be entered. The default value for this field is 45°. This rotates the wafer not the template and reduces the chance of the laser scanning along the edge of a region. The areas defined in the template are stage X-Y coordinates to begin a search routine, not exact location of the regions to be measured.

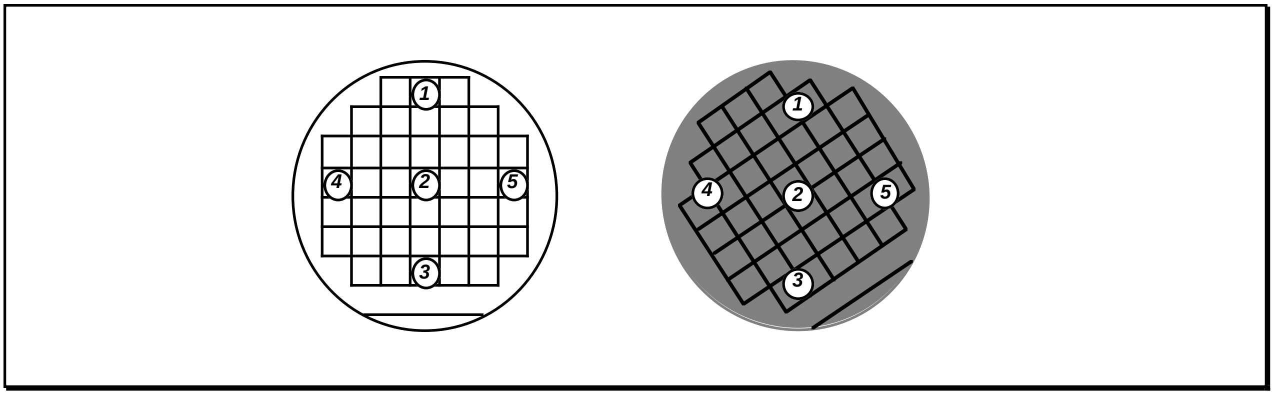

Figure 3-19. Search Scan Angle

The TW signal is effected by different oxide thickness which occur inherently at the edge of wafer geometries. The edge exclusion parameter is designed to avoid these areas by specifying a distance from 0 to 10 µm (dependent on geometry size) to exclude from each edge of the region, thus improving the reproducibility of the measurement.

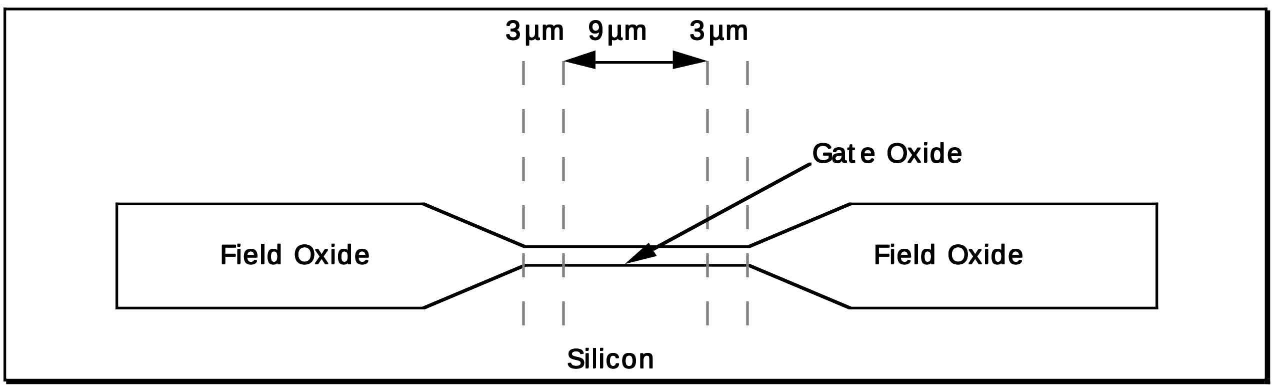

Figure 3-20. Edge Exclusion

PW Auto Software (continued)

Specify Search Parameters (continued)

At each X-Y coordinate of the measurement template the system scans for a region of reflectivity which matches the reflectivity stored in the job file. The system can be configured to use one or both lasers (HeNe (red) and/or Argon (blue)) to validate a region. The higher the number (± percent) entered for the tolerances the greater the oxide thickness variation is allowed for a valid region.

TW checking can also be selected to validate a region, but is recommended only in cases where there are regions of the same reflectivity with different implants. When TW checking is used, misimplanted wafers with out-of-spec TW signals are defined as having no valid regions and measurements are not taken, where as if TW checking is turned off the regions are measured and the user is notified of the out-of-spec condition.

The system automatically defines the center of the wafer as a measurement area if no other area is specified by a measurement template. The measurement offset function enables the supervisor to offset this area in the Y-direction in cases where the center of the wafer is an unacceptable measurement area (i.e., blank die).

Theory of Operation

Create a Template

Creating a template defines the number and the general areas (stage X-Y coordinates) for measurements to be taken (up to 128 sites).

The template is created using a product wafer of the type to be measured using this job file. With a wafer on the stage the areas to be searched are located using the system's trackball. Once located, the area is entered into the system's memory using the SELECT function from the Wafer Template menu.

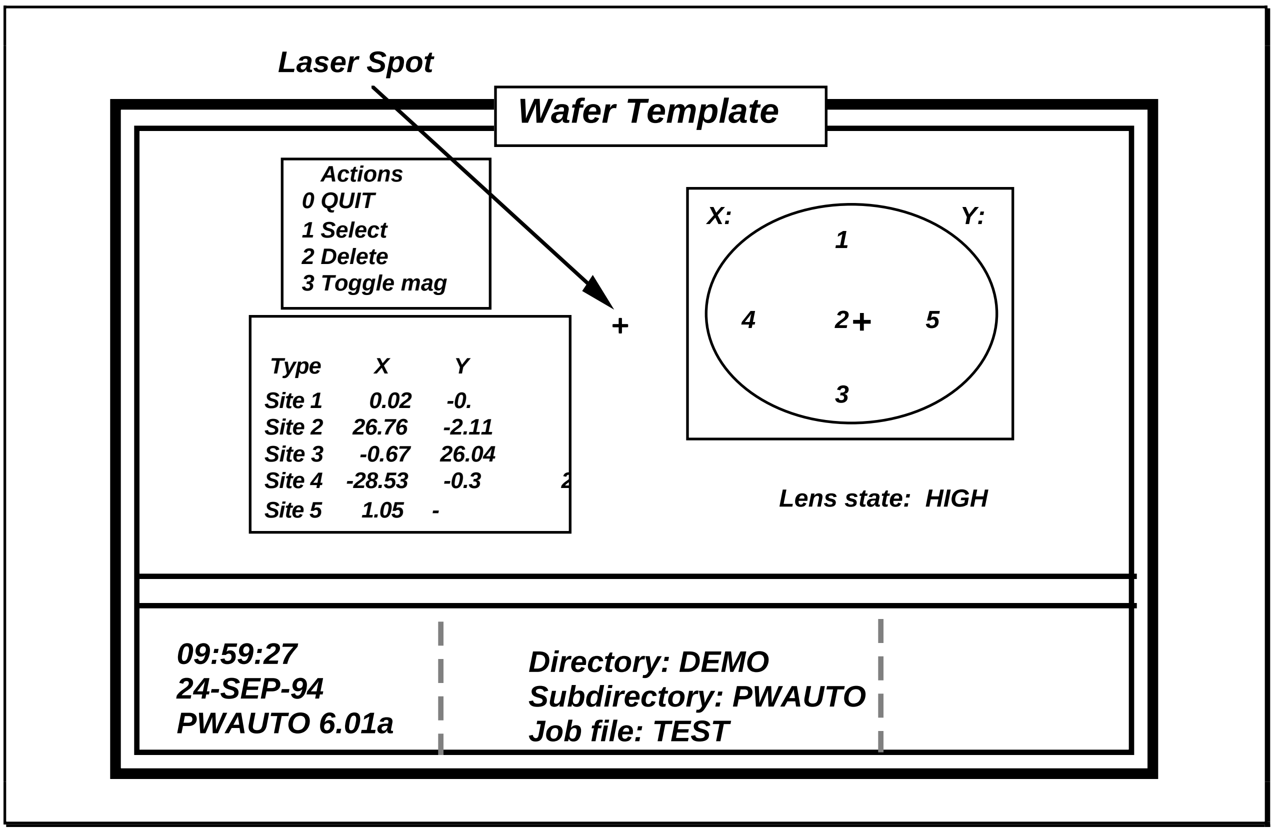

Figure 3-21. Wafer Template Menu

Note: The areas selected are based on the stages X-Y coordinates and are not the exact regions on the wafer. To take measurements in the same general area on each wafer, use a CENTER and FLAT FIND routine, with zero (0) defined as the SEARCH ANGLE, or operate the machine in manual mode from the ALTERNATE MENU and set the SINGLE WAFER SEARCH CONTROL to MANUAL.

PW Auto Software (continued)

Teach the Valid Region

Teaching the valid region involves teaching the system the optical characteristics of a valid implant region based on the region's reflectivity.

To teach the system the characteristics of a valid region, a product wafer of the type to be measured using this job file is required. With a wafer on the stage a valid measurement region must be located using the system trackball. Once located, the region's reflectivity and film thickness is determined. The TW signal can also be displayed along with the reflectivity to further verify the region. If by these readings it is determined that the selected region is not correct, the user can repeat the function until satisfied with the readings. Once a valid region is located the TEACH REGION function is used to store these values in to job file. The Thin Film Reflectivity graph below illustrates the periodic relationship between oxide thickness and reflectivity.

Teach the Valid Region

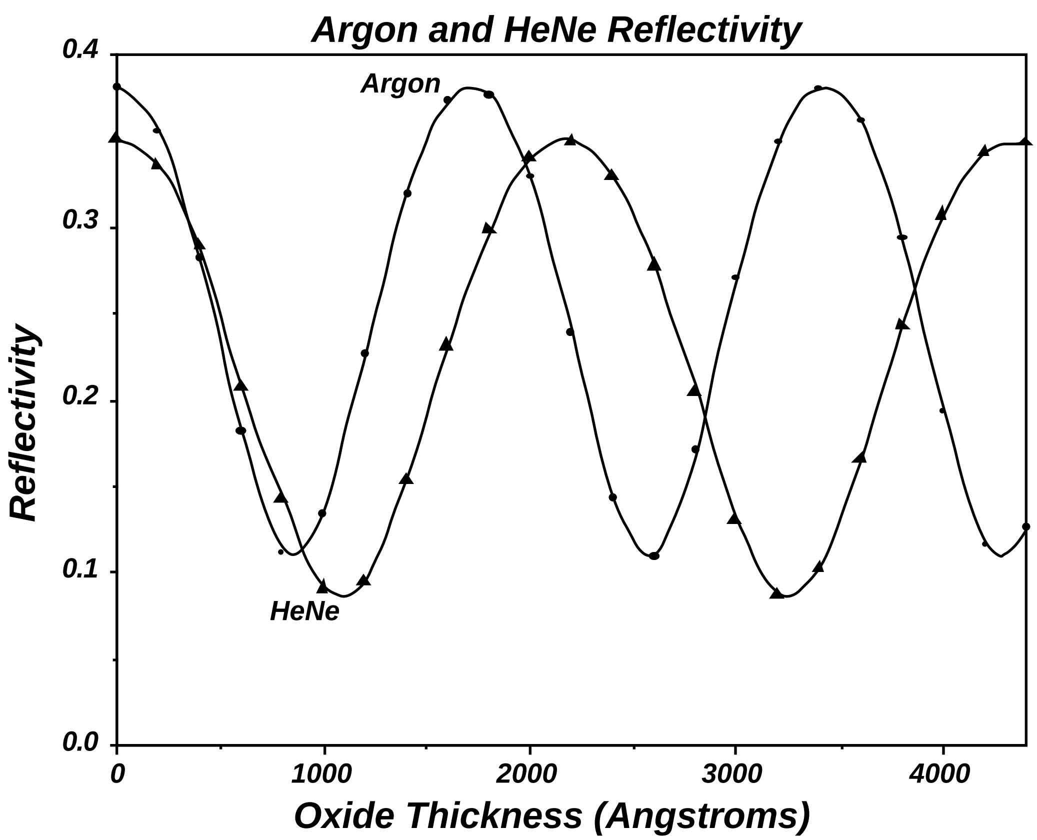

Figure 3-22. Thin Film Reflectivity Graph

Theory of Operation

PW Auto Software (continued)

Teach the Valid Region (continued)

Once a PW Auto job file is constructed, it should be tested. Testing consists of measuring a product wafer and (if necessary) adjusting the reflectivity tolerances. The tolerances should be set as wide as possible to allow for normal process drifts while still discriminating against non-valid areas. Obtain multiple reflectivity measurements and calculate the average. Subtract an end point from the average and divide by twice the average. The entered reflectivity tolerance in the scan parameters should be greater than this value. Refer to the figure below:

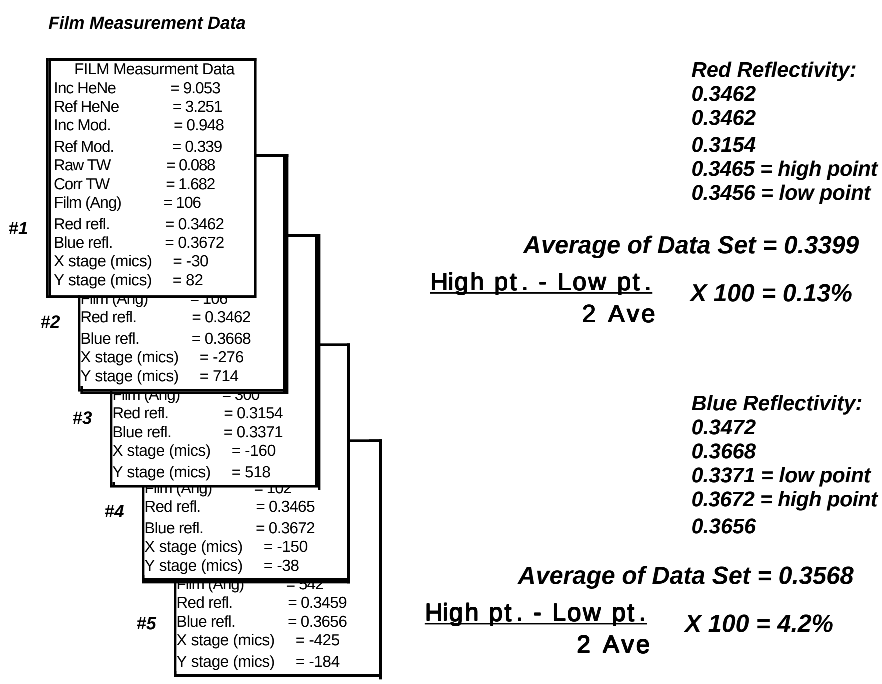

Figure 3-23. Calculate Tolerance