Contents

5.2.4 Point Generation Wizards

The Point Generation Wizards offer a shortcut to creating some of the most common types of measurement point patterns.

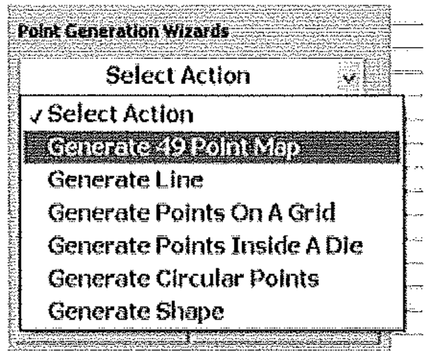

Figure 5-17 – Point Generation Wizards Menu

5.2.4.1 Generate 49 Point Map – Automatically generates a 49-point map with a center point and 3 concentric circles of 8, 12, and 28 points, respectively.

5.2.4.2 Generate Line – Generates points in a line.

5.2.4.3 Generate Points On A Grid – Generates a grid in which the points are separated by a specified amount.

5.2.4.4 Generate Points Inside A Die – Generates a grid of a specified size and number of points. If there is a die map on the wafer, it will generate the grid inside the die.

5.2.4.5 Generate Circular Points – Generates points in a circle.

5.2.4.6 Generate Shape – Generates points along multiple lines or along the edges of a customizable shape.

5.2.4.1 Generate 49 Point Map

The Generate 49 Point Map wizard automatically generates a 49-point map with a center point and 3 concentric circles of 8, 12, and 28 points, respectively.

Adjustable Settings: Wafer Diameter

Edge Exclusion – The distance from the edge of the wafer to the outermost ring. Note that the difference in diameter between rings is equidistant, so adjusting the Edge Exclusion will move the points on all three rings.

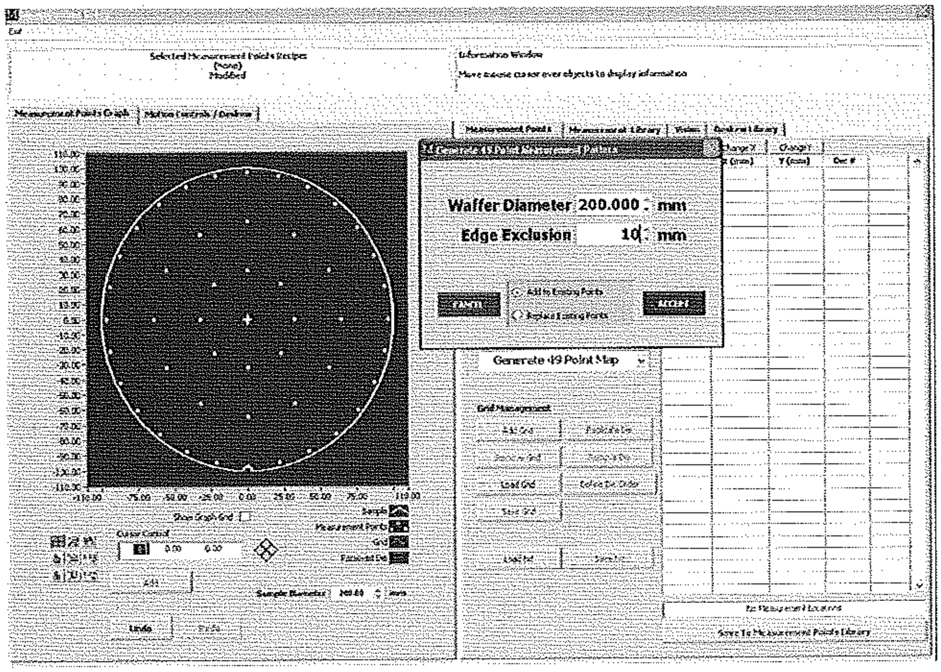

Figure 5-18 – Generate 49 Point Map

5.2.4.2 Generate Line

The Generate Line wizard generates points in a line, according to specifications set by the user.

Adjustable Settings: Start Location X and Y coordinates (adjustable within 1 µm)

End Location X and Y coordinates (adjustable within 1 µm)

# of Points On Line

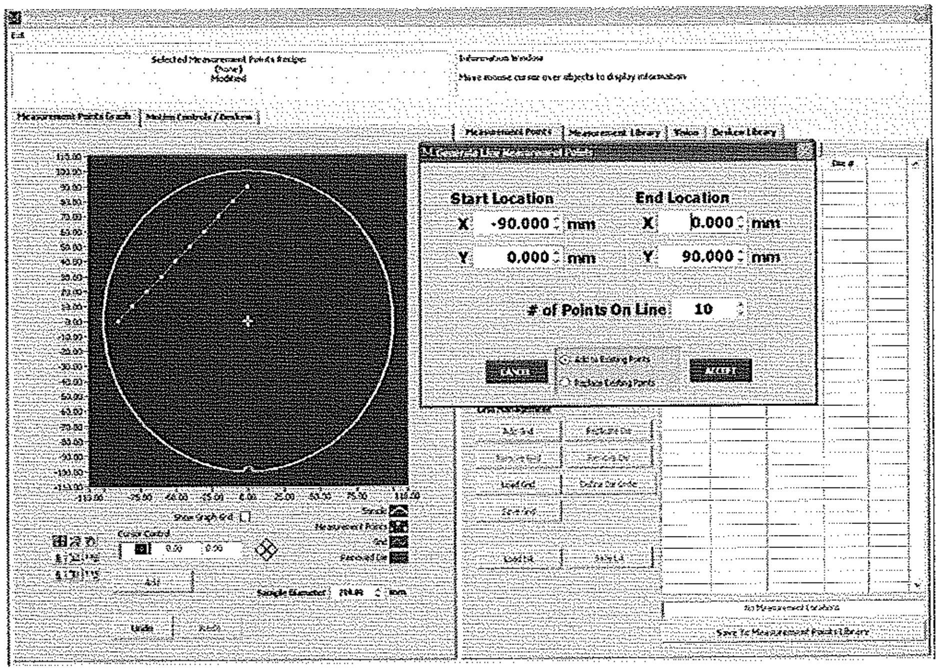

Figure 5-19 – Generate Line

5.2.4.3 Generate Points On A Grid

The Generate Points On A Grid wizard generates a grid of points, separated by a specified spacing.

Adjustable Settings: Point Spacing X and Y values and Units (mm, µm, nm) – the distance between each point along the x- and y-axes.

Edge Exclusion – The distance all points must be from the edge of the wafer.

# of Points in X and Y direction

Fill Sample Off/On – If selected, the wizard will fill the sample out to the Edge Exclusion point, separating the points as indicated by the Point Spacing values.

Grid Center – Adjusts the offset from center. Note: the wizard will not adjust the Edge Exclusion, so adjusting the Grid Center may move some points off the edge of the wafer, as shown in Figure 5-21.

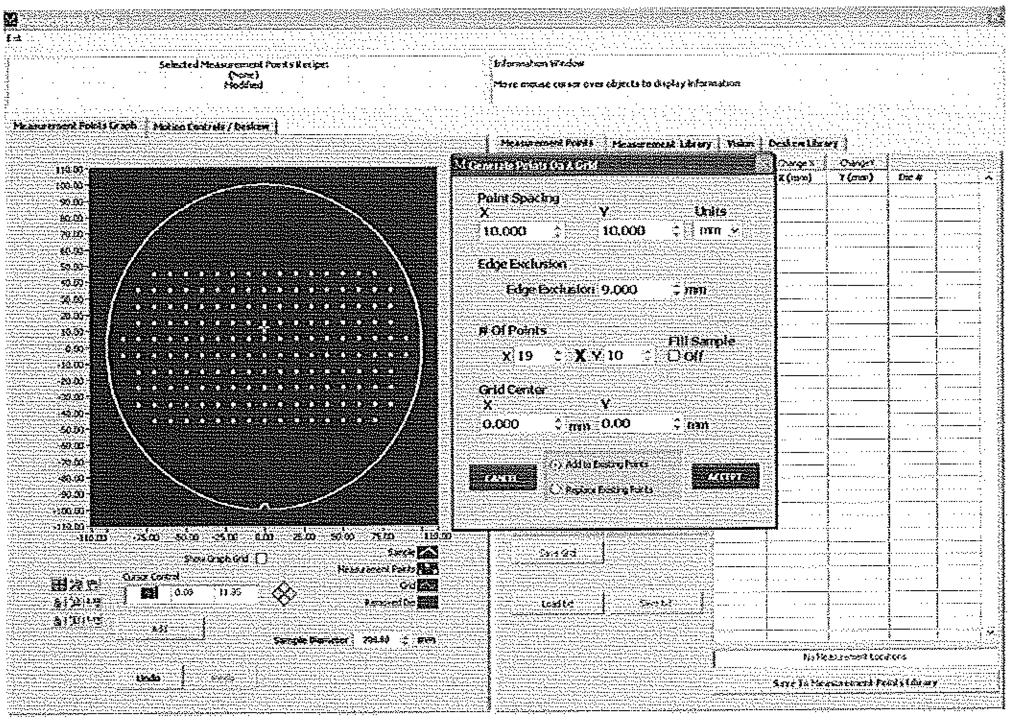

Figure 5-20 – Generate Points On A Grid

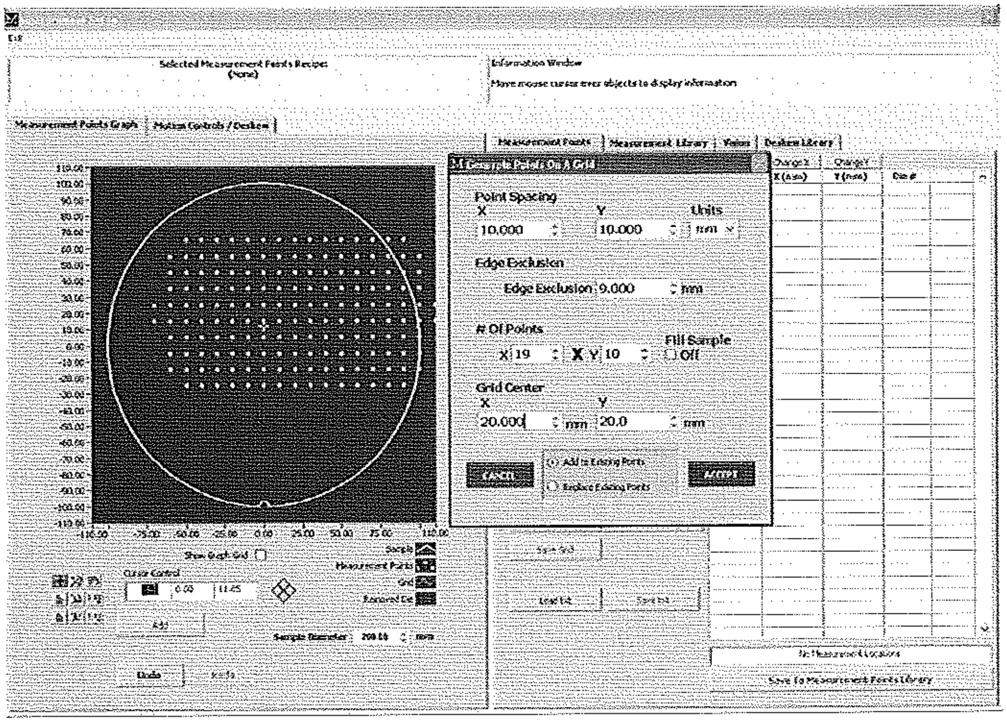

Figure 5-21 – Generate Points On A Grid – Center Offset

5.2.4.4 Generate Points Inside A Die

Use the Generate Points Inside A Die wizard if, instead of separating the measurement points by a specific amount, the user wishes to measure some number of locations inside a grid of a particular size.

This wizard can also be used to generate this grid inside a particular die. For more information on working with points inside dies, see Section 5.2.5.4.

Adjustable Settings: Points Centered About – Same as Grid Center, adjusts the offset/centerpoint of the grid.

Distance Between First and Last Points – X-distance
Y-distance
Units (mm, µm, nm)

# of Points in X and Y direction

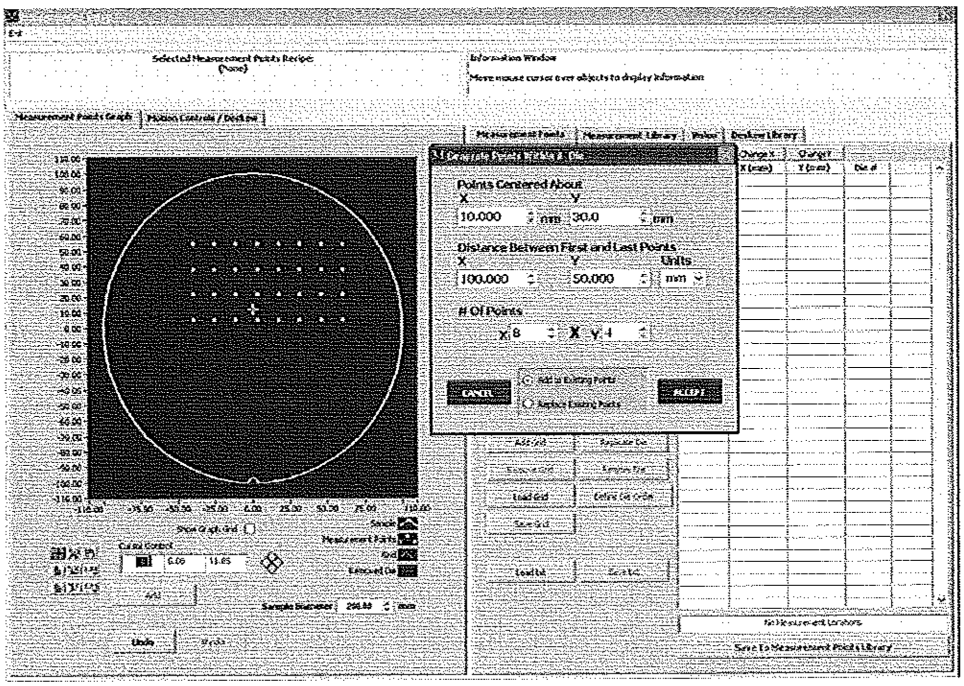

Figure 5-22 – Generate Points Inside A Die

5.2.4.5 Generate Circular Points

The Generate Circular Points wizard generates points in a circle.

Adjustable Settings: Circle Diameter

# of Points

Origin X and Y (centerpoint of circle)

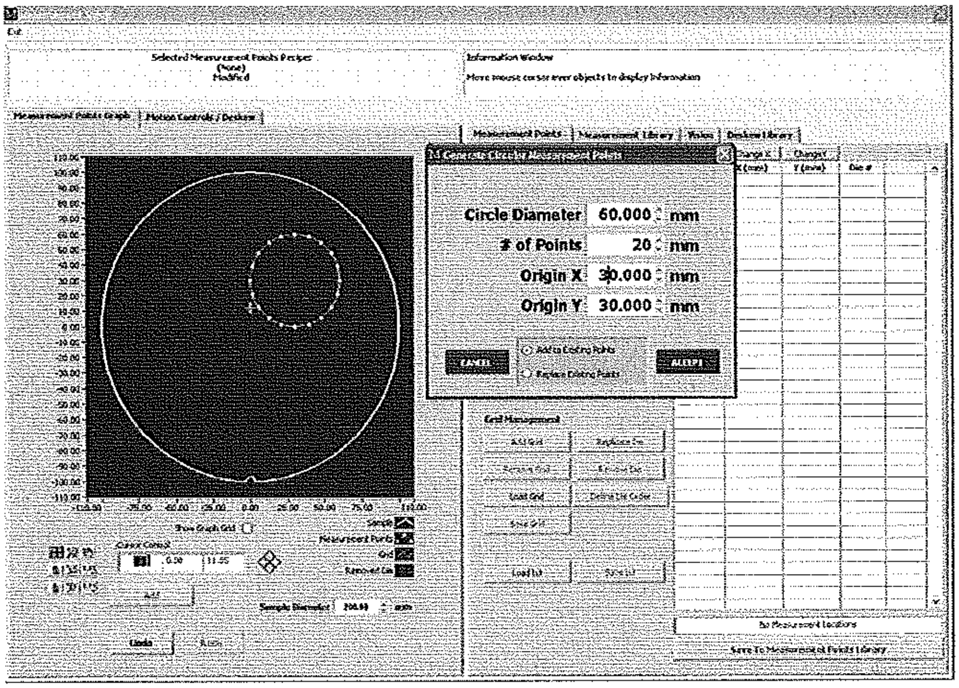

Figure 5-23 – Generate Circular Points

5.2.4.6 Generate Shape

The Generate Shape wizard creates a fully customizable shape and measures a specified number of points along the edges of that shape.

Adjustable Settings: Active Points – See below for a detailed explanation of adding and editing Active Points.

Shift Points – Shifts all points a given amount along the x- or y-axis.

Line Pairs (Connect/Disconnect) – See below for a detailed explanation of Line Connected/Disconnected Line Pairs.

# of Points on lines

To create a shape, select the **Generate Shape** wizard. The wizard will open with the default shape, a square with the corners at [0,0], [0,50], [50,50], and [50,0].

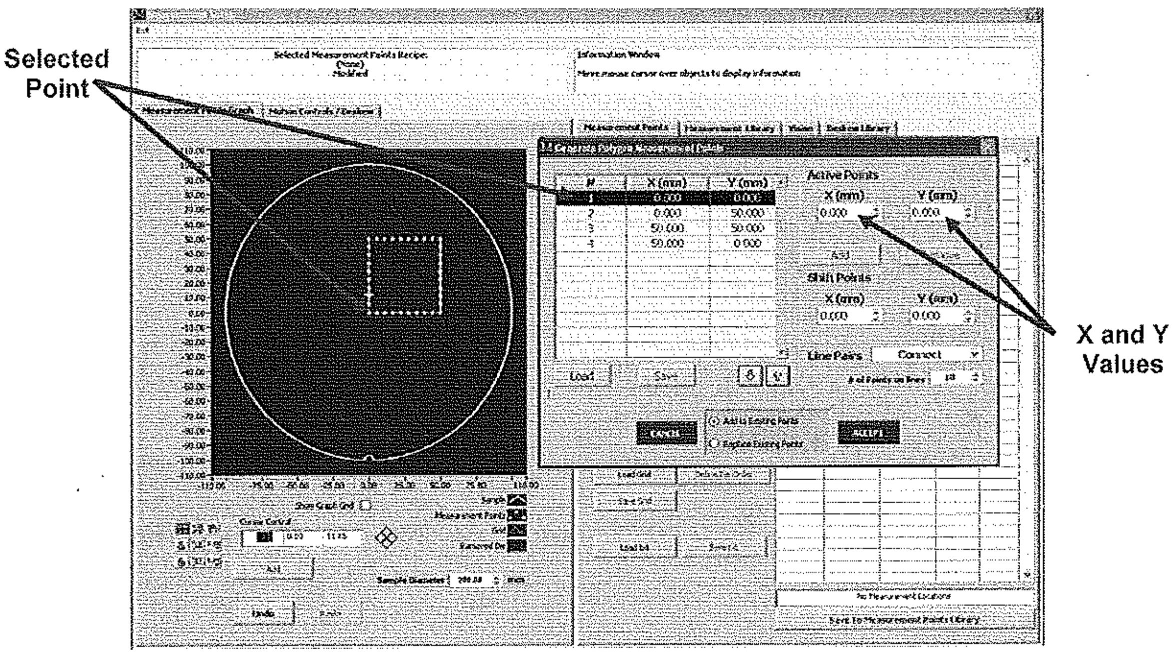

Figure 5-24 – Generate Shape – Default Square

Active Points

To adjust one of the corner points (Active Points), select the point and change the **X** and **Y** values accordingly. (See Figure 5-25.)

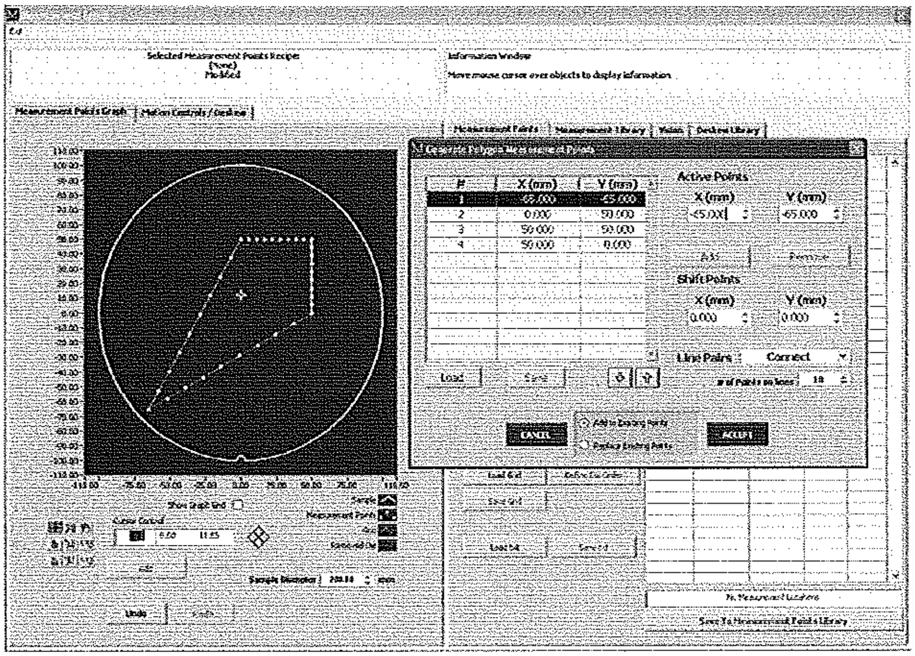

Figure 5-25 – Generate Shape – Active Point Adjustment

To add a point, click **Add**, as shown in Figure 5-26 and Figure 5-27.

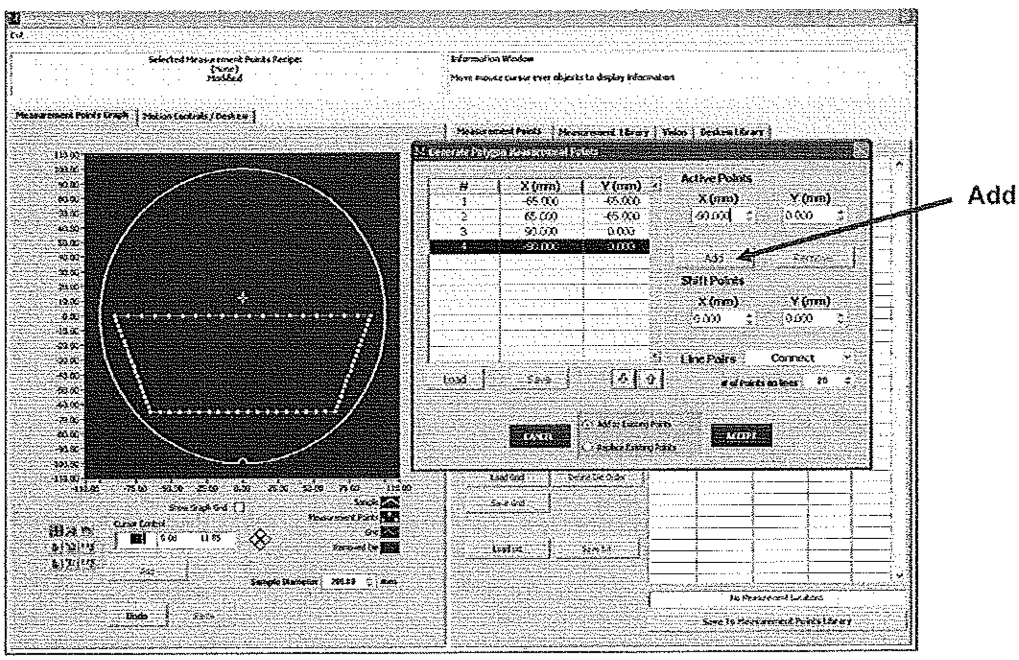

Figure 5-26 – Generate Shape – Trapezoid

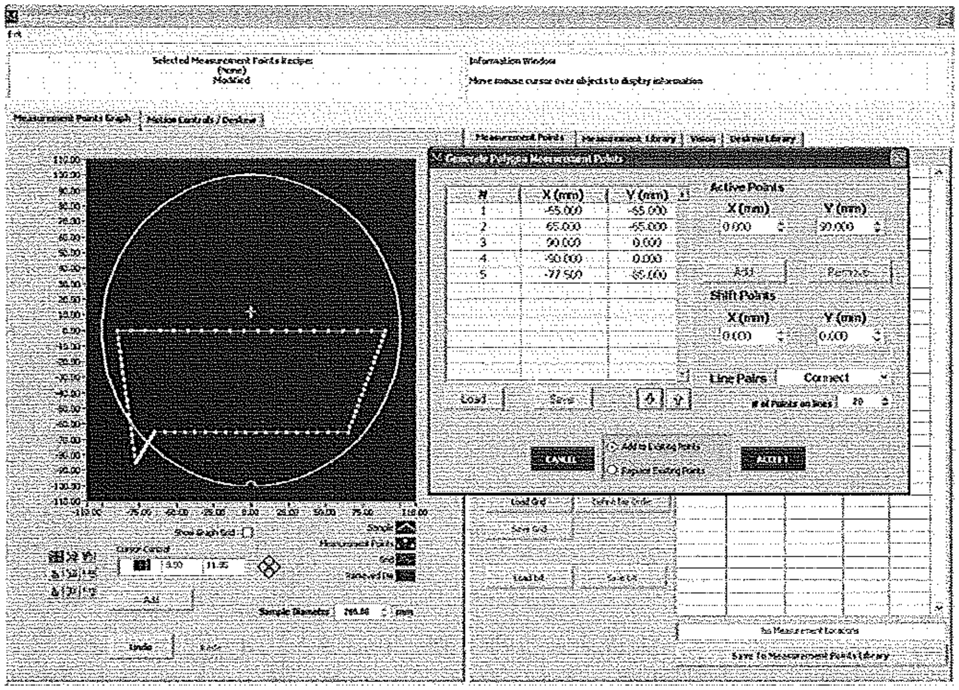

Figure 5-27 – Generate Shape – Trapezoid with Point Added

Change the order of the active points by clicking the **Up** and **Down** arrows below the Active Points list, as shown in Figure 5-28 and Figure 5-29. In this example, points 4 and 5 swap places.

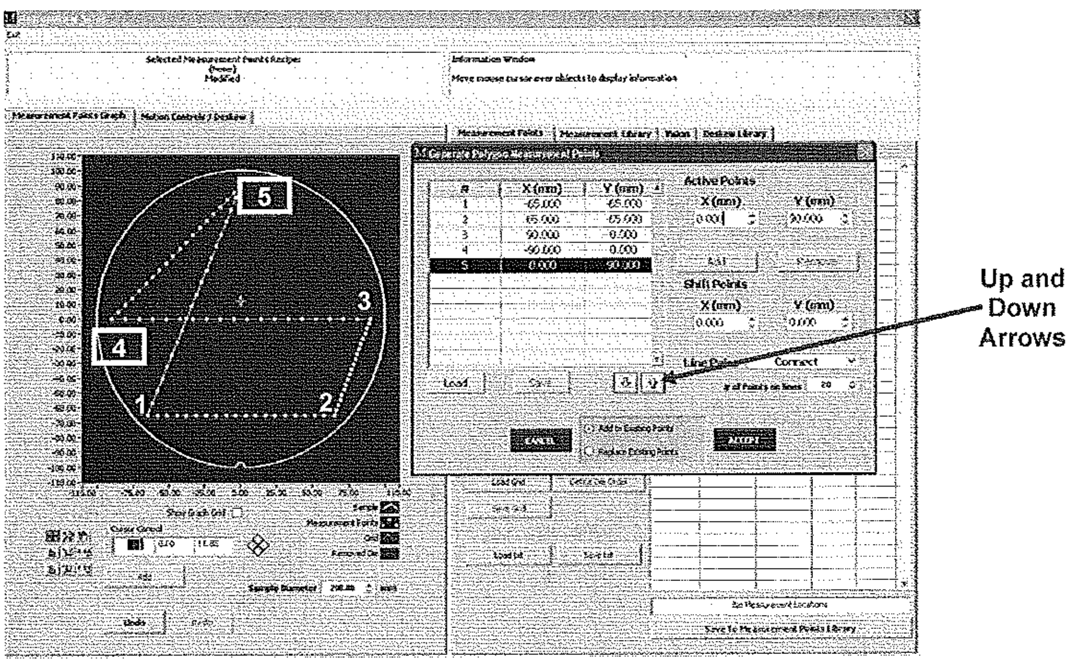

Figure 5-28 – Generate Shape – Five Points

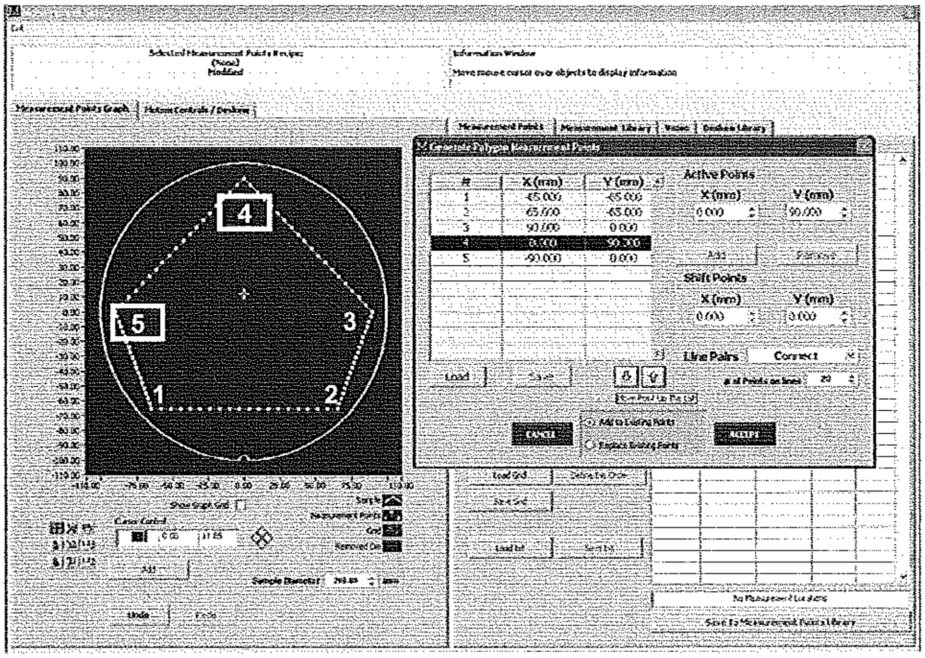

Figure 5-29 – Generate Shape – Pentagon

Line Pairs

If **Connect** is selected, the wizard will generate a line of points from each Active Point to the next and then a final line from the final Active Point to the first Active Point, as shown in Figure 5-30.

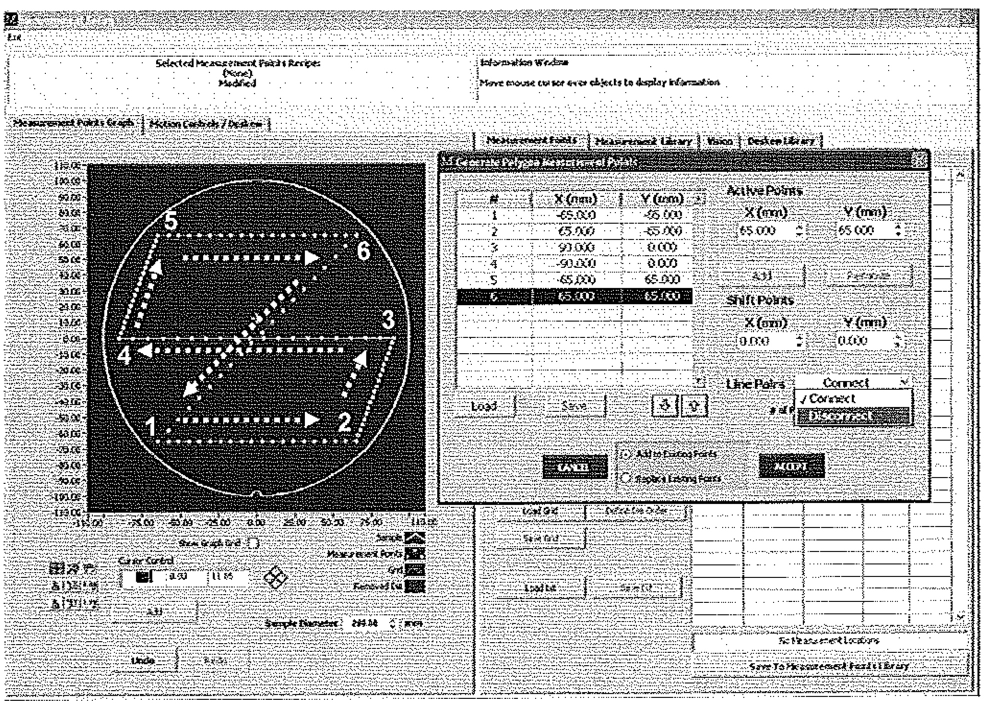

Figure 5-30 – Generate Shape – Connected Lines

By changing the **Line Pairs** setting to **Disconnect**, the points become the starting and ending points of individual lines – Active Points 1 and 2 become 1 Start and 1 End; 3 and 4 become 2 Start and 2 End; and 5 and 6 become 3 Start and 3 End, as shown in Figure 5-31, below.

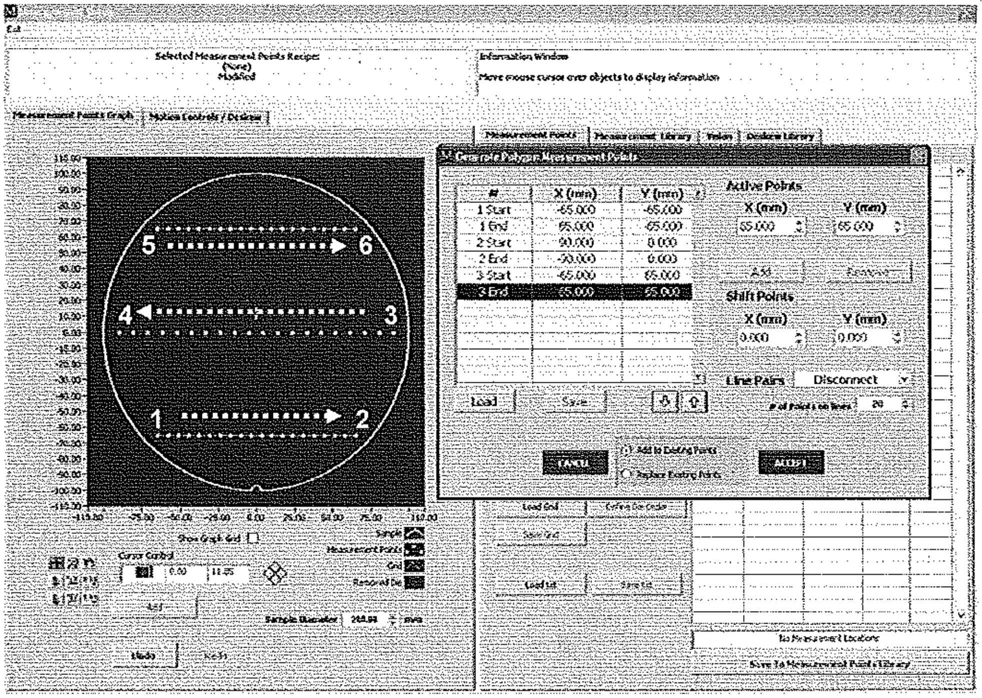

Figure 5-31 – Generate Shape – Disconnected Lines

6.3 Gas Flow & Pneumatics

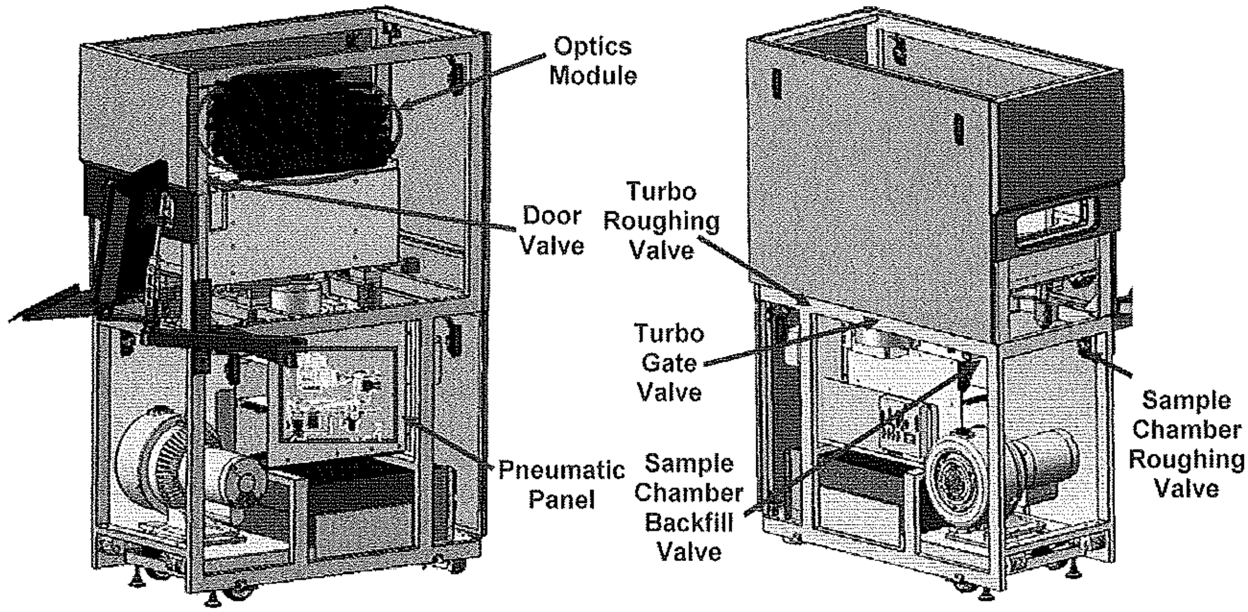

Figure 6-9 –Valve Locations (Note: Not all valves are shown in diagram. See below for pictures of valves indicated)

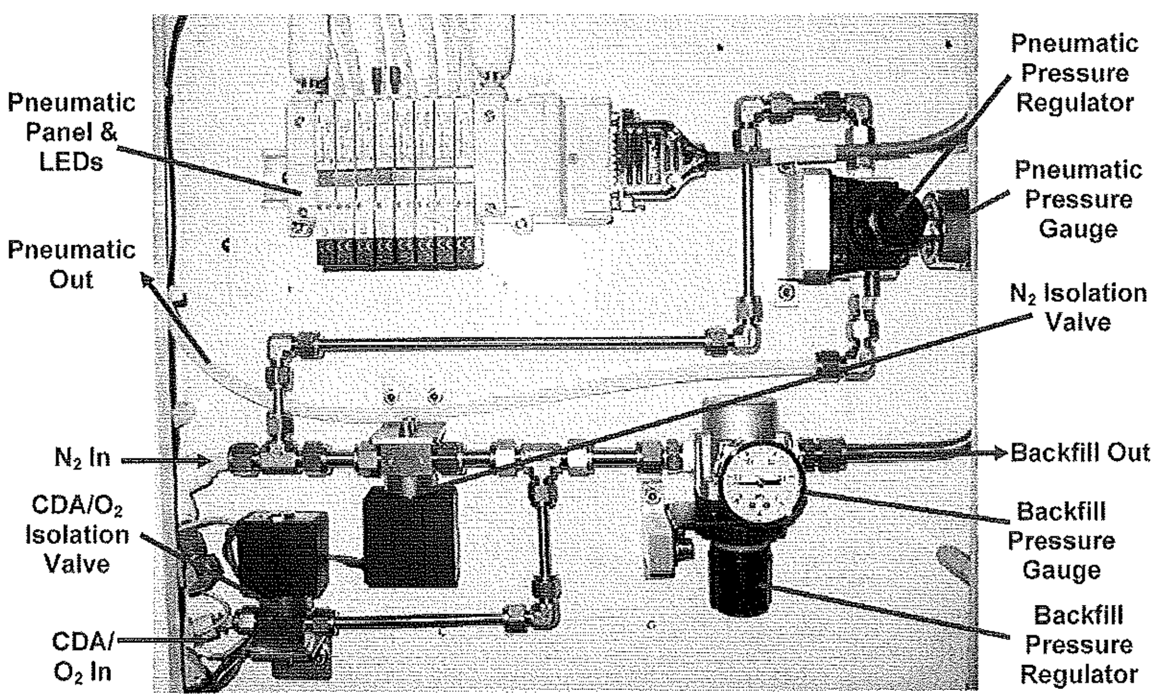

Figure 6-10 - Gas Flow

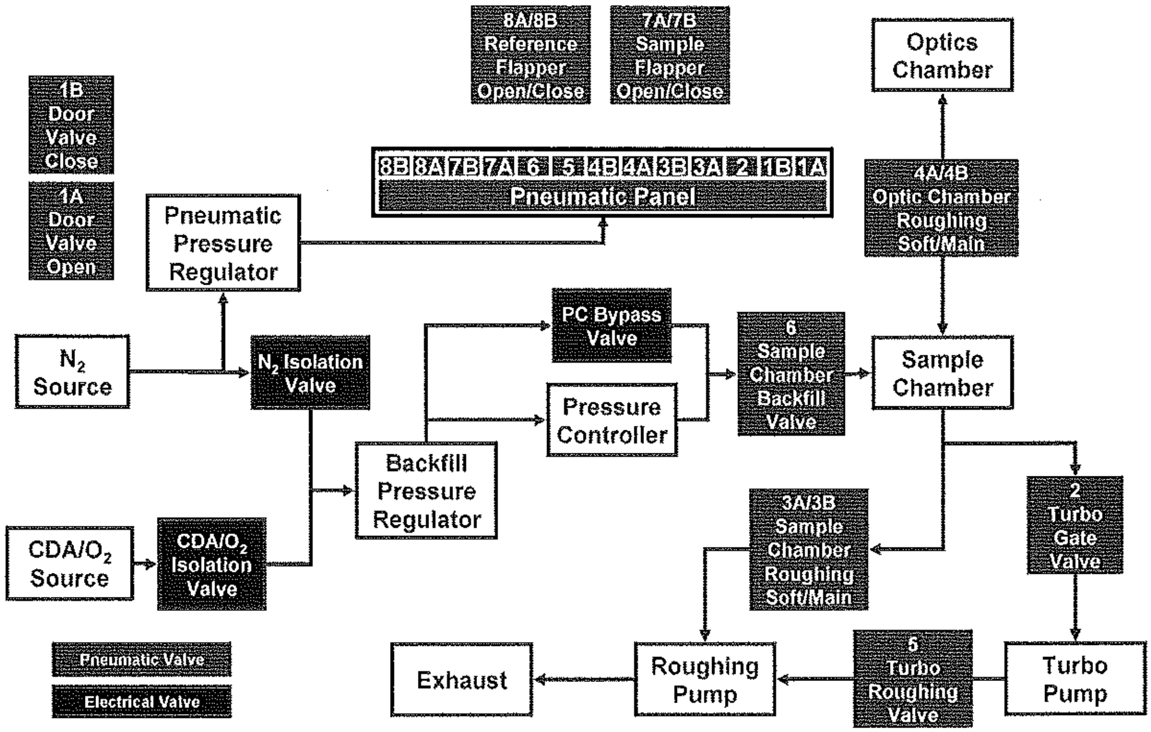

Figure 6-11 - Chamber & Pneumatic Gas Flow Flowchart

When tracing the lines from the pneumatic panel, there 2 lines going to the door (1A/B), 6 lines to the Optics Module (4A/B – Optics Chamber; 7A/B – Sample Flappers; 8A/B – Reference Flappers), 4 lines going to the pumps (2 – Turbo Gate; 3A/B – Sample Chamber Roughing; 5 – Turbo Roughing), and 1 line going to the Sample Chamber (6 – Sample Chamber Backfill).

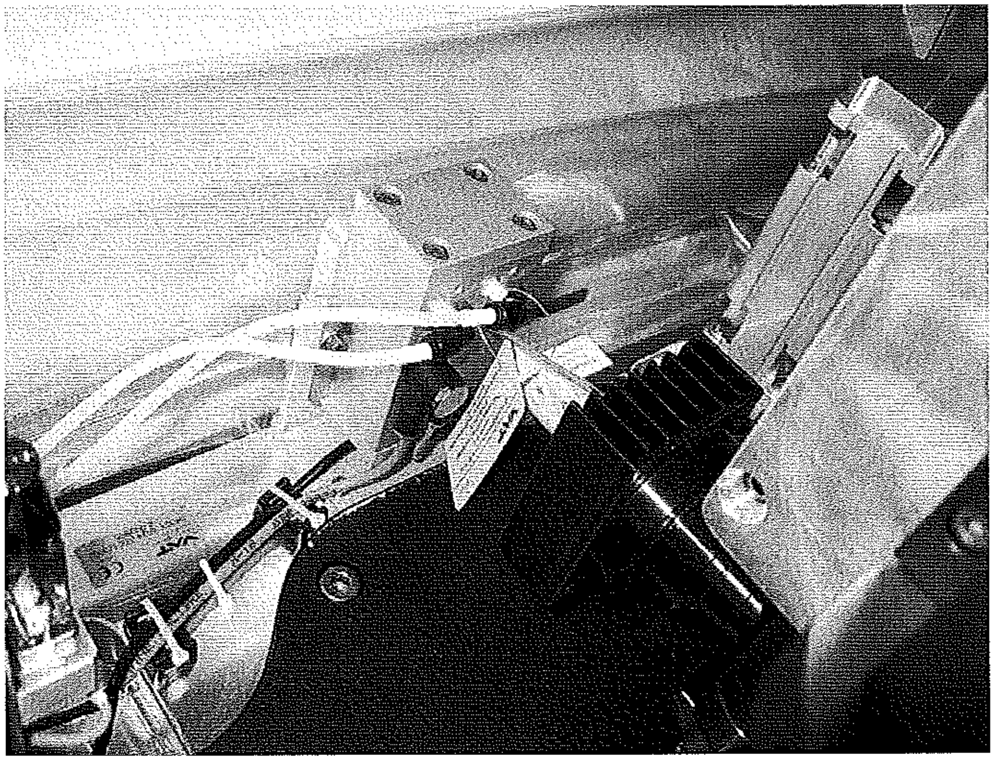

Figure 6-12 - Door Valve

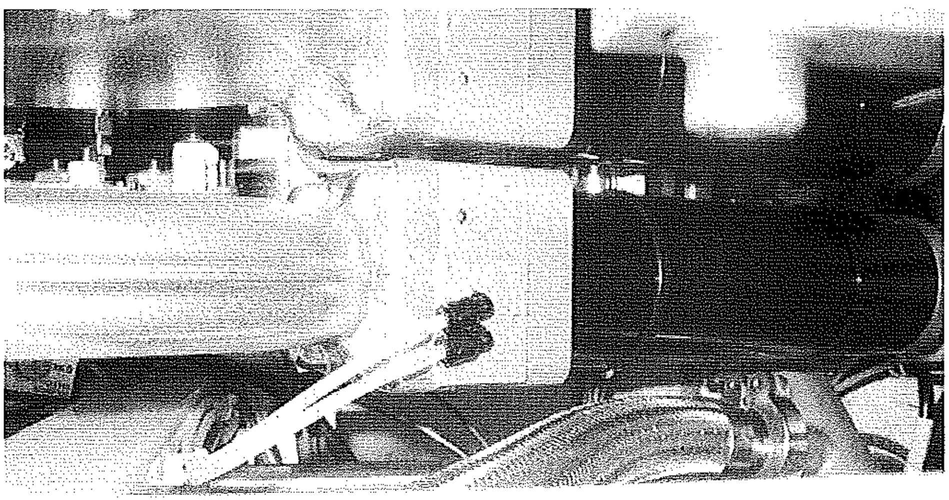

Figure 6-13 - Turbo Gate Valve

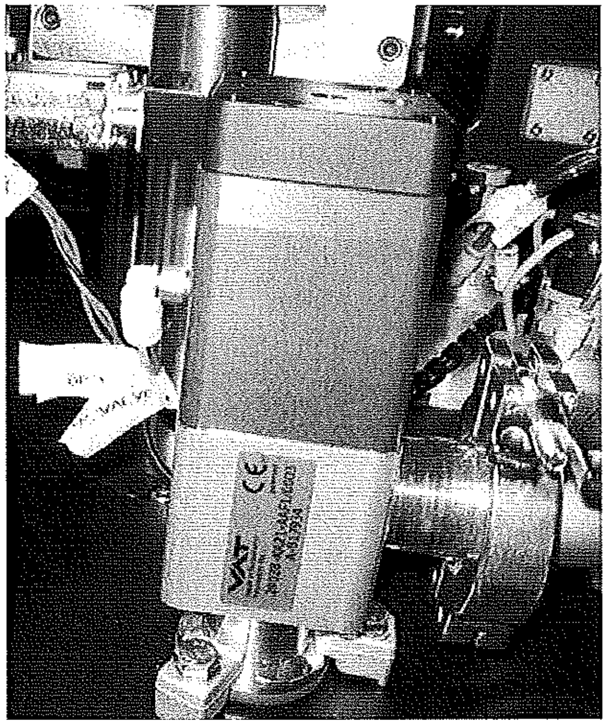

Figure 6-14 - Sample/Optics Roughing Valve

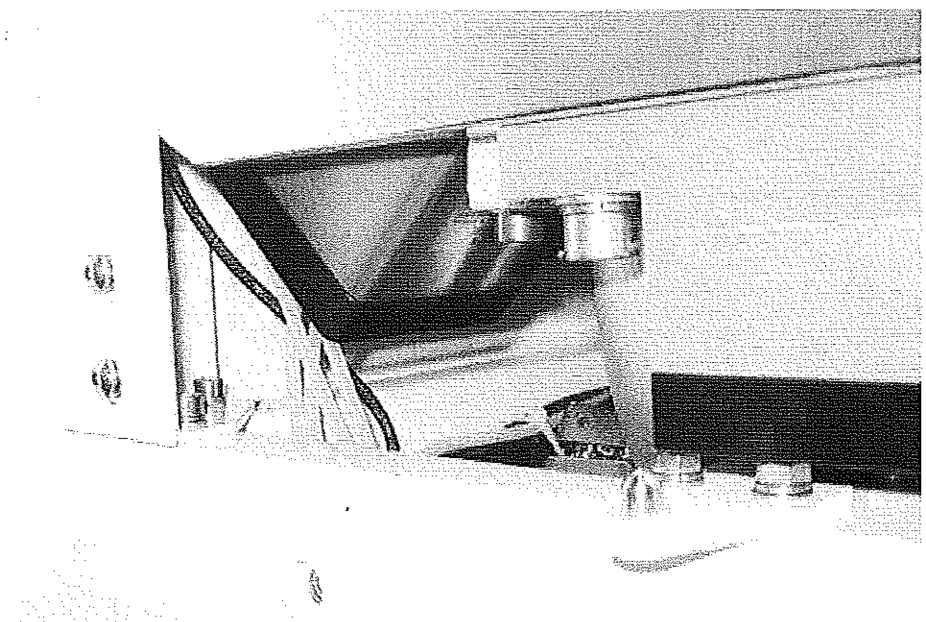

Figure 6-15 – Sample Chamber Roughing Valve

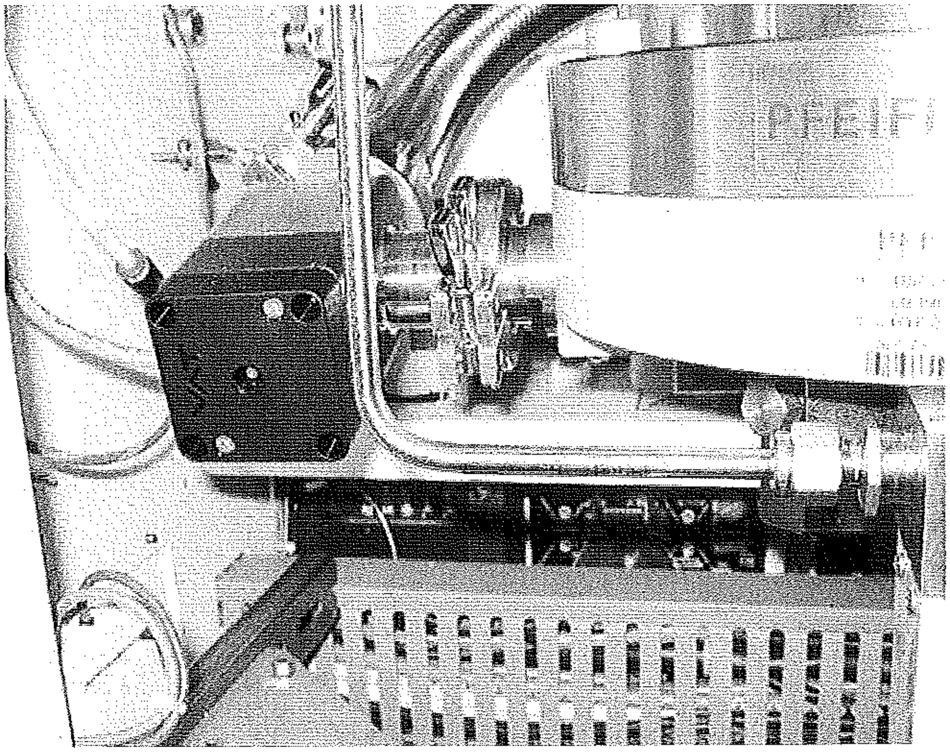

Figure 6-16 - Turbo Roughing Valve

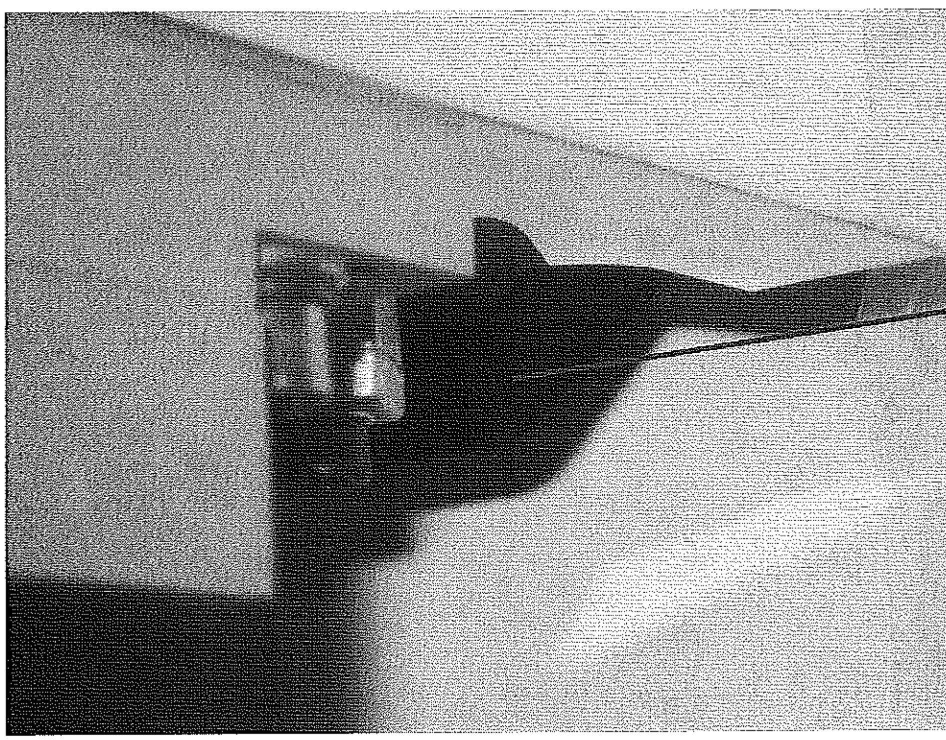

Figure 6-17 - Backfill Valve

6 Advanced Modeling Procedures

If the user is developing a new film (or working with a film not included in the Material Library), not all optical properties of the film will be known. In these instances it will be necessary to use known information to develop a model, which can then be used as an Analysis File and built into a recipe.

6.1 Modeling Optical Properties

When to Use This Fitting Method

- For a film with only one layer with unknown optical properties(plus a known substrate), where film interface behavior may be neglected and composition may be presumed constant **and**
- Thickness information is provided.

For best results, use multiple samples. The minimum recommended sample size is 5 wafers, but the more samples used, the greater the accuracy.

Procedure

1. Drag a *.tau (for amorphous/crystalline materials) or *.osc (for metals) file into the film stack. If possible, use a file with parameters known to be similar to those of the target material; otherwise start with _Blank.tau or _Blank.osc.
2. Enable fitting for all T-L parameters, change the **Film Thickness** to the known nominal value and **Hold**.
3. Load the first measurement file into the **Fitting** tab. Load all remaining measurement files into the **Linked Files** tab. Change the File Selector Dropdown Menu to **Linked Files** and launch the **Fit**, making sure that the cursors are set to 120 and 800. The system will perform a rough fit for the T-L parameters based on the known thickness information and the sample measurements.
4. Once Fitting is complete, right-click in the film stack and **Set All T-L Parameters to FIT Values**.
5. Add/remove parameters or adjust fit settings and then repeat #2-4 in order to form the tightest possible fit.
6. Right-click and **Hold** all T-L Parameters and then enable **Fit** for film thickness.
7. Save the Oscillator terms.
8. Change **Fit Settings** as desired for measurement.
9. Load and fit measured reflectance files to verify accuracy.
10. When finished, **Save Analysis Settings**.

    Note: All settings will be saved, including the Fit Settings, the cursor locations, which parameters are held, and which parameters are set to Fit. When a recipe is run, this is how the Analysis File determines whether the measurement passes or fails. For example, if *Film Thickness* is set to Fit, then the Analysis File will fit the film thickness when the recipe is run. If it is held and no other parameters are set to Fit, an error message will be generated because there is nothing to fit. In addition, the *Fit Settings* will determine the settings used for the Fit process as part of the recipe Analysis.

Demonstration

The following example walks the user through the above procedure for a Hafnium Oxide (HfO_2) film on a Silicon substrate, assuming that the user has just launched the system with the default settings. All files used in this example are pre-loaded with the **MetroSolver** software.

1. *Drag a *.tau (for amorphous/crystalline materials) or *.osc (for metals) file into the film stack. If possible, use a file with parameters known to be similar to those of the target material; otherwise start with _Blank.tau or _Blank.osc.*

   1.1. Select the **Material Library**.

   1.2. Select the **Tau** folder.

   1.3. Select **_Blank.tau** and drag it into the **Film Stack**. (Ordinarily we would start with an HfO2 file, since we know its optical properties will be similar to those of our target film. However, in order to introduce an additional level of complexity into the demonstration, we will use the Blank file.)

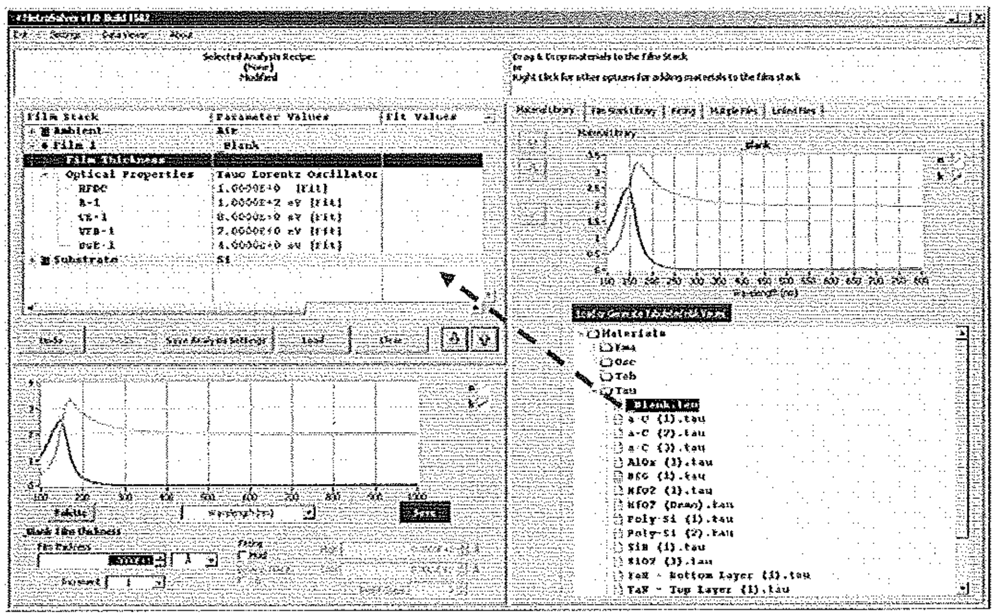

Figure 6-1 - Blank Tau File Loaded into Film Stack

2. *Enable fitting for all T-L parameters, change the **Film Thickness** to the known nominal value and **Hold**.*

   2.1. Since **_Blank.tau** is designed for this purpose, it starts with **Film Thickness** held and the **Optical Properties** set to fit. If using a different material here the user would right-click and select **FIT All Film Parameters** and then right-click and select **HOLD Film Thickness**.

   2.2. If not already highlighted, click the **Film Thickness** line in the film thickness so that it is highlighted in blue. Change the value at the bottom left to the known nominal value. (In this example we know the nominal thickness is 70 Å.)

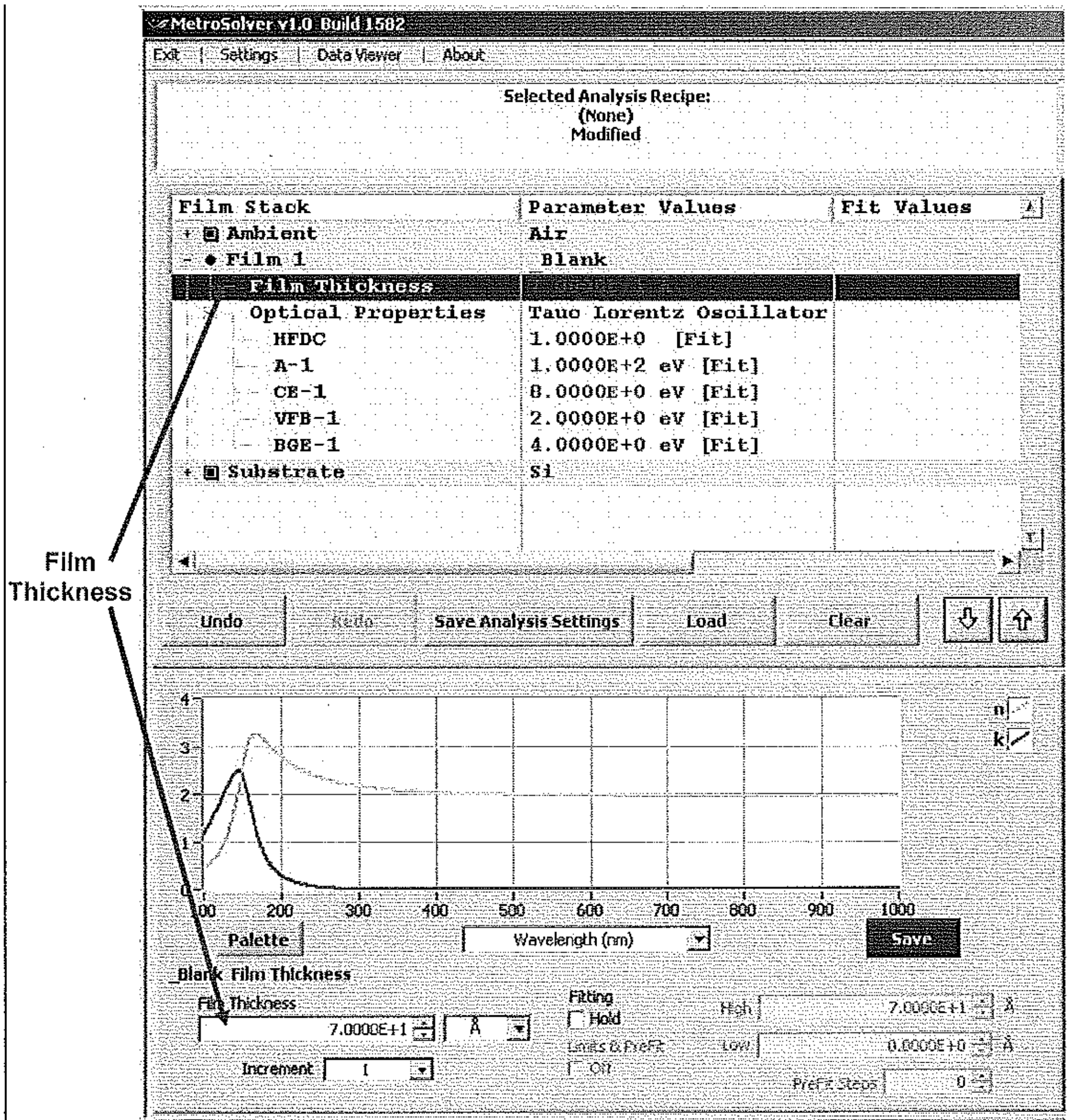

Figure 6-2 – Film Thickness Changed to 70 Å

3. *Load the first measurement file into the* ***Fitting*** *tab. Load all remaining measurement files into the* ***Linked Files*** *tab. Change the File Selector Dropdown Menu to* ***Linked Files*** *and launch the* ***Fit****, making sure that the cursors are set to 120 and 800. The system will perform a rough fit for the T-L parameters based on the known thickness information and the sample measurements.*
   - 3.1. Select the **Fitting** tab.
   - 3.2. Click **Load.**
   - 3.3. Navigate to the **C:\\Metrosol\MetroSolver Samples\Demos\Demo 1** folder and select the file named **HfO2 Demo, Location #01.tsv** and click **OK**.
   - 3.4. Click **No** when asked to "**Set Cursors To First & Last Data Points?**"

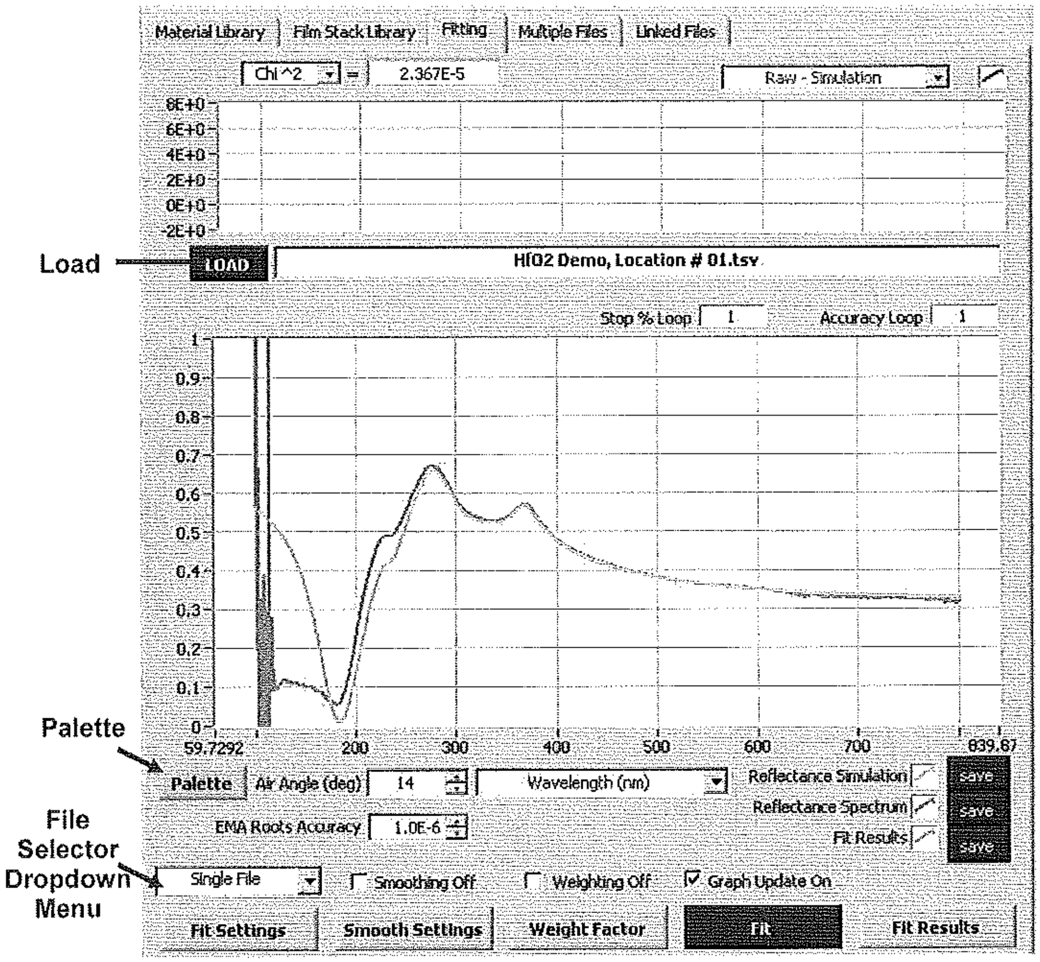

Figure 6-3 - Fitting Tab

3.5. Click **Palette**.

3.6. Change Cursor 0 to 120 and Cursor 1 to 800, and then close the Palette window.

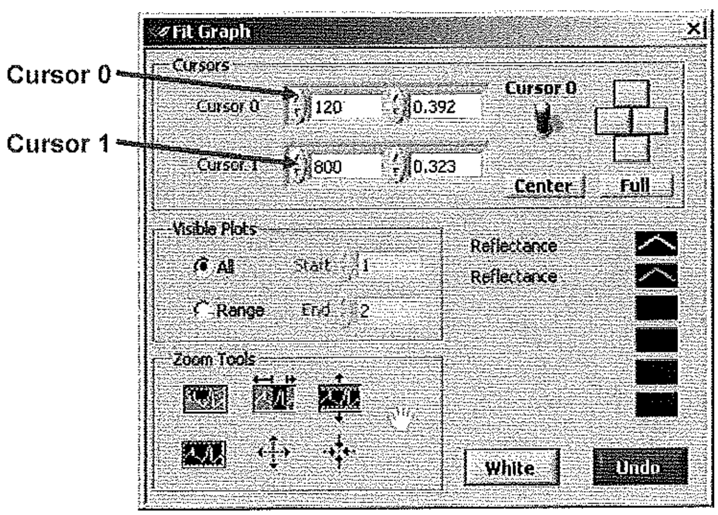

Figure 6-4 - Palette Window

3.7. Select the **Linked Files** tab.

3.8. Click **Select/Add Files.**

3.9. If it doesn't open to the folder automatically, navigate to **C:\\Metrosol\MetroSolver Samples\Demos\Demo 1** and hold down <shift> to select files #2-4. Click **OK.**

3.10. Change all thickness values to the known values.

3.11. Select the **Fitting** tab.

3.12. Change the **File Selector Dropdown Menu** from **Single File** to **Linked Files.**

3.13. Click **Fit.**

The system will perform a rough parameter fit based on the loaded data, and once complete will open the **Fit Results** window.

4. *Once Fitting is complete, right-click in the film stack and* ***Set All T-L Parameters to FIT Values****.*

4.1. **Exit** the **Fit Results** window.

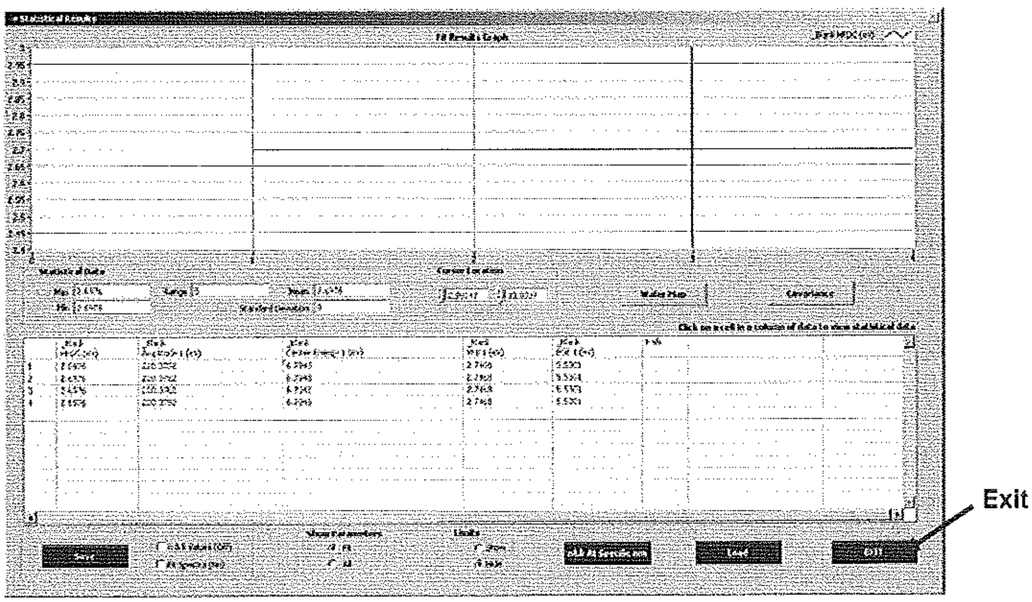

Figure 6-5 - Fit Results Window

4.2. Right-click in the **Film Stack** and select **SET All Film Parameters to Fit Values**. The yellow Reflectance Simulation graph will be redrawn over the green Fit Results graph.

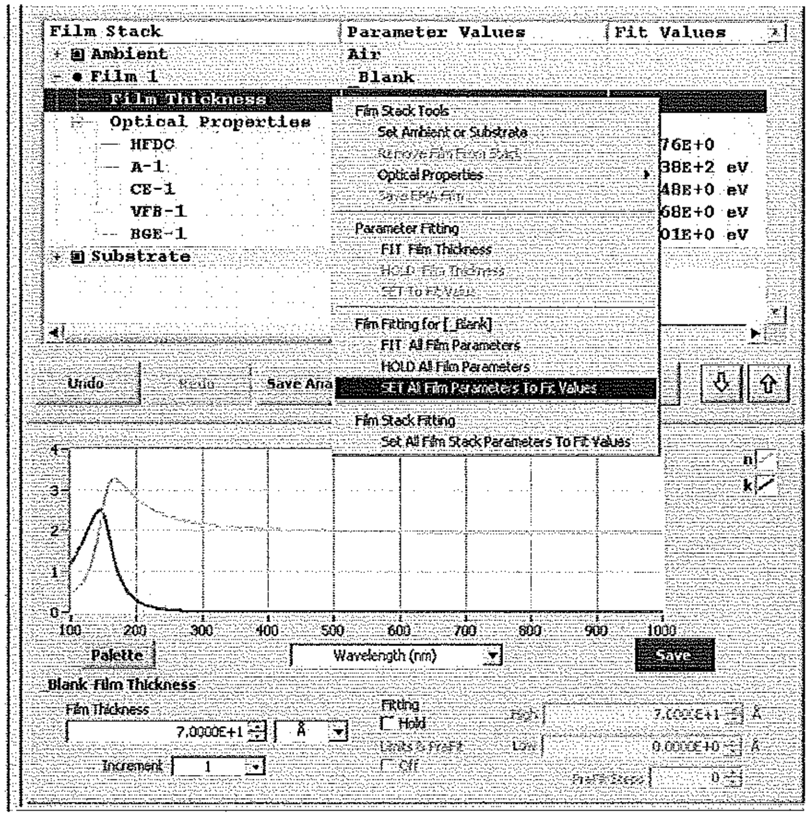

Figure 6-6 - Set All Film Parameters to Fit Values

5. *Add/remove parameters or adjust fit settings and then repeat #2-4 in order to form the tightest possible fit.*

Looking at the Fit Graph, notice that they don't overlay particularly well, even in the UV-Vis range. Also notice that the χ^2 value is 4.266E-5, which is a decent, though not particularly extraordinary fit. We will keep this number in mind and attempt to reduce this value as much as possible and produce a tighter fit.

There are two ways to do this: changing the Fit Settings or adding oscillator terms. We'll start by adding an oscillator term.

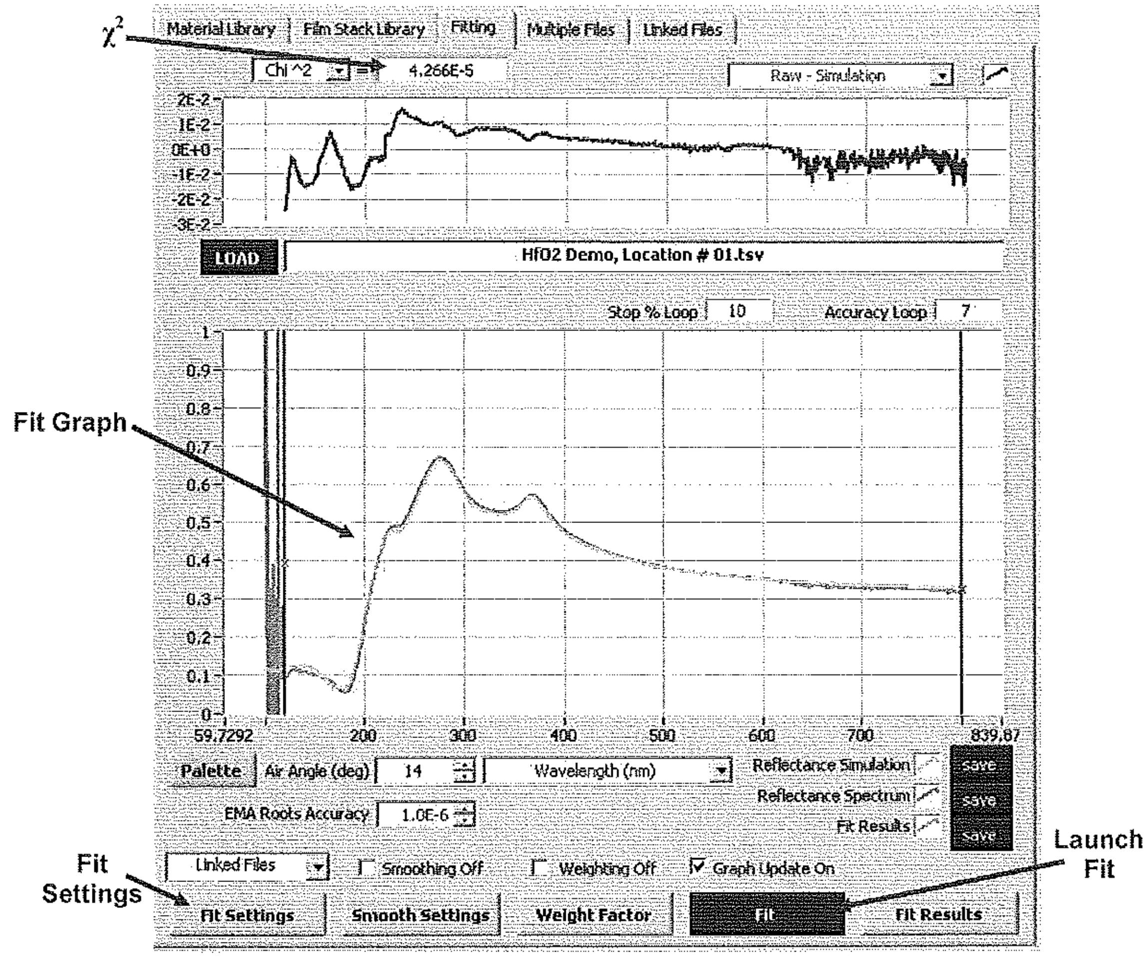

Figure 6-7 - Fit Graph

5.1. Click the **Optical Properties** line in the **Film Stack**.

5.2. Right-click and select **Optical Properties > Add [A-2, CE-2, VFB-2, and BGE-2] New Tauc-Lorentz Oscillator Terms.**

5.3. Right-click and select **FIT All Film Parameters.**

5.4. Click the **Film Thickness** line.

5.5. Right-click and select **HOLD Film Thickness**.

5.6. Select the **A-2** line and change the value to 100. We do this because the actual Amplitude values are almost always in the E+1 or E+2 range, and the closer we can get to the actual values, the more likely we are to find a successful fit.

5.7. Launch the fit by clicking the **Fit** command button.

When the fit finishes, the Fit Results window opens. Scroll to the left to see the files' χ^2 values, which are between 3.36E-5 and 3.85E-5. This is a slight, though not considerable improvement over the previous value, so now we will adjust the Fit Settings to provide a tighter fit.

5.8. Click **Exit.**

5.9. Right-click inside the Film Stack and select **SET All Film Parameters to Fit Values.**

5.10. Click the **Fit Settings** button.

5.11. Under **Simplex Settings** change **Accuracy** to **1.00E-11** and **Accuracy Max Itts** to **99999**.

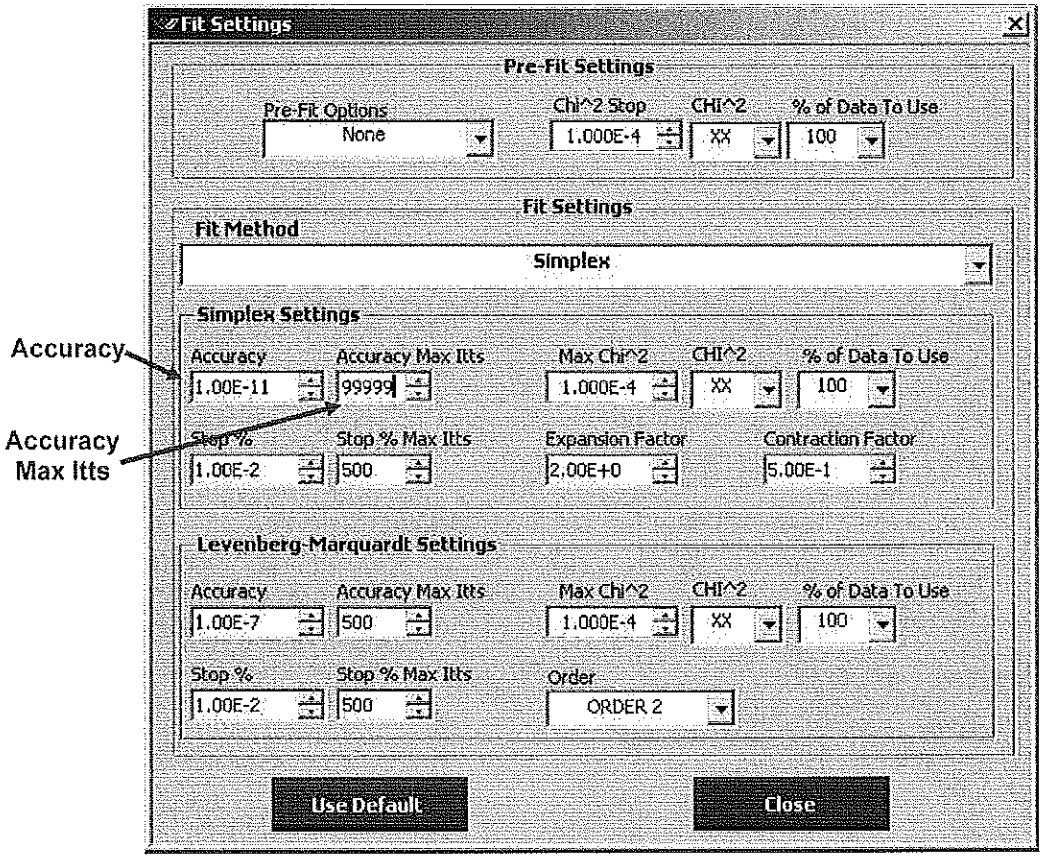

Figure 6-8 - Fit Settings Window

5.12. Click **Close**.

5.13. Launch the fit by clicking the **Fit** command button.

When the Fit has completed the Fit Results window will open. Scroll to the left to see the files' new χ^2 values: 1.30E-5 to 2.00E-5 – a considerable improvement over previous attempts.

Under normal circumstances, the user may attempt to further reduce the χ^2 fit by repeating either of the above procedures (adding another oscillator term or changing the Accuracy) until negligible improvements occur. In this case we've already reached that point, so we will finish this process here, and continue on to the next step. Note that randomly adding oscillator terms may lead to ambiguous results, and is therefore not necessarily the best way to improve the fit.

5.14. **Exit** the Fit Results window.

5.15. Right-click in the Film Stack and select **SET All Film Parameters to Fit Values**.

6. *Right-click and **Hold** all T-L Parameters and then enable **Fit** for film thickness.*

6.1. Right-click in the Film Stack and select **HOLD All Film Parameters**.

6.2. Click the **Film Thickness** line.

6.3. Right-click and select **FIT Film Thickness**.

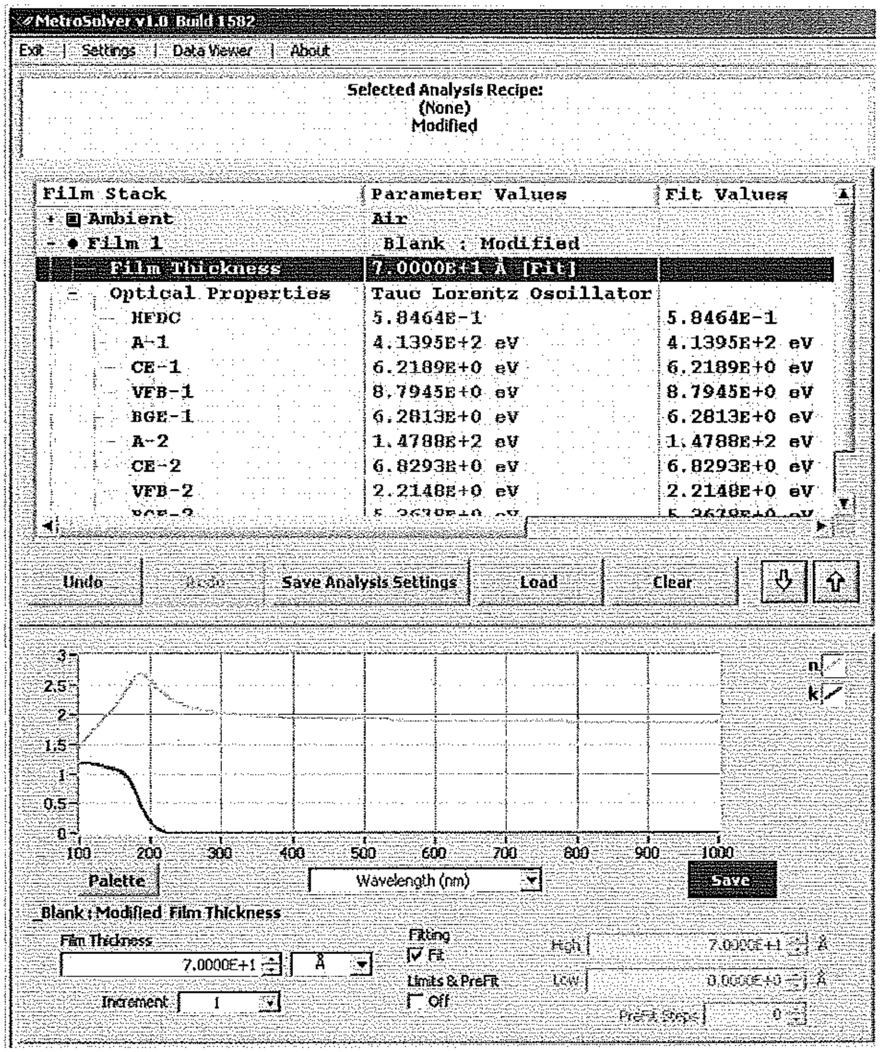

Figure 6-9 - Oscillator Terms Finalized

7. *Save the Oscillator terms.*
   7.1. Click the **Optical Properties** line in the Film Stack.
   7.2. Right-click and select **Optical Properties > Save Oscillator Terms**.
   7.3. Open the **Tau** folder, specify a filename, and click **Save**.

   The **Tau** file will now be available in the **Material Library**.
8. *Change **Fit Settings** as desired for measurement.*
   8.1. From the **Fitting** tab, click **Fit Settings**.
   8.2. Click **Use Default**.
   8.3. Click **Close**.
9. Load and fit measured reflectance files to verify accuracy.

9.1. Select the **Multiple Files** tab.

9.2. Click **Select/Add Files.**

9.3. Navigate to **C:\\Metrosol\MetroSolver Samples\Demos\Demo 1** and hold down `<shift>` to select files #2-4. Click **OK.**

9.4. Select the **Fitting** tab.

9.5. Change the **File Selector Dropdown Menu** from **Linked Files** to **Multiple Files.**

9.6. Click **Fit.**

When finished, the Fit Results window will open with the thickness of the 4 files.

10. *When finished, **Save Analysis Settings**.*

10.1. Click **Save Analysis Settings.**

10.2. Specify a filename and click **SAVE.** The analysis file will now appear in the **Film Stack Library** and can be loaded into a recipe.

6.2 Using EMA to Model a Compound Film

When to Use This Fitting Method

- The film has compositional variation in a film layer that must be tracked (e.g., a SiON layer, where the Nitride component varies in quantity) **and**
- Several samples of different film thickness and composition with reliable respective secondary data (e.g., film thickness and chemical composition) have been provided.

Procedure

1. Load an EMA file into the film stack.
2. Load the first file into the **Fitting** tab.
3. Change the Film Thickness and % of EMA Film in the film stack.
4. Load remaining files into the **Linked Files** tab.
5. Change Film Thickness and % of EMA Film for remaining files.
6. Fix known values and fit for optical properties.
7. Check results, change **Fit Settings**, and repeat for fine fit.
8. Check results by analyzing the control data.
9. Save Analysis and EMA Files.

Demonstration

The following example walks the user through the procedure for fitting a SiON film. In this example we used 10 wafers with nominal thicknesses ranging from 13.7 Å to 23 Å and Nitride composition ranging from 0% to 9.87%, as shown in Table 6-1 Typically the user will want to use nominal data that ranges +/- 10% outside the desired tolerance range.

Table 6-1 - Thickness & Composition for EMA Film

Wafer ID	Thickness[Å]	N Conc. [%]
11	23.0	0
12	19.8	0