

## FLX-2320 S Thin Film Stress Measurement Operation Manual

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### 1 Introduction

The FLX-2320-S determines stress by measuring the curvature change of pre- and post- film deposition. The stress calculation is based on Stoney's equation, which relates the biaxial modulus of the substrate, thickness of the film and the substrate, and the curvature change. The stress measurements can be made from -65°C to 500°C at a heating rate up to 30°C/min. Stress variation with temperature can be used to characterize film properties such as moisture concentration, phase changes, thermal expansion, volume changes, and plastic deformations.

Other characteristics of the instrument include:

- Dual wavelengths
- Calculation of biaxial modules of elasticity, linear expansion coefficient, stress uniformity and file subtraction
- Calculation of water diffusion coefficient
- 2-D and 3-D view of wafer topography
- Wafer size: 75 - 200 mm
- Measurement temperature: from -65°C to 500°C
- PC based controller
- Speed: 5 seconds for 150 mm wafer
- Minimum scan step: 0.02 mm
- Maximum points per scan: 1250

### 2. Operating Safety

- **Laser:** The FLX-2320 contains two 4 mW solid-state lasers with wavelengths of 670 nm and 780 nm. There is a shutter that will automatically block the laser beam when the chamber door is opened for loading and unloading a wafer. Therefore, there will be no reflected laser from sample.
- **High and Low Temperatures:** Do not open the instrument door or touch any inside components, or the sample, until the temperature reading on the front panel reaches room temperature.

### 3. Starting-Up Instrument

- 3.1. Fill in log book first
- 3.2. Turn on the **Main Power** switch
- 3.3. Turn on the **Laser**
- 3.4. If using Stress-Temperature mode, turn on the **Heater** and the **Fan**
- 3.5. If using Stress-Temperature mode, open the inert and N2 gas valves on the gas manifold.

- 3.6. If using Stress-Temperature mode and the designed temperature is lower than room temperature, open the LN2 tank and the LN2 valve.

#### 4. Using Wafer Locator Rings

- 4.1. A wafer locator ring is used to position the wafer at the center of the sample stage.  
 4.2. Available ring sizes: 3", 4", 5", and 6"; 8" wafers fit directly into the plate.  
 4.3. The locator ring is marked at 30° intervals and has a notch at each 15 ° interval.  
 4.4. By rotating the ring and wafer, stress mapping across a whole wafer can be performed.

#### 5. Performing Measurements

##### 5.1. Setting up a Process Program

- 5.1.1. From **Edit** menu, choose **Process Program**  
 5.1.2. In the **Process Program** dialog box, select the desired parameters (referencing followings)

| Field               | Description                                                                                                                                                                               |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Maximum Scan Points | a maximum of 1250 points per scan can be used but 50 points are sufficient for an accurate measurement. Also only 50 data points are saved with each scan to save space on the hard disk. |
| Low Intensity Alarm | Specify an intensity limit below which measurement points will be ignored; 0.2 is recommended.                                                                                            |
| Elastic Modulus     | The biaxial elastic modulus of the substrate                                                                                                                                              |
| Hole Diameter       | The diameter of the center region of the substrate to be skipped.                                                                                                                         |
| Laser Selection     | Use the drop-down list to select Automatic, 670 nm or 780 nm.                                                                                                                             |

- 5.2. **First Stress Measurement** – measure the stress before film deposition

##### 5.3. Single Stress Measurement

- 5.3.1. Enter the same filename as in the First Stress Measurement  
 5.3.2. Enter the same ID as entered in the First Measurement

##### 5.4. Stress-Time Measurement

- 5.4.1. A total number of records in a data file are limited to 1000.

- 5.4.2. Enter the same filename as in the First Measurement.
- 5.4.3. Enter the same ID as entered in the First Measurement
- 5.4.4. Enter the Time Interval the wafer will be measured.
- 5.4.5. Enter the total time the wafer will be measured.

## 5.5. Stress-Temperature Measurement

- 5.5.1. Be sure the **Heater** and **Fan** on
- 5.5.2. Be sure the inert and N2 gas lines are opened
- 5.5.3. For low temperature measurement, open the LN2 tank and the valve on the cooling line.
- 5.5.4. For the Temperature Measurement, the glass piece and the hot plate cover must be put on the wafer stage to create a controlled measurement environment.
- 5.5.5. Create a recipe
  - 5.5.5.1. Enter desired target temperature
  - 5.5.5.2. Enter a total time to reach the target temperature or enter a ramp speed.
  - 5.5.5.3. Enter a number of scans to be taken.
  - 5.5.5.4. Select the next recipe line and enter values. You can enter a maximum of 150 recipe lines and the total number of readings should not exceed 1000.
- 5.5.6. After finish the measurement, unload the wafer until room temperature.

## 6. Creating and Displaying Graphs

### 6.1. Creating Graphs

- 6.1.1. Display a data file in the **Data Editor** window
- 6.1.2. Choose **Create** from the **Graph** menu
- 6.1.3. Enter desired parameters
- 6.1.4. Choose the **Create Graph** button, the graph for the selected file is displayed.
- 6.1.5. To display a graph of only some records, select the block of records, then choose **Create Graph**.

### 6.2. Creating a Trend Plot

- 6.2.1. Display a data file in the **Data Editor** window
- 6.2.2. Choose **Trend Plot** from the **Graph** menu in the **Data Editor** window
- 6.2.3. Enter desired parameters using following references:

| Field          | Description                                                                        |
|----------------|------------------------------------------------------------------------------------|
| Upper SL       | The Upper Specification Limit in stress                                            |
| Lower SL       | The Lower Specification Limit in stress                                            |
| Calculate STDY | calculates the standard deviation; the specification limits will not be displayed. |

- 6.2.4. Choose **Trend Plot** from the **Trend Plot** dialog.

## 7. Data Analysis

### 7.1. Diffusion Coefficient

Note: The diffusion coefficient graphs only can be calculated from Stress-Time graphs.

- 7.1.1. To calculate the diffusion coefficient and plot it in a **Graph** window, choose **Diffusion Coefficient** from the **Analysis** menu
- 7.1.2. Select the desired filename
- 7.1.3. Select two points on the graph by double-clicking on the points.
- 7.1.4. A plot of Diffusion Coefficient vs. Time will be displayed.

### 7.2. Materials Database

Use the Materials Database option in the Edit menu to display a list of available elastic & expansion coefficients.

### 7.3. Elastic and Expansion Coefficient Calculation

Note: Elastic and Expansion Coefficient only can be calculated from Stress-Temperature graphs.

- 7.3.1. Use the Stress-Temperature mode to run two temperature cycles on two different substrates with the same film. For best results, use slow heating or cooling ( $<5^{\circ}\text{C}/\text{min}$ ) to minimize the lag of wafer temperature behind the heating stage.
- 7.3.2. Choose Elastic & Expansion from the Analysis menu
- 7.3.3. Enter the film names
- 7.3.4. Click on two points to plot and display the expansion coefficient.
- 7.3.5. The average values of the expansion coefficient and the biaxial modulus display in a dialog box.

### 7.4. Thermal Stress

Note: Use the Thermal Stress option to display the thermal stress superimposed on the stress-temperature measurement data.

- 7.4.1. Choose Thermal Stress from the Analysis menu
- 7.4.2. Enter the file name
- 7.4.3. Enter the temperature range

### 7.5. Displaying Deflection Maps

Note: Use the Deflection Maps to display 3-D view of the deflection. By taking several measurements at different angles you can display a complete 3-D map of deflection over the wafer surface. The deflection can be plotted as the difference of two groups of measurements (before- and after- a film deposition) or as an absolute deflection of a single measurement.

- 7.5.1. Measure the wafer at different angles using a wafer locator ring.
- 7.5.2. The IDs for each measurement in a group should be identical and in the format xxxx-###, where XXX is any character (including spaces) and ###

is the angular orientation. For example, the IDs for wafer T12 measured every 15° would be as follows:

|          |          |          |
|----------|----------|----------|
| T12 - 0  | T12 - 60 | T12 -120 |
| T12 - 15 | T12 - 75 | T12 -135 |
| T12 - 30 | T12 - 90 | T12 -150 |
| T12 - 45 | T12 -105 | T12 -165 |

7.5.3. When comparing two scans (before and after deposition), the first four ID characters must be identical for both scans and the orientation steps used must also be the same. Also, the dash must be in the fifth column and the ### portion must be right justified.

7.5.4. Choose 3DPlotting from the Analysis menu.

7.5.5. To change the viewing angle, use the following key combinations:

| Key Combination | Description                         |
|-----------------|-------------------------------------|
| F7              | 30° increment                       |
| CTRL + F7       | Face on view                        |
| ALT+F7          | 10° increment                       |
| F8              | 30° increment                       |
| CTRL + F8       | Face on view                        |
| ALT+F8          | 10° increment                       |
| F9              | 45° increment                       |
| CTRL + F9       | 90° increment                       |
| ALT+F9          | 15° increment                       |
| F10             | 45° increment                       |
| CTRL + F10      | 90° increment                       |
| ALT+F10         | 15° increment                       |
| F11             | Compress the view vertically by 50% |
| F12             | Stretch the view vertically by 50%  |

## 8. Shutting-Down the Instrument

- 8.1. Wait for the sample stage to reach room temperature.
- 8.2. Close all open windows and choose **Exit** from the **Measure** menu.
- 8.3. Exit from the **Program Manager File** menu.
- 8.4. Turn off: **Laser, Heater, Fan,** and **Main Power.**
- 8.5. Close the inert and N2 gas valves.
- 8.6. Close the LN2 tank and the valve.
- 8.7. Complete log book.

**9. Revision History**

| <b>Revision #</b> | <b>Date</b> | <b>Authors</b> | <b>Changes/Additions</b> |
|-------------------|-------------|----------------|--------------------------|
| 1.0               | 12/04/2007  | L. Xie         | Initial issue            |
| 2.0               | 4/28/2008   | E. Martin      | Revised                  |
| 2.1               | 6/16/2008   | E. Martin      | Revised                  |

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