FILMETERSICS F40 STANDARD OPERATION PROCEDURE

Rev C
Table of Contents

Contents
Table of Contents .........................................................................................................................1
1. Purpose / Scope ..........................................................................................................................2
2. Reference Documents ................................................................................................................2
3. Operation Manual ......................................................................................................................2
4. Equipment / Supplies / Material ................................................................................................2
5. Safety .........................................................................................................................................2
6. Set Up Procedures ....................................................................................................................2
7. Operation Procedures ...............................................................................................................3
8. Process Data .............................................................................................................................4
9. Revision History .......................................................................................................................6
1. Purpose / Scope

The Filmetrics F40 uses spectroscopic reflectometry to measure and analyze single layer or multilayer film stacks. The detector is mounted on an optical microscope, so known, selected areas on patterned wafers can be evaluated following deposition or etch steps. The F40 is a valuable technique to monitor a sequence of process steps. This SOP provides the procedures to set-up and calibrate the F40 system and then measure the thickness or thicknesses of a film or multiple films on known substrates.

2. Reference Documents

Information from the equipment supplier is available from the filmetrics web site.
http://www.filmetrics.com/technology

3. Operation Manual

NA

4. Equipment / Supplies / Material

Zeiss Microscope and microscope light source
Computer with AmScope and FilmMeasure software
Clean silicon reference wafer plus 18KA SiO2/Si test wafer
Tweezers to handle wafers

5. Safety

No unique safety requirements

6. Set Up Procedures

6.1. Turn on the microscope lamp power to 4-7V on the meter (bottom scale) Allow to stabilize for 5 minutes before calibrating the baseline or taking any measurements.

6.2. The aperture on the scope (top, right side, next to light source) should be set to 8 (max setting).

6.3. Log in the computer using your standard ASURITE or ASUAD account (may need to use asuad/user name, and password).

6.4. This instrument will use the microscope camera to focus the sample and select the area of interest. Place a sample or test wafer on the stage under the microscope lens; use either the 4X or 16X lens.

6.4.1. Open {AmScope} software (icon on desktop).

6.4.2. Click on [MU 1000] in the camera list (top left column). You should see an image from the microscope and a black square (the detector). Carefully, focus on your sample; start at the edge of the wafers if needed. [If no camera is listed, close and try again or unplug the USB plug on the camera, re-connect and re-launch software.]

6.5. Open the Filmetrics software by clicking on the {FilMeasure} icon on the desktop. Note that there are 2 tabs; [Measure Window] and [History]; select the [Measure Window] tab.

6.6. Select the appropriate microscope objective from the drop down list (right column); either 4X or 16x lens.
7. Operation Procedures

Reflectance Reference Procedure

1. Place a clean Si reference wafer on the microscope stage and use the AmScope software to view the image; Use microscope knobs to focus on wafer surface (use the wafer’s edge or “dirt” to help focusing on the surface); find a clean area.

2. Select [Baseline] in the FilmMeasure window, and follow the prompts.
   a. First, Select [Take Sample Reflectance]; Enter.
   b. Second, verify that the [Reflectance Standard] field is set to [Si]; Select Enter; when completed (note green bar in window); Software prompts for next step.
   c. Close the shutter on the microscope (black knob on the left side of the microscope head; push to the left; camera image goes black).
   d. Third, select [Take background]; select Finish when done. This should complete the reflectance reference setup.

3. Open the shutter to again see the microscope image with the AmScope software.

4. Place the test wafer with 18KA of SiO2 on Si onto the stage; Focus.

5. Select [FilmMeasure]; Select “SiO2/Silicon” from the pull down menu [ ↓ ] or select “edit structure” and find “SiO2/Si” in the dielectric film data base. Enter 18000A into the thickness box; check [x] box next to “d”, select “OK”.

6. Select [Measure]; the graph should show the reflectance versus wavelength (400nm to 800nm) with several peaks and valleys. Thickness results should reasonably agree with the nominal value. Check the fit parameter; If the fit is good (0.8 to 0.9), you are ready to measure your sample; Problems? Contact ASU’s Nanofab staff.

Sample Measurement

7. Load your sample, focus! “Black square” in the image is the detector. Locate the detector over the region of interest. This is a good technique for patterned and etched samples.

8. Click on [FilmMeasure] window.

9. Select a structure from pull down menu of recent models (such as “SiO2/Si”, “PR/Si” etc) if it matches your sample. Otherwise, build a model (next step).

10. Select [Edit structure]; Build an optical model for your sample.
   a. Select your Substrate material (pull down menus [ ↓ ] for database access)
   b. Insert Film #1, find the material using the [ ↓ ] and data base of materials and enter approximate thickness; check “Fit” box.
   c. Add other layers as needed using the “+ arrow”.
   d. Pull down layers allow access to the data base of materials: dielectrics, metals, semiconductors are listed alphabetically.

11. Estimate thicknesses for all layers; check “Fit” box [x] next to “d” so software will determine the thickness; press “OK”;

12. Press [Measure]

13. Measured data is plotted with “Blue”; modeled data is in “Red”.

14. Peaks and valleys should match at each wavelength for good fits; amplitudes may not fit as well.
15. Measured thickness will be displayed at the top right box; Measurement box on right bottom shows the film thickness values along with the “Goodness of Fit” values.
16. Goodness of fit values; perfect fit is 1.0; generally GOF should be in the 0.9 to 0.8 range; Values depends upon the accuracy of the model for your sample.
17. Move to a new sample or new location; re-do the structure as needed; the model may need a surface roughness component or another thin layer (such as a thin oxide above nitride films for example.
18. Collect statistics across wafers or sample (see next section).

8. Process Data
The simplest data collection is to write the thickness values into your note book. The spectra can be exported using the “file” menu commands.

Options for additional analysis:
Select [Edit Recipe] then “Analysis Options”; Change the wavelength range for the fit routine by entering the values in the corresponding boxes; the standard is 400nm to 800nm; however, for some material combinations, using only longer wavelengths improves the fit; try 500 to 800nm or 600 to 800nm to see if the fit improves. This approach is especially valuable for photo resist where k becomes larger at short wavelengths.

Check the initial thickness guess by trying different starting thickness values. For example, with the 18,000A SiO2/Si test wafer, try 12000A or 24000A. If you get the same final value, the software is converging on the correct value.

Thickness values below ~100A to ~200A are generally not accurate and is a limitation of reflectance measurements.

Very thin metal films can be measured using the F40. Reflectance from both the top and bottom film surfaces are required for valid measurements. Metal films such as Al, Ti or TiN that are less than 500A thick can be measured; thick metal films reflect the light from the top surface and cannot be measured.

Films on transparent substrates can be measured and analyzed, but special procedures are required; see the help menu for assistance.

On the first page of the FilMeasure software, there are two tabs, “Measure Window” and “History”. Select the “History” tab and, on the left is a table with the following column and row headings:

<table>
<thead>
<tr>
<th>Stats</th>
<th>Layer 1 ID</th>
<th>GOF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>Std dev</td>
<td>Min</td>
<td></td>
</tr>
<tr>
<td>Max</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8. Process Data
The simplest data collection is to write the thickness values into your note book. The spectra can be exported using the “file” menu commands.

Options for additional analysis:
Select [Edit Recipe] then “Analysis Options”; Change the wavelength range for the fit routine by entering the values in the corresponding boxes; the standard is 400nm to 800nm; however, for some material combinations, using only longer wavelengths improves the fit; try 500 to 800nm or 600 to 800nm to see if the fit improves. This approach is especially valuable for photo resist where k becomes larger at short wavelengths.

Check the initial thickness guess by trying different starting thickness values. For example, with the 18,000A SiO2/Si test wafer, try 12000A or 24000A. If you get the same final value, the software is converging on the correct value.

Thickness values below ~100A to ~200A are generally not accurate and is a limitation of reflectance measurements.

Very thin metal films can be measured using the F40. Reflectance from both the top and bottom film surfaces are required for valid measurements. Metal films such as Al, Ti or TiN that are less than 500A thick can be measured; thick metal films reflect the light from the top surface and cannot be measured.

Films on transparent substrates can be measured and analyzed, but special procedures are required; see the help menu for assistance.

On the first page of the FilMeasure software, there are two tabs, “Measure Window” and “History”. Select the “History” tab and, on the left is a table with the following column and row headings:

<table>
<thead>
<tr>
<th>Stats</th>
<th>Layer 1 ID</th>
<th>GOF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>Std dev</td>
<td>Min</td>
<td></td>
</tr>
<tr>
<td>Max</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Below the table are five buttons:

[Save As] [Delete All] [Copy]

[Delete Selected] [Send selected to measure]

If you highlight the statistical data and then [Delete Selected], it will clear the statistics. You can then make numerous measurements and generate the corresponding statistics for your sample.

On the right side is a table entitled “Measure” with the following headings:

<table>
<thead>
<tr>
<th>Measure #</th>
<th>Layer 1 d</th>
<th>GOF Results</th>
<th>Recipe</th>
<th>Date/Time</th>
<th>Elap time</th>
<th>User ID</th>
<th>Sample ID</th>
<th>Valid</th>
</tr>
</thead>
</table>

This table collects the measured data.

There are additional tabs on the right side: “Single Measurement” and “Meas. Trend”.

The “Single Measurement” will plot the Reflectance versus wavelength for the selected “Measure number”.

The “Meas Trend” will plot “d” (thickness) versus “Measure #”.

There is a [Help] windows menu that opens a manual for the F40 for additional information.

If you have a film material that is not in the data base, and you know the n and k versus wavelength values, you can enter that data using Edit > Material Library > New (check the file formats in the help menu).

If you have an optical model for a film {such as a Cauchy model where \( n = A + (B/\lambda^2) + (C/\lambda^4) \)}, you can generate a table in Excel and import the results as a “csv” file type with formats “name.nnn” or “name.kkk”; see the help menu for details.
## 9. Revision History

<table>
<thead>
<tr>
<th>Effective Date</th>
<th>Originator</th>
<th>DESCRIPTION OF REVISION</th>
<th>Issue</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/5/09</td>
<td>Name</td>
<td>Initial Release</td>
<td>A</td>
</tr>
<tr>
<td>7/13/07</td>
<td>Paul Boland</td>
<td></td>
<td>B</td>
</tr>
<tr>
<td>4/1/15</td>
<td>Wayne Paulson</td>
<td>Update instructions &amp; convert to SOP format</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>D</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>E</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>F</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>G</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>H</td>
</tr>
</tbody>
</table>