**Nanospec Operating Instructions**

**Description**

This machine is used to measure the thickness of dielectric thin films such as silicon dioxide, silicon nitride and photoresist. The Nanospec diffracts light from the halogen bulb and deuterium lamp into its component wavelengths from 200 to 900nm. The spectrophotometer scans the light from short to long wavelengths and the microscope focuses this light onto the sample. The Nanospec then measures the resulting reflectance versus wavelength and, from this data, determines film thickness. The measurement range of the instrument is from 10 to 500,000Å, with the UV deuterium lamp required for film thickness under 100Å and for several special programs. For information not found below, consult the operation and maintenance manuals (Nanospec/AFT 4100) in the characterization room.

**Introduction to the system**

**Equipment**

Like an optical microscope, the Nanospec has x-/y-position knobs and course/fine focus knobs, all located below the stage. The x-y position is manually adjustable to a resolution of about 2μm. There are four optical objectives: 5x, 10x, 15x (reflecting) and 50x. The choice of objective is determined by the program (sample structure) and sample feature-size. When looking through the eyepiece (and focused on a sample) a dark, circular spot is visible, indicating the measurement location. The diameter of this spot is set by the objective size as indicated by the table below:

<table>
<thead>
<tr>
<th>Lens power</th>
<th>Spot size</th>
</tr>
</thead>
<tbody>
<tr>
<td>5x</td>
<td>30 μm</td>
</tr>
<tr>
<td>10x</td>
<td>15 μm</td>
</tr>
<tr>
<td>15x (reflecting)</td>
<td>10 μm</td>
</tr>
<tr>
<td>50x</td>
<td>3 μm</td>
</tr>
</tbody>
</table>

For example, to probe a uniform sample using the halogen bulb, the 5x lens may be used, whereas to probe inside a 10μmx10μm contact hole, the 50x lens should be used.

The Nanospec uses two different light sources: (1) a tungsten halogen bulb, located to the right above the stage but below the spectrophotometer, in a black housing. When the halogen bulb is on, white light should stream out of the housing. (2) A Deuterium UV lamp, located in a green metal housing separate from the Nanospec. If you suspect that either lamp is malfunctioning or “burnt-out”, contact POEM staff. To control the exposure of the sample (and the users’ eyes) to the UV light, there is a UV shutter located behind the optical column, level with the eyepiece. The UV shutter is closed by pushing it all the way to the right. Keep this shutter closed except during UV measurements.

**Software program**

The software program will automatically load when the computer is turned on. If someone logs off, log back into the program using the username NANO and password 4000.
The screen has three parts. The top bar contains menu functions. These functions can be selected either by clicking on the appropriate bar button or by pressing the corresponding function key on the keyboard. The middle part of the screen contains the data output. The bottom left part of the screen gives information about the current measurement program, and additional program options are listed on the right side.

The top bar functions are:
- <F9> – STD – select a standard measurement program and take necessary references
- <F7> – REF – take a reference measurement
- <F10> – MEAS – take a measurement (with the currently selected program). This function can also be engaged by pressing <SHIFT>, spacebar or <ENTER>
- <F2> – GRAPH – plot the latest measured and modeled reflectance vs. wavelength. Before making another measurement you must “exit” out of the graph.
- <Alt-F3> – STATISTICS – Calculates mean and standard deviation on the current set of data
- <F6> – CLEAR – separate one set of data from another for the purposes of calculating statistics
- <F5> – LOGOFF – logout of the Nanospec program; only necessary for maintenance tasks.
- <F8> – USER – select a user-defined program; only necessary for maintenance tasks.

The following functions are disabled or not useful: <F1> – HELP, <F3> – AUTO, and <F4> – PRINT

**Operation**

**Initial setup**
If needed, turn on the computer. Push <F1> when prompted. The Nanospec program will start up and initialize automatically. After turning on the computer, wait 30 minutes for the instrument to warm up before taking measurements.

**Selecting a program and taking an initial reference measurement**
Press <F9> - STD. Click <NO> in response to “Option. Save measurement data into database?” Select the program you want and click <ENTER>. Select the desired magnification and rotate the lens turret to the appropriate lens. Click <ENTER>. Click <YES> when prompted “Reminder! Take a new reference? Age of reference <<xx:xx Hours>>,” unless you have recently (within ~ 1 hour) taken a reference with the same program and same objective lens. Use the existing reference wafer or place your own reference wafer (usually a bare silicon wafer) under the lens. Adjust the focus until the octagon edges are crisp. If using a UV program, open the UV shutter; otherwise, check that it is closed. Then click <ENTER> in response to “Reminder! Prepare Substrate for Reference” to take the reference measurement. The spectrophotometer will scan through the wavelengths and then finish loading the program.

**Measuring a sample using the tungsten halogen lamp**
Use the 5x, 10x or 50x objectives only. Press <F10> - MEAS. Follow the directions on the screen: Close the UV shutter if prompted to do so. Remove the reference wafer and place your sample under the microscope. Course, then fine focus on the octagon edges or sample surface.
Align the sample to the desired position using x-y stage knobs. When ready to measure, click “OK.” The film thickness will appear in Angstroms under the Thickness column.

The Fit column contains the statistical fit between the measured data and the model corresponding to the film thickness for the selected program. The smaller the fit value, the closer the measured and modeled data. Typical fits are < 0.10, although under some conditions the model can be good even when the fit is larger, >1.0. To view the measured and modeled reflectance vs. wavelength, press <F2> - GRAPH. The graph will appear in the lower right corner of the screen. The model and measured data sets can be toggled on/off using the buttons. It is recommended to always observe the fit values, and check the graph whenever using a new program or measuring a new type of sample. Click <EXIT> out of the graph to return to measurement.

To repeat a measurement, check the focus then press <F10>-MEAS. To get statistics (t, σt) on a table of measurements, press <Alt-F3>. To measure a new sample, place it on the stage and focus on it. Then press <F6>-CLEAR to create a new table and finally press <F10>-MEAS to measure. If you change the objective lens, redo the reference measurement by pushing <F7>-REF. If you change programs, also redo the reference measurement.

**Using the Deuterium lamp to make UV measurements**
The Deuterium lamp is used for measuring certain film configurations, including thin (25-500 Å) silicon dioxide or silicon nitride on silicon with programs #17 or #18, respectively, and oxide on poly-Si (#19, 150-10,000Å) or oxide on aluminum (#20, 500-20,000Å). Turn on the deuterium lamp power supply at least 15 minutes before taking any measurements. Use the special 15x reflecting lens only, and take a new reference each time a UV program is selected. Programs #19 and #20 require two reference measurements; see the operations manual, pages 4-11,12 and 3-16 for details. To protect your eyes, open the UV shutter only when taking the measurement; keep it closed during focusing and alignment.

**Shutdown**
When finished, remove your sample and reference wafer and TURN OFF THE COMPUTER by pushing the power button. This will turn off the tungsten halogen lamp and thereby extend its lifetime. Turn off the deuterium lamp power. Sign the logbook.

**Other notes**

Details on the programs can be found in the Operations Manual on pages 4-7 to 4-12.

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