EECS 143
Microfabrication
Technology

NanoSpec Manual

1. Background

The NanoSpec is an instrument for measuring the thickness of optically transparent thin (10 to 4000 nm) films on silicon wafers. The basic operating principle is that the intensity of monochromatic reflected light depends strongly on film thickness because of interference (the film thicknesses are comparable to the wavelength of the incident light). The machine uses a computer-controlled grating monochromator and a photomultiplier tube detector to measure the reflected optical spectrum (over the 350 to 800 nm wavelength band) from a bare silicon reference wafer and from the wafer under test. Given an index of refraction for a thin film and the two measured spectrums, the computer will analyze the interference pattern to determine film thickness. The equation for describing the interference is:

$$x_0 = \frac{\lambda}{2n_i}[g - (\phi_s - \phi_f)]$$

where x_0 is film thickness, λ is the wavelength (in vacuum) of the incident radiation, ϕ_s is the relative phase shift at the SiO$_2$/Si interface, ϕ_f is the relative phase shift at the air/SiO$_2$ interface, n_i is the index of refraction of the thin film, and g is the order of the interference. The intensity is a maximum when the bracketed term is an integer and a minimum when it is an integer plus 1/2.

2. Operating Procedures

The Nanospec should be on, warmed up for 30 minutes or more and ready for measurement. If not refer to the section "Rebooting The Nanospec":

Measurements (sample: SiO$_2$ on silicon)

1. Set the 460 nm optical filter in place. This filter is found along the cylinder that connects the illuminator to the microscope body.

2. Using the 10X objective focus on the wafer surface. When properly focused, an octagon is in view with a black spot in its center. The film thickness is measured in the area of this black spot. The size of the octagon can be controlled using the **FIELD DIAPHRAGM** located on the microscope illuminator marked **F**.

    The 10X objective looks at a 35 micron diameter.

3. From the FILM TYPE menu select the film to be measured. Press **RETURN**. Film type 1 is silicon dioxide on silicon.

4. Enter the objective number and press **RETURN** (1 = 10X.)

5. Press **M** for measure. A wavelength scan takes about 20 seconds to complete. Measurements that are out of range will report:

   > OUT OF RANGE
   > UNDER RANGE
   > LESS THAN 110 A
   > LESS THAN 20 A

6. Enter your sample number. Press **RETURN**.

7. When prompted, enter the refractive index. The AFT 200 has a refractive index table. Press **RETURN** for the table default value (1.45 for SiO_2)

8. Press **M** for measure.

9. **Repeat 5-8** to make additional measurements on the current sample.

10. To proceed to a new test press **C**. When querried "SWITCH TO PRINTER" press **N** for no.

    For films other than SiO_2 on silicon refer to the manual provided by Nanometrics.

    If you enter or are in the PRINTER mode the CRT will no longer respond. The above functions can then be entered via the Nanospec AFT 200 keyboard. To return the Nanospec to the CRT mode hold the **CALIB** button down for 5 seconds. Press **YES** when prompted "SWITCH TO CRT". The Nanospec is not usually operated in the printer mode to conserve paper.

3. Rebooting the Nanospec

If necessary the Nanospec AFT 200 can be rebooted. The following is the setup mode used for EE143:

1. Turn off the Nanospec red power switch located in the lower rear of the Nanospec computer. Wait 10 seconds.

2. Turn on the red power switch.

3. Confirm the microscope illuminator is on. The illuminator switch is at the top rear of the AFT 200 computer. If the system has been off, allow 30 minutes to warm up.

4. Follow the startup menu which appears on the terminal:

1. You will be prompted, "IS THE WAVELENGTH 480". If yes press **Y, RETURN**. If the wavelength is not 480 enter the current value and press **RETURN**. The wavelength readout is a numerical counter located on the optical head above the microscope. Setting the wavelength may require iteration.

2. At the next query, DATABANK I OPTION type **N**. The DATABANK I OPTION allows statistical analysis of collected data. EE143 does not use the DATABANK I OPTION.

3. Enable the REFRACTIVE INDEX OPTION by pressing **Y**. This allows manual entry of the film refractive index or the use of default values simply by hitting **RETURN**.

4. Rotate the microscope objectives 1/8 turn to a mid position so no light comes through. Set the ZERO potentiometer on the optical head so the photo-intensity meter reads 0.5 - 1.0.

5. Rotate the objective to the 10X position and set the photo-intensity meter between 31-32.

5. Setup is now complete.

For complete instructions refer to the Nanospec AFT Model 200 manual.

R. Hamilton, Spring 1996