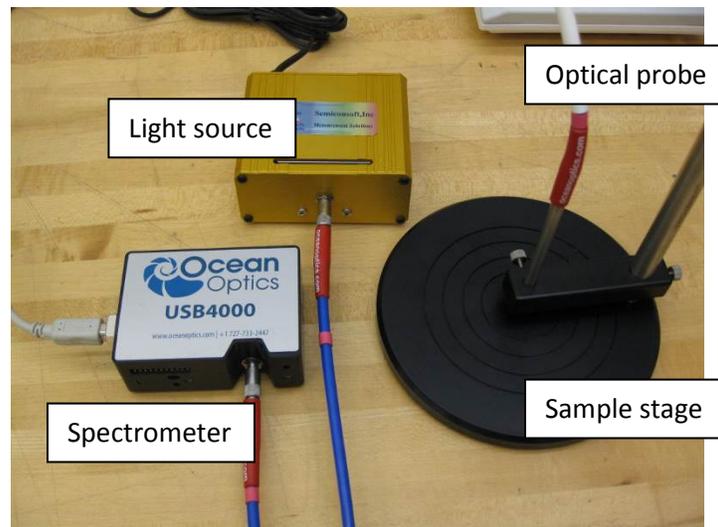


# Thin-film thickness measurements using reflectance spectroscopy

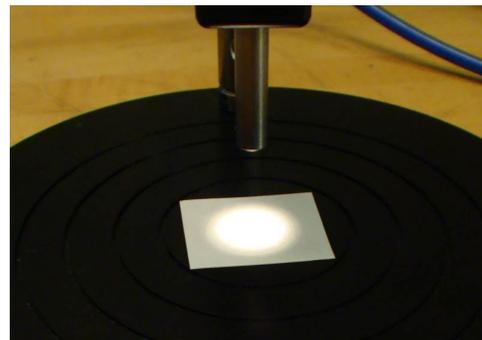
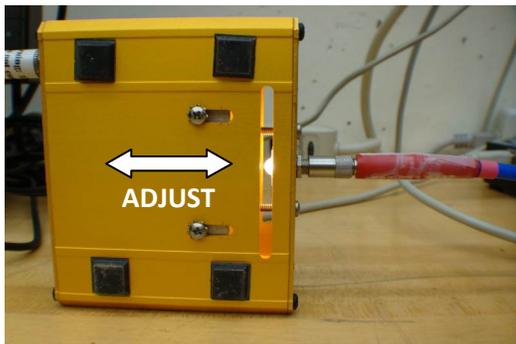
(Rm. Serin 286)

## Initial setup

1. The reflectometry setup consists of a white-light source, optical fiber probe, sample stage, and an Ocean Optics USB 4000 spectrometer connected to a computer via USB cable:



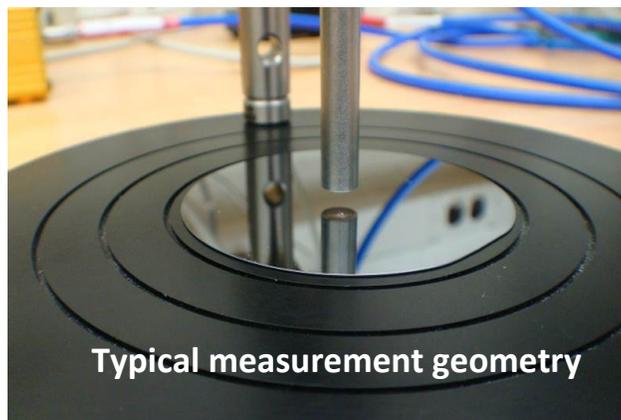
2. At the initial setup stage, the position of the light bulb relative to the lens inside the light source should be adjusted for efficient coupling of the light into the fiber. Proper adjustment will produce a symmetric bright illumination spot with maximized intensity at the sample stage:



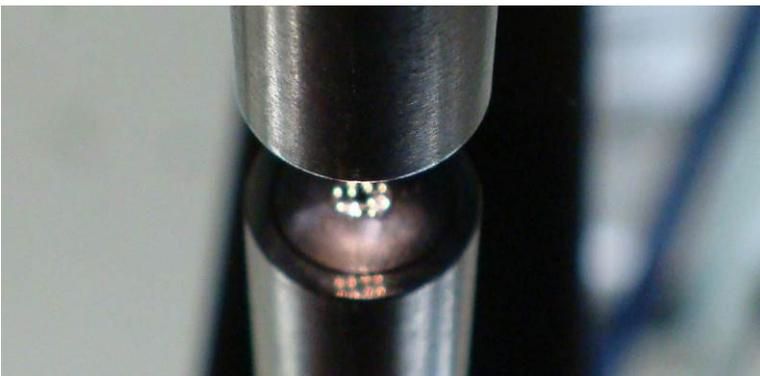
## Reflectance calibration

Every time the probe is moved, one needs to perform a reflectance calibration using the bare silicon reference wafer (labeled "USB 4000" on the wafer case). This wafer must be always kept in its case (when not in use) in rm. 286.

1. Place the bare Si reference sample at the center of the sample stage (polished side up). Always make sure the surface of the sample is clean: scattering from dust particles (especially with weakly reflecting samples) will distort the data.



2. Make sure the incoming illumination light travels through the six outer fibers, and the reflected light is collected by the single inner fiber. This is necessary for an efficient collection of the signal through a very narrow entrance slit of the spectrometer.



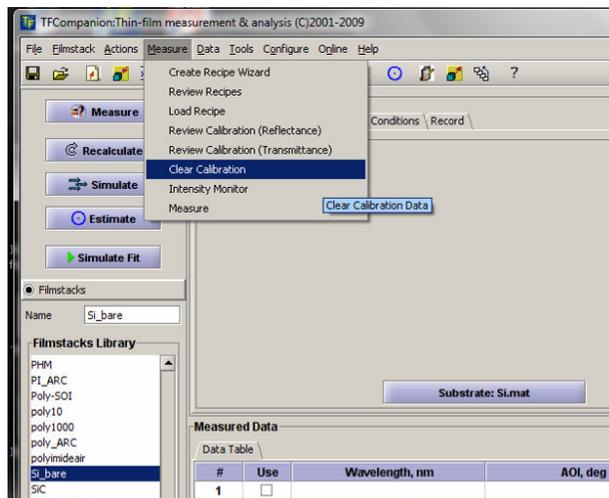
3. Adjust the height of the optical probe. The distance of a few mm between the probe and the sample gives an optimal signal.

4. Open "TFCompanion" program on the computer. The username is "Admin\_Hdw" and the password is "psw".

5. Two windows (TFCompanion and Signal monitor) will open. Make sure the program receives input from the spectrometer, and then close the "Signal monitor" window.

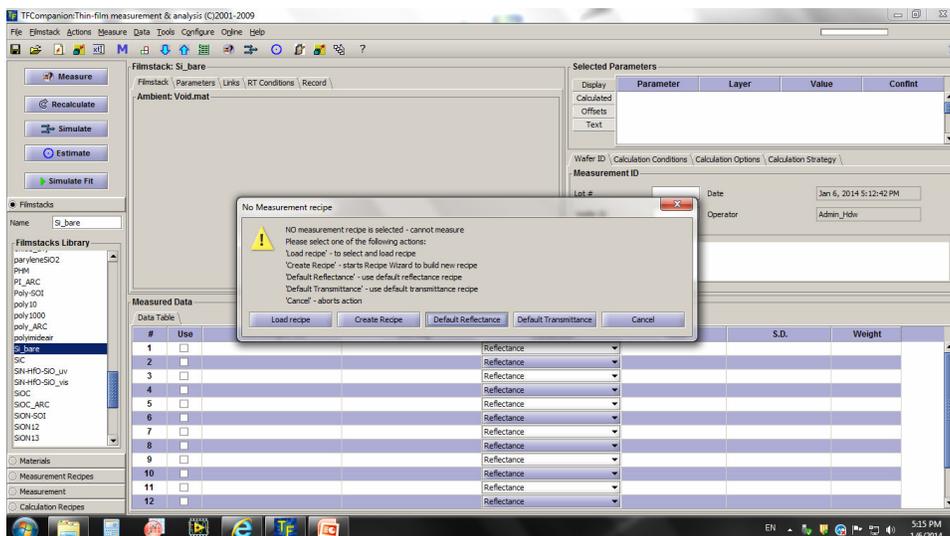
6. Now we can input the information about our sample in the "TFCompanion" window: Select "Si\_bare" in the filmstacks library in the TFCompanion window.

7. Select **Measure** → **Clear Calibration**.



8. Click **Measure**.

9. Select **Default Reflectance**.



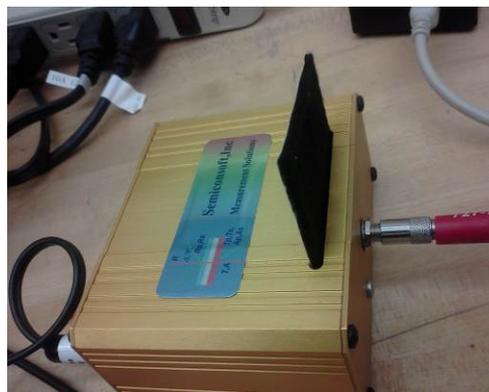
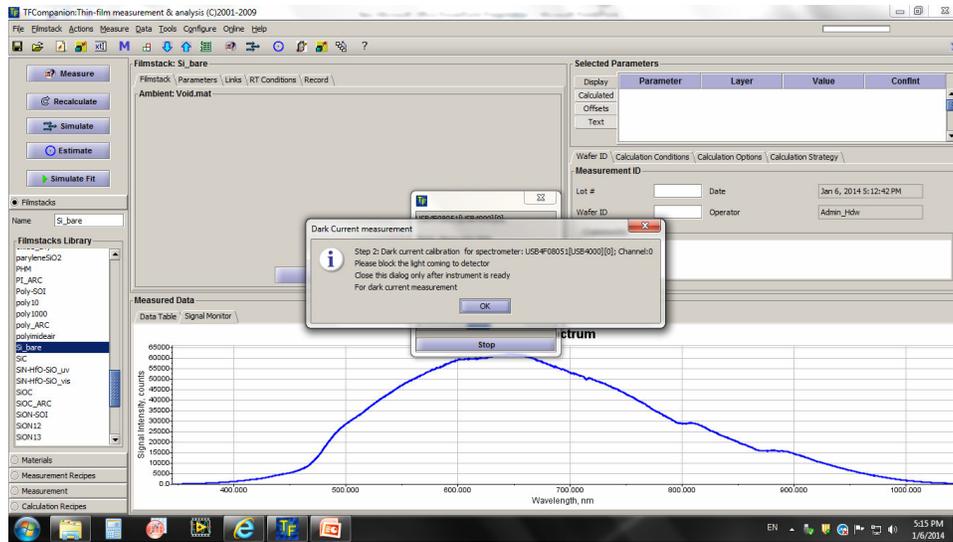
10. Click **Calibrate Now** in the pop-up window.

11. Start calibration by clicking **OK**.

12. When the sub-window "Dark Current measurement" pops up, block the light coming from the light source, then click **OK**. You can block the light by turning off the light source or inserting the rough black filter kept in same tray with the reference Si wafer.

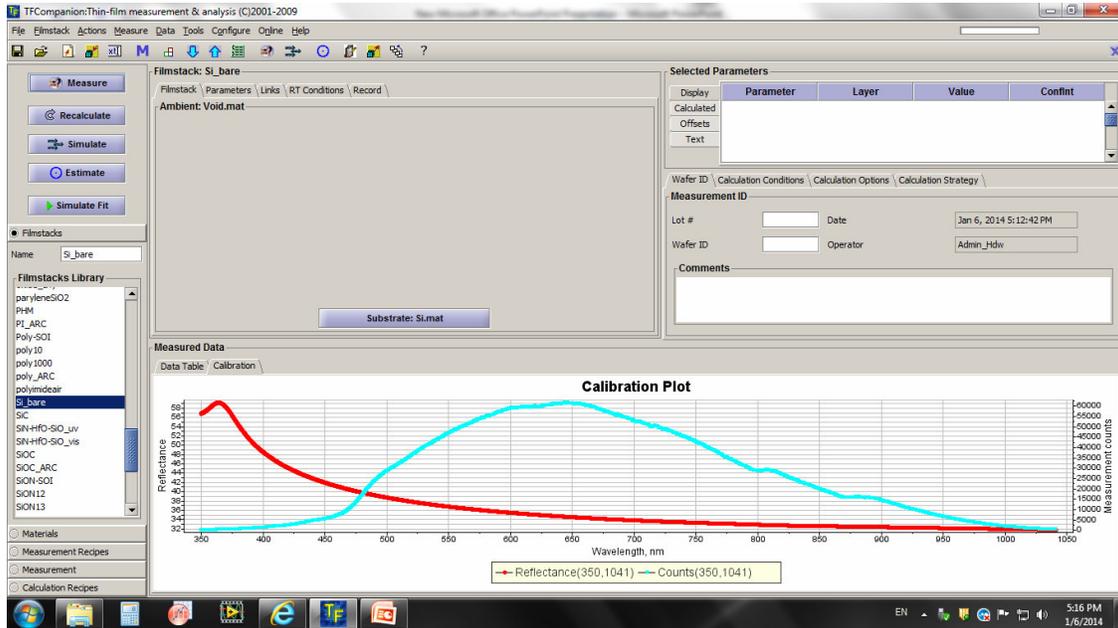
Regular amount of ambient room light is OK, but performing all the measurements in the dark or with dimmed ambient lights is preferred.

After this step, turn the light source back **ON**.



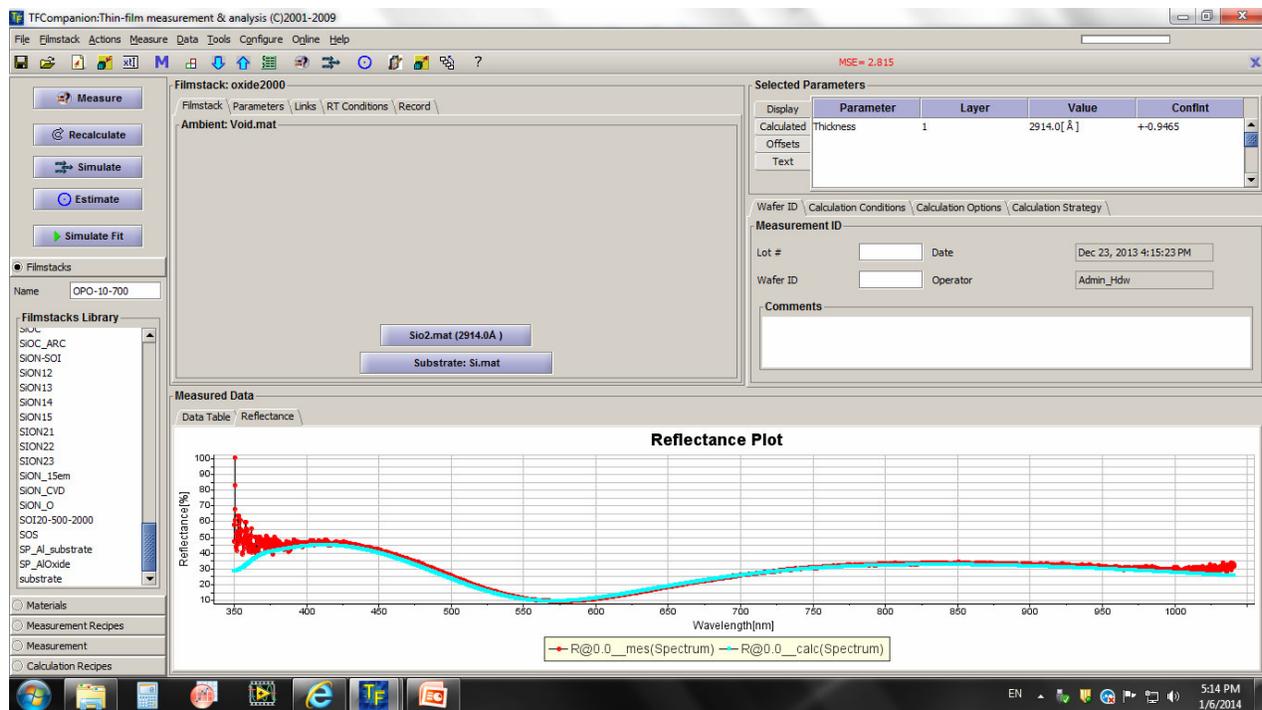
13. You should now see the data similar to that shown below. The cyan curve is the spectrum of the light detected by the spectrometer, and the red one is the reflectance spectrum of the silicon wafer. By comparing these two curves the program calculates the actual spectrum of light illuminating your

sample. It will use it as a spectrum of incident light in determining the thickness of the desired sample in your next step. If you get a plot identical to that shown below with the bare reference Si wafer, you are ready to measure other samples.



## Example of a thin-film thickness measurement

Next, we will measure the thickness of  $\text{SiO}_2$  on another Si wafer, as an example. After the calibration is done (see above), place a piece of wafer with  $\sim 300$  nm of  $\text{SiO}_2$  on the sample stage without changing the probe position. Select  $\text{SiO}_2$  from the Filmstack Library. Press **MEASURE**. The program does the measurement and fits the data using film thickness as a fitting parameter. If the fit looks as good as the one below, your measurement is satisfactory. The measured thickness of  $\text{SiO}_2$  in the case below is 291.4 nm, which is within the typical variations of the oxide thickness on commercial  $\text{SiO}_2/\text{Si}$  wafers.



For instructions on constructing multiple-layered filmstacks, refer to the **"QUICK START-UP GUIDE.pdf"**.

For a very detailed overview of the TFC Companion Thin Films Analysis Software, please see **TFC\_UserGuide.pdf**