Standard Operating Procedure: Spectral Reflectometer

FILMETRICS F20-UVX Thin-Film Analyzer

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1. Lab Safety Information

- ✓ All GMU NFF users are required to complete the Lab Safety Orientation (LSO) before performing any lab work.
- ✓ Proper Personal Protective Equipment (PPE) should always be worn before entering the clean room: safety glasses, hair net, shoe covers, gloves, and lab coat. Additional PPE is available for specialized chemical work as needed.
- ✓ No shorts, sandals, tank tops, or spaghetti-strap shirts are allowed in the clean room!
- ✓ Material Safety Data Sheets (MSDS) are available in a binder in the gowning room.
- ✓ Read the SDS for any chemicals you plan to use before proceeding with your work. Any materials used in the clean room for the first time should be brought in after the approval of NFF staff.
- ✓ A safety buddy is required in the clean room with you when doing chemical work. The safety buddy should be fully trained and qualified to work with the chemical you are using. They must remain in the clean room the entire time you are handling the chemical. Feel free to ask NFF staff if no one qualified is available!
- ✓ Prohibited clean room items: cardboard, pencils, cloth, hats/coats, and contact lenses.
- ✓ Accepted clean room items: plastic, pens, synthetic fabrics, clean room paper.

2. Spectral Reflectometer Safety Information

- ✓ Any irregular system behavior should be reported to NFF staff promptly. Never attempt to fix the system yourself! We are here to help.
- ✓ The reference samples should be handled carefully.
- ✓ Fluids should not be spilled onto the sample stage.
- ✓ Optical fibers can be harmed if they are bent or twisted. Avoid handling them unless absolutely necessary.
- ✓ Failure to use the system safely and properly may result in your access to the system being reviewed and/or revoked.
- ✓ Fill out the logbook before you begin.

3. Principles of Spectral Reflectometer

The Filmetrics system illuminates light on a sample using a light source at a specific wavelength within an effective measurement range. This light is transmitted through a fiber optic cable from the output port of the light source. The light reflected from the sample is collected and sent back to the Filmetrics unit through another fiber optic cable, entering the spectrometer's input port. The reflectivity spectrum of the sample is then compared to an internal mathematical model of the sample's reflectivity. A curve is calculated and adjusted to match the measured data, and the thickness of the sample according to this model is then reported. F20-UVX model has the thickness measurement range of 1 nm to 250 µm with a wavelength range of 190-1700 nm.

The reflection of light off a thin film is influenced by the film's properties, including its thickness, optical constants, and surface roughness. The F20 device determines these characteristics by first accurately measuring the light reflected from the thin film across various wavelengths (i.e., by analyzing the reflectance spectrum), and then comparing this data to a set of calculated reflectance spectra. The FILMeasure software that operates the F20 is primarily divided into two functions: reflectance acquisition and reflectance analysis. The fundamental steps for using the F20 include selecting and editing the film structure, conducting a baseline measurement, and then performing and interpreting the measurement. Detailed explanations of these steps, as well as other FILMeasure functions, are provided below.

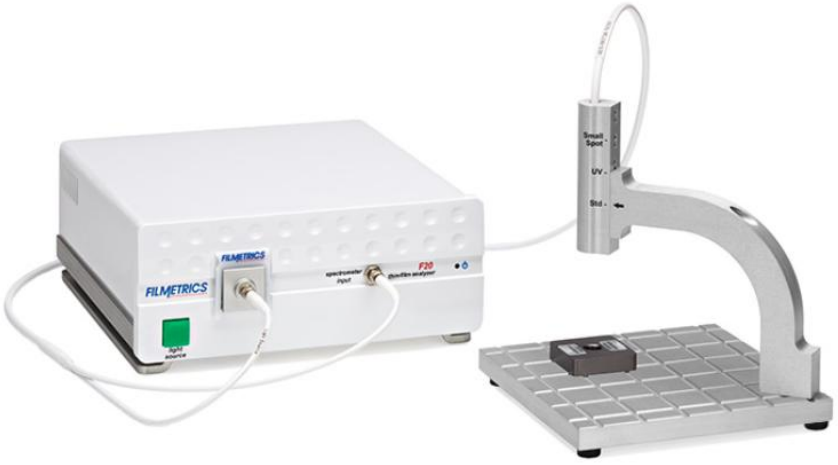

Figure 1. Filmetrics F20 Setup

4. Operation Manual

4.1. Starting with the F20-UVX Setup

1. Turn on the F20-UVX by pressing the buttons for the light source, deuterium lamp, shutter, and halogen lamp, as shown in Figure 2. (For photolithography purposes, it is recommended to keep the deuterium lamp off.) Before starting any experiment, ensure the light bulb has been on for 5 minutes.

Figure 2. F20-UVX Setup in the Nanofabrication Facility

2. Open the Filmetrics “FILMeasure” software. The software start page is shown in Figure 3, with two tabs at the top: "Measure" and "History."

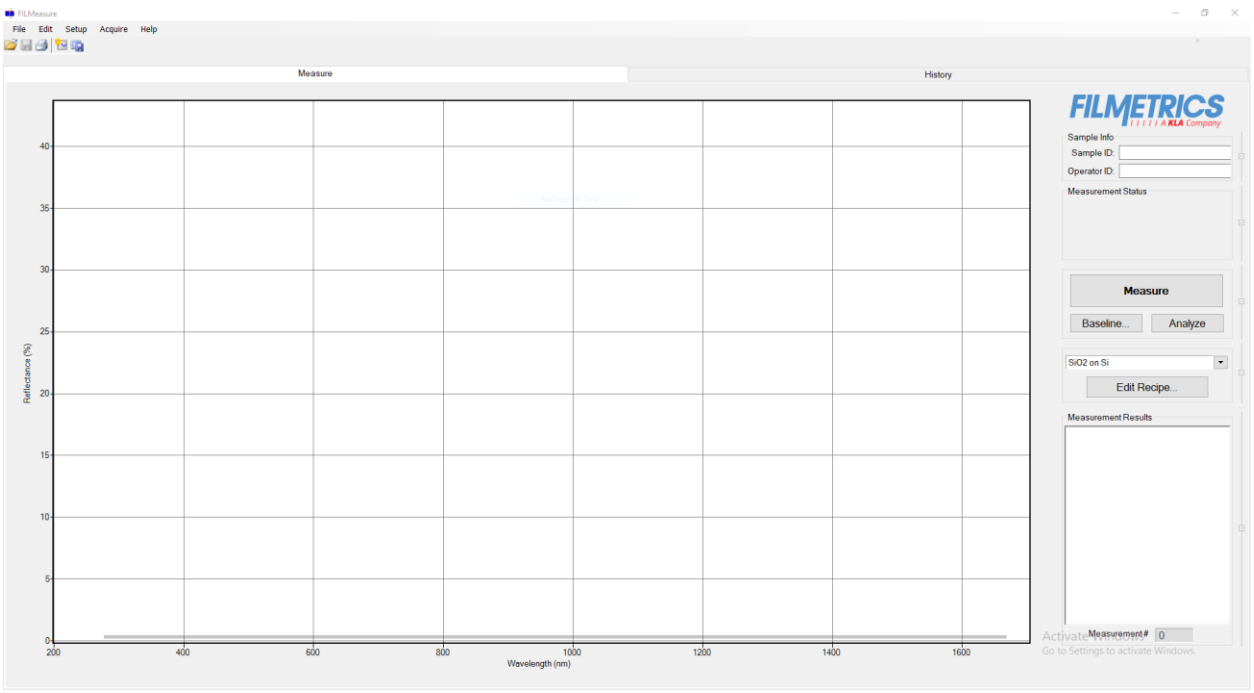

Figure 3. "Measure" Tab of FILMeasure Software

3. Click the "History" tab. If there is any data from the previous experiment, click "Delete All."

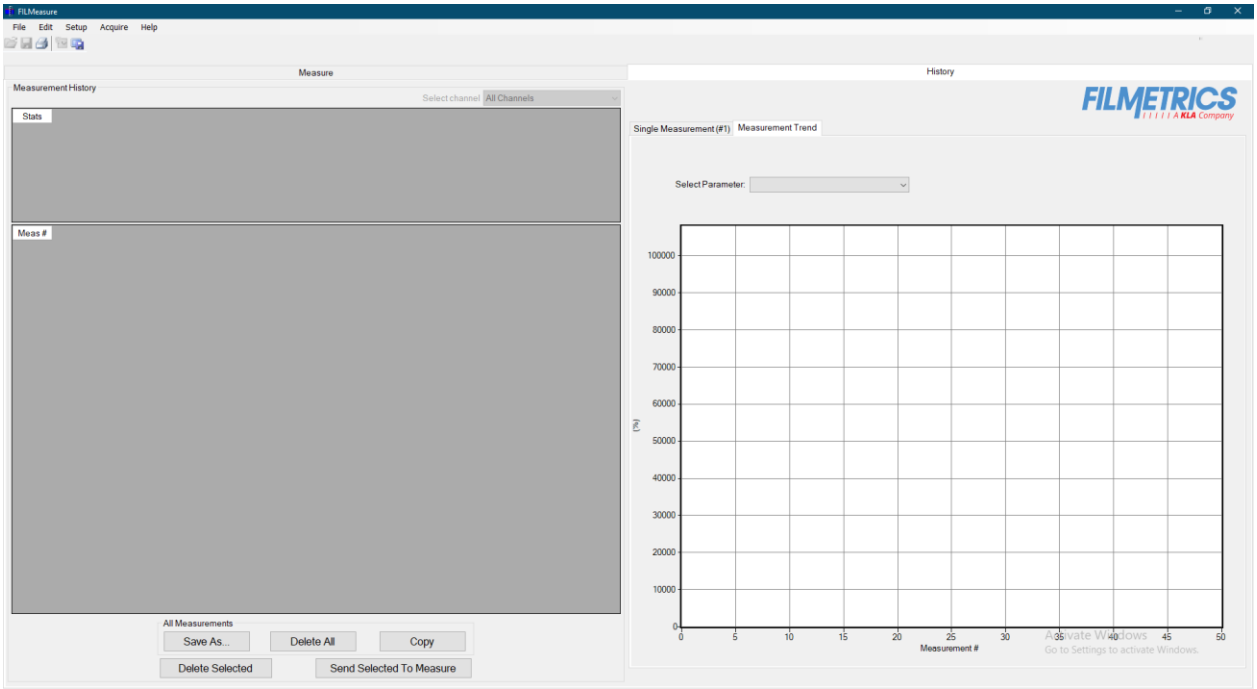

Figure 4. "History" Tab of FILMeasure Software

4. Click the “Measure” tab. If there is any previous data, click the “Clear Graph” icon (the 4th one on top) as shown in Figure 5.

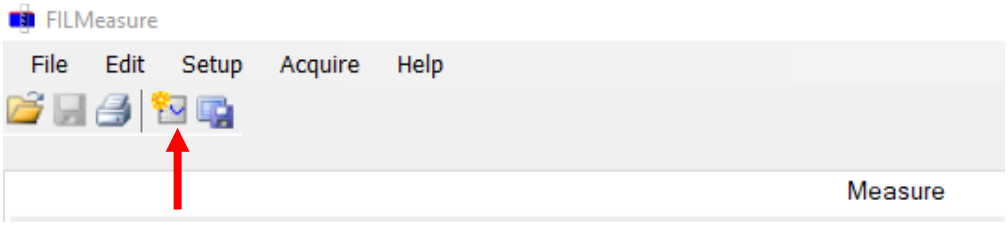

Figure 5. “Clear Graph” Icon of FILMeasure Software

4.2. Baseline Calibration

4.2.1. Take Sample Reflectance

5. The sample stage is shown in Figure 6. Place a bare Si wafer under the F20-UVX fiber optic detector on the sample stage.

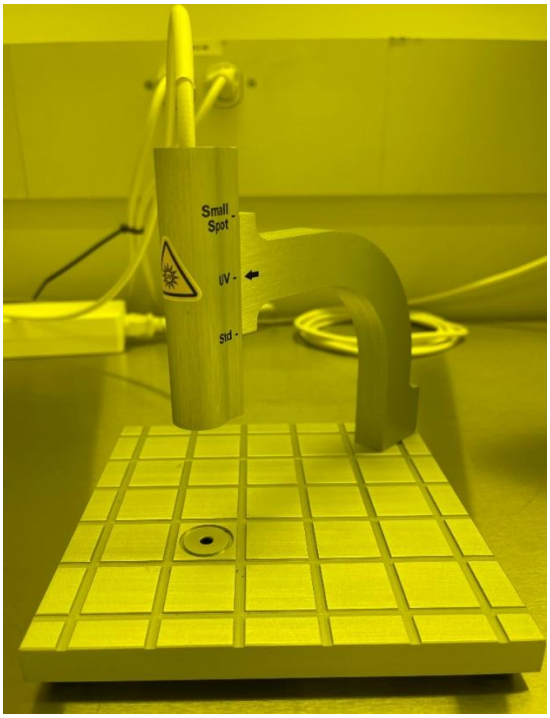

Figure 6. F20-UVX Fiber Optic Detector and the Empty Sample stage

6. In the FILMeasure software, click “Baseline” as shown in Figure 7.

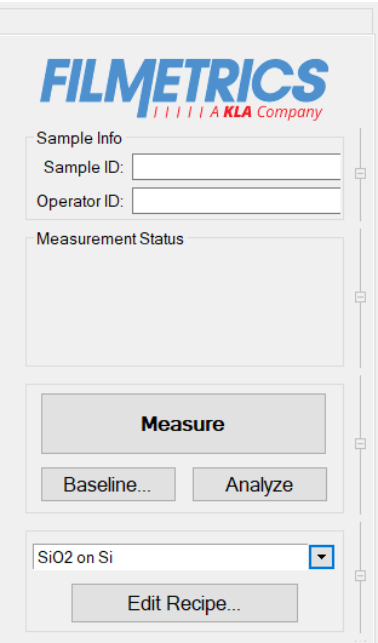

Figure 7. Operation Tab of FILMeasure Software

7. Click “Take Sample Reflectance” as shown in Figure 8 to measure the clean Si wafer. Then, click “Next.”

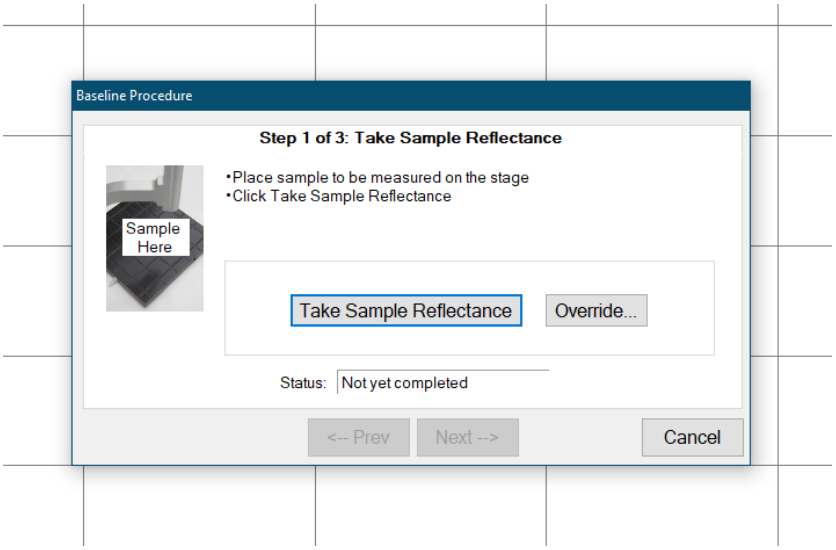

Figure 8. Step 1 of Baseline Calibration: Take Sample Reflectance

8. Remove the Si wafer.

4.2.2. Take Reflectance Standard

9. For the reflectance standard measurement, take the Si reference sample from the reference samples box shown in Figure 9 (left) and place it on the sample stage under the fiber optic beam, as shown in Figure 9 (right). The reference samples box is located in the drawer.

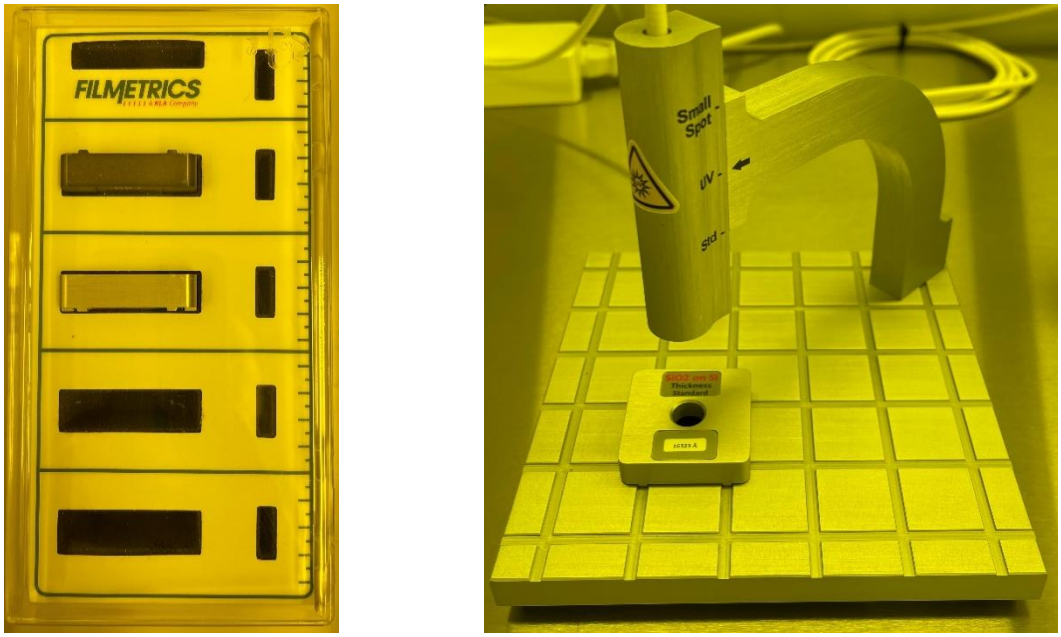

Figure 9. Reference Samples Box (left) and Sample Stage with the Reference Sample (right)

10. From the drop-down menu, select "Si" for the reflectance standard as shown in Figure 10. Click “Take Reflectance Standard” to measure the Si reference sample, then click “Next.”

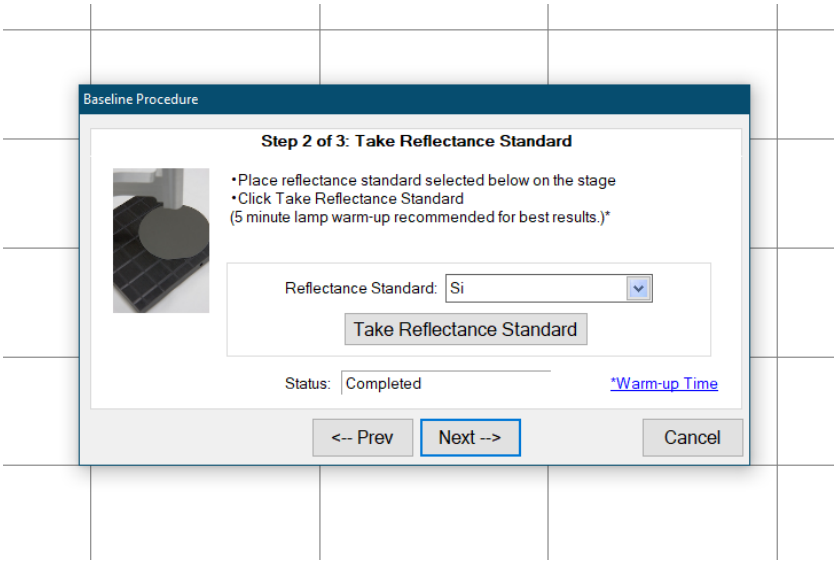

Figure 10. Step 2 of Baseline Calibration: Take Reflectance Standard

11. Remove the Si reference sample. Please ensure the Si reference sample is returned to the reference samples box once you finish the baseline calibration.

4.2.3. Take Background

12. Leave the sample stage empty, click “Take Background,” and then click “Next.”

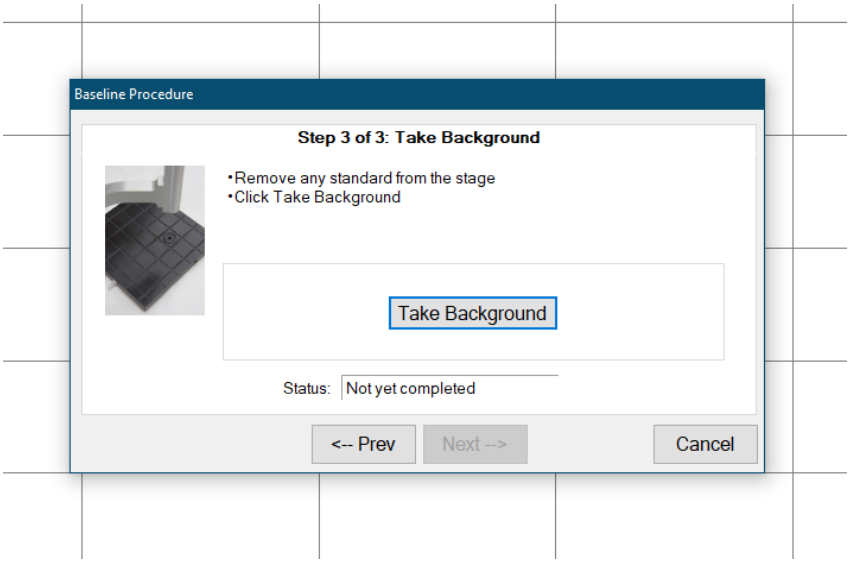

Figure 11. Step 3 of Baseline Calibration: Take Background

4.3. Reference Sample Measurement

13. Take the SiO2 reference sample from the reference samples box shown in Figure 9 (left) and place it on the sample stage under the fiber optic beam, as shown in Figure 9 (right).
14. From the drop-down menu under the “Measure” > “Recipe Selection” tab, select the recipe “SiO2 on Si” as shown in Figure 12.

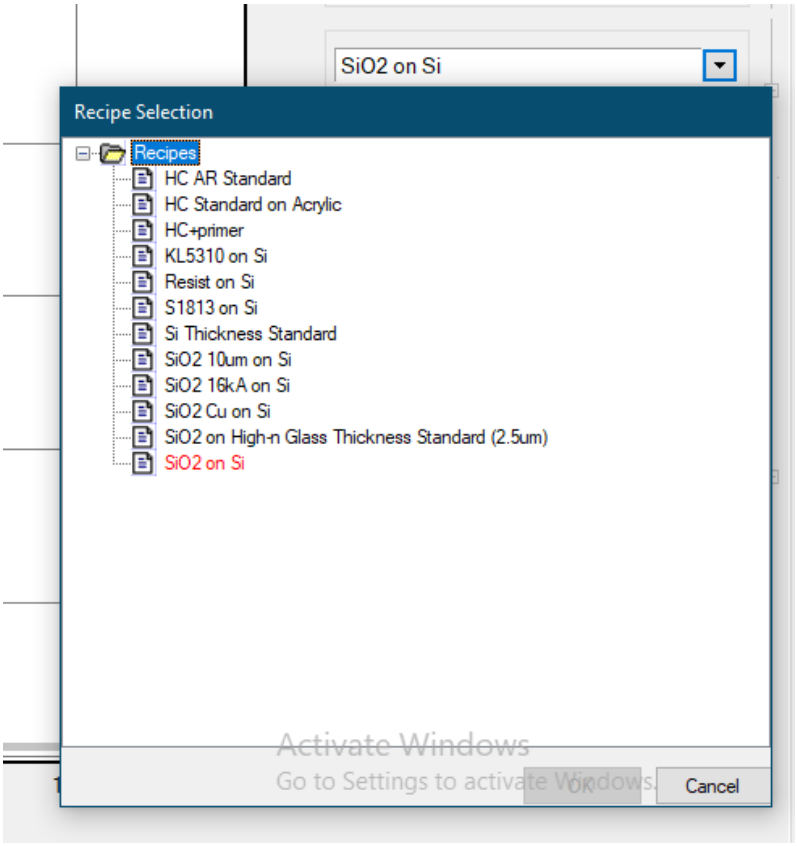

Figure 12. Recipe Selection Drop-Down Menu of FILMeasure Software

15. Click “Measure.”
16. After the measurement is complete, check the thickness value and goodness of fit under the measurement results shown in Figure 13. For the SiO2 reference sample, make sure the thickness is approximately 1632.3 nm.
17. Remove the SiO2 reference sample. Please ensure the Si reference sample is returned to the reference samples box after finishing the baseline calibration. Return the reference samples box to the drawer.

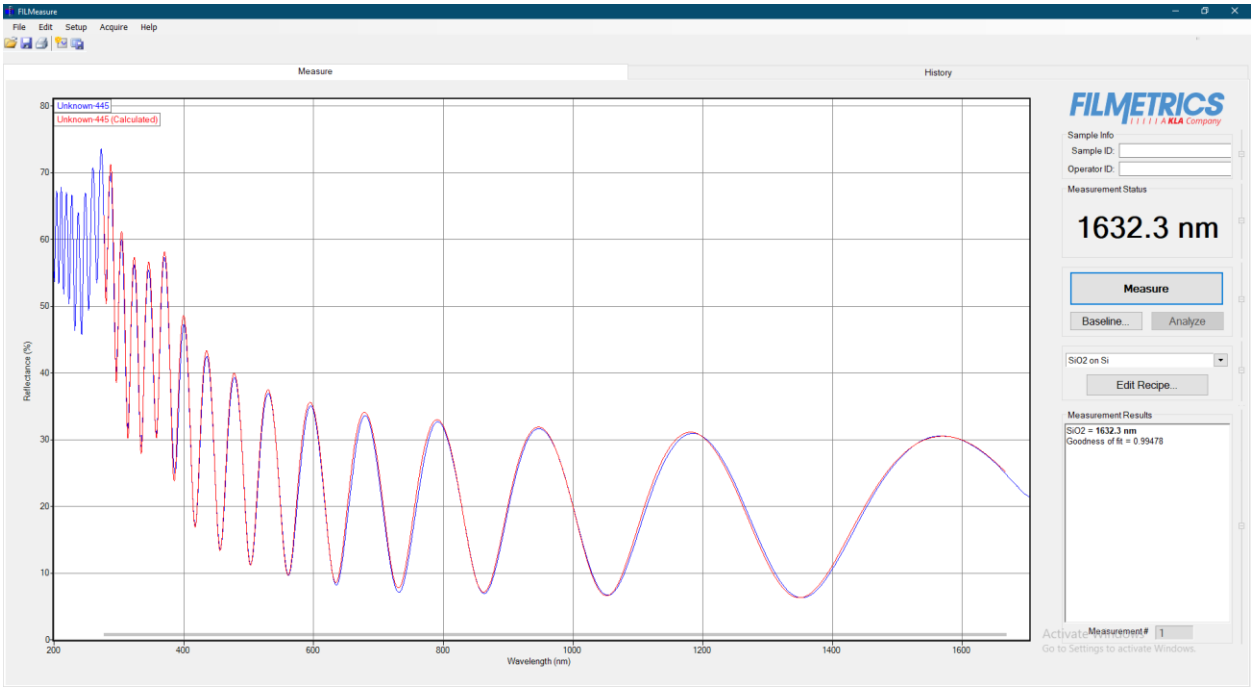

Figure 13. Measurement View of FILMeasure Software

4.4. Sample Measurement

18. Repeat steps 3 and 4.
19. Place your sample on the sample stage under the fiber optic beam.
20. Select the appropriate recipe for your sample from the “Recipe Selection” drop-down tab. If there is no recipe for your sample, please seek assistance from NFF staff to create a new recipe.
21. Click “Measure.” It is recommended to take multiple measurements from different points on the same sample to assess uniformity.
22. Remove your sample.

4.5. Analysis

23. Click the “History” tab.
24. Measurement statistics, including Mean, Median, Std. Dev., Min, Max, and Range, can be seen in the left column. For example, Figure 14 shows these values for five different measurements. The graph on the right displays Thickness (nm) vs. Measurement number for the example measurement.
25. After completing the analysis, click “Delete All.”

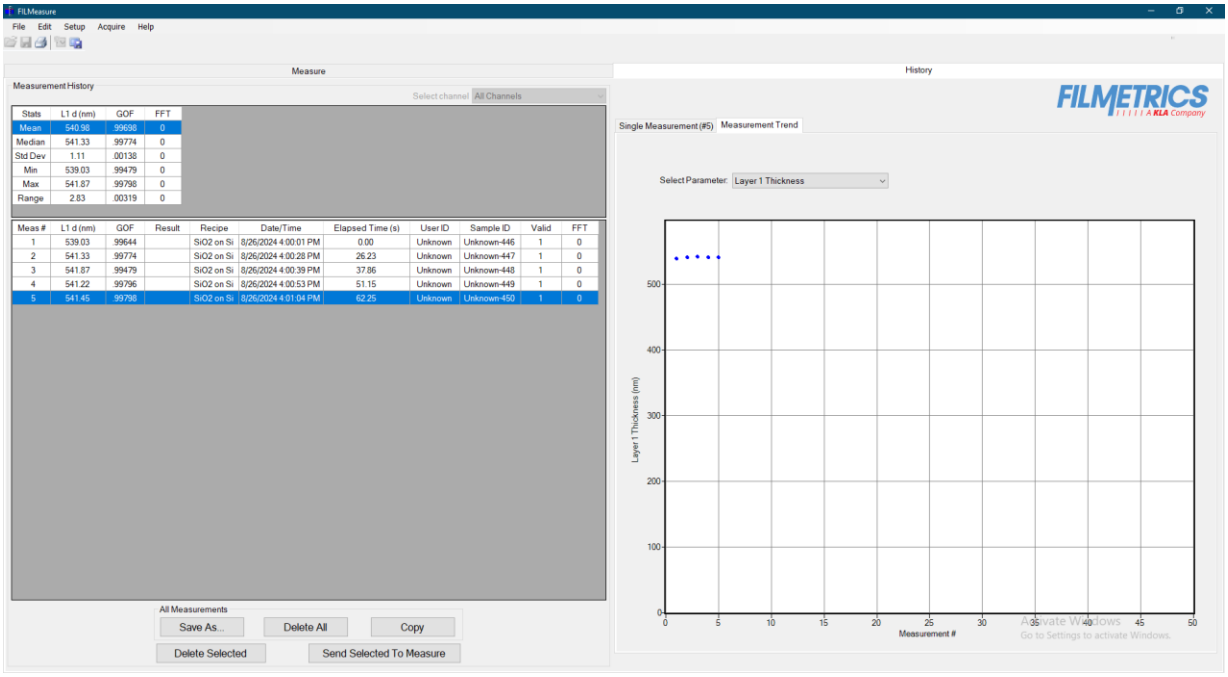

Figure 14. Measurement History View of FILMeasure Software

26. Turn off the F20-UVX by pressing the buttons for the light source, deuterium lamp, shutter, and halogen lamp as shown in Figure 2.