GENERAL PROCESS AND OPERATION SPECIFICATION

Ocean Optics Metrology System

I. SCOPE

1. The purpose of this document is to describe requirements and basic operating instructions for the Ocean Optics NanoCalc. This tool is used to determine the thickness and refractive index of various thin films using spectroscopic reflectometry.

II. SAFETY

1. Be sure that you are trained and signed off to use this equipment.
2. If you are unsure about any procedure or indication while operating this equipment, contact a staff member or trainer for assistance.

III. APPLICABLE DOCUMENTS, MATERIALS AND REQUIREMENTS

1. Troubleshooting is in "Appendix A".
2. Tips and tricks are in "Appendix B".
3. Materials in Nanocalc database are listed in "Appendix C".
4. For more detailed operation, the manual is available. A (Ask AggieFab staff for a copy)

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IV. OPERATION

Setup, Calibration, and Testing:

1. Turn on the tool:
    a. Turn on the "DEUTERIUM" and "HALOGEN" lights.
    b. Flip the silver switch to "ON."
        i. Make sure there is light coming from the light sensor.
        ii. Note:The longer the tool is on, the more accurate it will be.
    c. Turn on the Ocean Optics Laptop and use the password "AGGIEFAB" when prompted. (Password is case sensitive)
    d. Open the NanoCalc software.
        i. Always use a fresh software session! This ensures the correct settings are used for test measurements using the step wafer. Using old settings from the previous user will likely cause your test measurements to fail.
2. Make a few test measurements:
    a. Place the bare silicon strip (#6) of the step wafer underneath the light sensor.
    b. Click "Reference" in the top left.
    c. Click "Measure" in the top left.
    d. Click "Analyze" in the top right.
        i. The measured thickness will show in the top right next to the "Analyze" button. It should show between 0-2 nm.
        ii. The bar above the graph should be green. If it is red or yellow, make a new reference, re-measure, and analyze.
        iii. The tool may also have to warm up bit before the data gets accurate.

e. Repeat this test measurement using the 100 nm oxide strip (#5) of the step wafer. It should measure between 100-102 nm

Measure Samples:

3. Edit the Layer structure:
    a. Click “Edit Structure” in the bottom right next to the sample model image.
    b. Go to the “Oxides” Catalog and click “SiO2_(therm)”.
        i. Thermal oxide (minibrutes): “Oxides” > “SiO2_(therm)”.
        ii. Tystar LPCVD Oxide, Oxford PECVD Oxide: “Others” > “Cauchy_SiO2”
        iii. Tystar LPCVD Nitride, Oxford PECVD Nitride: “Others” > “Cauchy_Si3N4”
        iv. See “Appendix c” for more available materials.
    c. Confirm that your sample falls within the displayed estimated range.
        i. Change only if needed.
        ii. The “Estimated value” doesn’t matter much. “Wide” seems to work just as well as the other settings.
    d. Click “OK”
        i. The figure at the bottom right will update to show the changes.
4. Measure Samples:
    a. Place your sample underneath the light sensor.
    b. Press “Measure” in the top left.
    c. Press “Analyze” in the top right.
        i. The measured thickness will display in the top right next to the “Analyze” button.
    d. (Optional) “Appendix A” will help with troubleshooting and “Appendix B” has a few tips and tricks that will help with special measurements.
5. Turn off the tool:
    a. Close the software.
    b. Turn off the “Deu” and “Halogen” lights.
    c. Flip the switch to “Off”.
    d. Press the power button on the Ocean Optics laptop to log off and shut down.

V. SIGNATURES AND REVISION HISTORY

Revision History:

Revision	**Author**	**Date**	
Original Issue	E. Richards	7/16/2014	
Rev A	Mitchell Roselius	2/12/2020	
Rev B	Elijah Colter	1/20/2022	Ease of reading improvements, Added tips and tricks to a new "Appendix A".
Rev C	Elijah Colter	5/4/2022	Moved some operation steps to a new Appendix B.

Approvals:

Technical Manager Signature: ____Sandra G Malhotra_____

Date: _____5/4/22_____

Appendix A: Measurement Troubleshooting

Troubleshooting:

1. Change the estimated thickness and range
    a. Look at the thickness settings and make sure your sample falls within the estimated range displayed.
    b. Make a new measurement and see if it worked.
2. Make a detailed reference measurement:
    a. Place a blank sample underneath the light sensor. The bare silicon strip (#6) of the calibration step wafer will work.
    b. Turn continuous on by clicking on the black box in the upper left next to “Continuous: OFF”
        i. The tool will now show what it is reading in real time. This will help with calibrating.
    c. Click “Reference”
    d. Change the “Integration Time.” until the highest point on the line is about two lines away from the top of the graph.
    e. Press the continuous button again to turn continuous off.
        i. This will open the “Save to recipes?” window. Select the “Do not save” bubble then and press “Save/Quit”
    f. Make a new measurement and see if it worked.
3. Change the graph measurement bounds:
    a. Purpose: Sometimes the high/low frequencies of a measurement act weird and will throw off the accuracy of the tool.
    b. Right click on the chart area and click “Return to full xy-size”
    c. Click and drag a box over a better fitting area of the data (likely the center)
    d. Make a new “Reference”.
    e. Perform a new measurement and see if it worked.

Appendix B: Tips and Tricks

1. Reading the Accuracy Bar and Fitness value:
    a. After analyzing a measurement, the center window will display the measured frequency-reflectance curve (red) and the theoretical frequency-reflectance curve (black). A well fit measurement should have these two lines mostly overlapping.
    b. The color of the accuracy bar and the fitness value (bottom right) help show how well the frequency-reflectance curves fit.
        i. Green = good (fitness < 0.1)
        ii. Yellow = slightly off (fitness between 0.1 and 1)
        iii. Red = very off (fitness >1)
    c. **NOTE:** Thicker measurements may result in a yellow or red reading. This is acceptable if the extrema of both lines happen at the same frequencies.
2. Changing Fit Quality:
    a. Place your sample under the light sensor and click “measure”. The “Set fit quality” bar will pop up near the “analyze” button.
        i. The default value is 4 and it usually provides a satisfactory measurement.
3. Manually Fit a curve:
    a. Some materials might not fit well given the default automatic fit. This is especially true if it has odd many curves at the beginning of the graph.
    b. To fix a bad fit you can:
        i. Change the limits of the graph and remeasure. This will allow the software to only focus on the new limits you set. Usually, higher limits work better.
        ii. Use the blue slider to visually find a fit you think is best. (This is better used as an estimate, not an official measurement)

Appendix C: Materials included in Nanocalc Database

Below are the default materials the tool can measure. Custom materials are available in the “Other” Category.

Semi-conductors	Si poly 30	**Nitrides**	AZ NOVA 2071	**Resists Olin**	OiR 64	ma-N400
AlGaAs19	Si poly 40	Si3N4	AZ OFPR 800	APII	OiR 643	ma-P1200
AlGaAs31	Si poly 50	SiON 00	AZ111 exp	ARCH2	OiR 644	
AlGaAs41	Si poly 60	SiON 20	AZ111 non exp	ARCH5000	OiR 670	**Metals**
AlGaAs49	Si poly 70	SiON 40	AZ1350H exp	BPRS-100	OiR 672	Ag
AlGaAs59	Si poly 80	SiON 60	AZ1350J exp	HiPR 6512	OiR 897	Al
AlGaAs70	Si poly 90	SiON 80	AZ1350J non exp	HiPR 6514HC	OiR 906	Au
AlGaAs80	**Oxides**	**Glasses**	AZ1518	HiPR 6517	OiR 907	Co
GaAs	Al2O3	BK7	AZ1518 SFD	HPR 200 500	OiR 908	Cr
GaAs 100	CuO		AZ1518HS WI	OCG 825		Cu
GaAs 111	SiO	**Polyimides**	AZ4500	OCG 895	**Resists Shipley**	Mo
Ge	SiO2 (therm)	Hitachi PIQ	AZ6210B	OCG 896-10i	SPR500	Ni
Ge 100	SiO2 (CVD)		AZ7209	OCG NegRes	SPR955	Ni50Cr50
Si	Ta2O3	**Resists Clariant**	AZ7510	OFR 6800	UV5	Ta
Si porous	Ta2O5	AZ6212	AZ7700	OiR 32	UV6	Ti
Si poly 1	TiO2	AQUATAR	BARLI	OiR 5503		W
Si poly 2	TiO2 a	AZ EL 2015	DX46	OiR 620	**Resists Others**	**Others**
Si poly 10	Y2O3			OiR 622	ARU400	Air
Si poly 20	ZrO2					SiC

Table 1: Measurable materials organized by category