Standard Operating Procedure
Sinton WCT-120 Photoconductance Lifetime Tester

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System Components

- **WCT-120 Tool**
  - Flash head assembly
    - IR-Pass optical filter
    - Flash trigger
  - Heated sample stage
- **FPS-300 Power Supply**
- **Control PC**
  - Signal Connector Box
  - Reference (blue) and photoconductance (red) signal cables

Introduction

The Sinton WCT-120 Lifetime Tester is the premier lifetime tester for measuring and characterizing wafers, and it is widely used to monitor material quality, evaluate dopant diffusion, and investigate the quality of passivation layers. The tool utilizes an inductively-coupled RF coil to create a magnetic field for the wafer to sit in. The wafer is then exposed to a flash lamp which excites the carriers within the substrate, causing a measurable change in the conductance. This is known as the **photoconductance decay** method for lifetime analysis.

Precautions and Allowed Samples

Certain materials and samples may not be able to be measured by the WCT-120, and others may interfere with the operation or accuracy of the tool.

- Samples must be less than 200-mm (6-in) and greater than 40-mm (1.57-in) in diameter, with a thickness in a range between 10-µm to 2000-µm.
- Wafers ONLY on the WCT-120 sample stage. No ferrous or metallic contaminants which have the potential to interfere with the tool. Ensure any deposited films will not flake or break off on the stage.
- Avoid touching the WCT-120 filters or sample stage with gloved or bare hands, and avoid scratching the surface when using tweezers. Do not move the sample during measurement or block the light from the flash lamp.
- After power-on, allow the tool to reach a stable internal temperature before use (~30 mins).

1. Power On & Setup

1.1) The WCT-120 will typically be left on and in a ready position for use. If the green light on the front of the WCT-120 is on, and the two green LEDs for the “LO” flash lamp setting are on, then the tool is operational.

Two Green LEDS means PSU is ready.

1.1.1) The red “heater” LED indicates whether the internal heater for the WCT-120 is active or not. When the tool is at a stable internal temperature, this LED will repeatedly cycle on and off.

Heater OFF *Heater ON*

1.1.2) The tool MUST reach a stable internal temperature prior to measurement. Allow for around 30-minutes of warm-up time if the tool is not already on.

1.2) If the tool is NOT on, please ask a VMC staff member for assistance, or follow the procedure listed below:

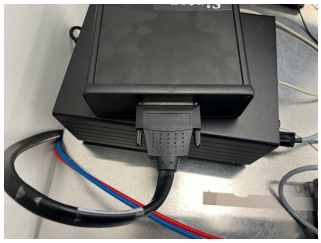
1.2.1) Unplug any cables connected to the FPS-300 power supply, and ensure the power switch on the back is set to OFF. Plug the FPS-300 power supply into mains voltage (100–240 VAC 50/60 Hz). Do NOT turn on the power supply until you are directed to.

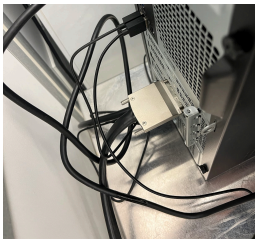
1.2.2) Plug the WCT-120 tool into mains voltage. Connect the photoconductance (red) and reference (blue) data cables into the WCT-120 tool, then connect these cables to the SOLID color-coded ports on the communication box.

1.2.3) Connect the green-and-gray flash signal cable to the solid green port on the connector box. The tool white-circled ports, as these are meant for the Suns Voc stage and are unused in our configuration.

Fully-wired signal connector box.

1.2.4) Plug the PCI cable into both the connector box and the back of the PC. Be careful not to bend or damage any of the pins on either side of the connector, apply only light force.





1.2.5) Connect the trigger cable from the flash lamp assembly to the front port on the power supply. Note that the trigger cable and flash signal cable should be in the same port (top or bottom).

1.2.6) Turn on the FPS-300 power supply using the back power switch.

1.2.7) Turn on the computer and open the **Lifetime software**.

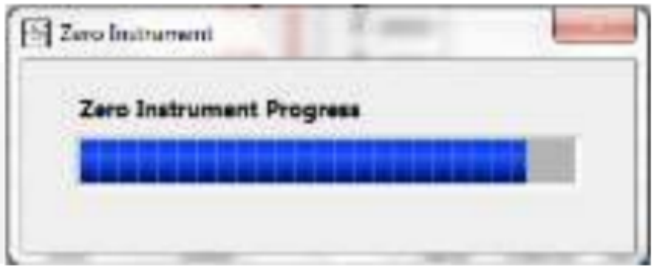
2. Calibration

2.1) Remove any wafers currently on the WCT-120 stage. If necessary, verify that the flash head assembly is 42.5-cm above the sample stage. Ensure the IR filter in the filter tray attached to the flash lamp is installed.

2.2) Select the reference cell aperture that will be used. Please note that if you switch to a different aperture setting or adjust the lamp height, you may need to re-zero the tool. The index of the aperture knob setting will be needed for your measurement, 1 to 3 from largest to smallest. Ensure the aperture cover (index 0) is not selected during your measurement or calibration.

2.3) To zero the tool, press 

. Wait while the data window indicates a process is active, then the tool will be calibrated and ready for use.



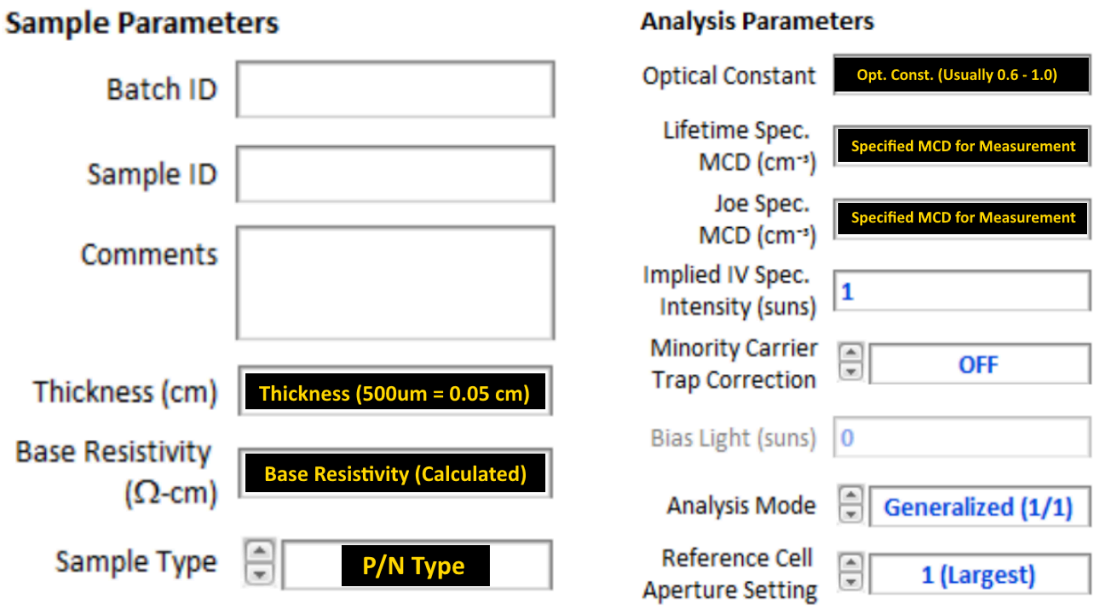
3. Taking a Measurement

3.1) Ensure that the tool has been calibrated and zeroed prior to measurement. Re-zero prior to each measurement *session* or whenever a new measurement template is opened. You do <u>not</u> need to re-zero between every wafer.

3.2) Place your sample on the sample stage, centered over the sensor at the middle of the stage. Ensure the wafer lies flat.

3.3) Enter the **sample** and **analysis parameters** for your sample. For more information on how to determine these parameters, please refer to **Appendix B** of this SOP or the WCT-120 manual.

4.3.1) The Batch, Sample ID, and comment fields are added to the filename and description when you export your results. The analysis mode switches the tool between quasi-steady-state (QSS) and transient (TPCD) analysis mode. Refer to **Appendix C** or manual for more information on which analysis mode to choose for your sample.

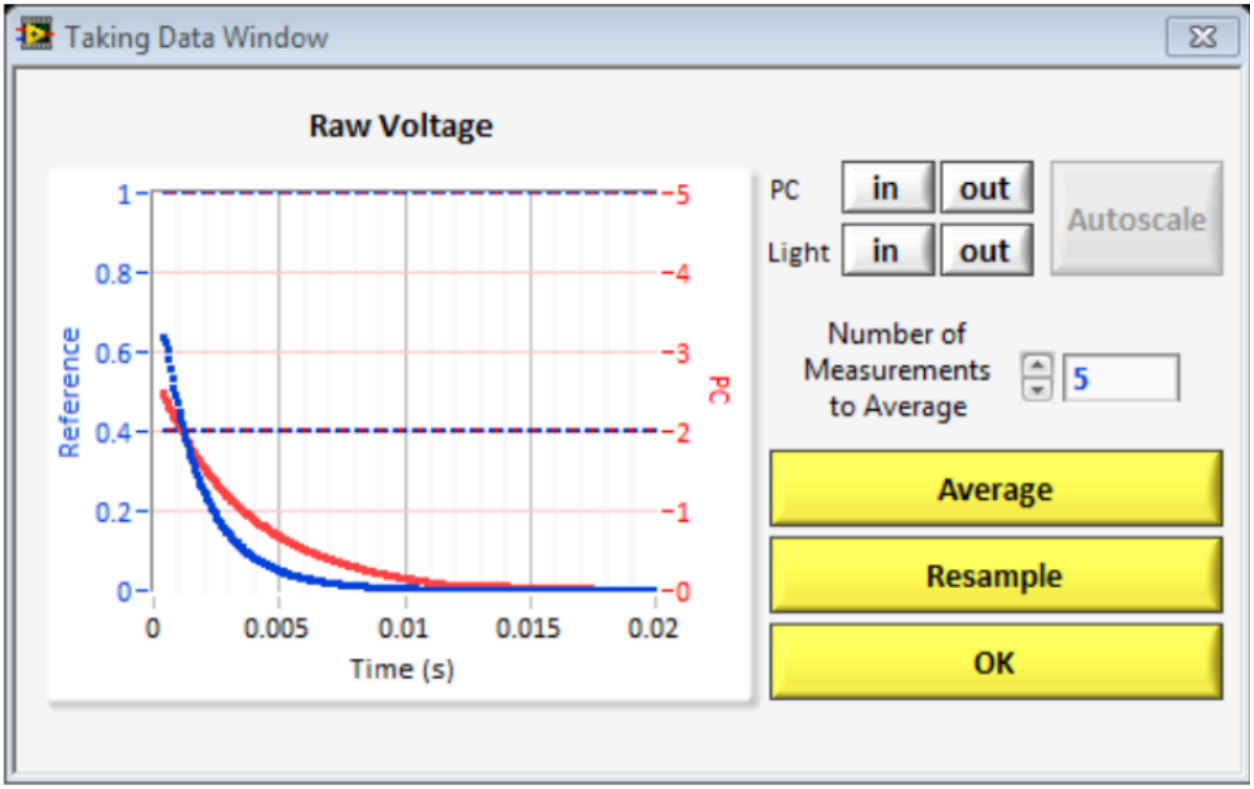


3.4) Press the 

button to conduct the measurement. You should see a visible flash from the flash head, then shortly the data will appear on the computer screen. If there is NO visible flash, or if you run into any other issues during your measurement, please refer to **Appendix A** for troubleshooting for common problems, or speak to a VMC staff member.

3.5) Following this measurement, the "Taking Data Window" will open with the data from your sample. Use the in/out buttons to adjust the red and blue traces until they are visible within the window. Use "average" to smooth out noisy data and "resample" to retake the data.

3.5.1) PLEASE NOTE!!! The WCT-120 will flash the lamp every time ANY of these buttons are pressed. Please allow 3-5 seconds for the lamp to recharge between each click, otherwise you may damage the lamp.

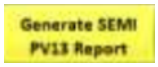


3.6) If your data traces are flat or nothing is shown, there may be an issue with the communication between the WCT-120 and the PC. Refer to **Appendix A** for troubleshooting instructions, or find a VMC staff member if necessary.

4. Reporting of Results

4.1) Results from the Sinton WCT-120 can be exported as a .txt file by selecting 

saving the data in a tab-delimited format which can later be accessed through Excel.

4.2) Alternatively, the results can be exported using the Semi PV13 format by pressing 

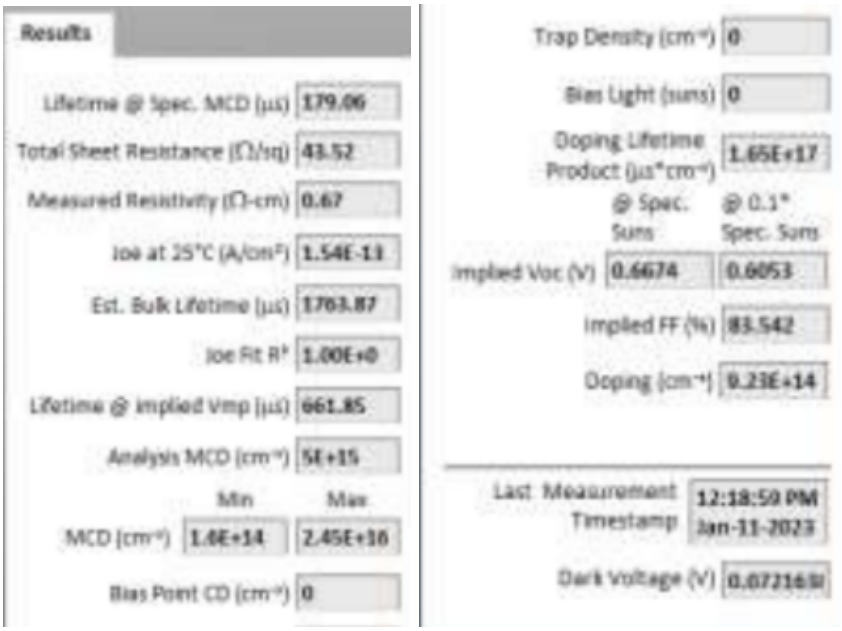
, which will produce an HTML result containing the measurement data, relevant graphs and figures, and more, which can be printed to PDF.

4.3) Finally, The 

button will save the measurement data used by the WCT-120 and can be reloaded into the Lifetime program, producing a .ltr file. Please note that the Save Result button will NOT export your lifetime data, use one of the above methods to export your data for use in an external program. This will ONLY save the information necessary for the Lifetime software to re-interpret your results and will not work with any other programs.

4.3.1) If you want to re-analyze your data or change the analysis parameters used to calculate the lifetime, use 

to open your saved file.



Appendix A. Troubleshooting Quick-Reference

Problem: No flash from lamp when a measurement is conducted
Solution: Press the small red "TEST" button located on the front of the FPS-300 power supply. This should cause a flash in the flash head without any command from the PC.

- If there is no flash, **the lamp is not receiving power**.
- If there is a flash, **the lamp is not receiving a trigger from the PC**

Ensure all cables are plugged in and retry, or move the flash lamp to a different port on the FPS-300 power supply. If issues persist, please contact VMC staff.

Problem: Flash is visible, but data traces are not present after measurement.
Solution: Follow the troubleshooting steps below in order:

- Make sure you are allowing 2-3 seconds between flash pulses. Note that pressing any button on the data acquisition window will immediately trigger another flash and regenerate the data.
- Verify that the reference cell aperture is not covered
- Check the connection between the wires communicating between the computer, signal box, and the PSU. Make sure the signal cables are attached to the solid red and blue terminals, NOT the terminals with a white outline.
- Switch the red and blue signal cables and see if the same result is given.
    - If the data is now available, this means one of the cables is dead. Please contact VMC staff so we can order a replacement.
- Ensure that the IR-pass filter is installed correctly in the filter tray
- Measure the flash head assembly to ensure it is between 40-cm and 45-cm above the measurement stage
- Ensure the 68-pin cable entering the PCI card on the PC is plugged in. Check the 68-pin cable for bent pins

If issues persist, please contact VMC staff.

Problem: Reference (blue) signal is available but no photoconductance trace (red)
Solution: Follow the troubleshooting steps below in order:

- Check that the signal cables are connected properly and in the correct terminals.

- Check that the WCT-120 is on, and that the heater LED indicates the tool is at a stable internal temperature
- Check that the 68-pin cable is connected securely and that no pins are bent.

If issues persist, please contact VMC staff.

Problem: Software errors appear when attempting a measurement
Solution: Follow the directions given in the error message to correct your parameters, measurement setup, or sample placement, and attempt the measurement again.

If issues persist, please contact VMC staff.

VMC Staff Contact

Lab Manager: Dr. Liang-Chieh Ma
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WCT-120 Tool Manager: Ricky Jones
jonesr30@vcu.edu

VMC Crew
ENGR_VMC_CREW@vcu.edu

Appendix B: Determining Analysis Parameters

In order to accurately determine the carrier lifetime in your sample, the Lifetime software requires some information about your sample. These parameters should ideally be calculated *before* you begin your measurement session.

B.1) Optical Constant → A combined quantity representing the absorption or reflectance of your sample. Can be determined through simulation using **PC1D** or other simulation software.

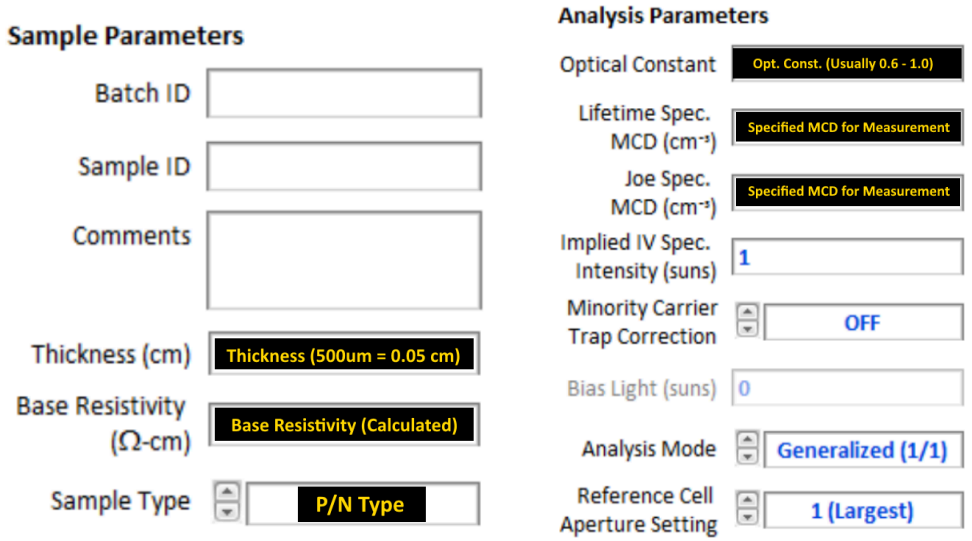
B.1.1) Small inaccuracies in this value will have a relatively small impact on the results produced by the WCT-120.

B.2) Base Resistivity → The bulk resistivity of the substrate, dependent on the substrate material, dopant species, and dopant concentration. Accuracy in this value is highly important for reliable results from the WCT-120

B.3) Wafer Thickness → Expressed in cm, the total thickness of your wafer. For samples where the incoming light is primarily absorbed in the top-most layers of the substrate, this behavior can be approximated by setting the thickness equal to half the diffusion length.

B.4) J_0e/Lifetime Spec. MCD → Specified minority-carrier density value at which the software will report the value for the lifetime and J_0e @ 25^{O}C. Can be set to any value within the MCD range of your sample measured by the WCT-120.

All other required parameters should be known for any given sample.



Appendix C. Measurement and Operating Principles

There are a total of four measurement modes available to the WCT-120, and each can be categorized into one of two measurement techniques:

C.1) Transient (TPCD) Analysis → Sample is exposed to a sudden flash of light, which decays much faster than the average lifetime of the carriers in the substrate. The system will use the decay rate in the minority-carrier density to determine the effective lifetime for your sample. The main advantage of transient analysis is that it does not require a value for the optical constant.

C.1.1) **Generalized (1/64)** → This is a transient technique which can be used for wafers with a relatively high effective lifetime, in a range between 200µs to 800µs.

C.1.1) **Transient** → The "built-in" transient analysis is used for very high lifetime samples, where the average lifetime is >800µs

C.2) Quasi-Steady-State (QSS) Analysis → Sample is exposed to constant illumination, or a flash which decays much slower than the average carrier lifetime. The carriers in the wafer will reach close to a steady-state equilibrium, where the photogeneration is roughly equal to the rate of recombination in your sample. The Lifetime software uses this information to extract the lifetime from the measured increase in conductivity.

C.1.1) **Generalized (1/1)** → This is a QSS technique which can be used for wafers with a very low lifetime, less than 200µs.

C.1.1) **Quasi-Steady-State** → Identical to Generalized (1/1) method.

Figure C1 shows which methods can be used given the average lifetime for your sample. Use QSS for lifetimes ≤100µs, TPCD for ≥200µs, and both should produce roughly the same results between 100 - 200µs.

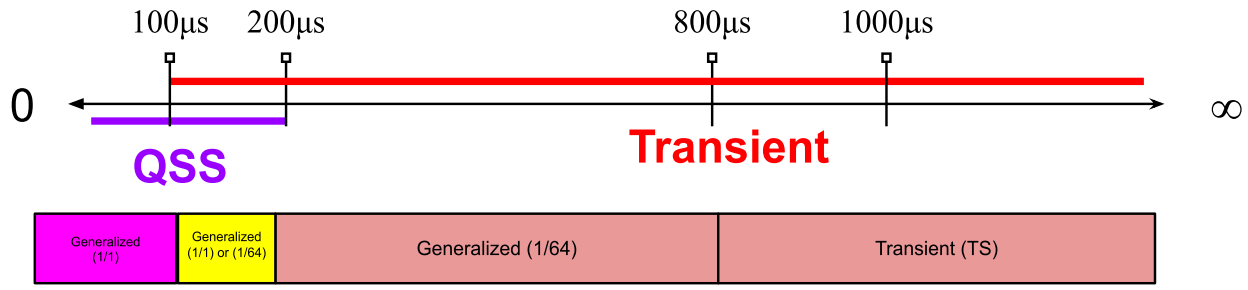


Figure C1

For more information regarding the specific physical phenomena of these methods and their operating principles, please refer to the WCT-120 manual stored in the office and included on the desktop of the WCT-120 control PC.

Appendix D. External Resources

WCT-120 User Manual:
https://drive.google.com/file/d/12jjSQOtoZJc7tZO7veRaXEEEmKpcAEo5/view?usp=sharing

WCT-120 Product Note:
https://www.sintoninstruments.com/wp-content/uploads/WCT-120WCT-120MX-product-note.pdf

WCT-120 Product Listing:
https://www.sintoninstruments.com/products/wct-120/

PC1D Software (For simulating analysis parameters):
https://www.pveducation.org/pvcdrom/welcome-to-pvcdrom/pc1d

Sinton WCT-120: Xenon Flash Lamp w/ IR-pass filter
Wavelength Spectrum (Right Curve, FLP2)