Standard Operating Procedure (SOP)

Corescan

National Centre for Photovoltaic Research and Education (NCPRE)
IIT Bombay
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Contents

1. Introduction

Corescan is a solar cell characterization instrument. In a solar cell, process optimization can be done by visualizing energy losses using Corescan. It reveals energy loss locations in solar cells by detailed surface mapping having four scan methods for four different types of energy loss to perform following tasks:

1. **Core (contact resistance) scan:** Full surface measurement of contact resistance of front side metallisation
2. **Shunt scan:** locates shunts on solar cells and finds out about their nature
3. **Open circuit voltage (Voc) scan:** finds the locations of increased recombination
4. **LBIC (Light Beam Induced Current) scan:** finds the regions on a solar cell with reduced short-circuit current density or lower bulk lifetime

It is a destructive type of characterization technique in which measuring probe scans the solar cell surface. All the essential parameters are measured in terms of potential drop with respect to surface and it gives qualitative idea about the solar cell.

Basic principle of all Corescan operating modes is almost same. It is the **measurement of the potential distribution on front surface of the solar cell**. The only difference between these methods is the **condition** at which the cell is operated.

1.1. System specifications

1. Solar cell dimensions: 5 - 21.5 cm
2. Solar cell shapes: round, semi-square, and rectangular
3. Maximum probe speed: 20 mm/s
4. Special resolution: 0.1 mm
5. Probe dimension: 0.2 mm (diameter)
6. Lamp intensity: 150-300 mW/cm^2
7. Lamp homogeneity: > 95%
8. Voltage range: 0-1000 mV
9. Voltage measurement accuracy: 1 mV
10. Output in 1D, 2D, 3D graphs
11. Output files in ASCII

1.2. System components and images

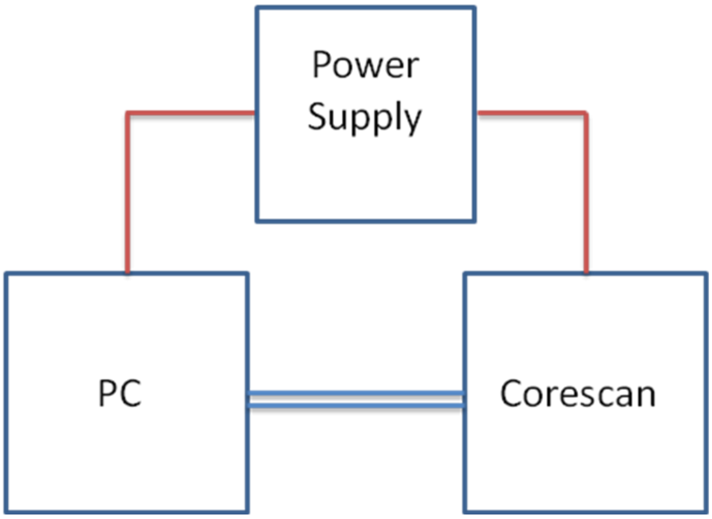

Figure 1: Block diagram of Corescan system

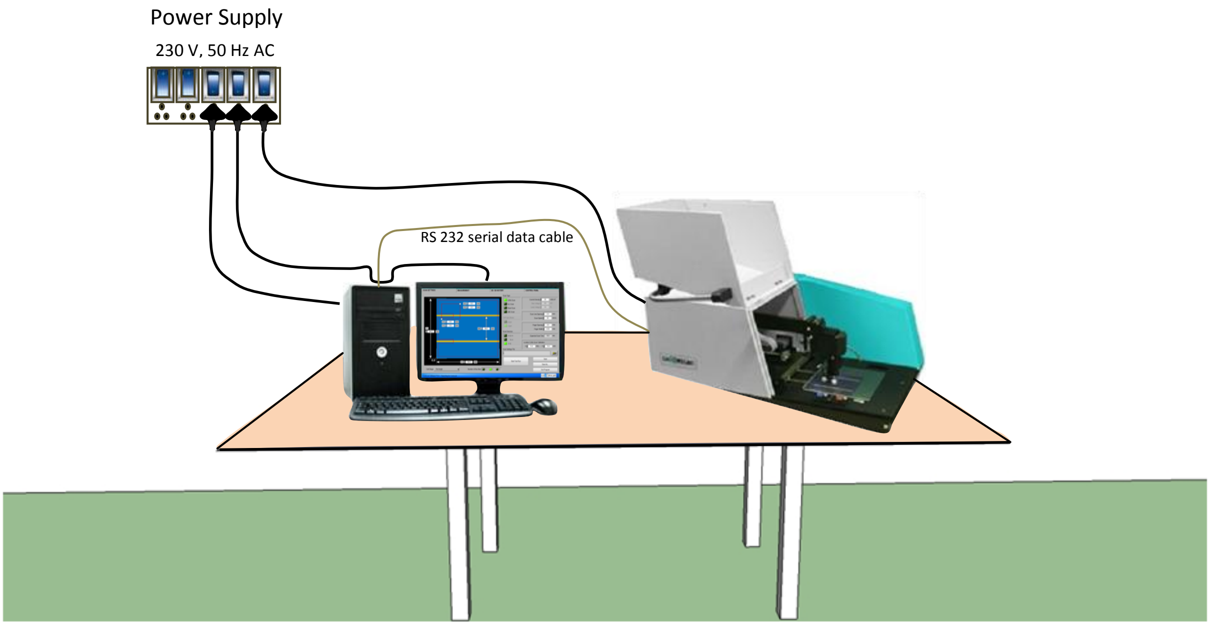

Figure 2: Assembly of Corescan system

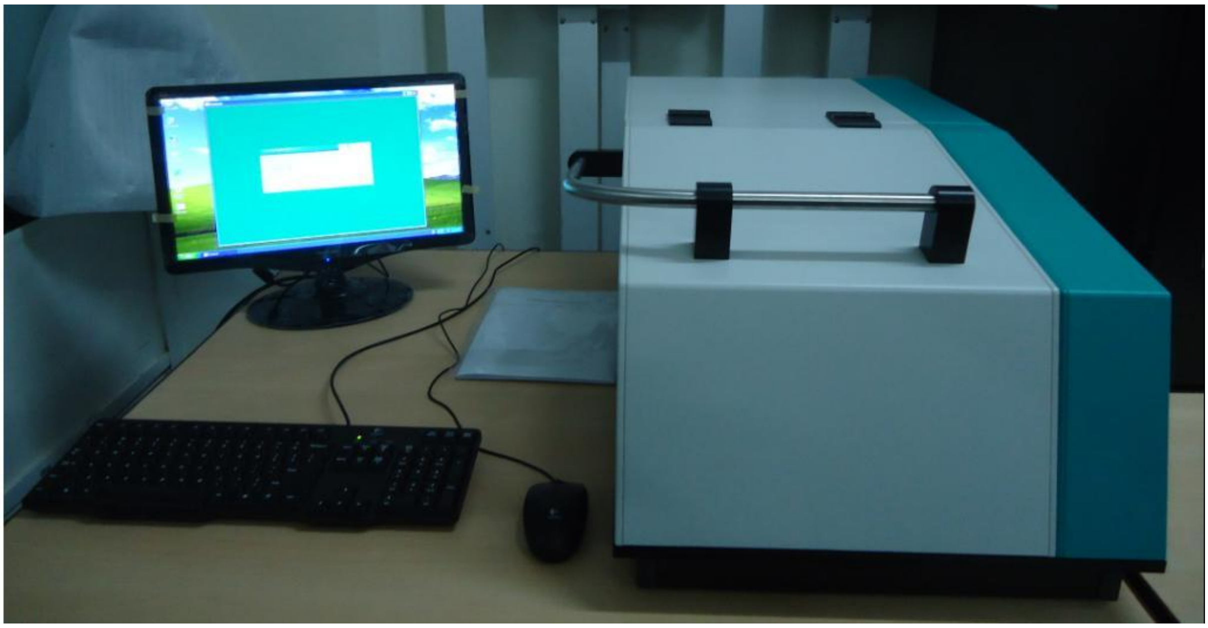

Figure 3: Corescan system with PC interconnected

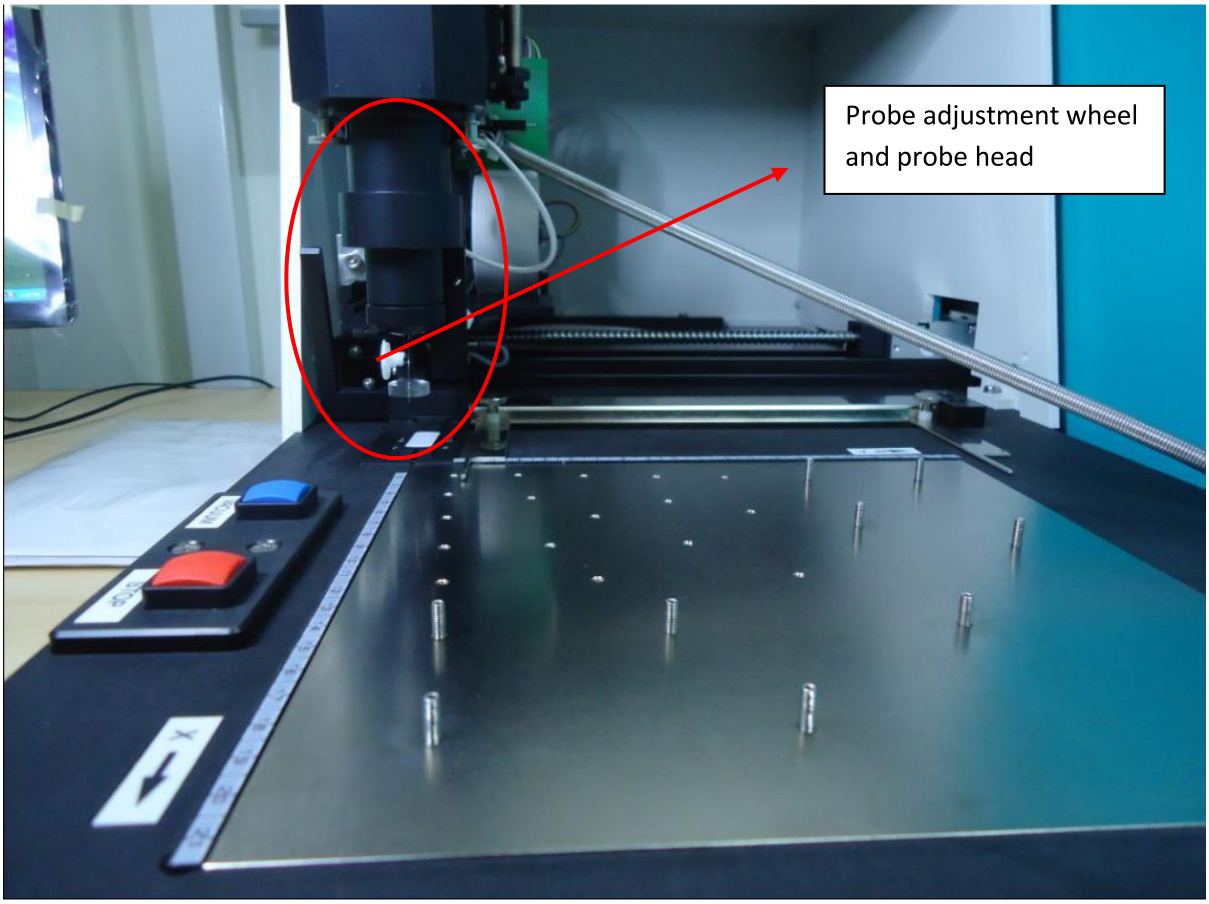

Figure 4: Corescan system Stage

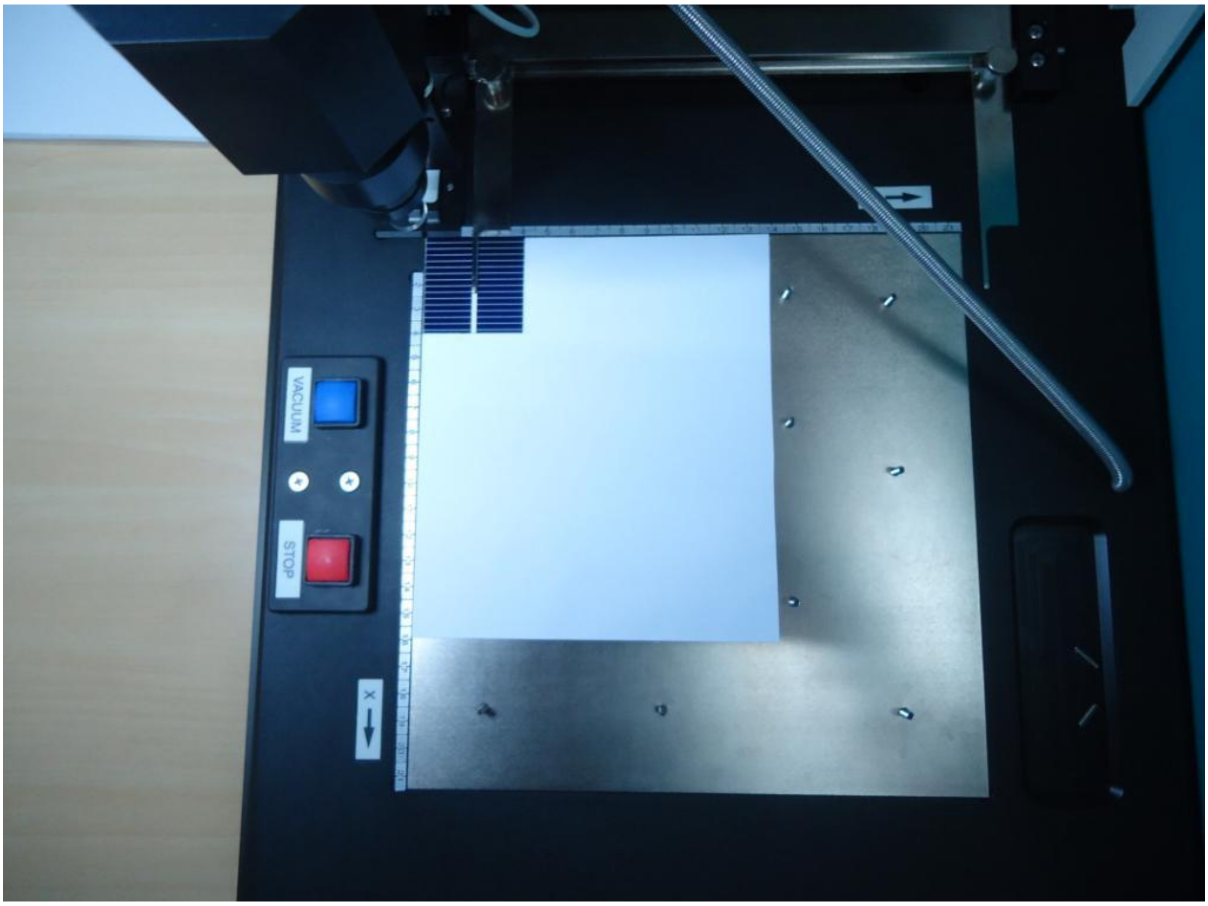

Figure 5: Corescan system stage – Vacuum table and installed solar cell

2. Sequential operating procedure

2.1. Read the user manual (provided by Corescan) carefully.

2.2. Since the system is already installed so no need to reinstall. Only thing is to know the system components and how they are interconnected.

2.3. Check for any notification about system's (up/down) conditions.

2.4. Check whether vacuum table of Corescan is clear and free from any foreign object. If not so report to the concern person.

2.5. Check, whether the electrical/ communication connections between system components are OK.

2.6. Enter the log details in the log book provided with the system.

2.7. Install the solar cell on the vacuum table of the Corescan.

2.8. Switch ON the Corescan first and then the computer system.

2.9. Start the Corescan software and run the application software for solar cell characterization.

2.10. There are two levels of passwords for running the software. One is low level intended for any user and administrative password for system operator to change the system settings. Entering the appropriate password enables the Corescan window to characterize the solar cell in all four modes of operation.

Now all four modes (Corescan mode, Shunt scan mode, Voc scan mode, LBIC scan mode) of Corescan operation are explained:

Core Scan:

Here, the solar cell is locally illuminated and short circuited.

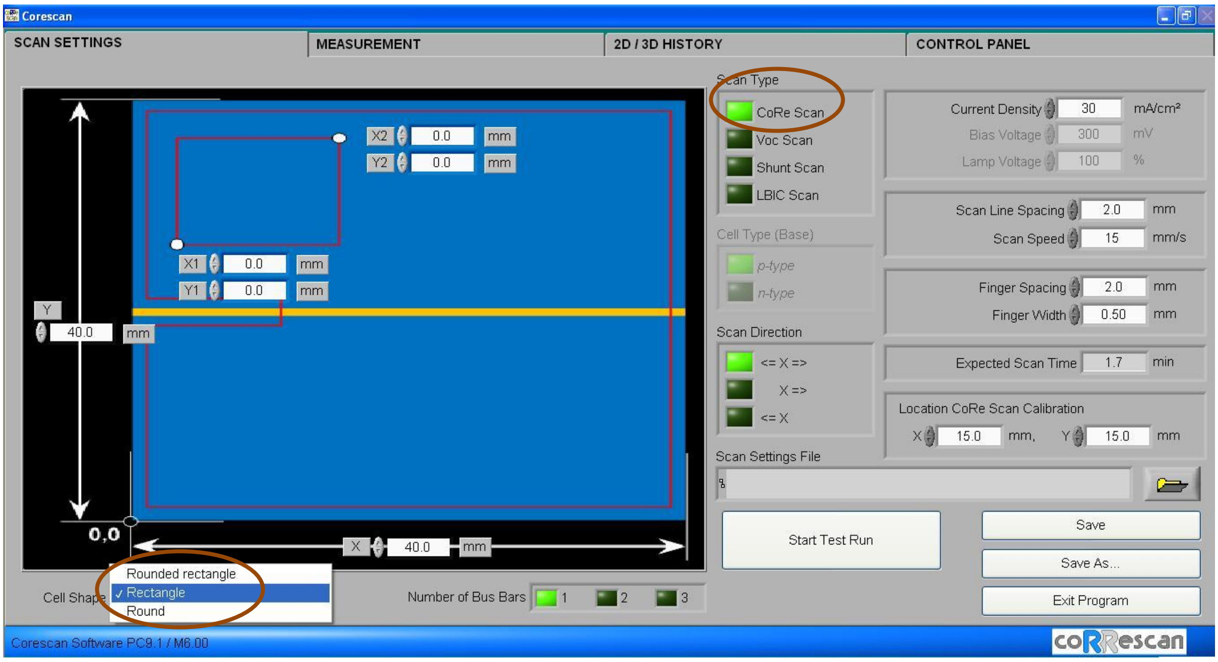

Figure 6: Scan settings window

- In this window, first we have to select the options for solar cell.
- The instrument can scan only three shapes of solar cells which are: rounded rectangle, rectangle and round.
- Once selecting the shape of the cell, we have to give exact dimensions of the solar cell which are shown in arrow boxes from above screen shot.
- Number of bus bars is limited to 3. We have to select the option for bus bars number.
- If we want to select only a particular area at anywhere of solar cell which is to be scanned, it is possible by giving appropriate value to the coordinates X1, Y1 and X2, Y2. These coordinates should not interfere with the contact pin on the bus bar. If we do not want this option, means entire solar cell has to be scanned, enter zero values at the coordinate boxes.

- Once we select core scan option, we have to enter the current density in mA/cm² for the same solar cell.
- Scan line spacing and scan speed is to be selected. The scan speed of the instrument is limited to 20mm/s. The scan line spacing and scan speed are recommended to be 2mm and 20mm/s. As scanning at lower line spacing and scan speed does not add any additional value to the measurement. According to these settings, the system estimates the expected scan time and it will be displayed.
- Finger spacing and finger width are the parameters which are to be entered for the same solar cell.
- In scan direction window there are three options provided and any option can be selected. It is recommended to select two ways (←X→) as it reduces the scan time and wear of the instrument. This is for 90° probe which is installed with the instrument. But for 60° probe, the scan direction must be changed to pull (←X) only.
- Now enter the coordinates of the solar cell for calibrating the Corescan. These coordinates should not interfere with the finger / bus bar and near the edge of solar cell because the instrument calibrates itself for the current density value provided for the solar cell.
- Now we start the test run of Corescan so that it will locate the coordinates entered for which the scanning is to be performed.
- Once we are done with all parameter provided on scan settings window and test run, we can start the measurement by selecting measurement window.

Screen shots of software interface are provided below.

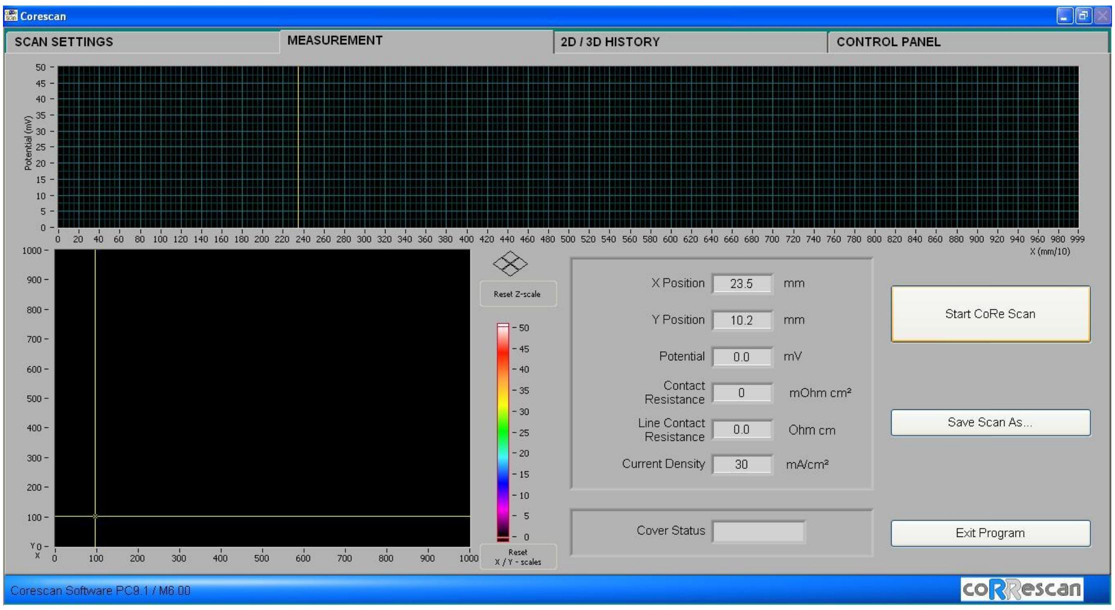

Figure 7: Measurement window

- The measurement window will take all options from scan settings window. Only we have to start the Corescan measurement by clicking on tab START CORE SCAN.
- This will pop up to save the file. After saving the file, it will start the measurement immediately.
- Once the scan is complete, the results can be observed in 2D/3D history window by clicking on it.

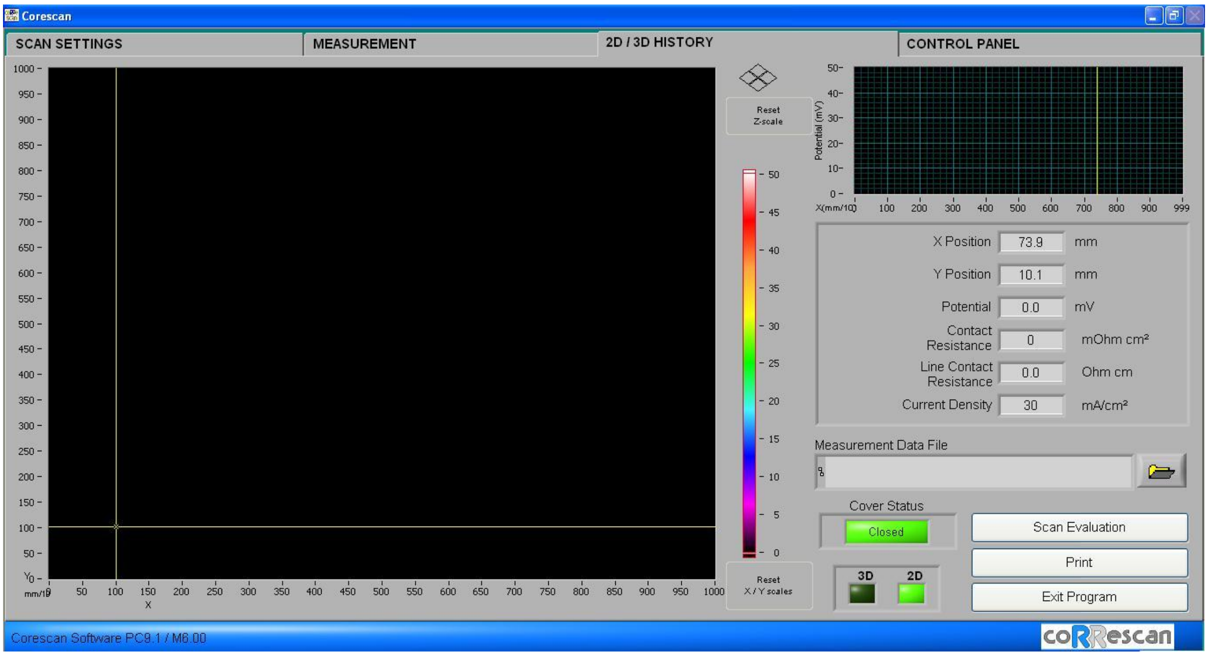

Figure 8: 2D/3D history window

- The 2D/3D history of core scan measurement for sample solar cell is as shown in the following figures.

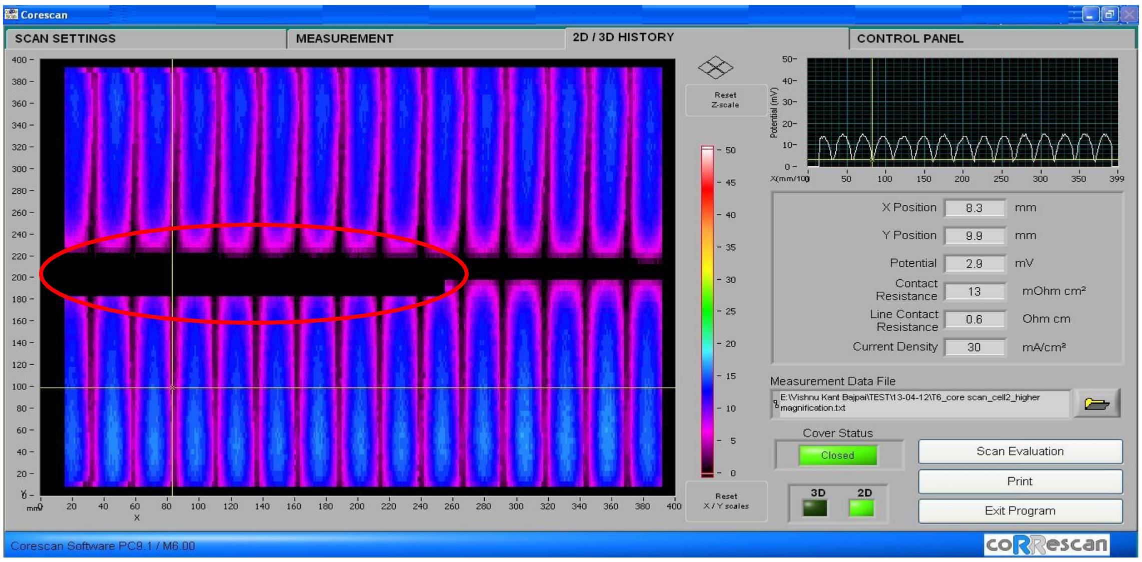

Figure 9: 2D history of Corescan

- In the above 2D history of core scan measurement, the black region which is spotted is not scanned because of contact pin over the bus bar.
- The region not scanned near the sides is left by the instrument as a safety margin.
- To enlarge the image of scan result in 2D/3D history, the RESET X/Y scale option can be used.

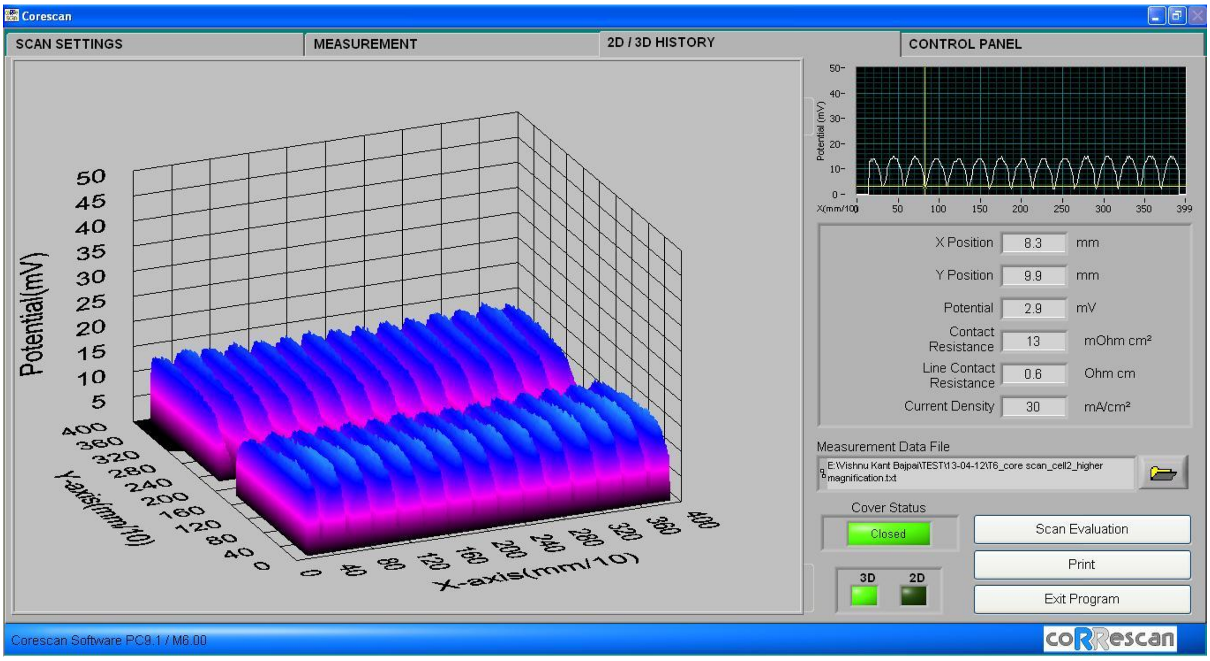

Figure 10: 3D history of Corescan

- Scan result can be printed / saved accordingly.
- Scan evaluation is one option for estimating overall quality of the solar cell
- The Corescan measurement of the solar cell is complete and scan settings window can be again used to select another scan type otherwise directly exit the program by clicking EXIT PROGRAM.
- There is control panel window which is common for all the measurements having features like probe adjustment, probe movement and vacuum pump etc.,
- At normal operating conditions, probe movement should not to be changed.
- While scanning the solar cell, the vacuum pump automatically switches on/off. But for manual operation, one tab is provided on the control panel as well as a switch on the stage of the instrument.

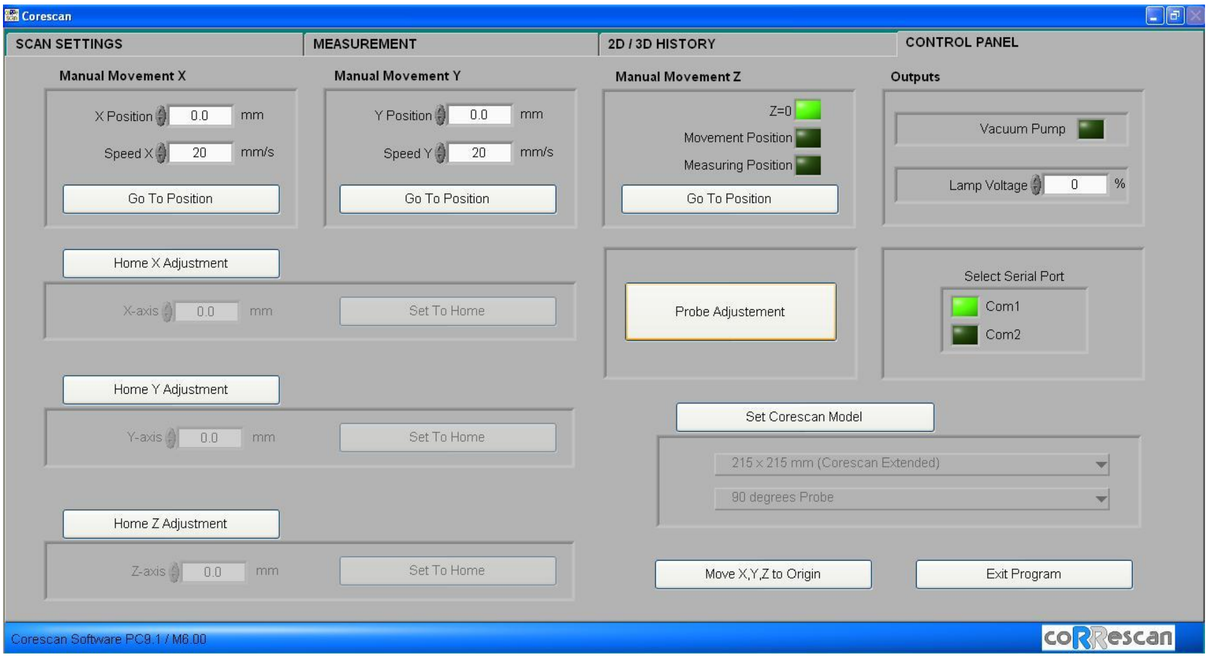

Figure 11: Control panel (common for all measurements)

- Before starting the measurements, once the probe adjustment can be checked by using the option at control panel window.
- Main objective is to measure the length of the probe by the probe adjustment option. Once it is clicked, the system will automatically measure the probe length and suggests accordingly. This is shown in the following figure.

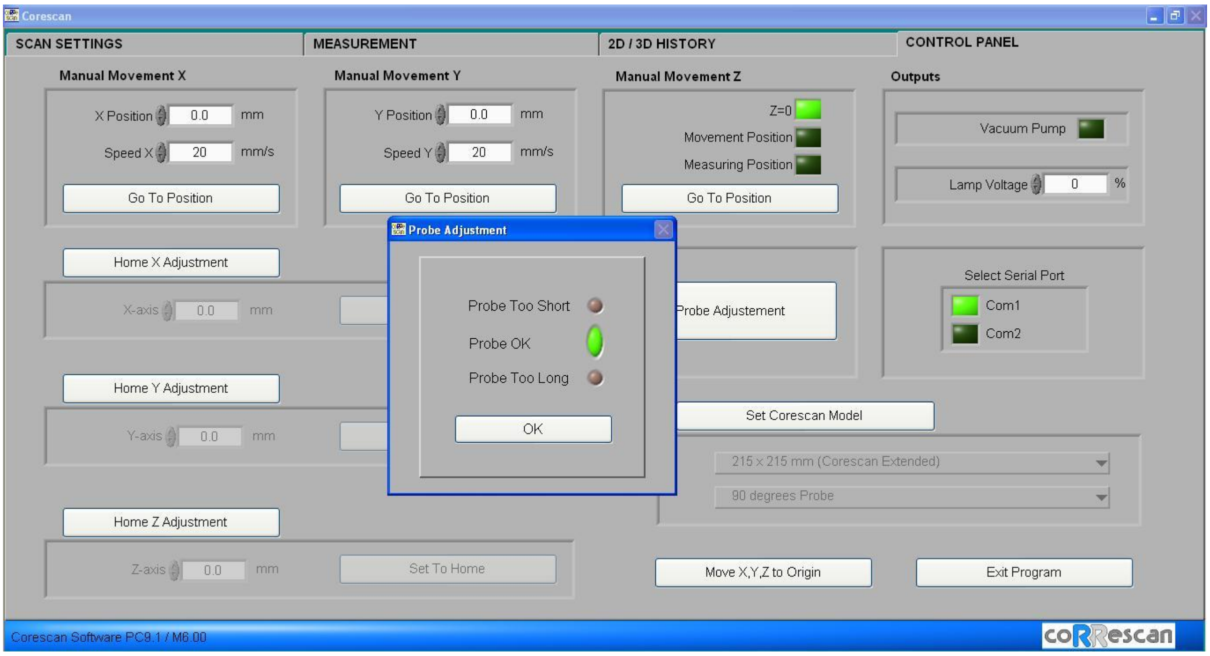

Figure 12: Control panel (Probe adjustment)

Voc Scan:

Here, the solar cell is locally illuminated and open circuited.

- By selecting Voc scan option on scan setting window, one pop up window will suggest removing the contact pins on the bus bar as fixed for the other measurements.

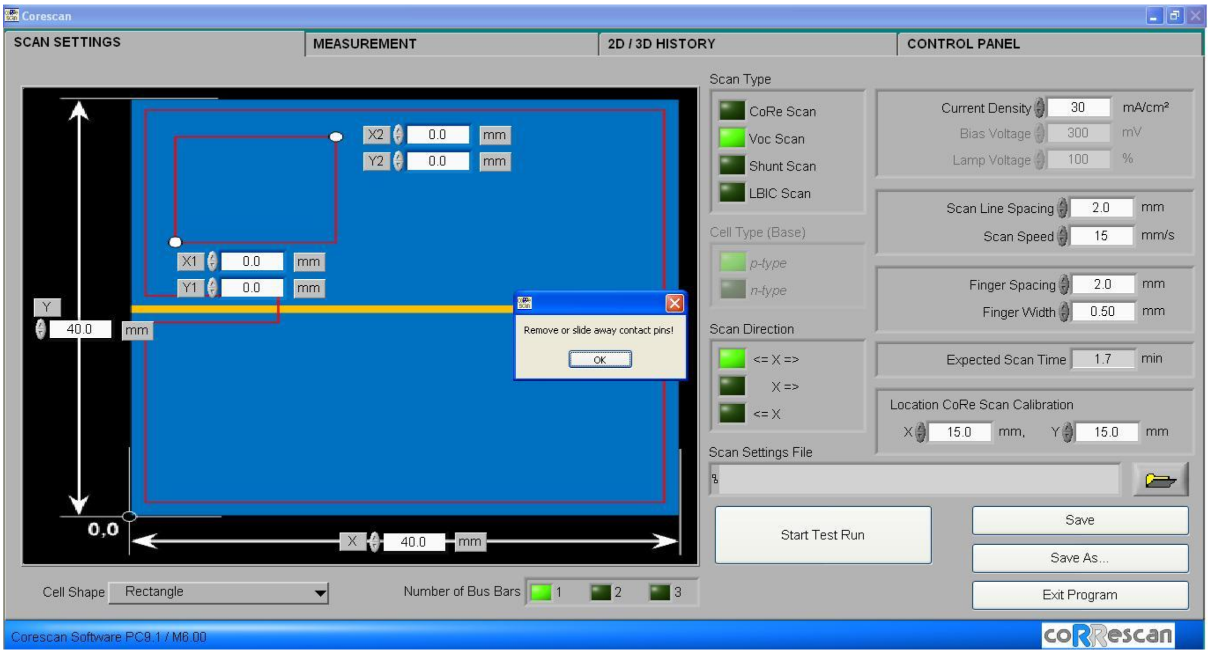

Figure 13: Scan settings window – Voc scan

- By removing the contact pin on the solar cell, the system enables to the measurement of Voc scan.
- The only options need to be changed here are cell dimensions, scan line spacing and scan speed.
- The Voc scan should not be clubbed with other measurements.
- The Voc scan is only useful for non finished solar cells with rear side metallization but without front side metallization to prevent smearing of the Voc via front grid.

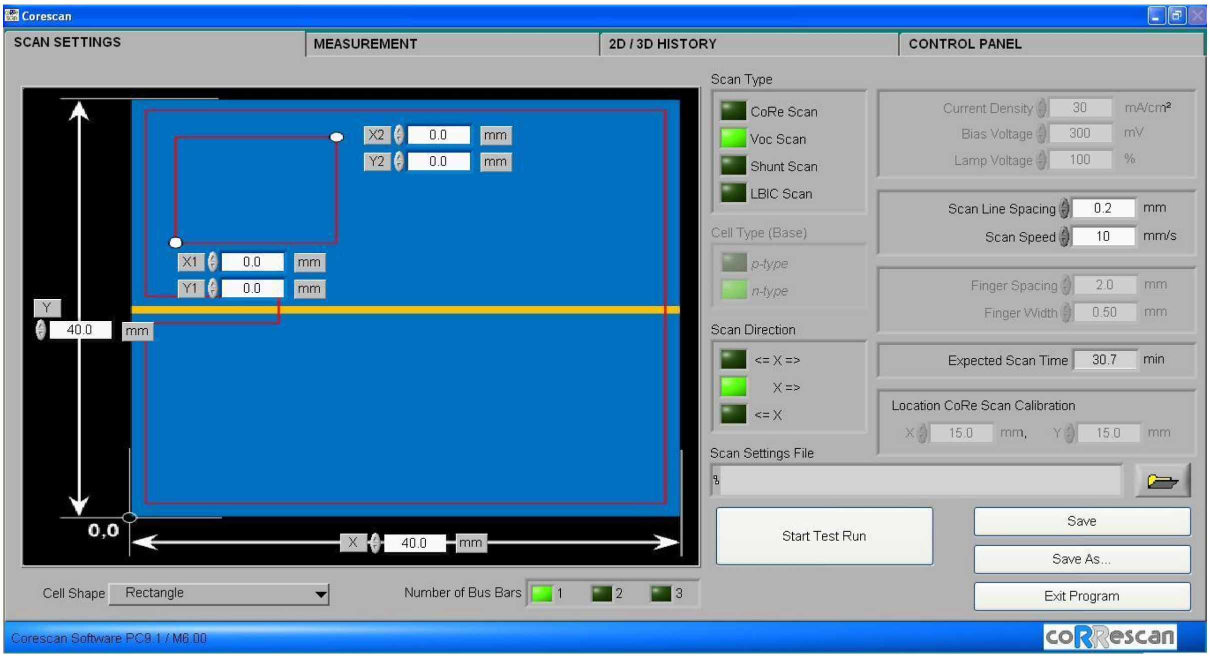

Figure 14: Scan settings window – Voc scan

- Now the test run has to be started for Voc scan measurement.
- Once the test run is complete, select the measurement window and follow the same sequence as described earlier for Corescan measurement as well as 2D/3D history.
- Voc scan results of sample solar cell are shown below:

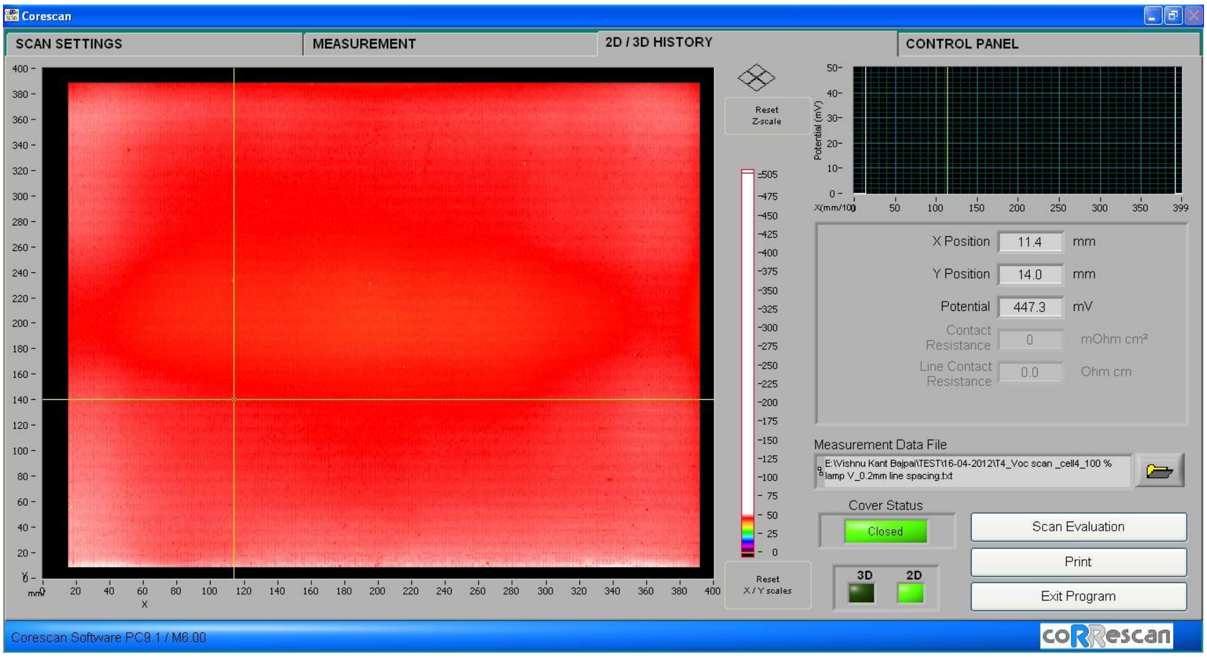

Figure 15: 2D history of Voc scan

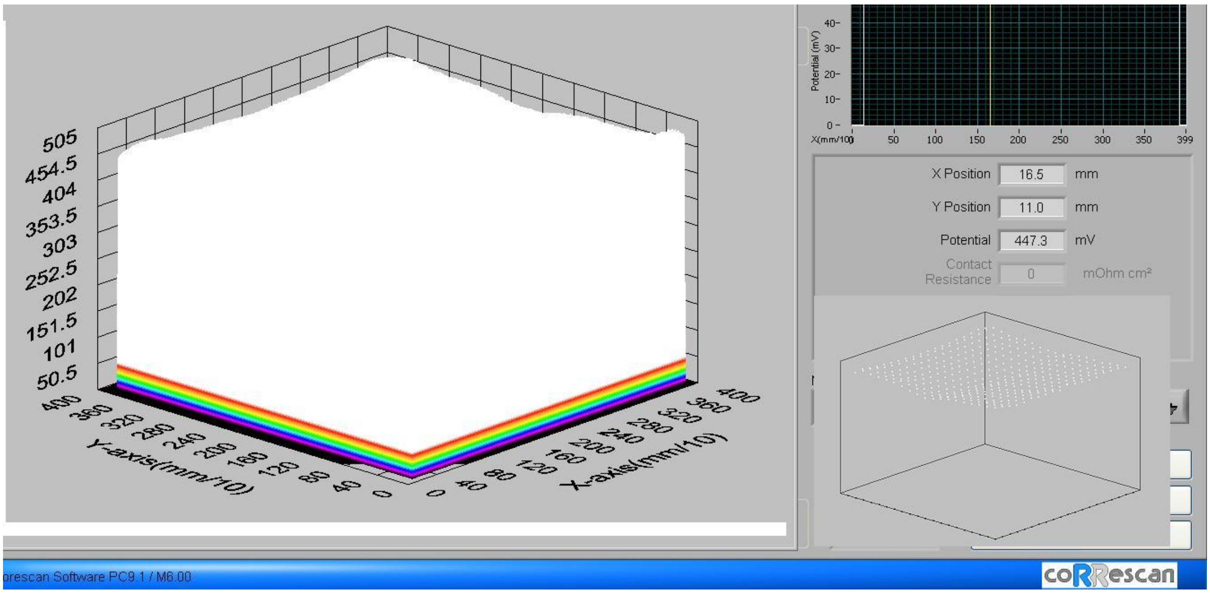

Figure 16: 3D history of Voc scan

Shunt Scan:

Here, the solar cell is operated at 300mV forward bias in dark.

- By selecting shunt scan option on scan setting window and contact pins are to be attached with the bus bar of the solar cell as in the case of Corescan measurement.

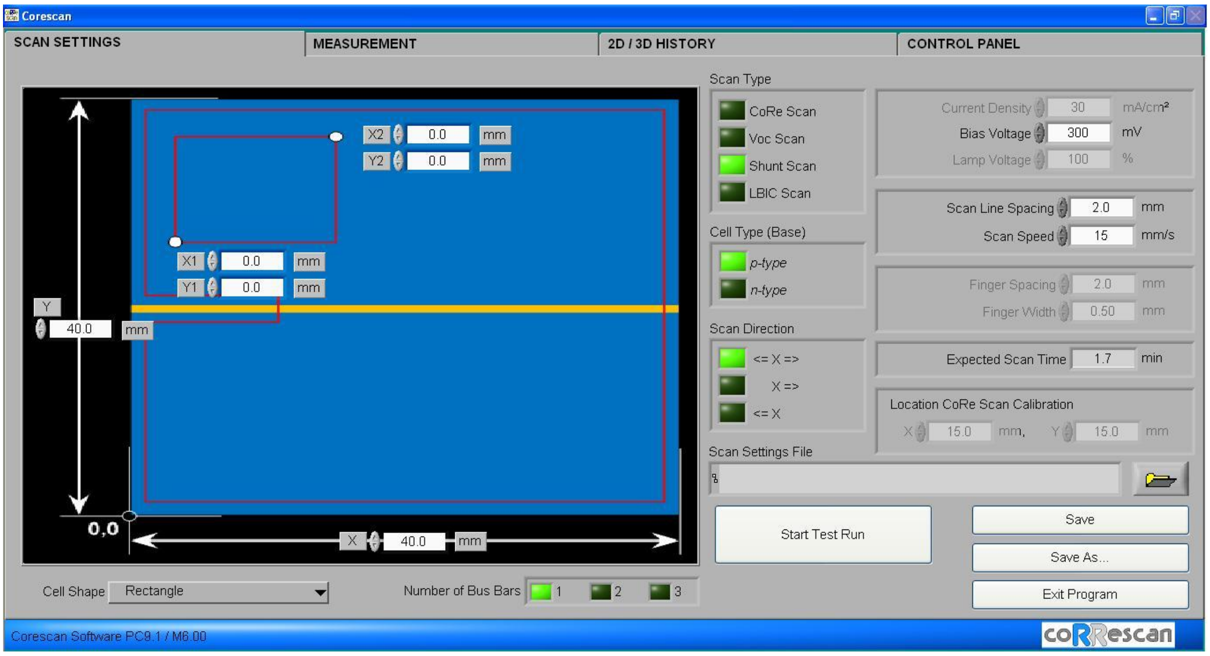

Figure 17: Scan settings window – Shunt scan

- Here some of the parameters to be selected according to solar cell: cell type (p-type/n-type) and other settings like cell dimensions, scan direction, scan line spacing, scan speed as discussed earlier.
- Now the test run has to be started for shunt scan measurement.
- Once the test run is complete, select the measurement window and follow the same sequence as described earlier for measurement as well as 2D/3D history.
- Shunt scan results of sample solar cell are shown below.
- Lower mV means cells are not shunted and here in the following images shows that there are no considerable shunts are present. Only two spikes and some spikes of higher mV near the edge are observed.

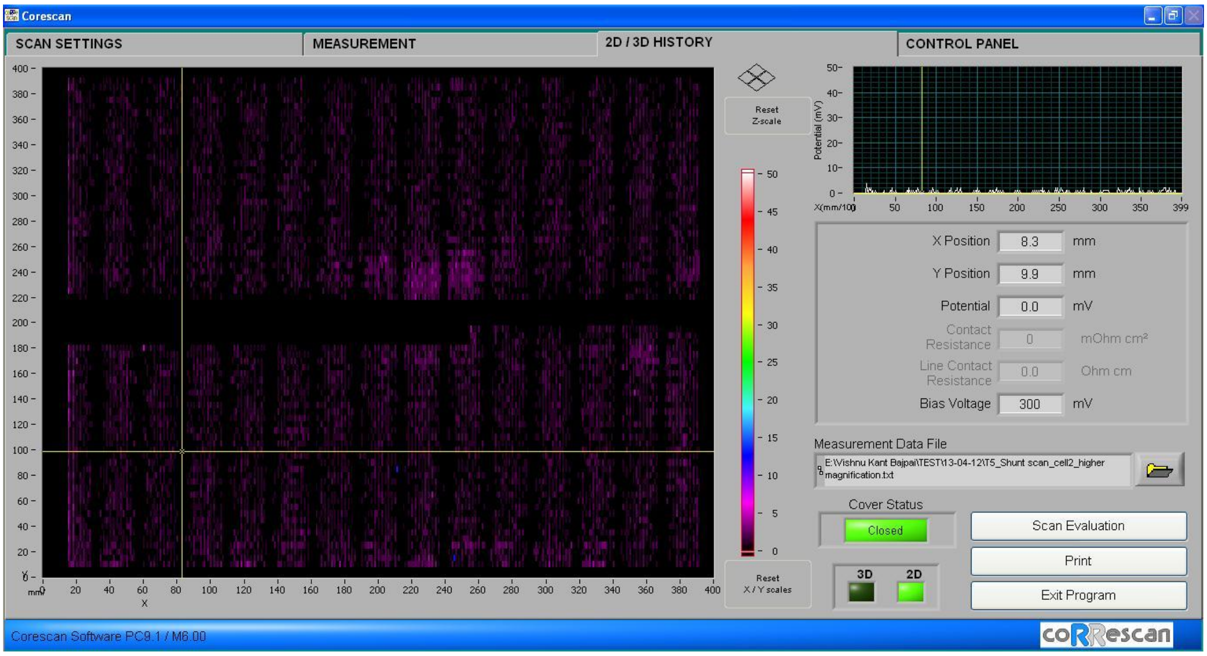

Figure 18: 2D history of Shunt scan

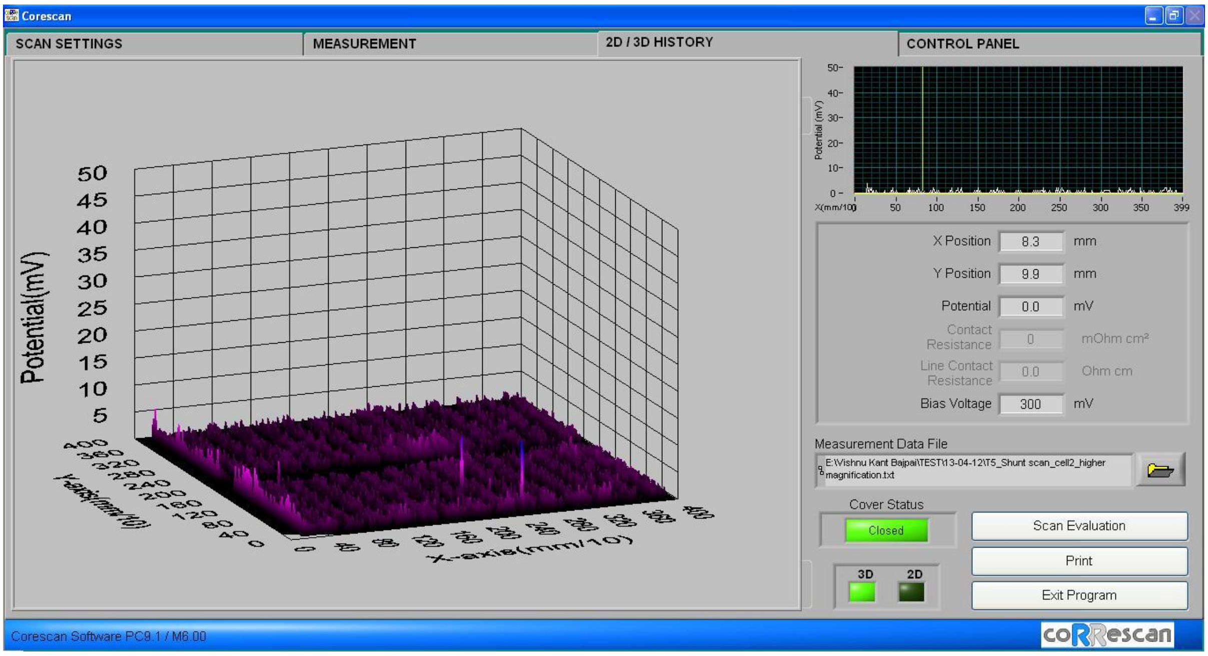

Figure 19: 3D history of Shunt scan

LBIC Scan:

It is not based on potential mapping. Here, scanning of the light beam over cell while measuring the short circuit current to each position.

- Select the LBIC scan option on scan setting window to operate the instrument in LBIC scan mode.

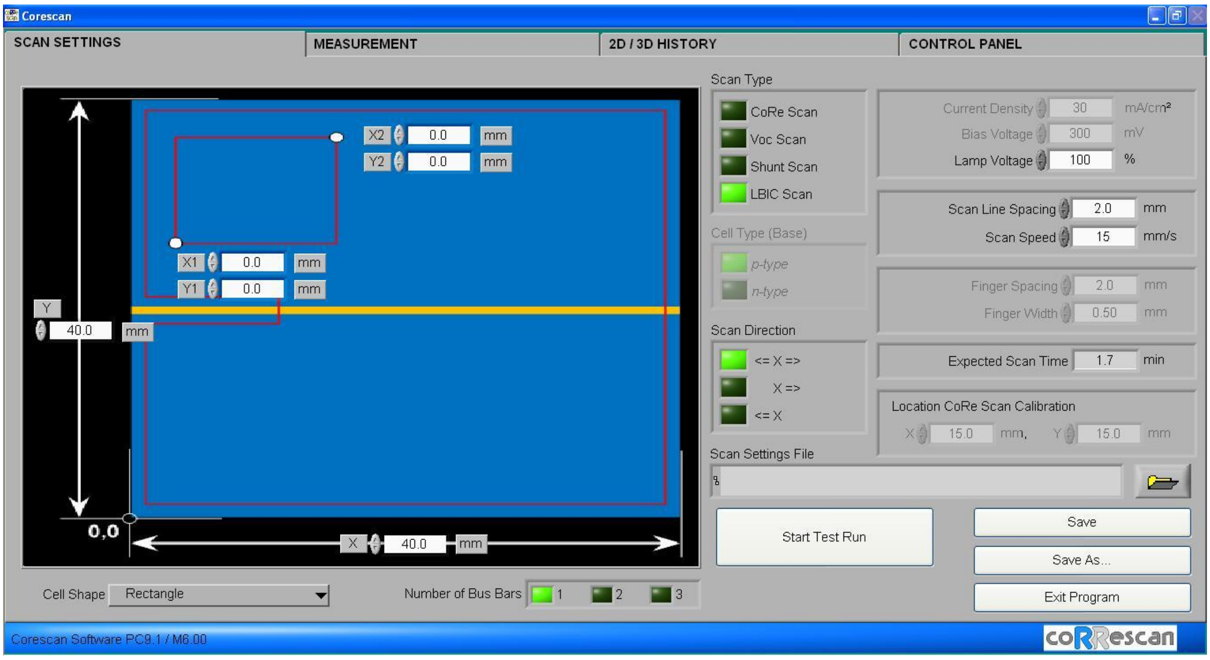

Figure 20: Scan settings window – LBIC Scan

- Here some of the parameters are to be selected according to solar cell: lamp voltage and some solar cell parameters like cell dimensions, scan direction, scan line spacing, scan speed as discussed earlier.
- The lamp voltage is recommended to be 100%.
- Now the test run has to be started for LBIC scan measurement.
- Once the test run is complete, select the measurement window and follow the same sequence as described earlier for measurement as well as 2D/3D history.
- LBIC results of sample solar cell are shown below.

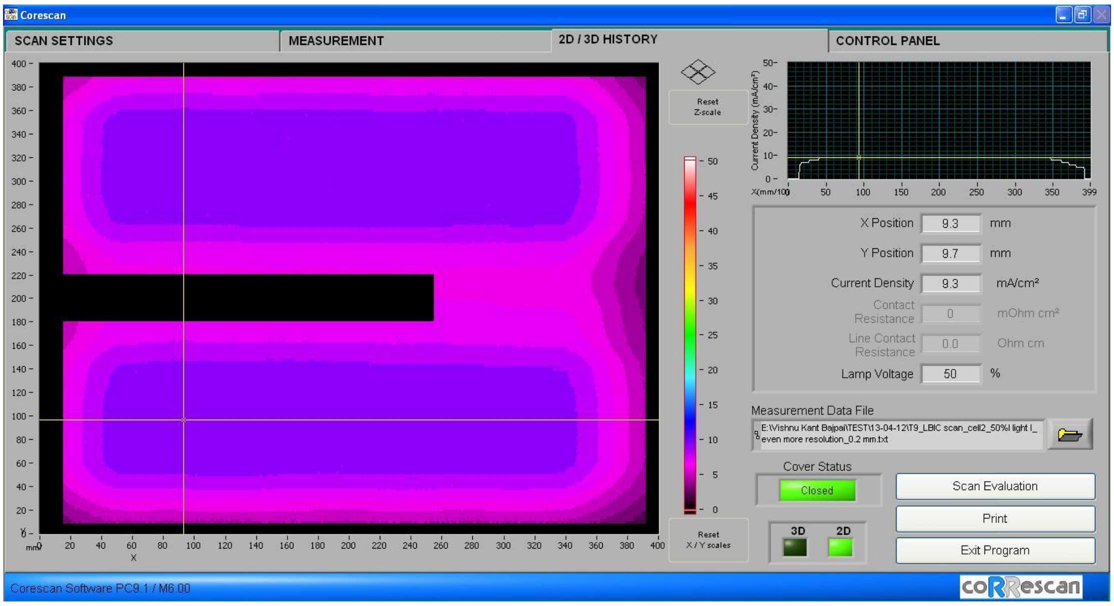

Figure 21: 2D history of LBIC Scan

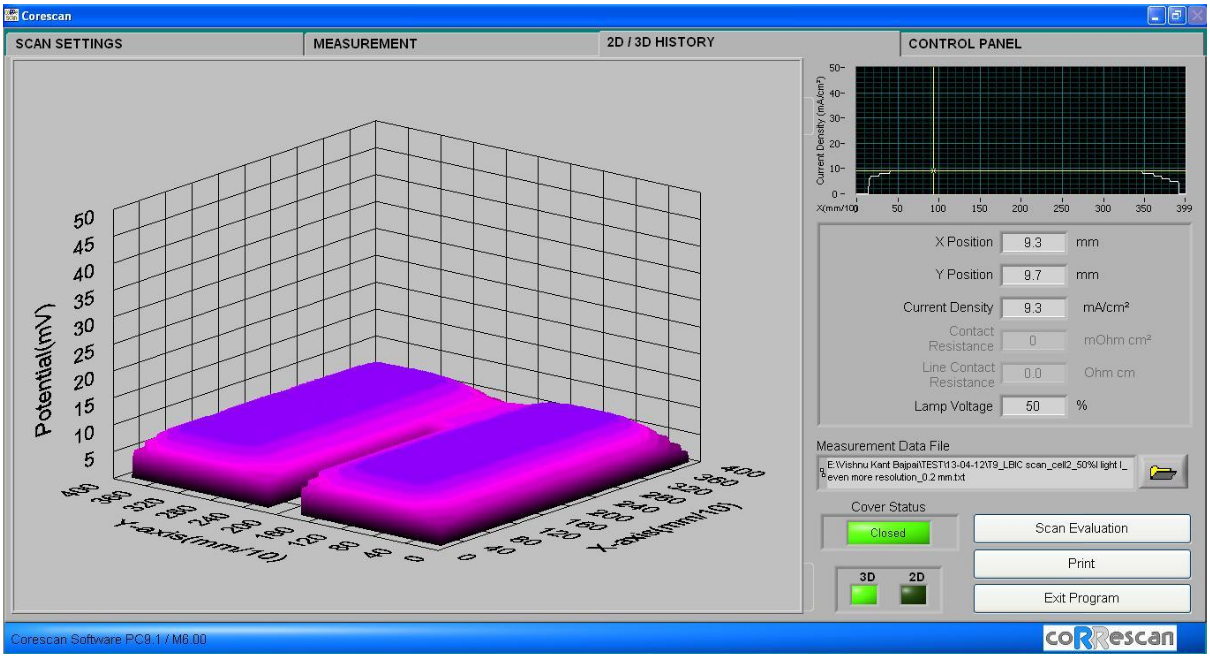

Figure 22: 3D history of LBIC Scan

- Here short circuit current density is quite uniform.
- Lower LBIC values near the bus bar and cell edge is caused by the large area of light spot being partially over the edge or on the bus bar.

3. Do's and Don'ts

1. Ensure the proper probe length before starting measurements.
2. For Corescan calibrating always the position on the solar cell should be selected in such a way that there should not be any finger/ bus bar by visual inspection using the scale provided on the vacuum table.
3. The cover of Corescan should be closed while doing the characterization.
4. All holes other than the solar cell area should be closed for enabling proper vacuum for the solar cell.
5. In case of emergency, stop button provided on the instrument can be used.
6. Always ensure that the contact pins are aligned and in contact with the bus bar for characterization.
7. Don't keep the samples inside the instrument after characterization
8. While operating the system, the Corescan components should not be touched / disturbed.
9. Using Corescan, only the standard sized solar cells should be characterized because the scan probe will estimate the surface area of cell and scans accordingly.
10. Data transfer should be made using CD mode only.