Using a Closed Loop Scanner

Introduction

The traditional SPM control systems assume that the SPM scanners have a linear response with the applied voltage, i.e: if applying 10V you get a displacement of 10nm, applying a voltage of 100V you should obtain a displacement of 100nm in the position. This way, you can apply a linear voltage ramp in the lateral movement axis (we will call them X and Y), and you will hopefully scan a square of the sample.

But the reality is different: due to they very own nature, the scanners have more difficulties to move when you are applying a voltage near to their maximum allowed, and also they respond in a different way if you change the voltage fast or slowly. This has the result that the borders of the images are not representing perfectly the shape of the object that is being scanned. Also, when you zoom or center in a zone, you do not get exactly the expected result.

While this problem has been studied and several algorithms have been developed for the analysis and the correction of the problem (you can find more information about software non linearity correction in Technical Note #6), the best solution up to now is to measure the real position of the scanner, in order to get the most precise data. Currently, there are many scanners available including this kind of sensors, and allowing perfect control of the position.

While, in the Z axis, the own measurement of the position is enough for a perfect image, in the X and Y direction it is needed to use a particular algorithm for, based on the measured data of the position, correcting the voltage ramps that were linear in a way that they compensate the non-linearity of the scanners. This algorithm, instead of just giving a voltage linearly depending on the position of the scan, will determine what voltage it wants to measure from the sensor, and will apply a closed-loop control in order to move the axis voltage the right amount for a linear behaviour of the scanner.

In Nanotec Electronica, we have developed a versatile and easy-to-use method to control scanners with position sensors. We have applied this method with our own scanners, and also we have controlled other scanners with our control system applying the closed-loop scan algorithm. The difference between the traditional scanning method and the closed-loop can be appreciated in the Figure 10.1.

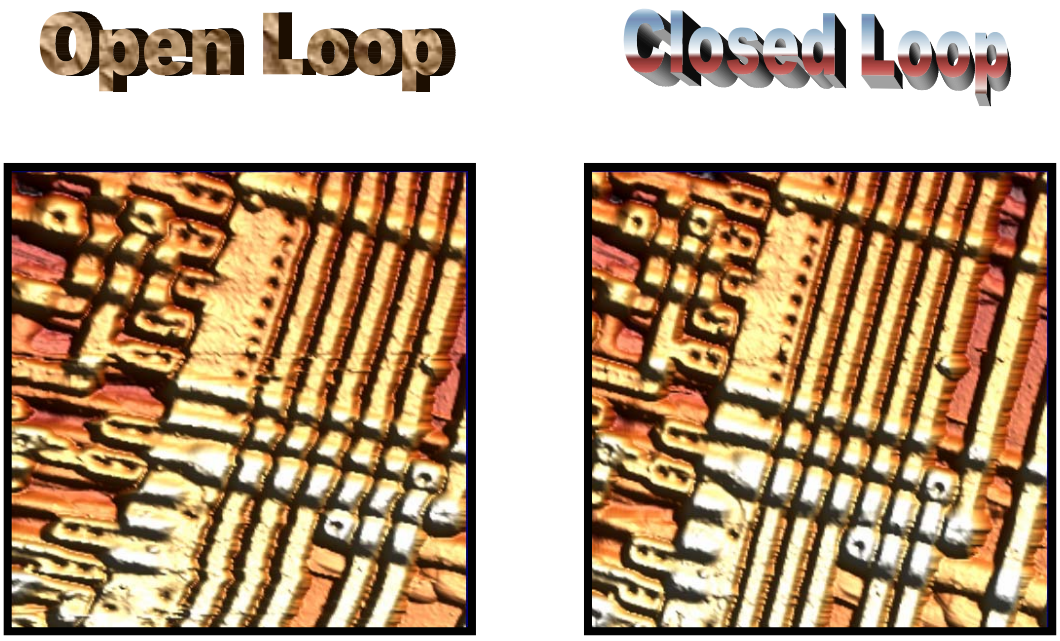

Figure 10.1. Integrated circuit imaged without closed-loop and with closed-loop. The differences in non-linearity are easily appreciated, mainly in the borders of the scan area

Using a Closed-Loop scanner from Nanotec.

Once you have your Closed-Loop scanner well connected (refer to the Nanotec's User Manual for connecting your Nanotec Closed-Loop scanner), there are just a few steps left for closing the loop.

First of all, take care of using a WSxM version 4.0 or higher (check at http://www.nanotec.es if there is a more updated version of WSxM 4.0 than the one you are using, and upgrade if possible).
Then start the WSxM acquisition as usual, and open the XY Feedback Control dialog-bar (see Figure 10.2 for details on opening the XY Feedback Control dialog-bar and for a preview of the dialog-bar).
Four of the parameters can be automatically calculated. Just press the "Autocalibrate" button and, when the new parameters have been found, press "Update".

The "Power" parameter indicates the strong the feedback will be. If the feedback is too soft (small power), then you can have problems scanning fast. If the feedback is too strong (big power), then there can be oscillations that will give you noise in the image. For the Nanotec closed-loop scanners, there is an on-factory calibration that will be included in your software installation, so the default "Power" will be OK.
Press the button with the blue closed loop to start controlling.

Using the Dulcinea Control System for controlling an external closed-loop scanner.

The Dulcinea Control System has been designed for easy use of Closed-Loop scanners. The instructions for using them are mainly the same as for the Nanotec Closed-Loop scanners, but for two points you should pay attention:

You should input the output of your sensors to the control system. There are two channels reserved for **X Correction** and **Y Correction** that are the input channels 9 and 10. Just input your signals (+/-10V) by those channels and check that the values in the **Autocalibrate** function are different than when there is nothing connected to those inputs (see Technical Note #4 for reference on the pins where you can find those channels).

The Z Sensor output (if exists), can be input to the Dulcinea Control System by any channel, as there is not any particularity in the channel. Just use the channels manager to give the right units to the channel in nm. Anyway, you can use the input channel 11, that we have reserved for that use, if you want to keep free your four (CH5, CH6, CH7, CH8) user input BNCs for other applications.

The **Power** value can not have a default value corresponding with your scanner: you should try. Just increase it while you are scanning over a well-known periodic image like a grid until you see that the non-linear behaviour is not there. If you see noise while you are increasing the value, reduce it. Once you find a value that works fine for your scanner, you will not need to repeat the process.

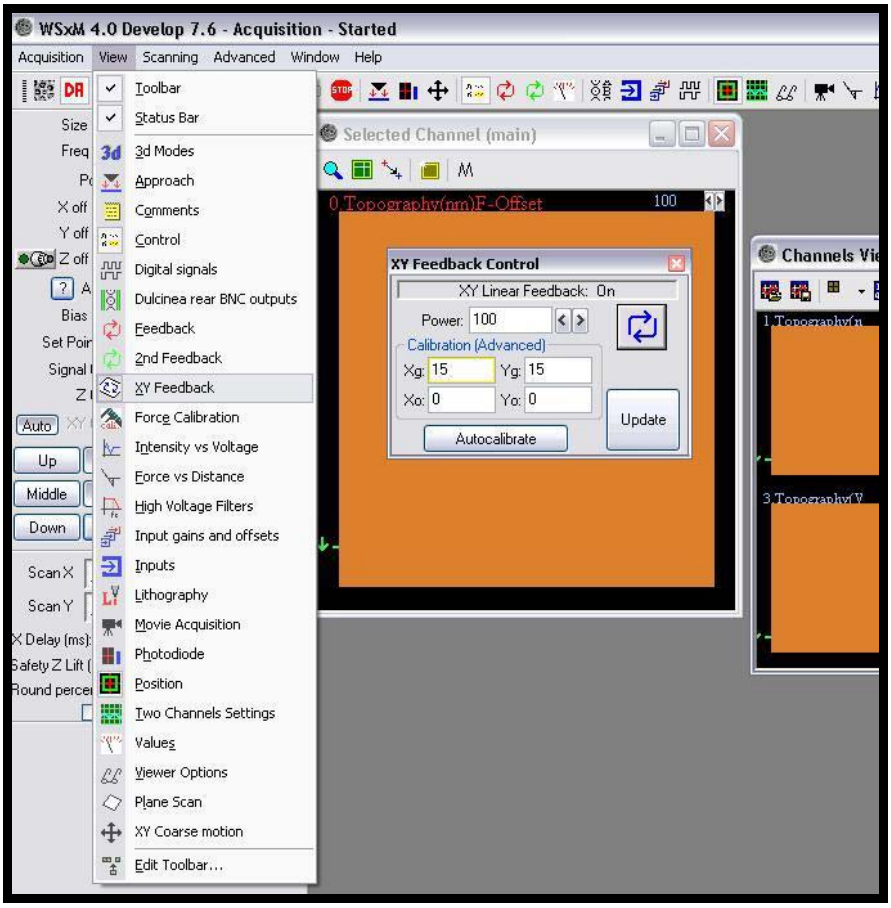

Figure 10.2. View of the XYFeedback Control dialog-bar and its menu access.

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