Potting setup

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June 16, 2015

The potting process imply several steps which we want to describe in some detail here in this document.

1 webcam setup calibration and needle tip offset (NTO) measurement

Since we are using needles to deposite the sylgard and these needles are not straight we need to correct for this factor every time we use a different needle. The way to find this needle tip offset (NTO) is by using two web cameras disposed as shows in the figure 1 left.

The setup calibration strategy is:

With the needle mounted on the syringe we move the gantry head to the webcam setup area. A labview program have been written to show the images from the cameras[1], thus, each camera provide a diferent view of the needle tip. The screen has two lines acting as rulers (with no scales) forming a coordinate system concentric with the field of view of the cameras, so we can put the needle tip center in the center of the image for each camera and adjust the cameras focus to see the needle tip clearly visible. To calibrate the height of the web cameras we just put a readout chip (ROC) over a pedestal and adjust the cameras height so that the upper edge of the ROC coincides with the horizontal axis in the screen for both cameras simultaneously (figure 1 right); we should not see the upper plane but only the transversal view/plane. These gantry head coordinates are a well defined reference to find the NTO of any needle. Lets call them reference coordinates (RC)

[1] /andres/routine/Multi_USB_Camera.vi

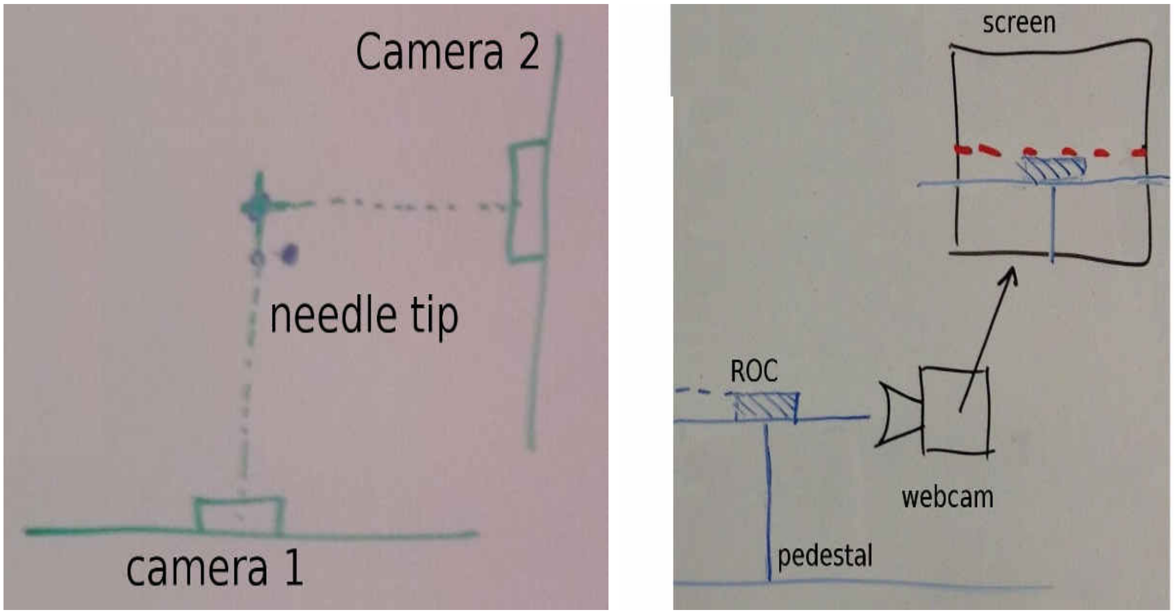

Figure 1: webcam setup

Specific steps:

- Run the labview program: Multi_USB_Camera.vi
- Put a ROC over a pedestal and adjust its positions such that it can be seen by the cameras(figure 2).
- Adjust the height of the camera 3 using the screw located right below the cable.
- Mount the syringe and the needle on the gantry head.
- Move the gantry to have the needle tip in the fiel of view of the cameras (figure 3).
- Adjust x-y camera 3: using the joystick adjust the x and y position of the gantry head to have the needle tip focused and centered (don't need to adjust the screws). At this point the needle tip must be a the level of the ROC
- Adjust the camera 2: unscrew the screws and adjust the position of the camera such that the needle tip is centered in the screen; tighten the screws to fix the x-y position.
- Adjust the height of the camera 2 using the screw located right below the cable. At this point, both cameras must show the needle tip centered, focused and at the level of the ROC

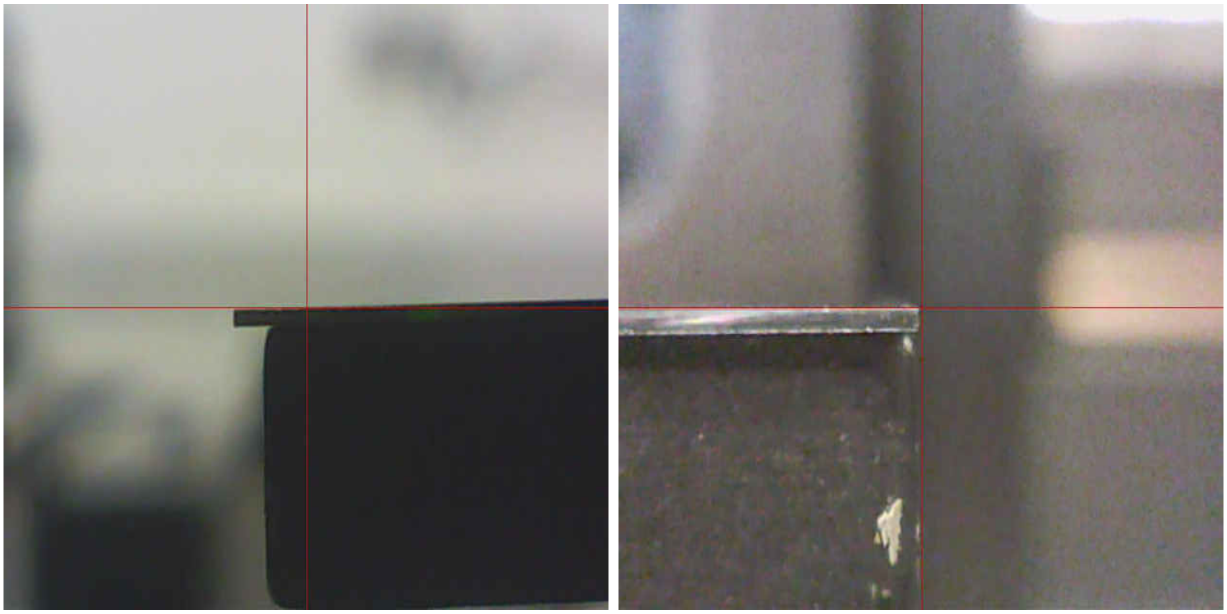

Figure 2: ROC seen by webcam setup

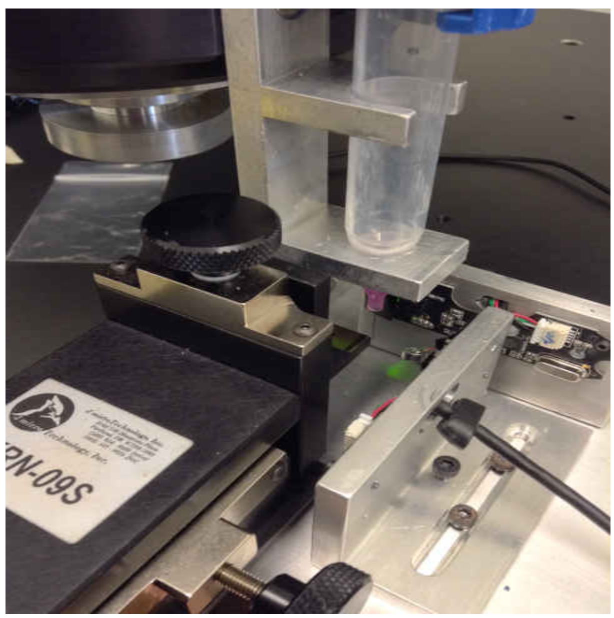

Figure 3: Webcam setup calibration

which coincides with the horizontal line in the screen (figure4).

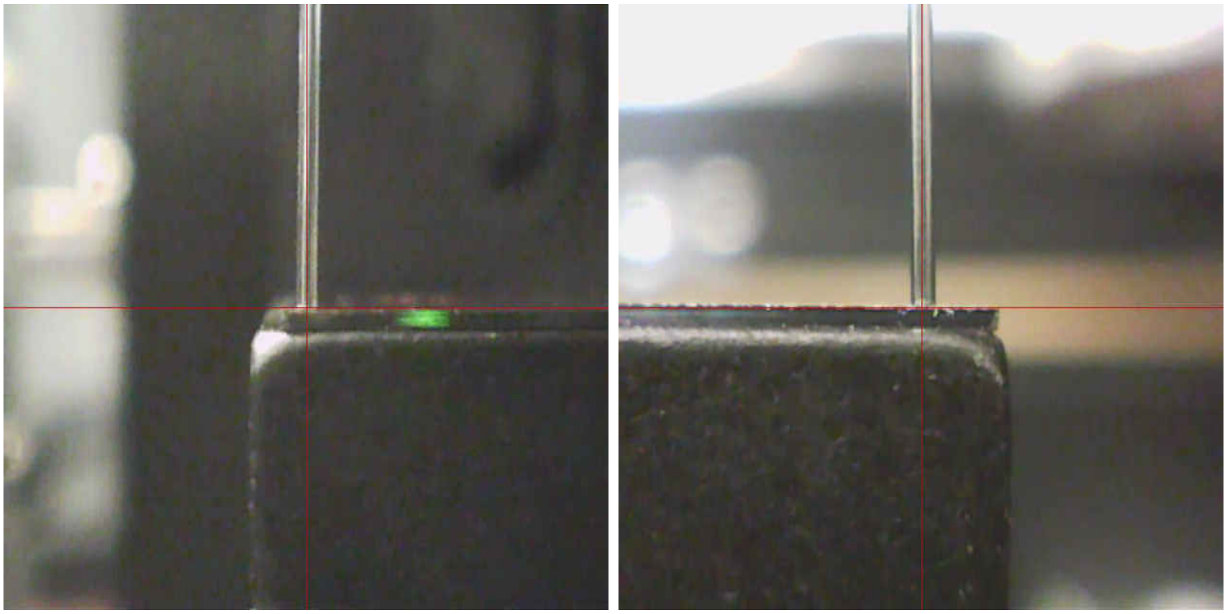

Figure 4: Webcam setup calibrated

the RC from the first calibration are:

$$\boxed{\begin{aligned} x &= 17.33703mm \quad (1a)\\ y &= 80.14393mm \quad (1b)\\ z &= 88.48577mm \quad (1c)\end{aligned}}$$

After this process the setup will be covered and the focuses kept fixed. We are ready to measure the NTO. Recall, in every single potting session we use a new needle and then we have to measure a new NTO, but we do not need to recalibrate the setup.

The NTO is found as follows: With the needle mounted on the syringe, move the needle into the webcam setup and adjuts the needle tip position so that it is in focus in both cameras simultaneously and at the level of the horizontal rule in the screen. Lets call them measured coordinates (MC) ; the difference between the reference coordinates and the gantry coordinates after adjust the needle tip correspond to the NTO, i.e

$$NTO = MC - RC \tag{2}$$

A labview program have been written to make all the motions, except the needle tip adjustment which is done by the user using the gantry joystick, and it will be included as part of the potting routine

2 Needle tip heigh measurement

The camera attached to the gantry head will be used to measure the in-focus position of the different elements in the modules and then relate these measurements with the height of the needle tip, but some measurements are needed before. Consider the gantry table over which we put calibrated block of 1 inch and on top of it a ROC (we measured its thickness previously using a micrometer); we move the gantry head camera to get a fiducial on the ROC in focus. In the scheme of the figure 5 up, the distance between the camera sensor and the ROC (in focus) is known as focal lenght (f) and it is a constant for the camera.

If we put now the ROC over the pedestal used to calibrate the height of the webcam setup, we can use the three cameras to link the position measured using the gantry head and the reference provided by the webcam setup. In particular, note that we can measure the height of the pedestal h_1.

With the needle mounted on the syringe, we move the gantry head camera to get the ROC in focus and we write the position of the gantry head(z_1), then move the gantry head to get the needle tip touching the ROC and we write the position of the gantry head (z_2), note that we can adjust this position using the images from the webcam setup since the ROC level coincides with the x-axis rule in the screen. Actually in this measurements we don't need to use the ROC because the webcam setup provides the reference. Figure 6 right show an scheme for this measurements.

The offset between the gantry head camera focus and the needle tip is

$$\Delta z = z_2 - z_1 \tag{3}$$

Considering only the z coordinates, it tell us that if we found an HDI fiducial (in focus) in the position z_{HDI} (figure 6 right), then we can get the needle tip touching this fiducial by moving the gantry head to the position $z_{HDI} + \Delta z$. Note that, z_1 is a constant defined after the calibration,

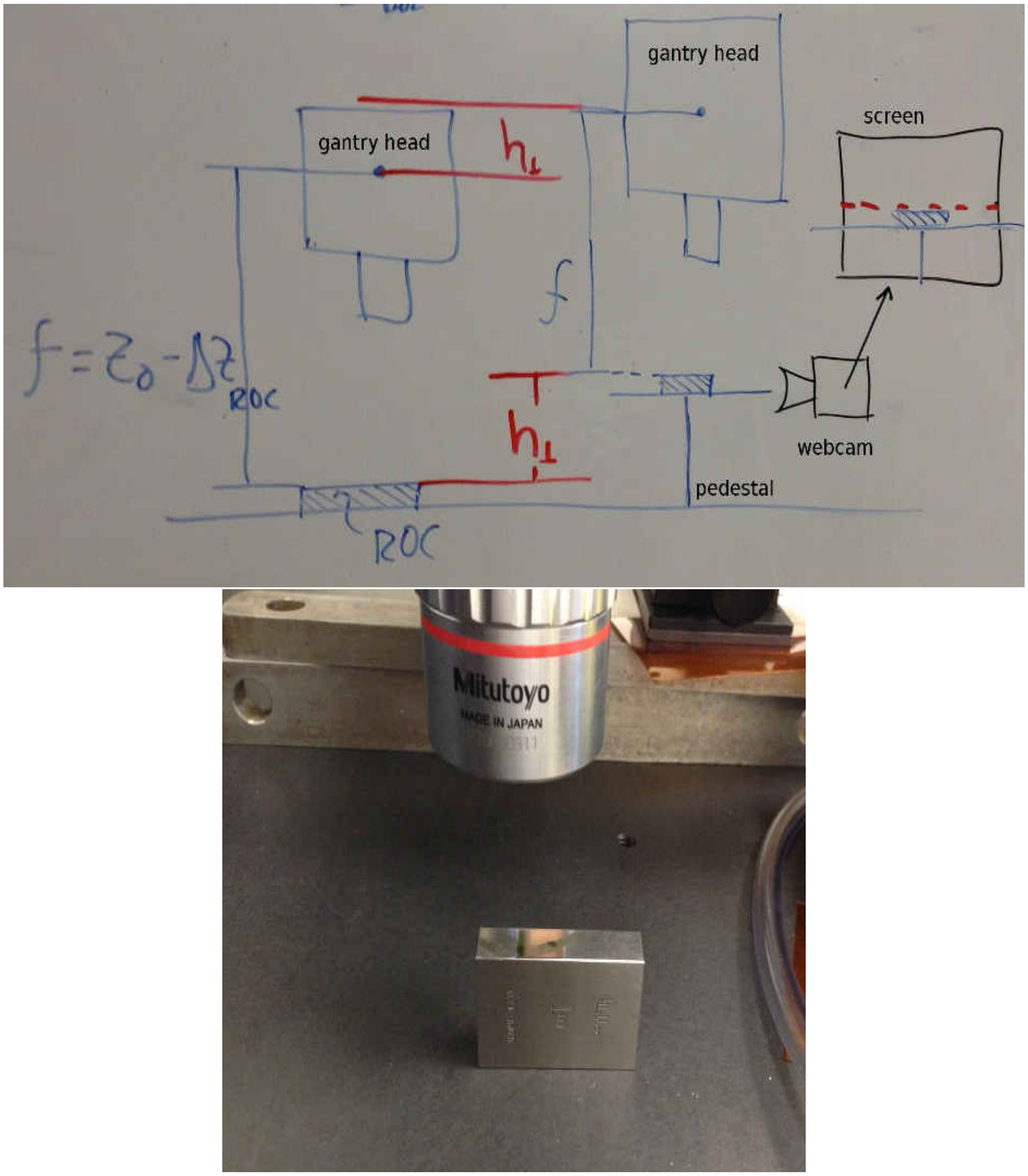

Figure 5: gantry head focal lenght - webcam setup height calibration

but z_2 change from one needle to another, so, for each needle we need to measure Δz.

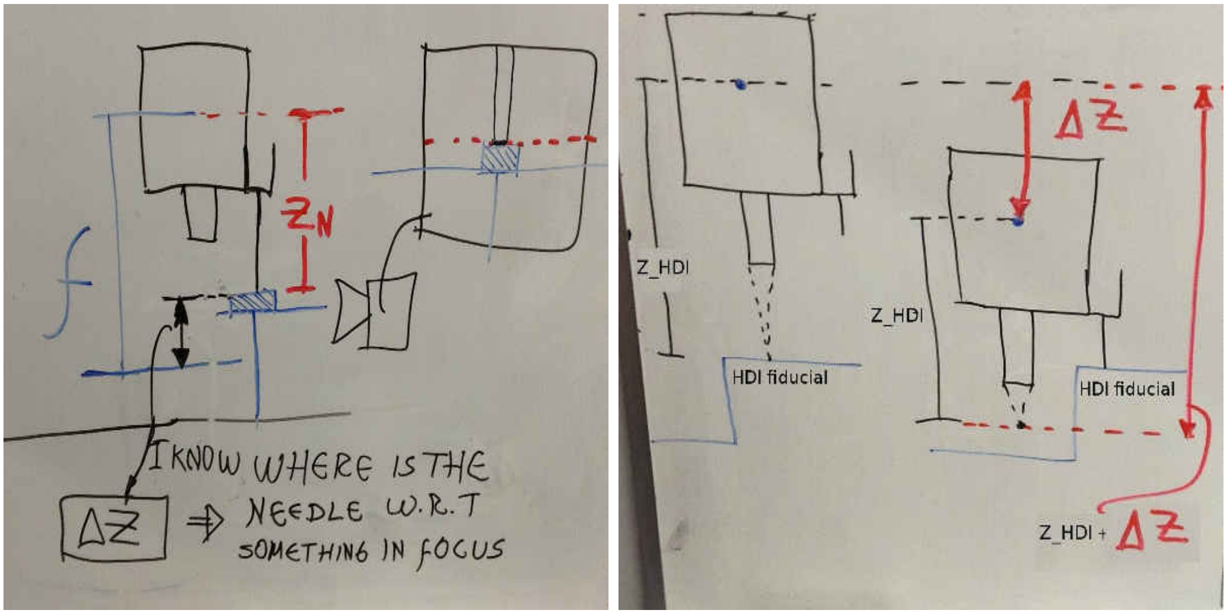

Figure 6: Link between the gantry head camera focal lenght and the position of the needle tip

After the first calibration, we have

$$\boxed{\begin{aligned} z_1 &= 58.47918mm \qquad (4a)\\ z_2 &= 88.48577mm \qquad (4b)\\ \Delta z &= 30.00659mm \qquad (4c)\\ f &= 99.17767mm + 1in = 124.47767mm \qquad (4d) \end{aligned}}$$

3 Space-time synchronization of the Sylgard deposition

The purpose of the sylgard deposition over the modules is to cover all the wire bonds; to do that, we will take a basic routine: depositing a sylgard line between two defined positions and repeat it as many times as needed. If these positions are:

- initial position $\rightarrow (x_o, y_o, z_o)$
- final position $\rightarrow (x_f, y_f, z_f)$

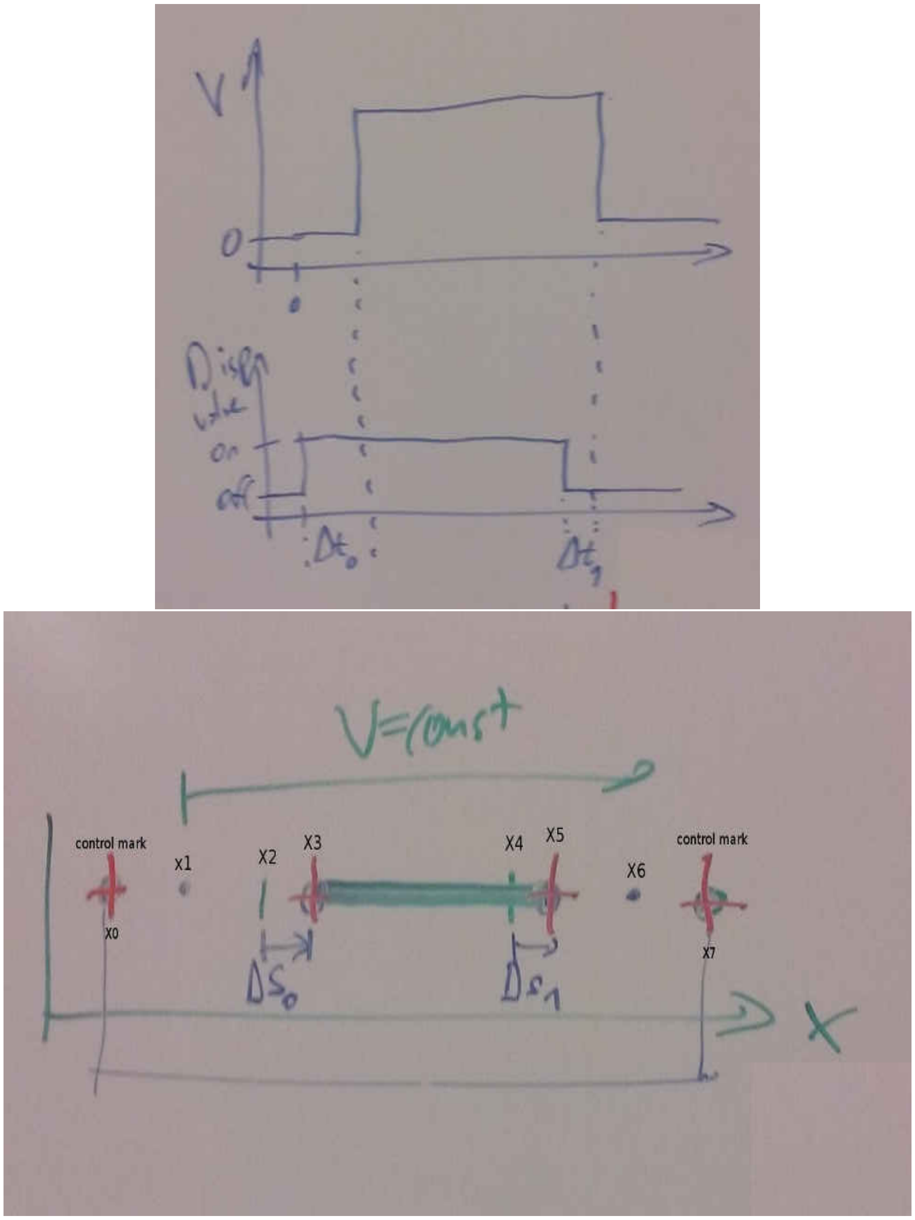

Figure 7: Sylgard deposition synchronization

the distance between these to positions is what define the lenght of the sylgard line. To be sure that all the wire bonds are covered we need to syncronize the dispenser valve action and the gantry motion.

The figure 7a show sketchs of the gantry velocity and dispenser valve action as a function of the time. When the valve is open the sylgard start to flow out of the needle, however the sylgard need some time to come out and get in contact with a surface in order to be spread, otherwise it will start to accumulate in a drop until it has enought weight to fall down. Thus, there is a time delay between the valve opening and that the gantry start to move, it is called Δt_0. Accordingly, after the valve is closed there is a remaining sylgard flow, so we have to close the valve before the gantry reach the final of the way, this time delay is called Δt_1

To find these time delays we proceed as follows: With the needle mounted on the syringe we will make a sylgard control mark at x_0 over a glass slide (See figure 7b) then at x_1 the gantry start to move at constant speed V; at x_2 the dispenser valve is opened and at x_3 the sylgard gets in touch with the glass slide and it start the spreading. At x_4 the dispenser valve is closed but some sylgard still will be flowing until x_5. At x_6 the gantry stop and at x_7 we make another sylgard control mark.

We can now calculate

$$\Delta S_0 = x_3 - x_2 \tag{5}$$

and

$$\Delta S_1 = x_5 - x_4 \tag{6}$$

and from there, we can get the time delays

$$\Delta t_0 = \frac{\Delta S_0}{V}, \tag{7}$$

$$\Delta t_1 = \frac{\Delta S_1}{V} \tag{8}$$

The speed V needs to be adjusted so that the sylgard line is not segmented; this segmentation occurs when the speed is too high to ensure that the sylgard flux is continuous and/or when the contact between the sylgard and the surface is lost. Several tests are needed to fine tune the speed as a function of the potting height(see section 4)

4 The potting height

As we mentioned before, if the sylgard does not touch any surface(object) it start to accumulate in a drop, so in that sense, the height of the needle tip with respect to the surface is a critical parameter, however is not the only one; we have to ensure that the needle tip does not touch the

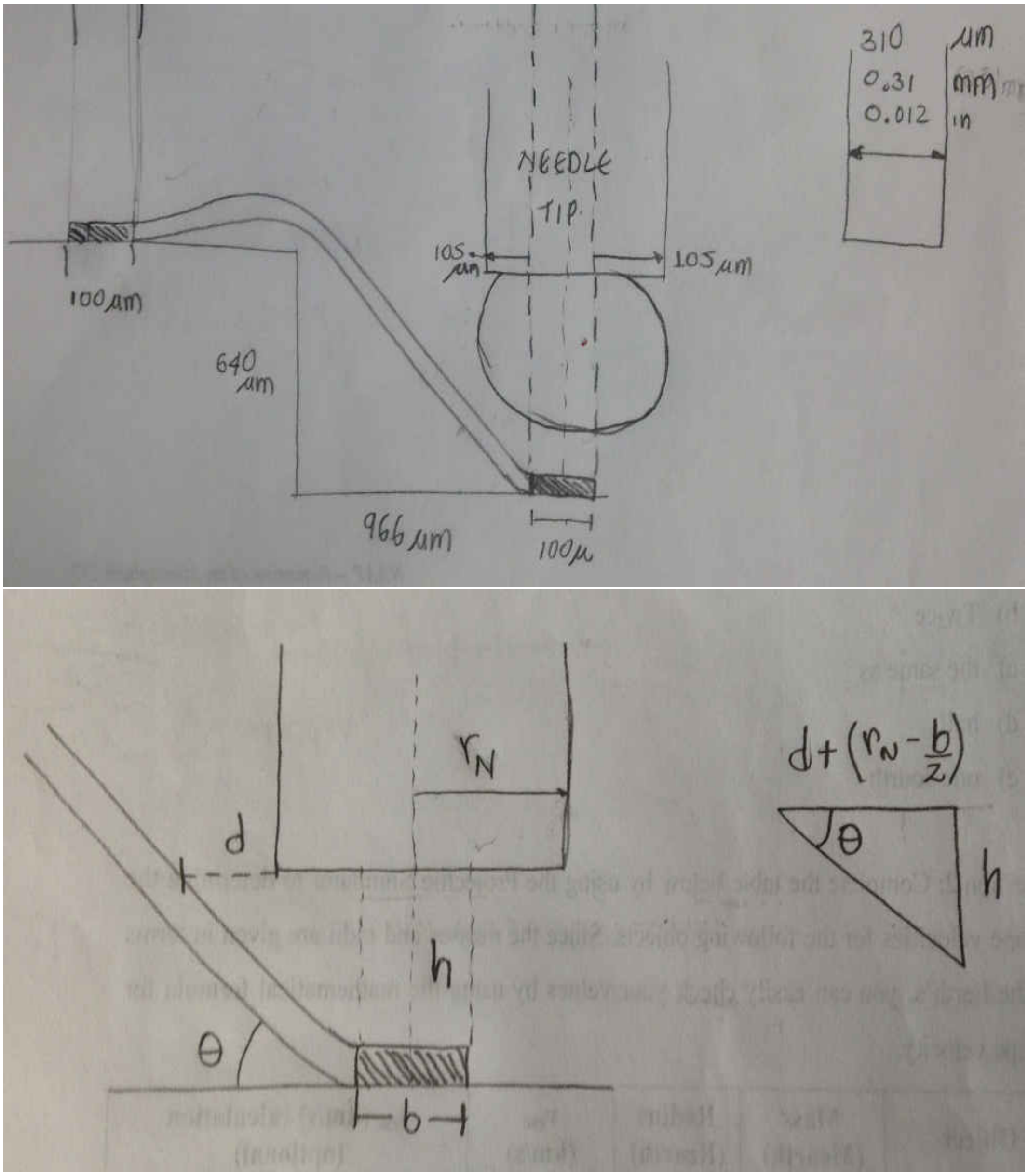

Figure 8: Wire bond region. Values presented are the typical dimensions involved in the system

HDI, the ROC's or the wires. Figure 8 shows an schematic of the wire bond region and some typical dimensions involved in the system. The slope of the wire is about 34^o but we can explore in the calculations several angles, just to be sure that the wires will be safe. If we choose as reference to deposit the sylgard the center of the bond (i.e the center of the needle will be right above the center of the bond), then we can calculate the height (h) needed to have the wire as far as we want from the needle tip using

$\theta(^o)\backslash$ d(μm)	100	150	200	250
30	207.8	236.7	265.6	294.4
45	360.0	410.0	460.0	510.0
60	623.5	710.1	796.7	883.3

Table 1: Values of the needle tip height (h (μm)) for several combinations of parameters d and θ.

$$h = \left(d + r_N - \frac{b}{2}\right) tan\theta \tag{9}$$

where d is the distance from the needle tip edge to the wire (safe distance), r_N is the external needle radius (310 μm), b is the size of the bond (100 μm) and θ describe the slope of the wire. Note that it will define the size of the sylgard drop and then the time delays because we will need to have the correct drop size before to start to move the gantry. The table 1 shows the results of the calculation for several combinations of the parameters d and θ (r_N and b fixed).

We can increase the safe distance by choosing as reference to deposit the sylgard, the edge of the bond and even with that choice we will cover the whole bond.

4.1 experimental work in synchronization and height determination

A labview program to perform the NTO calculation and then the sylgard deposition to make the space-time synchronization have been written. We did several initial test to find the better needle tip height, using the heights from table 1; results are in the table 2

$speed(mm/s)\backslash h(mm)$	207.8	236.7	265.6	294.4	360	410	460	510	
0.25	0.3520	0.9558	0.8320	1.2064	2.2018	3.0336	-	-	$\Delta t_0(s)$
	3.63364	4.70769	2.05617	1.96479	5.51082	6.55363	-	-	$\Delta t_1(s)$
	0.3520	0.9558	0.8320	1.2064	2.2018	3.0336	-	-	$\Delta t_0(s)$
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	

Table 2: Regular wire bonds parameters

5 Potting regular wire bonds

The usual place to make a bond is the center of the pad, in both the HDI and the mondule; these bond are called “regular wire bonds” (Figure 10). For regular wire bonds all the bonds will be on a line from the first to the last pad. Sometimes, due to several reasons, the bonds does not stick where they should be and they need to be shifted; these are called “irregular wire bonds” and for potting purposes they needs to be treated in a special way because they won’t be on the regular potting line. A complete module has 16 ROC’s and their 16 counterparts in the HDI, and both sides have to be potted. Additionally, the token bit manager (TBM) is also wirebonded to the HDI in its 4 sides, so in total we have to make 40 sylgard lines. Our approach is to define the parameters for every single line and then dispense the sylgard individually.

Lets describe in detail the potting process for regular wire bonds.

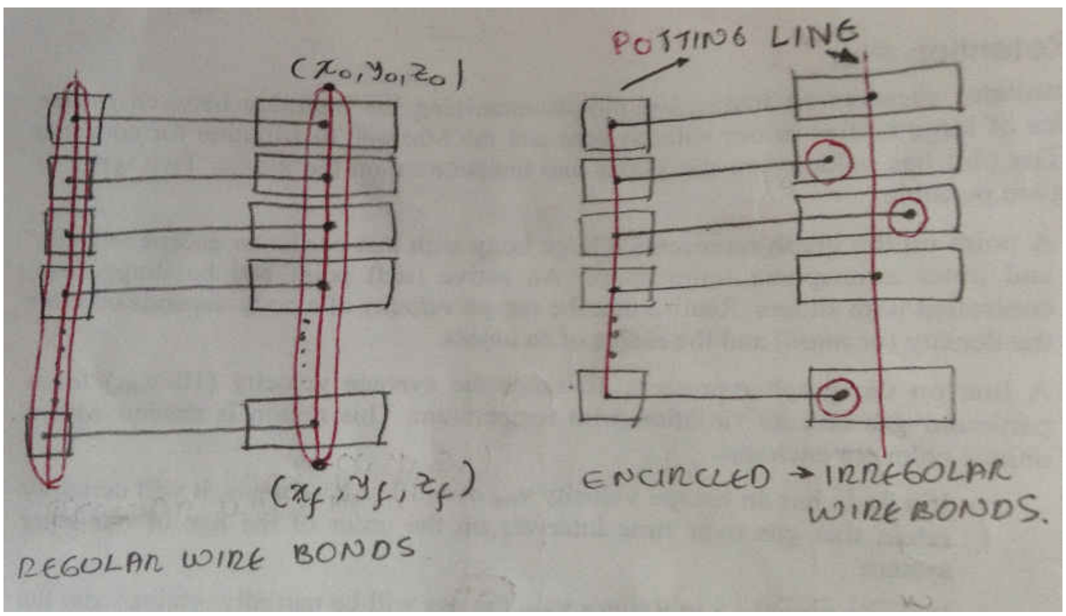

Figure 9: Left: regular wire bonds; right: irregular wire bond

To define the sylgard line or potting line, we need to determine

- Initial position:(x_o, y_o, z_o)
- Final position:(x_f, y_f, z_f)
- Element to encapsulate (HDI, ROC, TBM)

line #	x_i (mm)	y_1 (mm)	z_i (mm)	x_f (mm)	y_f (mm)	z_f (mm)	v (mm/s)	h (μm)
1	335.276	227.873	62.532	335.294	235.864	62.543	6	200
2	335.282	238.645	62.602	335.289	248.514	62.523	5.2	100
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$

Table 3: Regular wire bonds parameters

- Potting height: h (section 4)
- potting speed: V (section 3)

Using the gantry head camera, determine the initial and final positions, then, according to the element to encapsulate, define the potting height (recall: for the ROC's the wire slope is bigger than the HDI wires slope (see figure 8)) and then determine the potting speed. Do the same for every line. Once all the information is gathered, just go and deliver the 40 sylgard lines.

In general, the potting line live in 3D because the module is not perfectly aligned with respect to the coordinate system (the HDI neither) and even thought the ROC's are flat, the HDI could be bent, so the gantry motion is carried in 3D; of course the displacements in each direction are determined from the initial and final positions. All the motions are done in the same time interval, so the speed for each direction is different, however, the displacement in y-direction (8 mm; recall: the time delays calibration in the section 3 takes into account this distance)) is much larger than in x and z directions (which we expect are the about 10-50 μm), so essentially the potting speed is the same as the speed in y-direction.

The front panel of the potting software will show a table similar to the one showed in the table 3

An important task is to determine if there is any irregular wire bond; to do that, we will use the fact that we need to go from the initial to final position for every line and by using the gantry head camera we can inspect the wire bonds in the way. If an irregular wire bond appears we can mark that line as such and skip it in the regular potting process. An alternative to this search could come from the wire bonding process itself as a report.

6 Potting irregular wire bonds

A simple approach to pot irregular wire bonds is to redefine the sylgard line as a set of parts, but it imply a more complex space-time synchronization. We need to learn how wide is the sylgard squeezing and if it is wide enough to cover the irregular wire bonds completely; if so, then it is not an issue anymore. Another option is to use a wider needle and change the reference to deposit the sylgard, in that case we will have a wider sylgard line but also more sylgard deposited. Conclusion: more investigation on this part is needed.

7 Potting flow chart

The complete potting process is described by the potting flow chart showed in the figure **??**

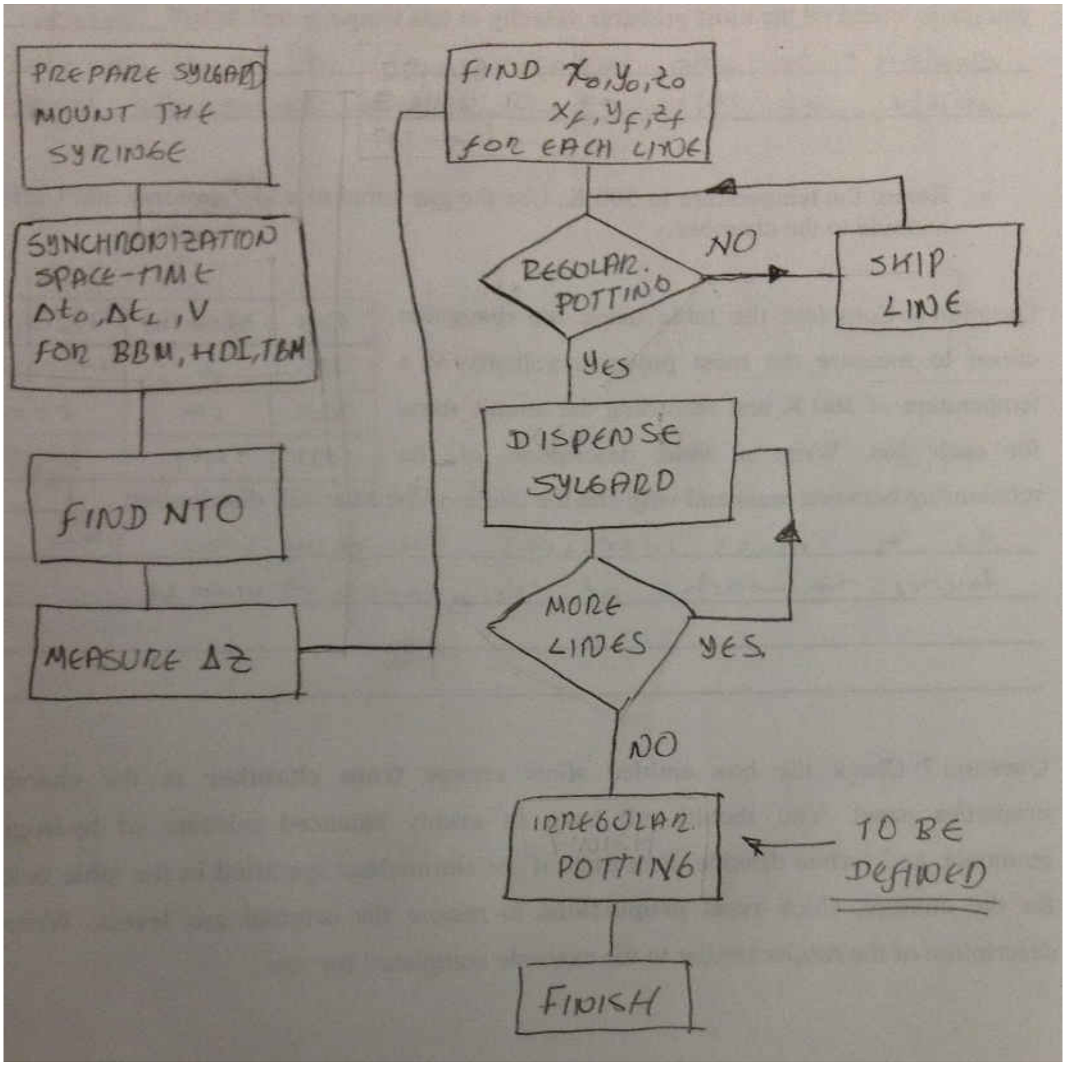

Figure 10: potting flow chart