Instruments Setting Up guiding for Wafer Electric Measurements

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To set up the instruments for wafer measurements, there are basically two functions that are needed to be achieved:

1. Controlling Dual Output DC Power Supply (PS) and Digital Multimeter (DMM) by programming or software.
2. Configurating Probe station including microscope, probes, measuring platform and air pump.

Part 1 Controlling Instruments

Please be noted that this guidance only fits Agilent (Keysight) all series PS and DMM products. To start prepare yourself on setting up, a software named *Keysight BenchVue* (for windows only) should be installed first. *Keysight BenchVue* is a graphical programming package that contains several applications for different products. Once you finish installing *Keysight BenchVue*, run it. Check out the UI Guide for the software.

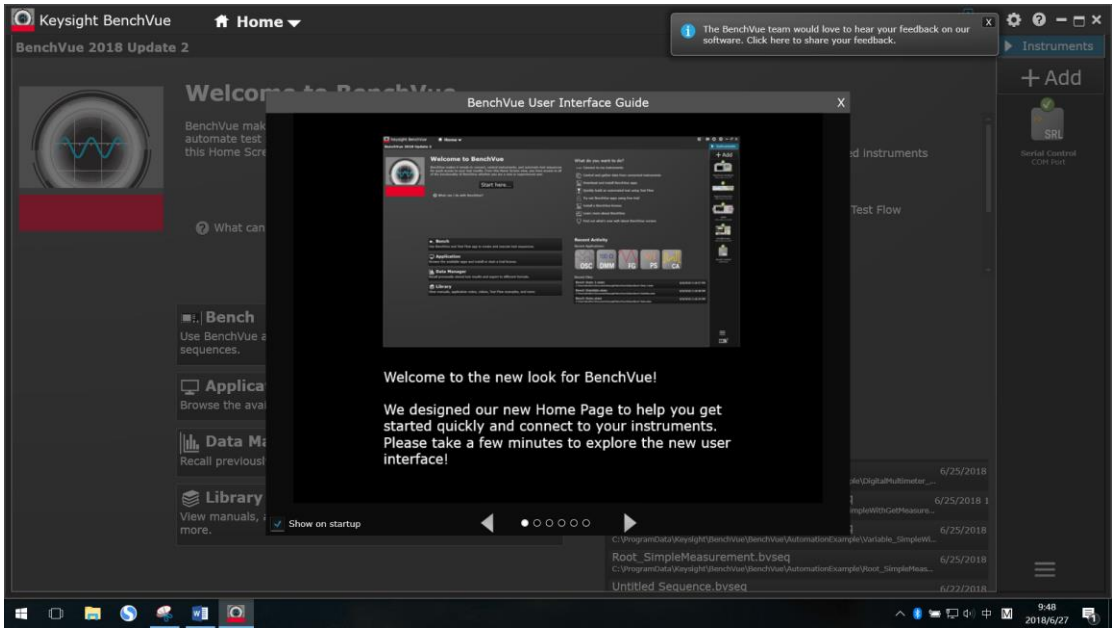


Figure 1 Keysight BenchVue UI Guide

Click *Home –> Applications* and install two applications, namely *BenchVue DMM* and *BenchVue Power Supply*. These two applications require licenses while they also allow a 30 days Trial.

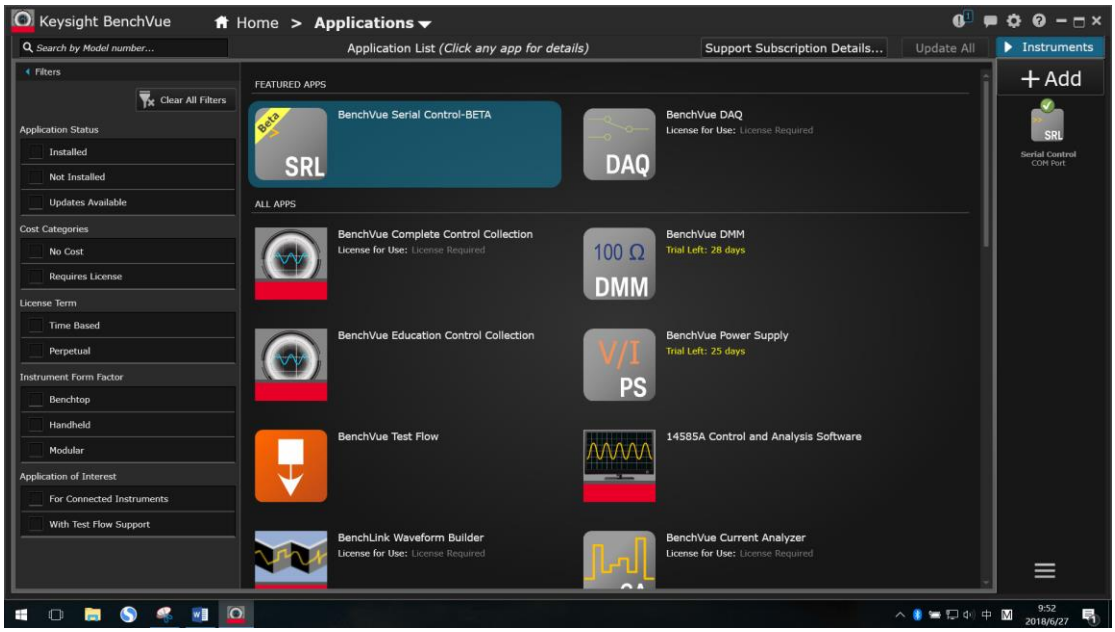


Figure 2 Keysight BenchVue Applications

Figure 3 Agilent Power Supply (E3647A) & Agilent Digital Multimeter (34401A)

Find your Agilent devices (PS & DMM, shown in Figure 3), GPIB and USB/GPIB interface (shown in Figure 4). Connect the two connectors of GPIB into PS and DMM respectively (as shown in Figure 5). Please be noted that we use GPIB to connect the instruments, in this case we have two instruments so we will only one use GPIB. If we need more instruments, then more GPIB are required to hook up the instruments.

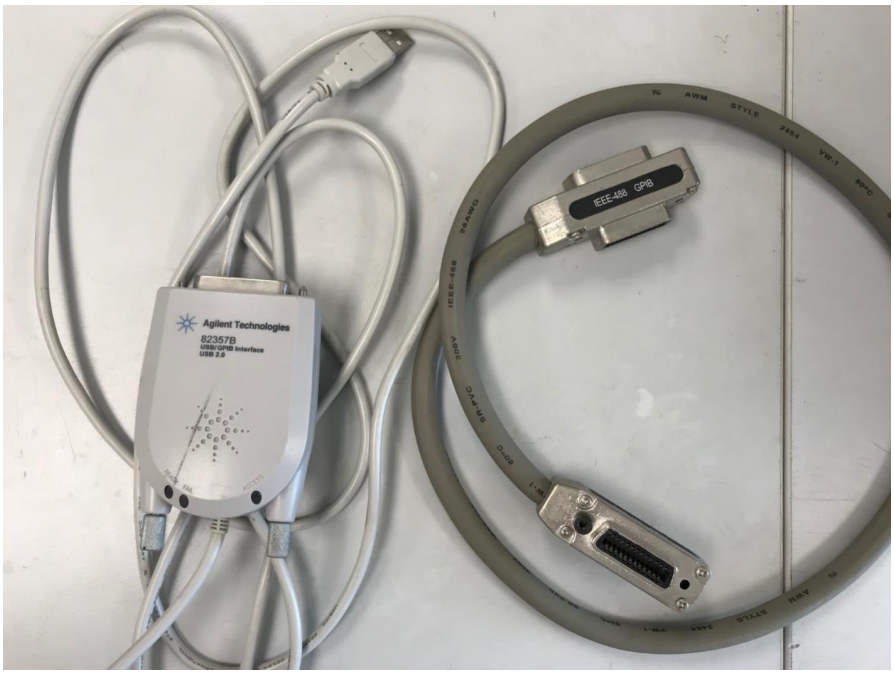


Figure 4 USB/ GPIB Interface (left) & GPIB (right)

Figure 5 Connect GPIB into PS and DMM

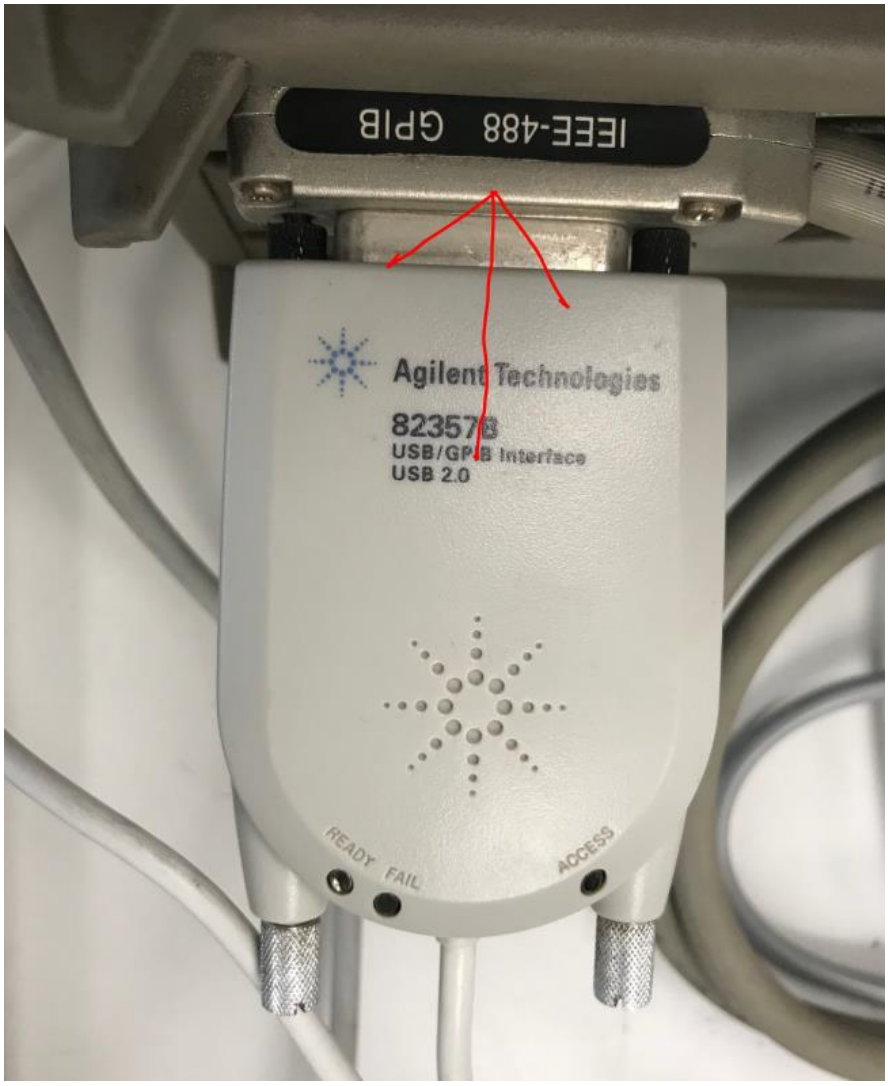


Figure 6 Connect USB/GPIB Interface into GPIB (either one)

Once you finish connecting the two connectors into GPIB, plug the USB/GPIB interface into either one of the two connectors of GPIB to connect the instruments to your computer (as shown in Figure 6 and Figure 7). Figure 7 shows the finished connection, the last step is plug their power supply cable (not Dual Output DC Power Supply). Then connect the USB from USB/GPIB interface to your computer.

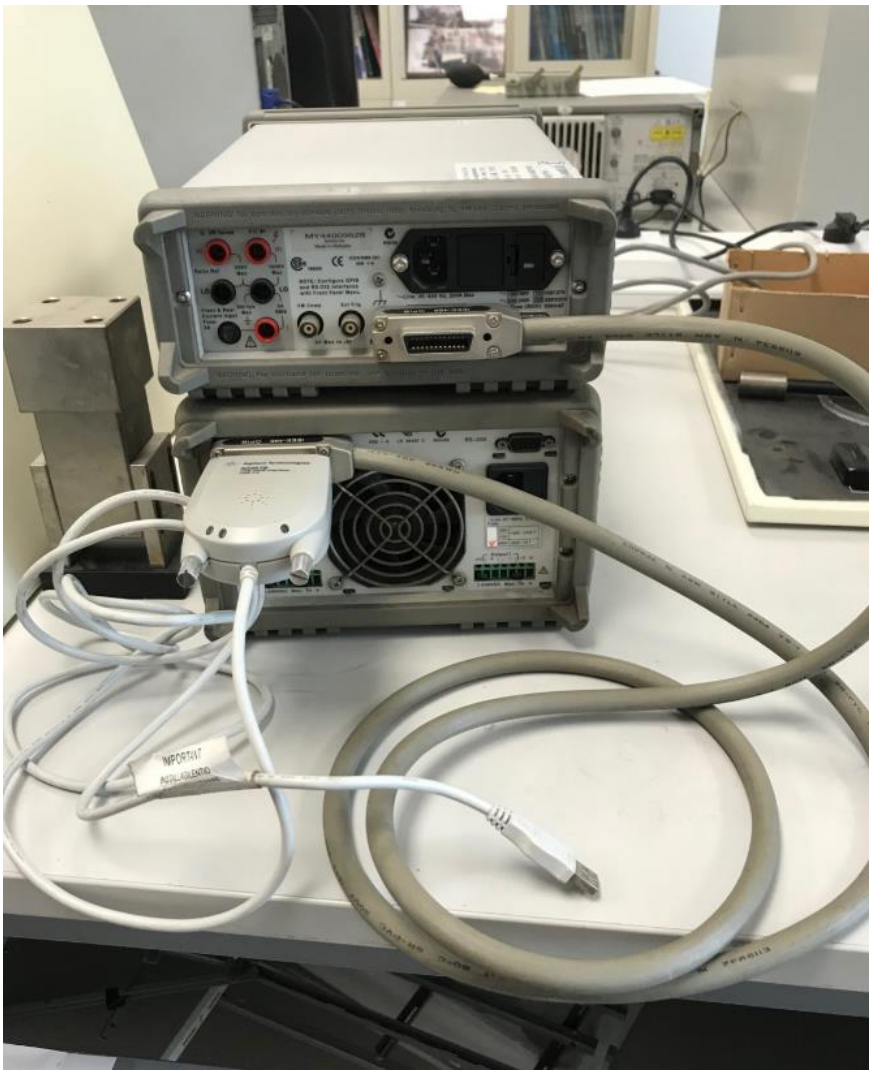


Figure 7 Connected instruments

Once you have finished the previous steps, your *Keysight BenchVue* should automatically detect the connected instruments and show them in the *Instruments* column in the right side of the user interface of *Keysight BenchVue* (shown in Figure 8). Click them one by one to launch the application you have installed (*BenchVue Power Supply* and *BenchVue DMM*)

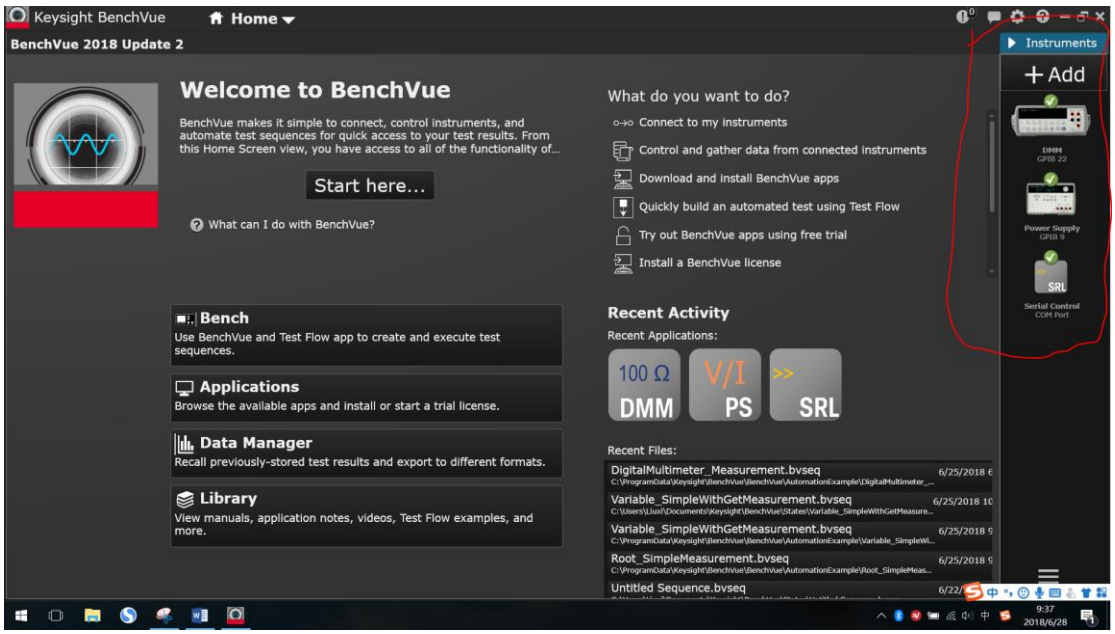


Figure 8 Instruments column

Then the user interface will become more meaningful as shown in Figure 9, click the red circled tool symbol to direct to the instruments controlling menu. The controlling menu will work together with the *test flow* in the right side.

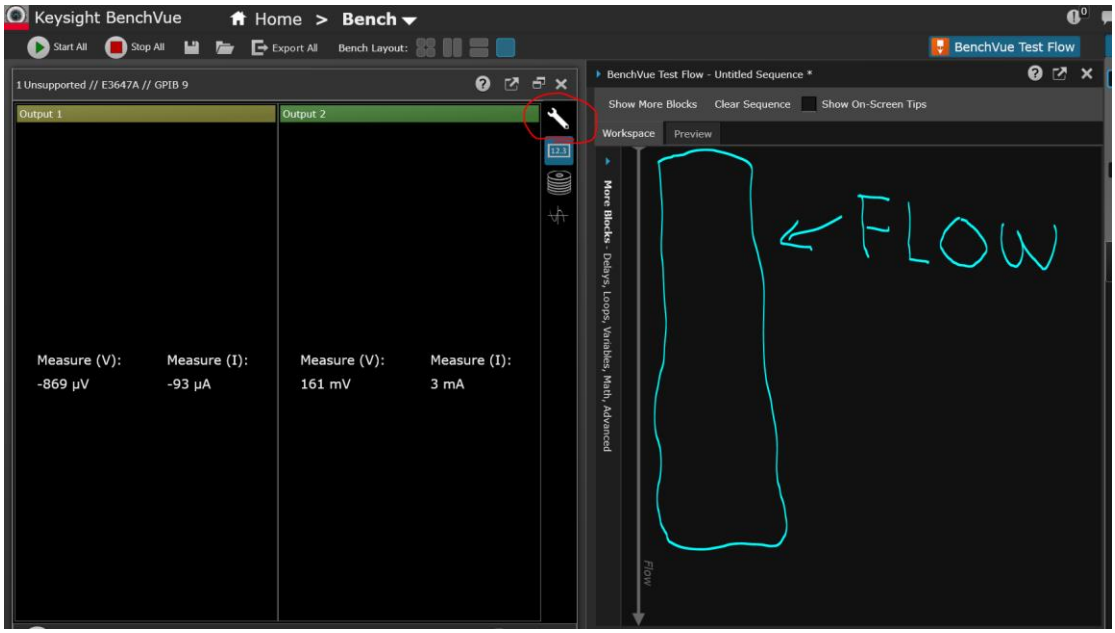


Figure 9 Launched applications

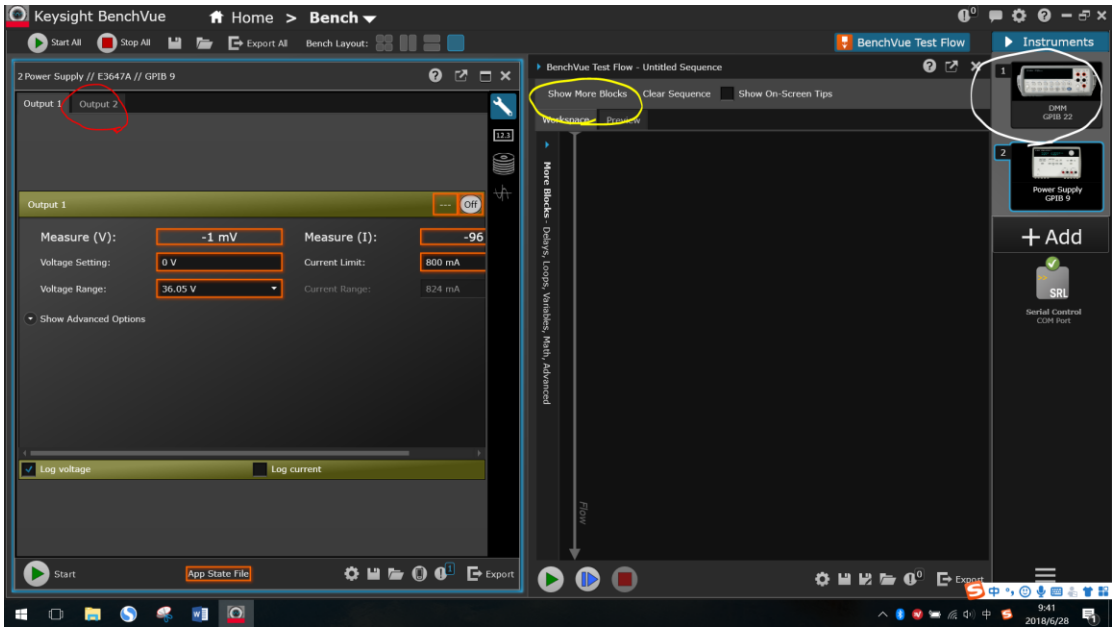


Figure 10 Controlling menu

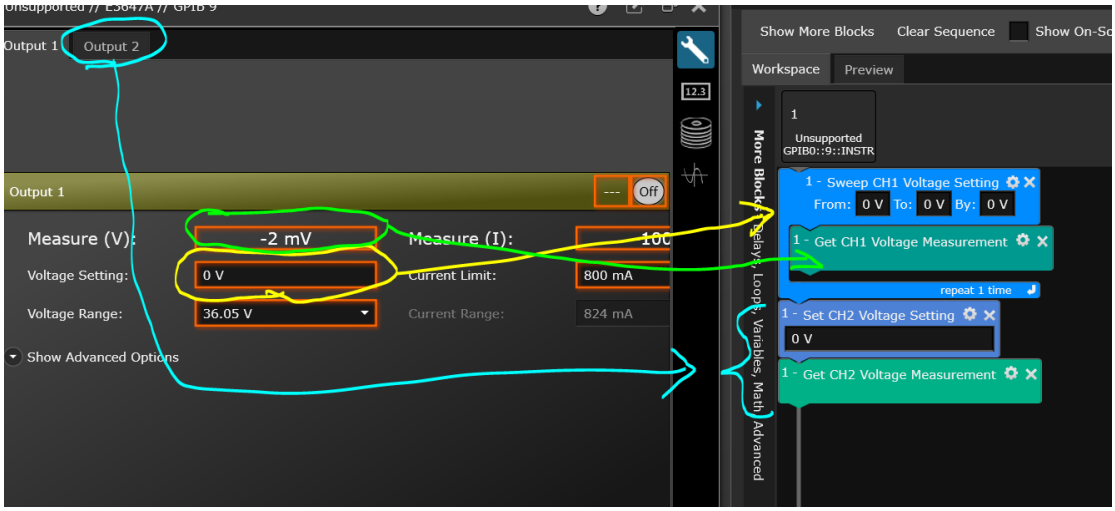


Figure 11 Test flow

Figure 10 shows the controlling menu for PS, you can simply click the DMM symbol in the *instruments* column in the right side to shaft it to DMM control (as shown in Figure 12). Let's back to PS control by click the PS symbol in the *instruments* column. As shown in Figure 11, you can simply start your controlling by directly drag any orange box into the test flow. When you are dragging the boxes, it requires you to choose its property (*set*, *sweep*, *list*, *get*). The yellow circle shows a *sweep* that you can make your output changing in a range with a specific interval. While the green circle shows a *get* that you can get the measurement of output voltage from your power supply. You can also control your second power supply output by click the cyan circle. *Set* is shown with the cyan circle that you can set a constant value for your output.

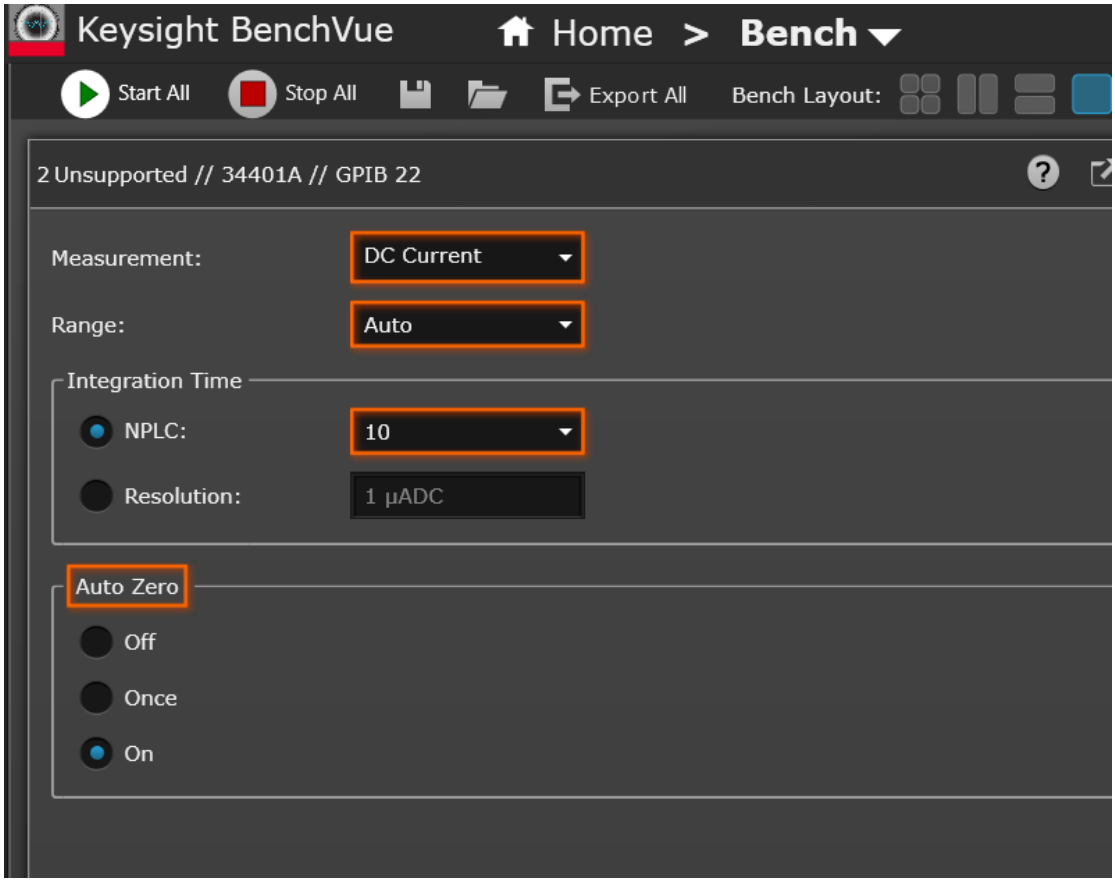


Figure 12 Controlling menu of DMM

Once you have finished trying the PS controlling, click DMM symbol in *instrument* to control your DMM right away (shown in Figure 12). Firstly you want to make sure what measurements do you want from the DMM, simply set the measurement type in the *measurement* shown in Figure 12. In this case, DC current is required to be measured. So the *measurement* is set to be DC current. Now you see that you have no place from this menu to get your measurements value, the measurements getting is located in *Show/Hide More Blocks* (shown in Figure 13). Choose your measurement instrument which is DMM in this case and drag *measurement value* into your flow to get your measurements !

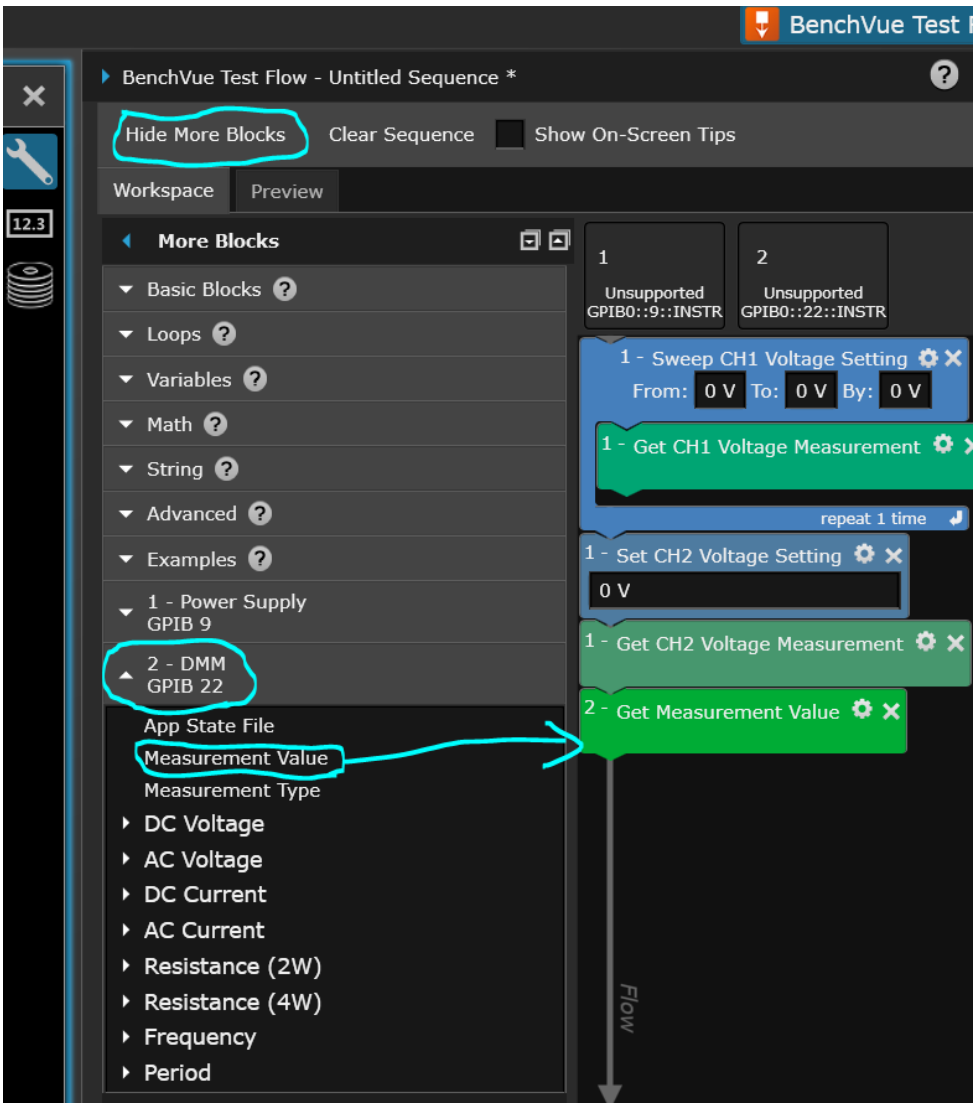


Figure 13 Get DMM measurements

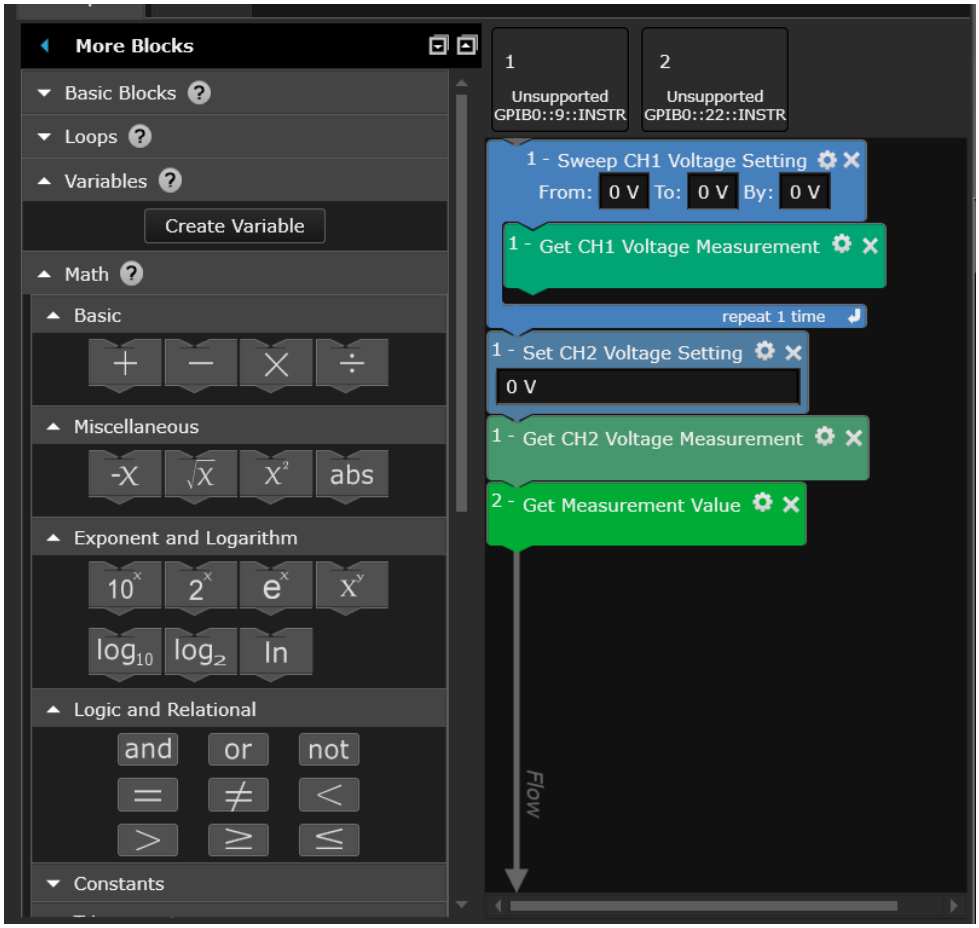


Figure 14 BenchVue supported blocks

What's more amazing, *Keysight BenchVue* is graphical programming tool as I mentioned at beginning, you can almost find anything from the blocks. Even you don't know how to program, it will help you to finish your testing as long as you have some logics.

Now, let's test your configurated instruments to make sure this part is successfully finished. Get a LED and a resistor and construct a series-connecting circuit for testing. We know that the I-V characteristics of a LED should have an exponential behavior in a proper built circuit. Please be noted that you need to make sure your LED is under forward bias otherwise you will not get the correct results.

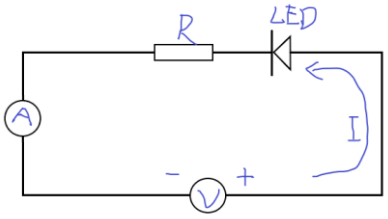


Figure 15 Testing circuit

We will firstly test the output channel 1. To achieve the testing, your instrument test flow should be set as shown in Figure 16. Then click *Preview –> X-Y Chart* to have a better view during the testing.

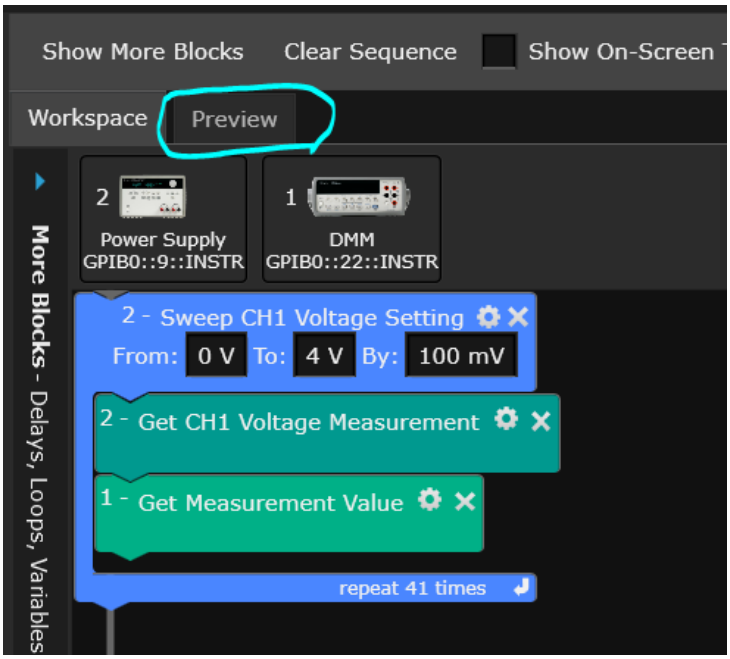


Figure 16 Test flow for testing

Figure 17 Power supply turning on

Figure 18 Testing results preview

As shown in Figure 18, you can choose your x-axis and y-axis to the measurements you want, then click *start* in the red circle to start your testing. Don't forget to turn on the power output by click *off* as shown in Figure 17. Once you start the testing, you will see a very neat exponential curve if you have configurated correctly as shown in Figure 19. You can simply export your testing results with all the details in the formation of excel, MATLAB, word and CSV by clicking cyan circle. You can test output CH2 in the same way as CH1.

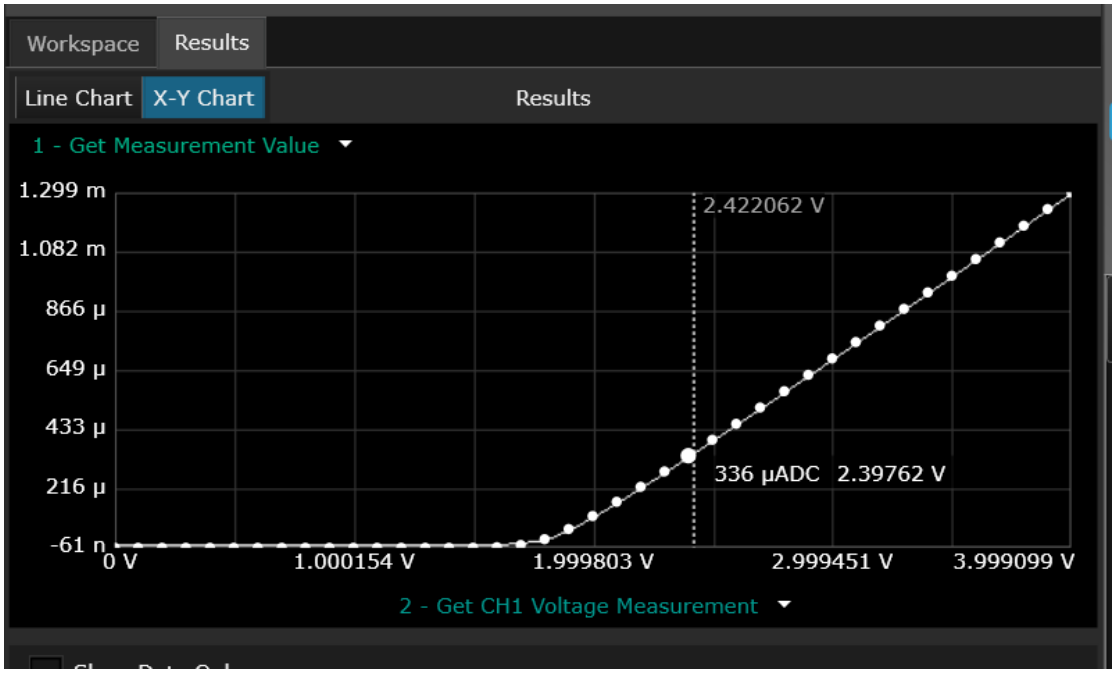
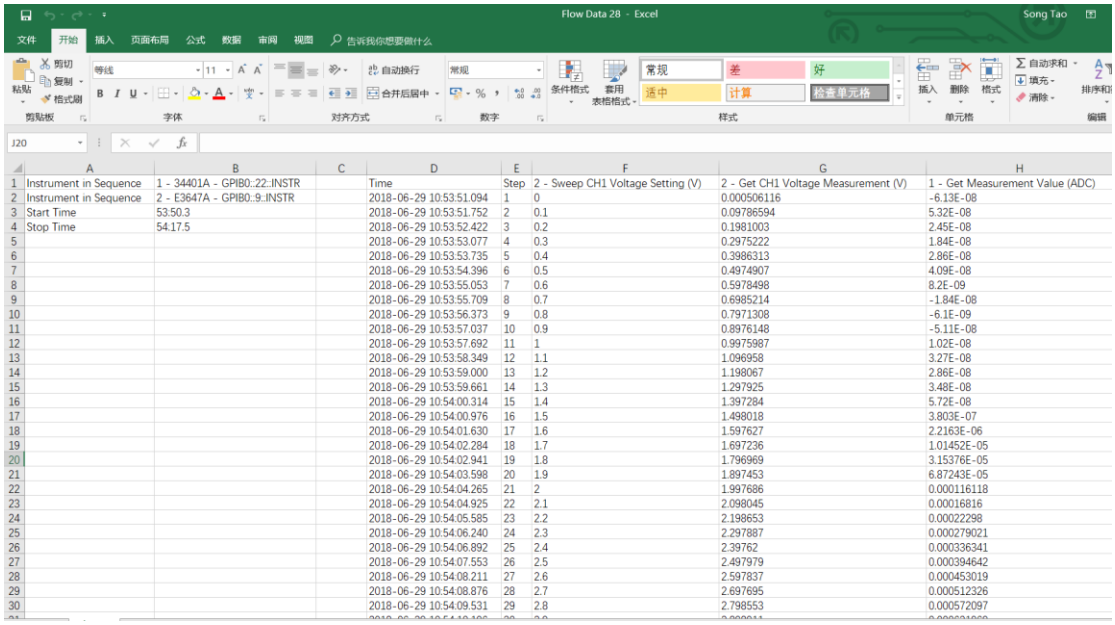


Figure 19 Exponential I-V behavior of LED



Flow Data 28 - Excel

	A	B	C	D	E	F	G	H
1	Instrument in Sequence	1 - 34401A - GPIB0::22::INSTR		Time	Step	2 - Sweep CH1 Voltage Setting (V)	2 - Get CH1 Voltage Measurement (V)	1 - Get Measurement Value (ADC)
2	Instrument in Sequence	2 - E3647A - GPIB0::9::INSTR		2018-06-29 10:53:51.094	1	0	0.000506116	-6.13E-08
3	Start Time	53:50.3		2018-06-29 10:53:51.752	2	0.1	0.09786594	5.32E-08
4	Stop Time	54:17.5		2018-06-29 10:53:52.422	3	0.2	0.1981003	2.45E-08
5				2018-06-29 10:53:53.077	4	0.3	0.2975222	1.84E-08
6				2018-06-29 10:53:53.735	5	0.4	0.3986313	2.86E-08
7				2018-06-29 10:53:54.396	6	0.5	0.4974907	4.09E-08
8				2018-06-29 10:53:55.053	7	0.6	0.5978498	8.2E-09
9				2018-06-29 10:53:55.709	8	0.7	0.6985214	-1.84E-08
10				2018-06-29 10:53:56.373	9	0.8	0.7971308	-6.1E-09
11				2018-06-29 10:53:57.037	10	0.9	0.8976148	-5.11E-08
12				2018-06-29 10:53:57.692	11	1	0.9975987	1.02E-08
13				2018-06-29 10:53:58.349	12	1.1	1.096958	3.27E-08
14				2018-06-29 10:53:59.000	13	1.2	1.198067	2.86E-08
15				2018-06-29 10:53:59.661	14	1.3	1.297925	3.48E-08
16				2018-06-29 10:54:00.314	15	1.4	1.397284	5.72E-08
17				2018-06-29 10:54:00.976	16	1.5	1.498018	3.803E-07
18				2018-06-29 10:54:01.630	17	1.6	1.597627	2.2163E-06
19				2018-06-29 10:54:02.284	18	1.7	1.697236	1.01452E-05
20				2018-06-29 10:54:02.941	19	1.8	1.796969	3.15376E-05
21				2018-06-29 10:54:03.598	20	1.9	1.897453	6.87243E-05
22				2018-06-29 10:54:04.265	21	2	1.997686	0.000116118
23				2018-06-29 10:54:04.925	22	2.1	2.098045	0.00016816
24				2018-06-29 10:54:05.585	23	2.2	2.198653	0.00022298
25				2018-06-29 10:54:06.240	24	2.3	2.297887	0.000279021
26				2018-06-29 10:54:06.892	25	2.4	2.39762	0.000336341
27				2018-06-29 10:54:07.553	26	2.5	2.497979	0.000394642
28				2018-06-29 10:54:08.211	27	2.6	2.597837	0.000453019
29				2018-06-29 10:54:08.876	28	2.7	2.697695	0.000512326
30				2018-06-29 10:54:09.531	29	2.8	2.798553	0.000572097

Figure 20 Testing results exported in Excel

There is also another way that I am strongly recommend you to perform the test. Find a transistor (e.g. JFET) and test its Drain current vs Drain - Source voltage and Gate - Source voltage. It will benefit your further measurements and get your familiar with the I-V characteristics of FET as well as testing all the three terminals at the same time.

Once you have successfully finished the testing, that means your instruments controlling part has successfully finished.

Part 2 Probes Station Building Up

Wafer measurements are not same as normal electronic devices since the contacts on wafer are tiny. A microscope is required when you perform the electric measurements on wafer (as shown in Figure 21).

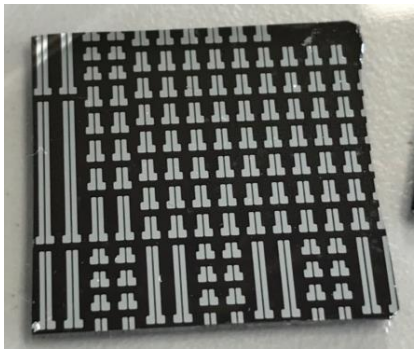


Figure 21 Wafer

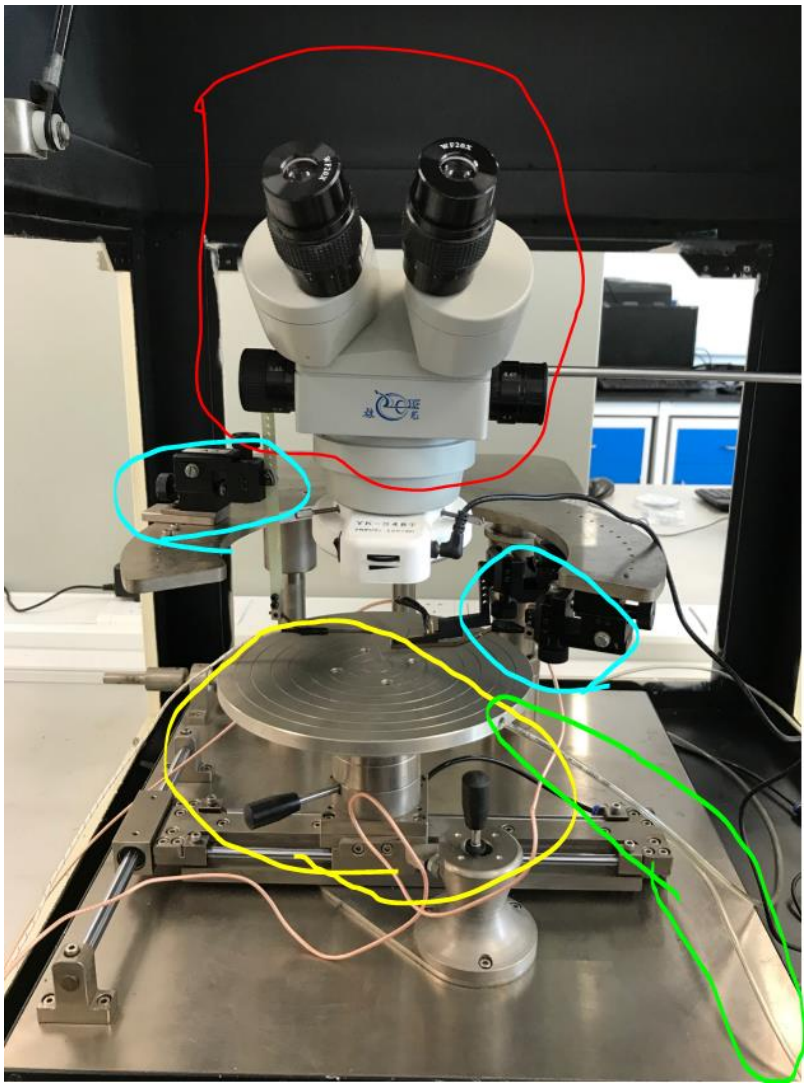


Figure 22 Probes Station

Figure 22 shows a configurated probes station which contain four major components.

The one in the red circle is called a microscope. Probes are shown inside the cyan circles. While the yellow circle shows the measuring platform that is moveable. The measuring platform is connected to a tube (green circle) that eventually connected to the air pump to keep the measured wafer stable.

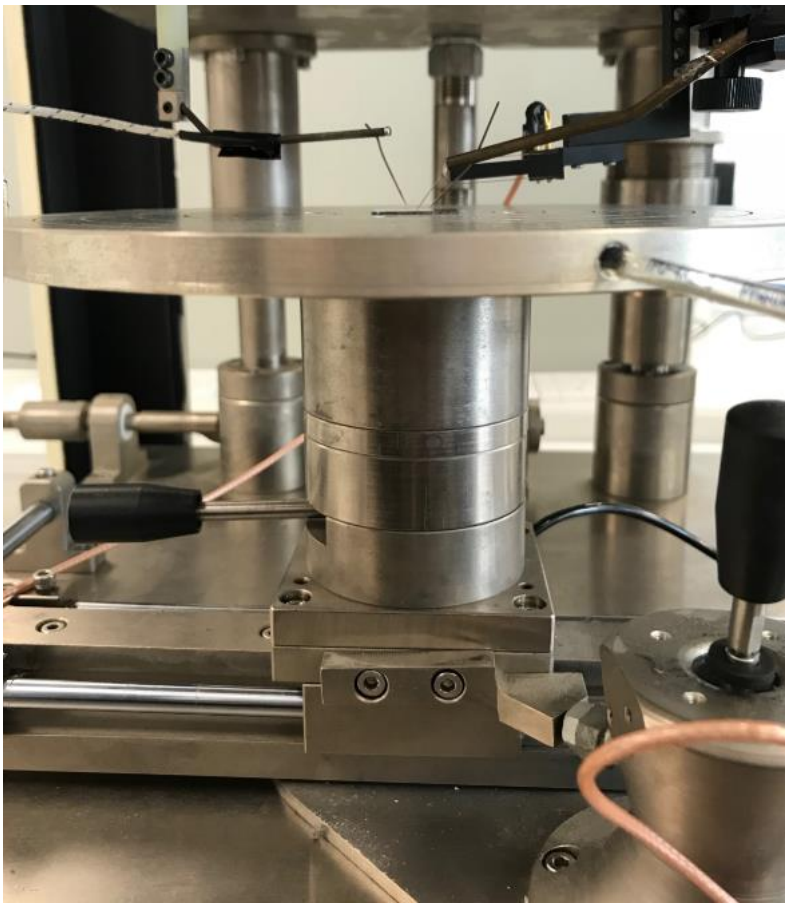


Figure 23 Platform configuration

The component shown in Figure 23 is corresponding to the yellow circled part in Figure 22. The construction of this part is all about screwing while all the components must be connected following a specific sequence otherwise connections may fail.

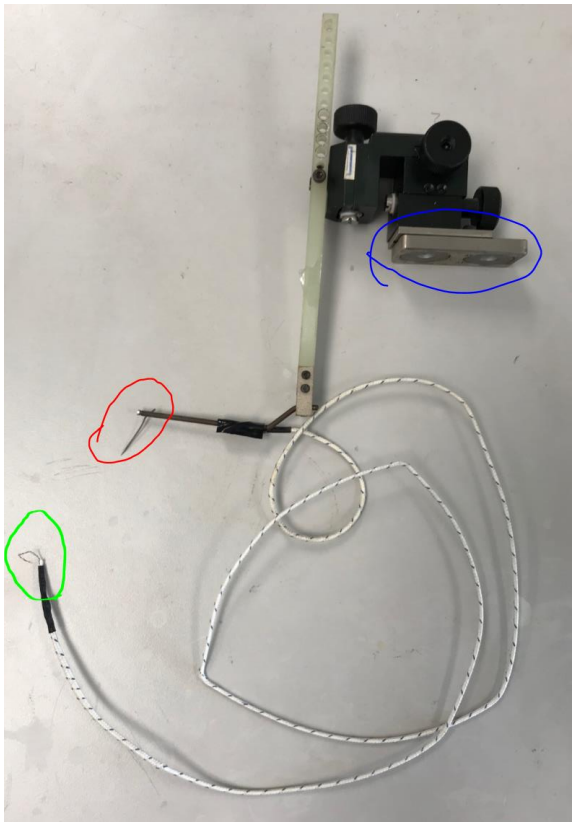


Figure 24 Probe

Figure 24 shows a probe that is used to contact the wafer on the measuring platform. The probe is a simple physical structure that working as a conductor. A needle (red circle) is placed on one side of the structure to contact the wafer, from which the current will go through the needle to the conduction line and then eventually to the instrument that connected into the other side (green circle). This is the basic working principle for probe measuring. However, the structures may not fit the height of platform, microscope and the probe holder that connected to the blue circled part by magnet. You may need to adjust or change the structure of the probe to fit the probe station following the simple working principles described above. Usually at least two probes are needed for wafer measuring, capacitors require two probes while transistors usually need three probes.

Figure 25 Microscope

The third part is microscope, connect the components as shown in Figure 25 if they come in that way. Plug the connected microscope into its holder (the white ring) shown in Figure 26. The focus of this microscope can be adjusted by using the three screws shown in Figure 27, the sequence is from left to right (adjust the screw in red circle first for a rough observing, and then adjust the screws in green and yellow circle for clearer view).

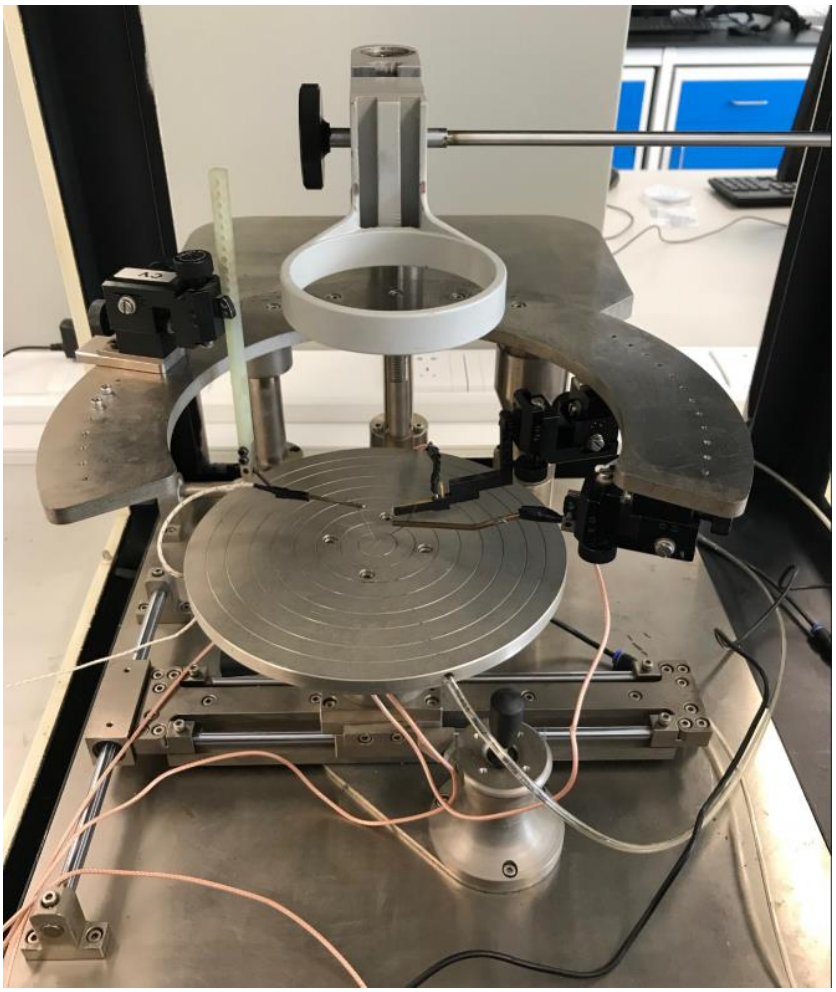


Figure 26 Microscope holder

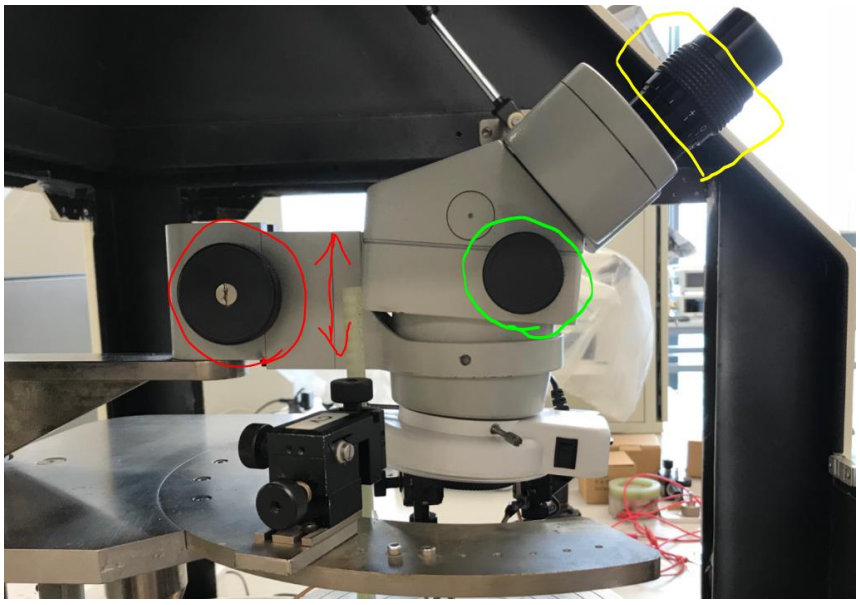


Figure 27 Adjusting screws

Figure 28 Air pump

The last part we need connect is the air pump (shown in Figure 28). It is supposed to be three tubes that related to the air pump. The first one is the yellow one in Figure 28 and the tube labeled ① in Figure 29, these two are actually the two terminals of one tube which connects the probe station and air pump.

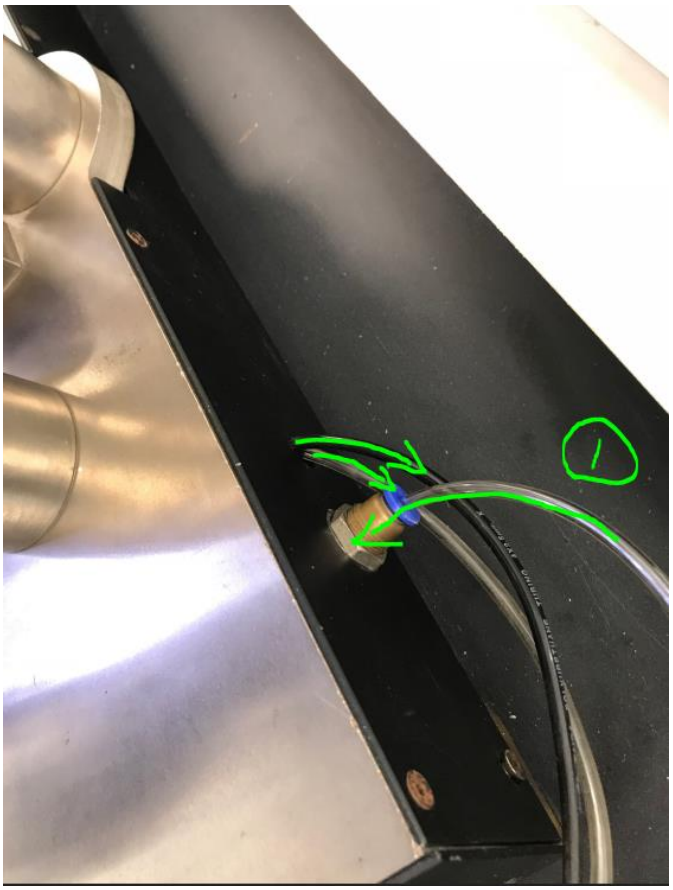


Figure 29 Air pump connection in the back of probe station

The two tubes that are labeled “going out”, one of them will be connected into the plate of the probes station which you don’t need to worry about. While the other one should go into the measuring platform as shown in Figure 30. It is able to be observed that there are several holes in line with the tube which are used to suck the wafer.

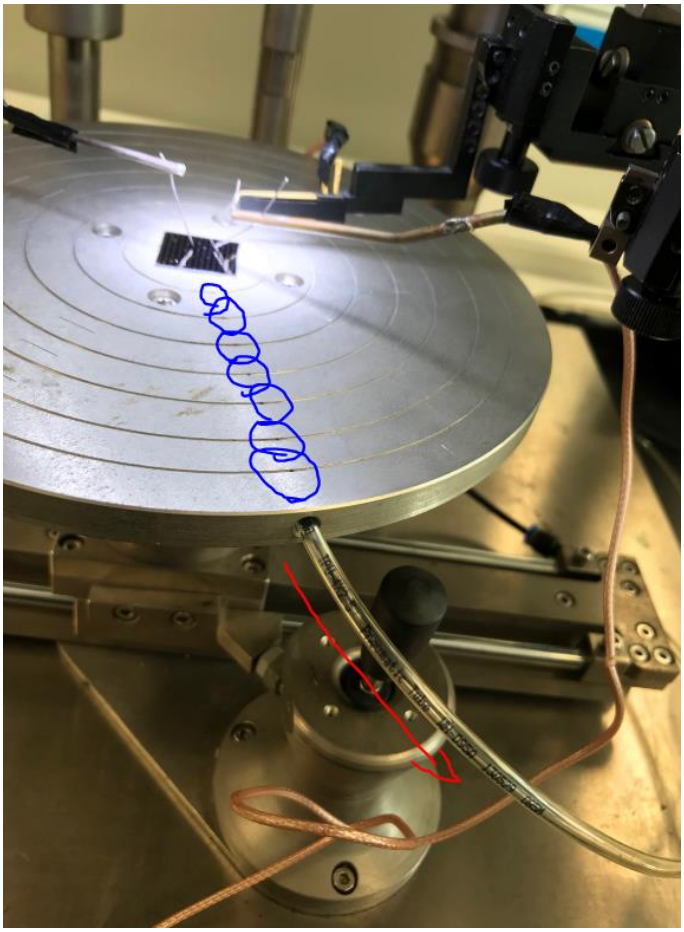


Figure 30 Air pump connector and holes

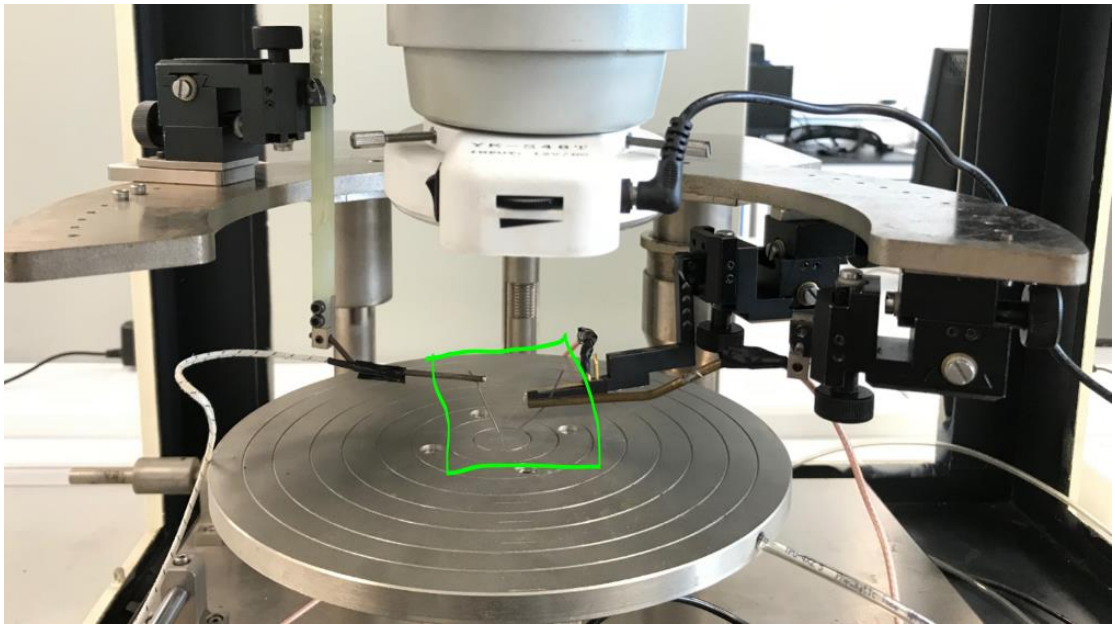


Figure 31 Probes

Once you have finished construct the four parts of the probe station, you can adjust the focus of microscope for further measurements. Before you start your

measurements, here are some ways for you to test your connections of probes. You can try to test a resistor or LED using probes to make sure the probes are well conducted. Furthermore, the wafer will be placed on the area that is inside the green circle in Figure 31 for the better observation (because of lighting).

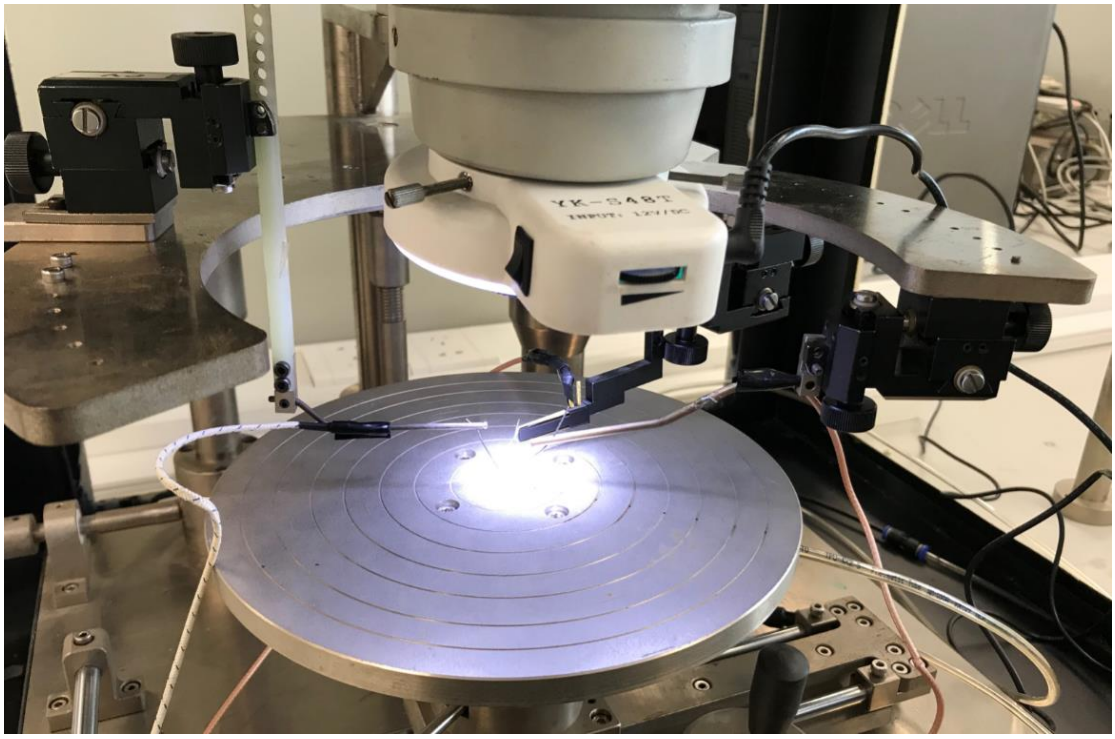


Figure 32 Observing lights

Now what you need to do is that adjust the focus of microscope by turning the screws described previously, a well focused microscope should have the views of Figure 33 (without wafer and with wafer).

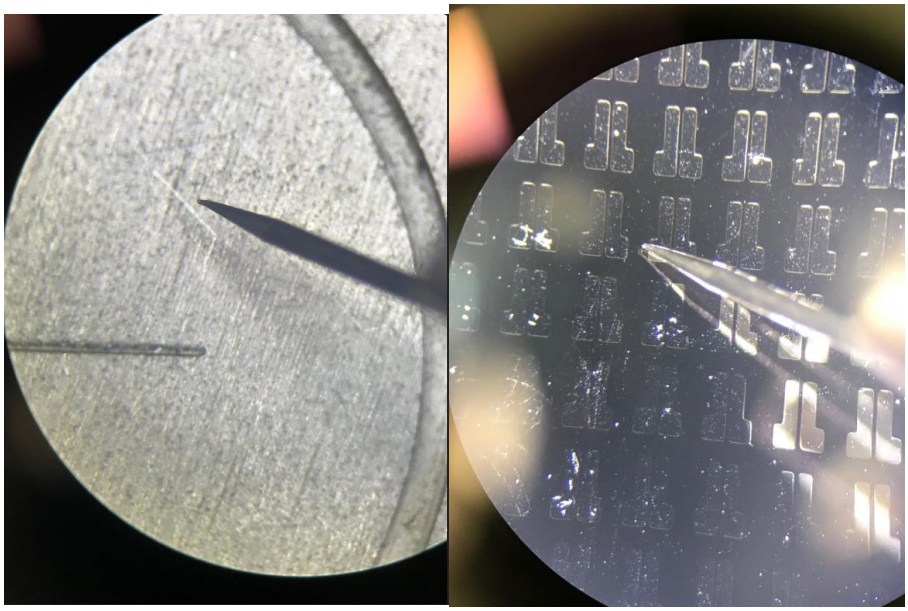


Figure 33 Focusing

At this stage, the configuration of probes station has been finished with the remaining unconnected conduction lines from the probes. Simply connect them with your measuring instruments and happy measuring !