



# Manual DC-Spark System I

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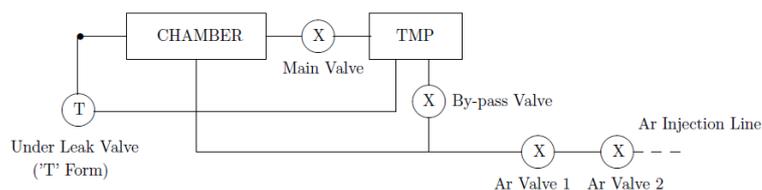


Figure 1: Schematic of System II

## 1 Pumping

- Close every flange, with new Cu gaskets. Screw the flanges 'symmetrically'
- Make sure the main pneumatic valve is closed (in the roughing pump box, placed on the right side of the system, in the rack, it should say that the valve is indeed closed)
- Open the leak valve (T form next to gauges)
- Open the black valve closest to the chamber on the Ar venting line (Ar valve 1, see drawing). The second black valve (Ar valve 2) should be closed
- Open the by-pass valve to pump slowly on the chamber (we don't want the turbo-pump to see atm pressure when main valve is opened)
- Check that the fan for the turbo-pump is on
- Turn on the roughing and the turbo-pump by pressing 'pump-on' on the control panel in the roughing pump box. The valve from the roughing pump to the turbo-pump opens automatically when a difference in pressure is reached, so no oil can come inside the system
- $P < 1$  mbar after a few minutes
- Eventually, the second black valve on the Ar venting line (Ar valve 2) can be opened for a couple of minutes to empty the line. This valve should be closed afterwards, when 1 mbar is reached again
- When the light diode on the roughing box front panel is green (turbo-pump speed is  $> 80\%$ ), open the main pneumatic valve by pressing the button 'open'
- Close the by-pass valve
- Switch on the penning gauge A1 (follow the directions in the front panel of the device IMG300. To switch from one gauge to another press 'Sensor')
- Close the first black valve on the Ar venting line (Ar valve 1)
- After a few hours, pressure should be  $\sim 10^{-7}$  mbar. The bake-out can start

## 2 Bake-out

**Important:** do not start a bake-out if you cannot stay around for approx. 2h, as you'll have to check that everything is working before leaving for the day. See Table 1 for the temperatures and Fig. 2 for the temperature step.

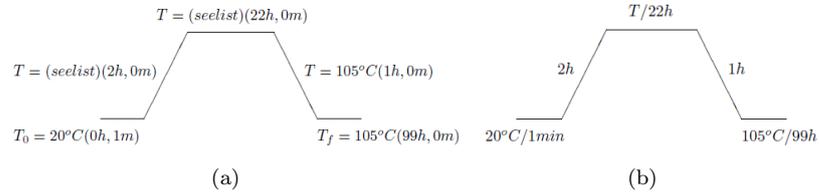
- (a) Put back heaters and thermocouples everywhere it is necessary (sample-holder for example), and wrap the chamber with Al foils
  - Make sure that no rubber cable is in contact with the chamber (could melt)
  - Heating collars do not need to be covered
  - **DO COVER** the view-port (the crystal port)
  - **DO NOT COVER** the magnets
- (b) If present, remove the controller of the gas analyzer
- (c) Check the performance of thermocouples and collars. To do this:
  - Select for example plug 1 (then display 1) in the bake-out rack. Press M (set a higher temperature, for example 40°C with the arrows), press M to confirm. This will give power to the collars connected to plug 1. Make sure all corresponding collars heat up and that the thermocouple is increasing the reading (which means its working)
  - Press again M (use arrows to go back to 20°C), and M again
  - Do the same with all the plugs
- (d) Set the heating programs of the different channels according to the bake-out list (see appendix). To do this:
  - Press F $\Delta$ FMM: This means select Menu, program 1 (with the arrow  $\Delta$ ), and check parameters.
  - Press F to move along the step temperature settings:
    - First parameter (press F once) is the set temperature (initial temperature)
    - The second (press F again) is the hours it should stay at that temperature
    - The third (press F again) the minutes
    - the fourth (press F again) is the second temperature (the temperature it should reach at the top of the step)
    - the fifth parameter (press F again), the hours it should take to reach that temperature
    - the sixth (press F again), the minutes. And so on
  - To change the temperature or time (hours or minutes), whenever in the desired parameter select with the arrows and validate afterwards by pressing 'M'. Keep on navigating through the different parameters.
  - The menu ends when again appears the actual value of the temperatures (usually 20°C)
- (e) Start the program 1 (push F $\Delta$ M)
- (f) From time to time check the pressure and keep an eye on the bake-out rack, could be that some collars are not working properly and the set temperatures are not reached

### 3 Out-gassing (at 105°C)

- (a) Place the RGA on the chamber. Be CAREFUL when placing it, as some pins might bend!
- (b) Connect the power and the RS-232 cables
- (c) To check that the connections are ok, in the computer open Quadstar 422

**Table 1:** Bake-out temperatures

Rack Channel	Plug	Part	T[°C]
1	1	Dome Turbo-Pump	140
2	2	Top RGA	200
3	3	VTA (Top Turbo-Pump)	125
4	4	Chamber Bottom	150
5	5	Injection Line	150
7	7	RGA	200
8	8	Chamber Middle	150
9	9	Chamber Top	150
10	10	Ceramic Piece RGA	150
11	11	Optical Feedthrough	150
12	12	Gauges	150



**Figure 2:** Diagram of the temperatures for the bake-out process.

- (d) To degas the filament, open Quadstar 422 → Tune-up → Setup → Degas Control. The parameters are:
- Filament number: Fil 1
  - Current [mA]: 10.0
  - Protect [A]: 3.50
  - Time [min]: 45
- (e) Click 'Start'. Wait for the degassing to finish
- (f) When the program 'Degas Control' finishes, it leaves the filament on. Switch on the bake-out rack and leave the filament on all the time the chamber is closed (i.e. the experiments are running). In this case no particles or dust can adhere to the filament
- (g) Stop the heating program with program 0 (manual program). Push F0M, FFF and set 20°C with M, arrows, M
- (h) When the system is cold, the pressure should be  $< 10^{-9}$  mbar
- (i) Ready to make sparks!

## 4 How to set the electrodes in position

- (a) First time:
- Connect the beeper to both electrodes
  - Set the tip in zero position (typically 9.00)

- If necessary, adjust the sample position with the Z manipulator. Don't go into contact
  - Approach the sample VERY SLOWLY towards the tip by pushing behind with the linear drive. Warning: turn in reverse direction, i.e. anti-clockwise. Stop as soon as it beeps (electrodes in contact). 2nd warning: go slowly and don't push too hard on the tip, otherwise the ceramic piece holding the tip will break
  - Retract slowly, and when the sound from the beeper goes from continuous to irregular, stop the rotation. Define this as your zero position
  - Retract the tip to its final position (typically to 9.64  $\rightarrow$  gap  $\sim$  20 $\mu$ m)
  - Disconnect the beeper and connect the HV cables
  - Switch on the power supply
  - According to the zero and final position of the tip, calculate the gap distance with *Gap&FieldCalculation.vi*
- (b) To check the gap after a breakdown experiment:
- Switch off the power supply
  - Disconnect HV cables and connect the beeper
  - Approach SLOWLY the tip, and stop as soon as it beeps (it should beep continuously)
  - Read the new zero position and calculate the new gap
  - According to the new zero position, calculate a new final position to have  $\sim$  20 $\mu$ m again
  - Retract the tip to the new final position
  - Disconnect the beeper and connect the HV cables
  - Switch on the power supply
- (c) To move to a new spot:
- Check the final gap if necessary (see 2nd paragraph above).
  - Move away the sample from the tip with linear drive (warning: turn in reverse direction, i.e. clockwise), until it hangs freely
  - Move the sample vertically to the new spot
  - Set the electrodes in position (see 1st paragraph above)

## 5 The sparking experiments

**NOTE: if the RGA is needed during spark tests, make sure that the Aluminum foil around the ceramic piece and the collars (if any) connected to the RGA have been removed, otherwise the RGA and the chamber will be electrically connected!!**

- (a) Start *BetaEvolution\_Ver3.5.vi* (or latest version). This program will alternate FE measurements with Spark Cycle / Breakdown Rate measurements
- (b) Click on the switch 'Breakdown Rate' if you want to make FE / BDR cycles, or leave it unselected if you want to make FE / SC cycles
- (c) Set the zero and the final position of the tip under 'Read0' and 'Read' respectively
- (d) Run the vi
- (e) Click on 'Reset'. This will calculate the gap and initialize the run parameters

- (f) Set 'Nb Cycles', which is the number of cycles FE / SC or FE / BDR
- (g) Set 'Nb runs (sparks) / Cycle', which is the number of sparks within one run of SC, or the number of attempts within one run of BDR. Set this value to 1 if you want to make a FE measurement after each spark or each attempt
- (h) If necessary, modify the lower, upper and step values for the voltage FE scan under 'Vmin FE', 'Vmax FE' and 'DeltaV FE' respectively (typically 200, 6000 and 25). You can also modify the window of current values in which the calculation of beta will be made, under 'Imin FE' and 'Imax FE' (typically  $2 \times 10^{-11}$  and  $10^{-9}$ )
  - If SC is chosen, you can adjust the lower, upper and step values for the voltage under 'Vmin SparkCycle', 'Vmax SparkCycle' and 'DeltaV SparkCycle' respectively (typically 800, 10000 and 200)
  - If BDR is chosen, set the working field under 'BDR Field [MV/m]'. The corresponding working voltage is calculated automatically
  - If necessary, adjust the value of the capacitance (usually 27 nF)
  - If necessary, adjust the trigger level and the timebase of the scope
- (i) If desired, the signals of the scope can be saved. In this case, push 'Save current (CH1)' and other channels if needed. The number of sample points recorded by the scope ('Sample points') and in the file (='Sample points' / 'Sparsing') can be adjusted
- (j) Click on 'Power on' to start the power supply
- (k) Click on 'Start' to begin the measurement
- (l) Enter the names of the files where the values will be saved:
  - First file: all I/V data from all FE scans
  - Second file: only the beta values for all FE scans
  - Third file: only the breakdown field and pressure ratio for each SC run / results of BDR runs
  - Fourth file: complete field and pressure data (all values of every SC runs)
  - Fifth file, if available: values from the scope
- (m) The run is stopped when 'NbCycles' is reached, but it can also be stopped manually at any time by pushing 'End' in the main program (the current cycle will be completed), or 'Stop' in the main program or in any subroutine (the current cycle will be aborted)

## 6 Venting

- (a) Move away the sample from the tip with linear drive (warning: turn in reverse direction, i.e. clockwise), until it hangs freely
- (b) If necessary, turn off the mass spectrometer
- (c) Close the main pneumatic valve by pressing 'close' in the roughing pump box (rack on the right side of the system)
- (d) Make sure that the bypass and the under leak valves are closed
- (e) Switch off the penning gauge A1 by looking at the drawings in the devices IMG 300

- (f) Turn off both pumps by pressing 'Pump-off' in the roughing pump box. After a few seconds they will vent automatically
- (g) Turn off the roughing pump (use the black button on the wall, which switches off both the pump and closes the safety valve)
- (h) Open the red handle on Ar line (in the column). Regulate the manometer if necessary, until it reads 0.1 - 0.3 mbar (its an overpressure). Open the small black valve
- (i) Open SLOWLY the two black valves on the Ar line close to the chamber, but first the farthest one and secondly the closest one. The turbo-pump will slow down. Make sure to have the argon in the system before the turbo-pump reaches low rpm
- (j) Wait for a couple of minutes, until the chamber is filled (check by closing the red handle: if the needle is going down rapidly, gas is still flowing)
- (k) When pressure gauges read atm pressure, close red handle, small valve (close to the red handle) and two black valves on the Ar line
- (l) Remove Al foils, heaters and thermocouple, open the chamber.

## 7 Changing the electrodes

- (a) **Remember to check the perpendicularity of sample and tip before tightening the screws!**
- (b) Before starting:
  - Always wear gloves and use clean tools to operate
  - Be careful with the levering system for the tip: do not lose any of the 5 sapphire balls when screwing and unscrewing the anode!
  - Be careful with the ceramic parts of the sample-holder and of the tip-holder when screwing and unscrewing: they break easily!
  - Check the electrical continuity from the electrodes to the feedthrough before putting them back into the system.

## 8 Safety first

- (a) Always shut down the power supply before manipulating any HV cable!
- (b) Before opening the electric box, always disconnect:
  - the HV cable coming from power supply
  - the cable controlling the switches (24V)
  - the cable at rear powering the Ross solenoid savers (220V)
- (c) Always short circuit the two series of capacitances first, before doing any maintenance inside the electric box. Some charge can still be stored! Use the long grounded security stick for this
- (d) Don't forget to ground the electric box
- (e) Switch on the yellow blinking warning light sign when HV experiments are running

## 9 Saving data: where and what

- (a) Whatever has been done on the system, write it down on the lab's logbook
- (b) Whenever the run is finished and the gap has been check (if needed), save this data to dfs (to be able to access it from any computer):  
G:\Divisions\EST\Groups\SM\ThinFilms\Clic\_Spark\_test\_Project\Lab Measurements\!Measurements Spark System I
- (c) Whenever a spot is finished, fill in the excel file in dfs named !Measurements System I.xlsx, under:  
G:\...\Clic\_Spark\_test\_Project\Lab Measurements\!Measurements Spark System I
- (d) If a SEM analysis report has been sent, save it under:  
G:\...\Clic\_Spark\_test\_Project\Lab Measurements\SEM\_Analyses\SEM\_syst1

## 10 When experiments are finished

If the sample, tip or both are already out of the system, and depending on the analysis is needed, they will be sent out for a SEM analysis.

- (a) Once they are out of the system, wrap them in silk paper, and AFTERWARDS in Al foil (if only wrapped in Al foil the surfaces can be scratched)
- (b) Prepare an excel sheet or any other document where the following information must be included, so the person doing the SEM analysis knows what to look for:
  - Spots and their order, with what has been done on each of them. Usually what is sent is part of the table filled in in !Measurements System I.xlsx
  - A diagram showing the spots and their order in the sample, so they can compare it to the real sample and match spot by spot
- (c) Give sample and/or tip, data sheet and spot's diagram to the person in charge of the SEM analysis

## A Electric Circuit for System I

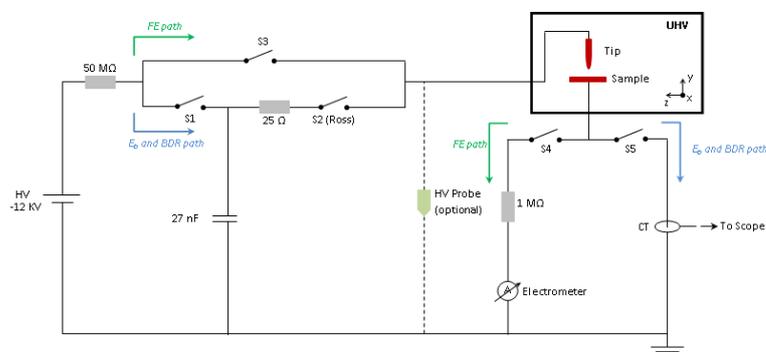


Figure 3: Circuit schematic of system II

To control the switches in Labview, the digital lines that controll them are given in Table 2

**Table 2:** *Digital lines for the switches to be used in LabVIEW*

Switch	LabVIEW
S1	1
S2	2
S3	3
S4	4
S5	6