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# AIRCO TEMESCAL FC 1800 #1
# Operation Manual

## University of Notre Dame
## Department of Electrical Engineering



# General Precautions

## Contacts

For problems, clarification of procedures, or general information pertaining to this machine please contact lab staff at **staff-ndnf-list@nd.edu**.

**IF ANY STEP DOES NOT RESPOND AS IT SHOULD, STOP AND PUT THE TOOL INTO STANDBY AND CONTACT STAFF! If unsure on how to get to standby mode safely, leave the machine as it is and contact staff as soon as possible.**

**In Case of Emergency, Please Contact Notre Dame Security at**

**911**

# Several reminders/precautions:

1. **Metal Verification is MANDATORY –** Failure to verify >50% metal in the crucible can result in serious equipment damage. Refer to page 4 for verification steps.

2. **ONCE E-BEAM IS ON, USERS CANNOT WALK AWAY!!!**

    a. **Users must constantly be watching the source, beam current, dep rate.**

    b. **Alignment and Sweeping of the E-beam is MANDATORY.** Failure to sweep the beam can cause damage to the machine and cause you to lose your privileges to use this machine.

    c. **Do Not Exceed 2 Å/sec**. 1 to 2 Å/sec is normal, deposition Rates > 2 Å/sec can result in damage quickly**.**

    d. **You have to turn off the beam and wait for 10 mins after every 1 hour deposition!**

3. **Ask yourself the following questions before firing the gun:**

    a. **Did I set up the Film Thickness Monitor correctly?** (Refer to page 11)

    b. **Did I set the sample holder in the correct position? (Or did I block the crystal sensor?)**

    c. **Did I see a plastic shield behind the top view port?** Contact staff before proceeding.

    d. **Did I add precious metal (Au, Pd and Pt) additional charges in iLab reservation?**

# Source Material Verification

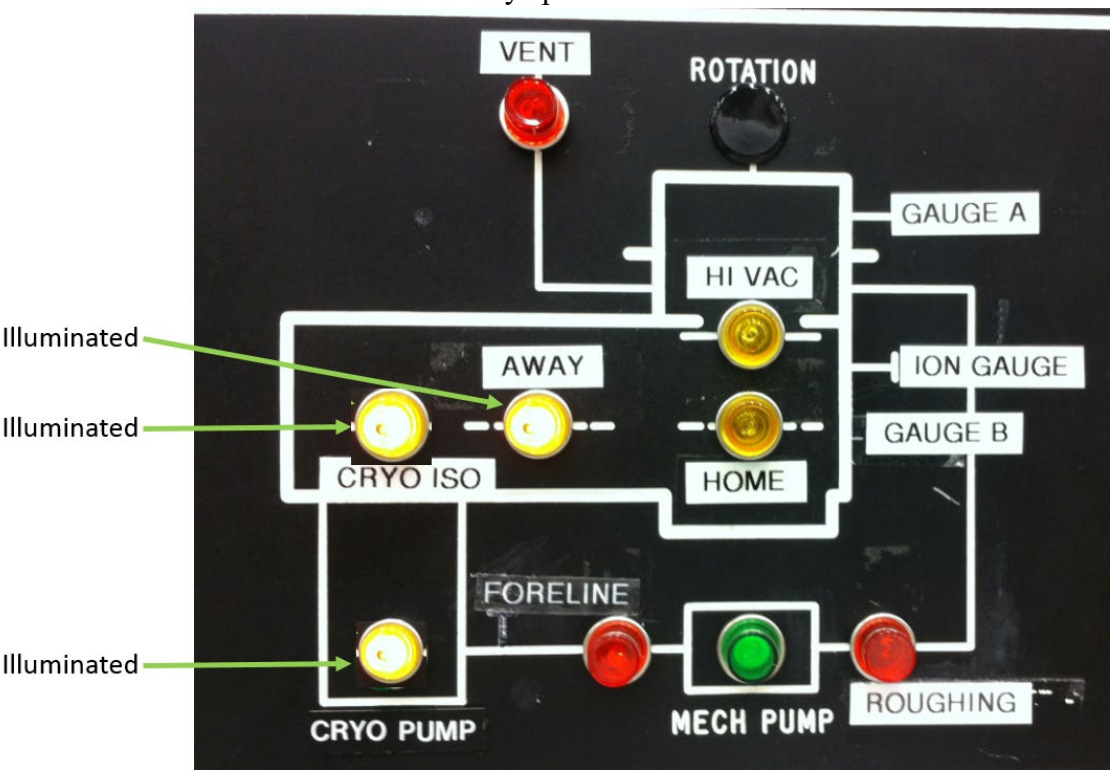
1 – Turn “ON” the chamber light
2 – Open the shutter in the lower portion of the chamber. Advance film (1/4 turn) if necessary
3 – Change Pocket or Turret Selector to appropriate metal and check EVERY desired source level
4 – Turn “OFF” the chamber light after verification.
5 – If crucible needs refill, contact staff; if not, proceed.
6 – Close the lower shutter

!!!!!!!!YOU MUST VERIFY ALL METALS – EVERY TIME!!!!!!!!!

## Standby Conditions:

(These conditions allow for the safest and best conditions for the machine, your safety, and the best results for your research)

1. Main Chamber lid should be closed and under High Vacuum.
2. Valves that should be illuminated, open, or on in Standby conditions on the Automatic Pump Controller (**APC**).
    a. "Cryo Iso."
    b. "Cryo pump"
    c. Gate should be in the "Away" position.



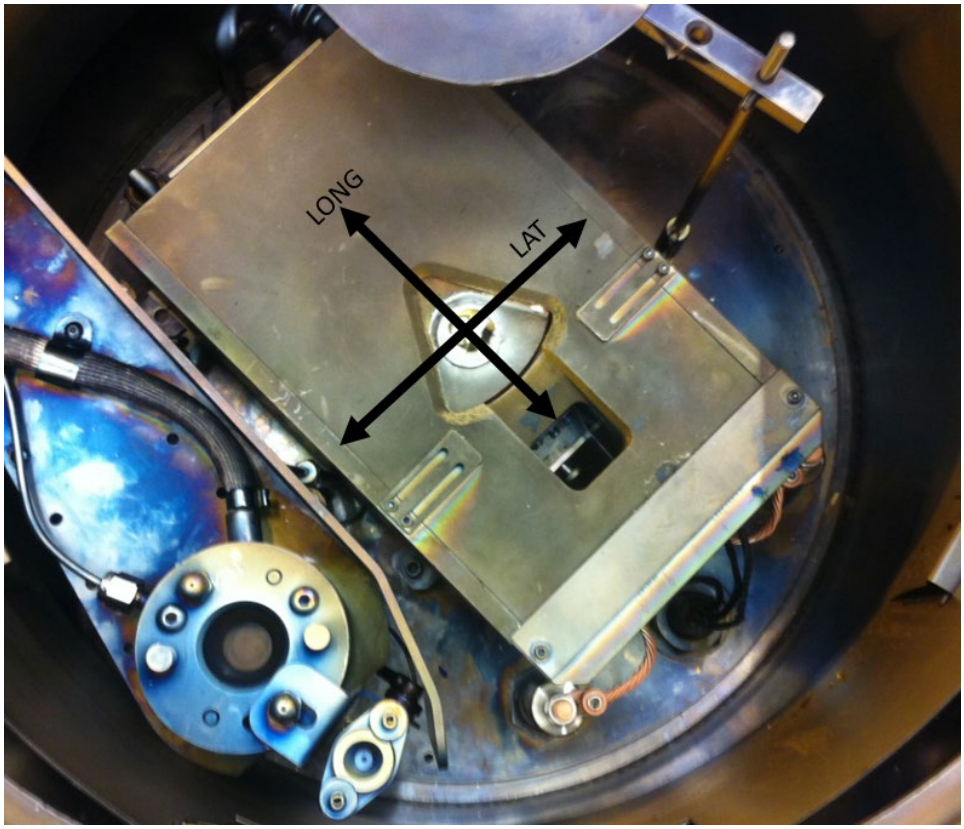

3. Valves that should closed or not be illuminated in Standby Mode.
    a. "Roughing" Valve
    b. "Fore Line" Valve
    c. "Mechanical Pump"
    d. "Vent" Valve
    e. "Hi Vac" Position
    f. "Home" Position
4. Shutter should be on "Closed".
5. Bottom view port shutter is in closed position.
6. High Voltage & Emission (e-beam gun) Controllers should be off
7. CV14 Main Breaker OFF.
8. Chamber light should be turned off.

# Depositing a Metal:

Refer to Figure 1 on page 11 for all indicator light locations.

From Standby Conditions:

1. Enable FC 1800 #1 in iLab. Machine will not operate unless enabled.
2. Follow the procedure to "Change a sample" on Page #9.
3. Follow the procedure "Programming the SQM-160" to setup the Film Thickness Monitor on Page #10.
4. Switch the pocket to the position of your desired source by rotating (clockwise) the knob on the Turret (a.k.a Pocket) Selector to the desired number. When the light turns on the system has found the selected metal.
5. Wait for the system vacuum to be below **$2x10^{-6}$** Torr to continue.
6. Pull up on the High Voltage Power Supply Breaker to turn it on (CV-14). Located on the front of the High Voltage Power Supply.
7. Verify interlock light stacks on CV-14 HVPS Controllers:
    a. On the Gun Controller:
        i. "Vac Tank" is illuminated.
        ii. "Vac Gauge" is illuminated.
        iii. "Gun Water" is illuminated.
        iv. "Aux" is illuminated.
        v. "Focus" is illuminated.
        vi. "Gun 1 Tank 1" is illuminated.
    b. On the HVPS Controller:
        i. "Power ON" is illuminated.
        ii. "Triode Water" is illuminated.
        iii. "Doors" is illuminated.
        iv. "Air" is illuminated.
        v. "PC Cards and key lock" is illuminated.
8. Verify "Emission Current" knob is fully counter clockwise.
9. Turn High Voltage on by depressing the "HV ON" button on the High Voltage Controller.
10. Switch on the Filament on by depressing the "GUN 1 Fil ON" button on the gun controller.
11. Open the shutter by pushing the shutter switch up on the shutter controller.
12. Verify filament is on by looking thru the view ports and making sure a white light is coming from the filament area.
13. Slowly advance "Emission Current" on the gun controller until you are just able to see the blue beam spot on the crucible when looking into the top view port.
14. Position the beam on the metal inside the crucible by adjusting the lat and long beam position on the XY controller for the settings you are wanting. **Warning**: The beam spot should never come into contact with the crucible walls or turret at any time or location.




15. **Verify the beam is sweeping across the source within the crucible. Warning:** Failure to sweep the beam can cause damage to the source crucible, turret, FC 1800 system, your wafers, and/or your privileges to use this machine.
16. Close the shutter by pushing down on "shutter" switch on the shutter controller.
17. Slowly ramp current over a couple of minutes until a deposition rate of 0.5 to 1 Å/s on the film thickness monitor is achieved. Allow the crucible to heat for ~2 minutes.
18. **Slowly** increase emission current by turning the "emission current" control pot on the gun controller until you have reached your desired deposition rate.
    a. DO NOT EXCEED 2 Å/s – Bad Things can happen quickly!!!!
    b. After deposition rate of 0.5 to 1 Å/s is achieved, you have to very slowly advance the emission current because a tiny adjustment causes noticeable rate change or even spiking over 2 Å/s.
19. To start deposit onto your substrate: zero Film thickness meter by pressing "zero" and open shutter by pressing up on the "shutter" toggle switch on the shutter controller. Wait until desired thickness is almost achieved.
    a. Keep monitoring the rate: DO NOT EXCEED 2 Å/s!
    b. Keep monitoring the tool status.
20. Once desired thickness is achieved, CLOSE shutter by pressing down on the "shutter" toggle switch on the shutter controller and log your results.
21. Note: if your deposition is longer than one hour, you have to ramp off the beam current, turn off the high voltage, and wait for 10 minutes after one hour deposition and before doing more deposition.

22. Set emission current to ZERO by rotating the "emission current" control pot fully CCW on the gun controller **slowly** but continuously.
23. Switch off Filament by pressing the "GUN 1 FIL OFF" button on the gun controller.
24. Switch off HV by pressing "HV OFF", located on the High Voltage controller. Note: do not turn off High Voltage Circuit Breaker yet!!
25. **Wait 10 minutes** for turret and source to cool down from last deposition before continuing to the next step.
26. Repeat step #3 thru step #24 for as many layers as you need.
27. Push down on the High Voltage Circuit Breaker on the CV-14 High Voltage Power Supply.
28. To remove your samples, follow the procedure "Changing a Sample from standby" on page #9.
29. Remove the plastic shield behind the top view port. Put it in the METAL RECLAIM bag by Oerlikon evaporator.
30. Place a new plastic shield behind the top view port. Spares are located in a box on top of CV-14. If the plastic shield doesn't fit into the clamps, trim it using a scissor BUT make sure it is not falling off the clamps easily!!! Use a tape to fix it in place if needed. **Warning**: If a plastic shield fell into the chamber, it can cause source contamination or damage to the filament assembly.
31. Verify the machine is in Standby.
    a. Main Chamber lid should be closed and under High Vacuum.
    b. Valves that should be illuminated, open, or on in Standby conditions on the APC.
        i. "Cryo Iso"
        ii. "Cryo Pump"
        iii. Gate should be in the "Away" position.
    c. Valves that should not be illuminated or open in Standby Mode.
        i. "Roughing" Valve
        ii. "Fore Line" Valve
        iii. "Mechanical Pump"
        iv. "Vent" Valve
        v. "Hi Vac" Position
        vi. "Home" Position
    d. Shutter should be on "Closed" and the indicator should not be illuminated.
    e. HV & Gun Controllers should be off.
    f. Ion Vacuum Gauge should be heading into the $10^{-6}$ torr range or better.
32. Disable the machine in iLab, check if you have precious metal usage added and take trash with you when you leave the machine.

# Changing a Sample:

**Refer to Figure 1 on page 11 for all indicator light locations.**

1. Move the Gate Valve to the "Home" position.
2. Verify the indicator light switches from "Away" to "Home".
3. Close the "High Vac" valve by pressing down on the switch labeled "High Vac" on the APC.
4. Verify the "High Vac" light comes on and the "Home" light goes out.
5. Open the N2 "Vent" valve by pressing up on the switch labeled "Vent" on the APC.
6. Verify the "Vent" light illuminates.
7. Allow a couple of minutes for the lid to come up to atmosphere pressure.
8. After the lid has been released from vacuum, the lid will pop up slightly. Pull up and open the lid.
9. Close N2 "Vent" Valve by pressing down on the switch labeled "Vent" on the APC.
10. Verify the "Vent" indicator goes out.
11. Verify a new and clean plastic shield is in place for your deposition.
    a. If the plastic shield is coated by metal, it means the last user didn't replace it after done. Remove the old shield and put a new one in place. Verify it being clamped safely and not falling off easily. Use a tape if needed.
    b. If no plastic shield is found, either the last user forgot to replace it or it may drop into the chamber. DO NOT proceed. Contact staff to check.
12. Install or remove samples on the FC1800 #1 sample holder.
13. Verify the Lid O-ring has not popped out of the groove.
14. Pull down the lid and set it gently down on the O-ring.
15. Start mechanical pump by depressing the "ON" button on the M.P. Control.
16. Wait for 10-15 seconds for the mechanical pump to start.
17. Open the "roughing" valve by pressing up on the switch labeled "roughing" on the APC.
18. Verify the "roughing" indicator illuminates.
19. Allow system to pump down to **$5.0x10^{-2}$ Torr** or lower on Gauge A
20. Close "roughing" Valve when Gauge A reads less than $5.0x10^{-2}$ Torr by pushing down on the switch labeled "Roughing" on the APC.
21. Quickly Verify the "Roughing" indicator goes out.
22. Quickly Open "High Vac" by pressing up on the switch labeled "High Vac" on the APC.
23. Verify "High Vac" indicator goes out and the "Home" indicator illuminates.
24. Verify the "Cryo Iso" light is illuminated and if not press up on the switch labeled "Cryo Iso".
25. Move the gate valve to the "Away" position by pressing up on the switch.
26. Verify the "Home" indicator goes out and the "Away" indicator illuminates.
27. Shut off the mechanical pump.

## Programming the Film Thickness Monitor (SQM 160):

The FTM should be on at all times. You HAVE TO verify every materials information every time you use this machine.

1. If you start using this monitor and it is displaying CRYSTAL 1, press "Xtal life" button to bring it back to its normal view. This reading shows the amount of life the Crystal has left.
2. Press "Zero" button to zero the monitor readings (Thickness and Time)
3. On the film thickness monitor. Press the "program" button.
4. Pick your film by rotating the knob to "Film X". X can be any number between 1 and 9
5. Press "Next" button. "Density" should be displayed. Density and Z-Factor charts will be available in Appendix B and posted on side of the control rack as well.
6. Rotate the knob until the density you want is displayed.
7. Press "Next" button. "Tooling" should be displayed.
8. Rotate the knob until the tooling for your sample holder is displayed. Appendix A contains a list of tooling factors for the different sample holders and will be posted on side of control cabinet as well. **NOTE:** There will be specific sample holders for this machine and will be labeled FC 1800 #1". **WARNING**: Do not use the numbers from FC 1800 #2 or #3, these numbers will be wrong for the setup in the FC1800 #1.
9. Press "Next" button. "Z-Factor" should be displayed.
10. Rotate knob until the Z-Factor you desire is displayed. Density and Z-Factor charts will be available in Appendix B and posted on side of control rack as well.
11. Press "Next" button. "Finl Thk" should be displayed. This step saves the last setting of "Z-factor" into the program.
12. Press "Program" button to exit program mode. It is now ready for the deposition.

**NOTE:** The Film thickness monitor does not stop sampling of the deposition when you close the shutter. You will need to watch the monitor and log the thickness when you close the shutter.



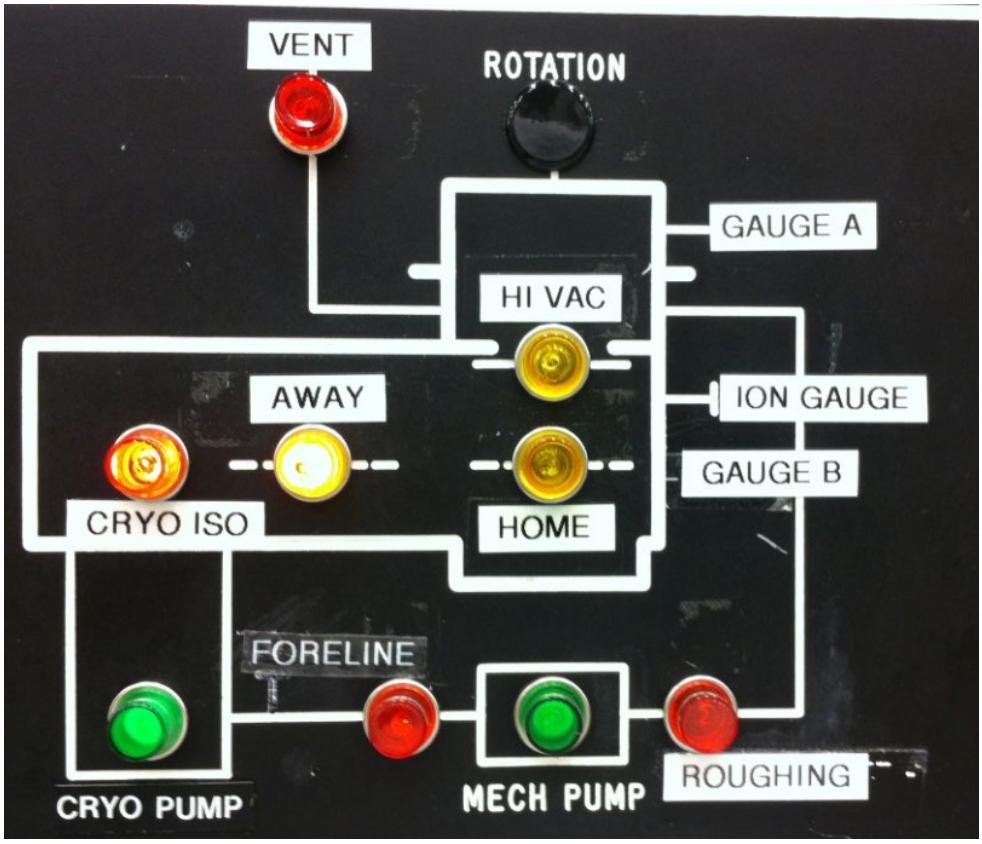


Figure 1: Indicator Panel of Automatic Pump Controller (APC)



Figure 2: HVPS Controls
Emission current and High Voltage on left. Beam Position controls on Right.

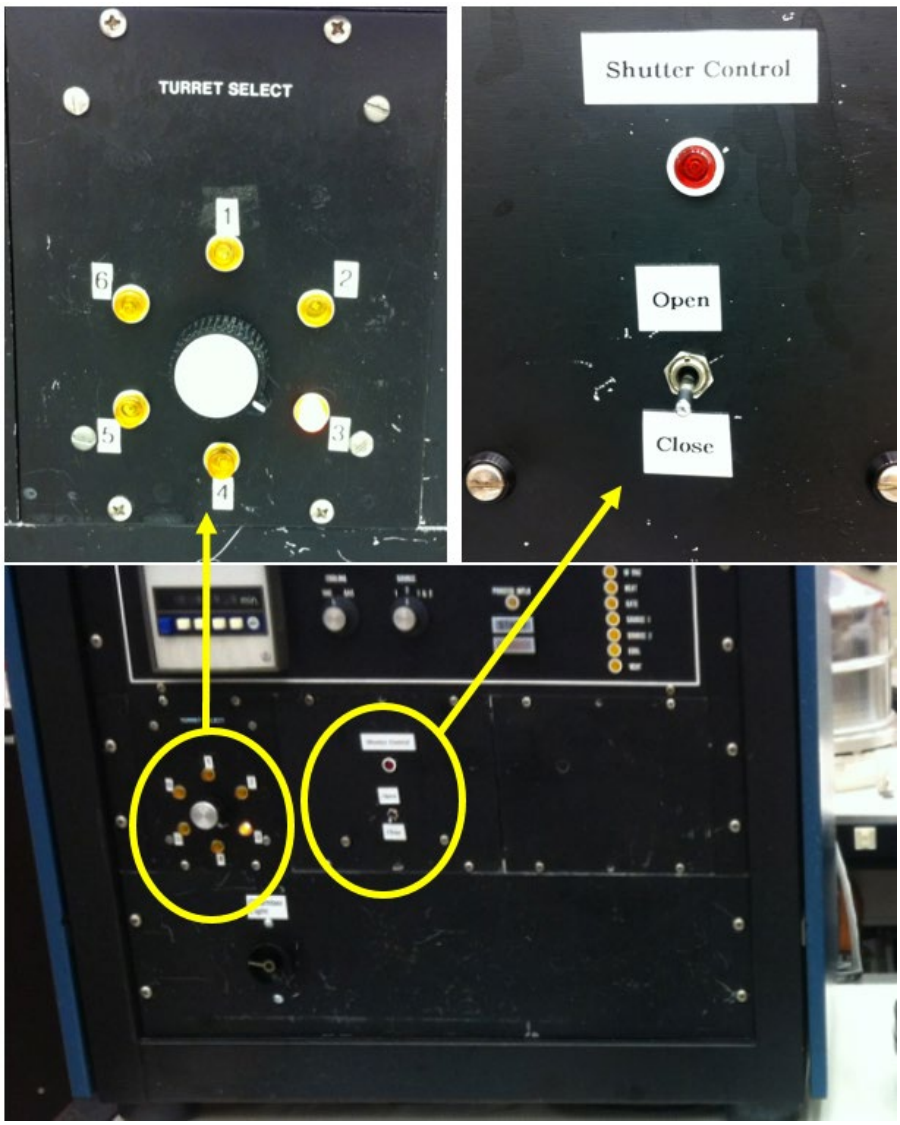


Figure 3: Turret or Pocket Selector (Left), Shutter Control (Right).

## Appendix A:  Tooling Information

Flat Bar: 330
U-Bar: 155

## Appendix B: Density and Z-Ratio Chart

| Material | Formula | Ratios | Density | Z-Ratio | Notes |
|---|---|---|---|---|---|
| Aluminum | **Al** | | 2.700 | 1.080 | **Slowly** heat – crucibles crack easily |
| Aluminum Oxide | Al2O3 | | 3.97 | 0.336 | |
| Aluminum Boron Silicon | Al/B/Si | 98-1-1 | 2.693 | 1.169 | |
| Aluminum Silicon | AlSi | 98-2 | 2.692 | 1.073 | |
| Chromium | Cr | | 7.200 | 0.305 | Sublimes |
| Cobalt | Co | | 8.710 | 0.343 | |
| Copper | Cu | | 8.930 | 0.437 | |
| Germanium | Ge | | 5.35 | 0.516 | Permission Required |
| Gold | Au | | 19.300 | 0.381 | |
| Gold Germanium | AuGe | 88/12 | 17.626 | 0.397 | |
| Gold Palladium | AuPd | 60/40 | 16.380 | 0.371 | |
| Hafnium | Hf | | 13.09 | 0.34 | |
| Molybdenum | Mo | | 10.200 | 0.257 | |
| Nickel | **Ni** | | 8.910 | 0.331 | **Slowly** heat – crucibles crack easily |
| Palladium | Pd | | 12.038 | 0.357 | |
| Platinum | Pt | | 21.400 | 0.245 | |
| Platinum Iridium | PtIr | | | | Permission Required |
| Silicon | Si | | 2.320 | 0.712 | Permission Required |
| Silicon – p-doped | Si (boron) | | 2.320 | 0.712 | Permission Required |
| Silicon Dioxide | SiO2 | | 2.200 | 1.070 | Permission Required |
| Tantalum | Ta | | 16.6 | 0.262 | |
| Titanium | Ti | | 4.500 | 0.628 | |
| Tungsten | W | | 19.300 | 0.163 | |
| Vanadium | V | | 5.96 | 0.53 | |