

# Standard Operating Procedures

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## Large Sputtering Machine

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# Important

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- You can only use CeNSE laboratories and equipment if you have been approved by Brian or Chuck, reserved the tool on the calendar, and filled out a form. No Exceptions!
- If the equipment is acting unusual STOP! Please discuss with Brian or Chuck before proceeding and leave a note on the machine.
- Gloves should be worn while handling substrate and deposition to reduce contamination.
- Any accidental damage must be reported immediately.
- All CeNSE laboratories are protected by video surveillance.



# Machine exterior and chamber

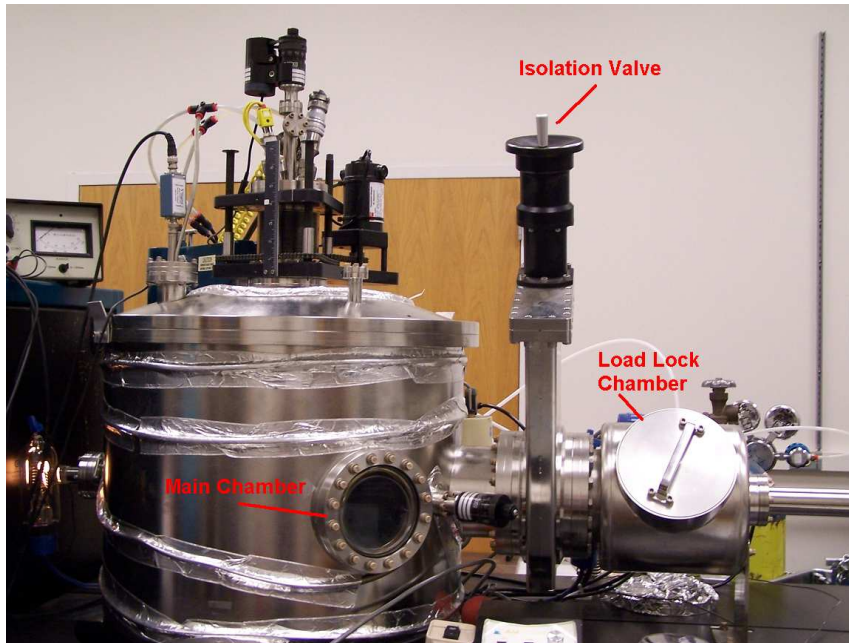


Figure 1a: Chambers

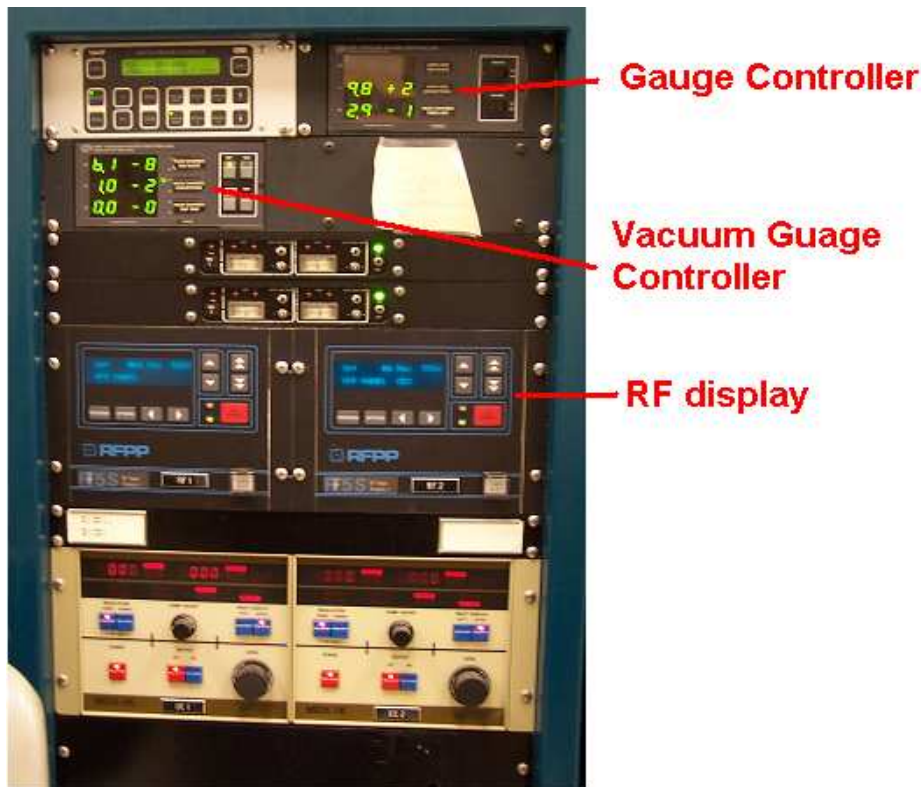


Figure 1b: Left panel control

Figure 2a: Right panel control

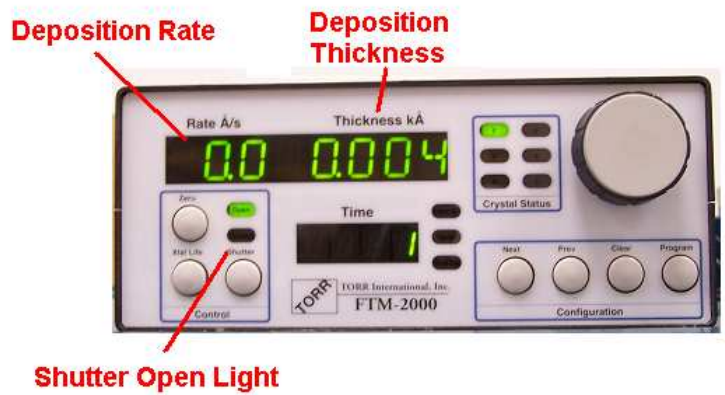
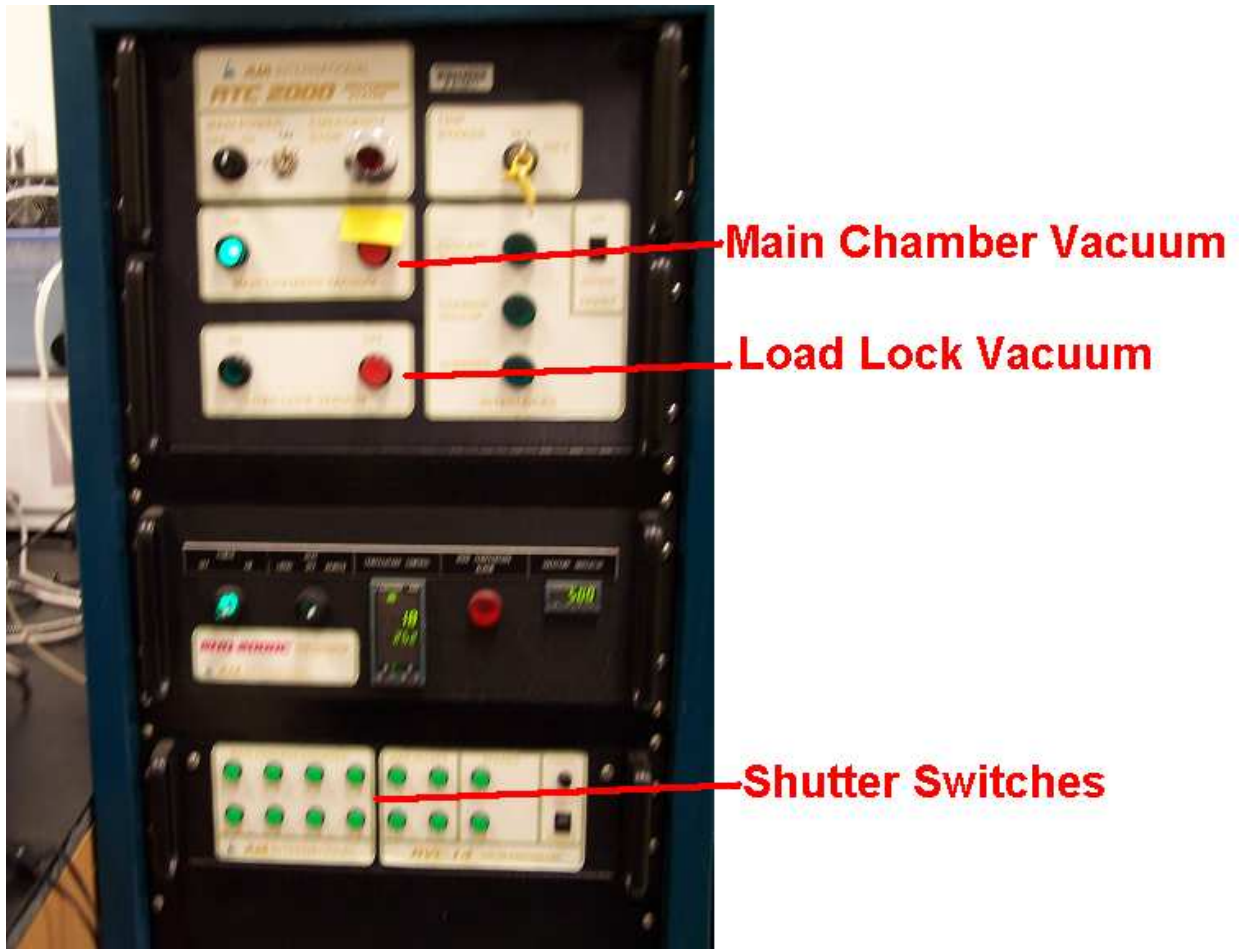


Figure 2b: Deposition Monitor

# Other Parts of the Machine

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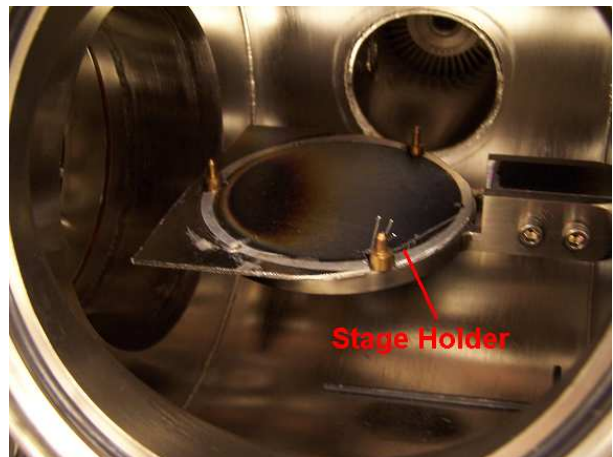


**Wrench**

**Stage**

Figure 3a: Stage

Figure 3b: Inside Load Lock Chamber



**Stage Holder**



**Motor Controllers**

Figure 3c: Motor controllers

# Operating Procedure

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## 1. Preparation

1.1. Before beginning, be sure to wear gloves to reduce contamination and to protect the hands.

## 2. Start-up operations

2.1. Turn on compressed air cylinder. Check that regulator is set to 60 psi.

2.2. Turn on argon cylinder. Check that regulator is set to 30psi.

## 3. Load the sample

3.1. Remove the lid from load lock chamber.

3.1.1. If the chamber is under vacuum, turn on nitrogen gas to flood chamber to open it. Be sure to turn off nitrogen afterwards.

3.2. Use wrench from inside chamber to loosen clamps on the stage. Be sure to place the wrench back inside the chamber

3.3. Clamp the sample to the stage

3.4. Place the stage back in the chamber, with the sample facing down, aligning the slots on the pins

3.5. Replace the lid on the load lock chamber

3.6. Put the “on” button for the load lock vacuum located on the machine control cabinet

3.7. Turn on the load lock ion gauge. Press the “gauge” button on the display that says load lock ion gauge. Wait for the gauge to stabilize ( at least 5 e-6)

3.8. Turn on the main chamber ion gauge. Press the “IG1 button on the display that says main chamber ion gauge.

3.9. Wait for chamber to pressurize (About 30 minutes)

## 4. Transferring the holder

4.1. Turn gauges off.

4.2. Manually crank open the isolation valve in the counter-clockwise direction until the crank stops.

4.3. **Slowly** slide in your sample using the transfer handle. Push slowly add steadily until the handle rests against the stop ring. **DO NOT TWIST THE HANDLE**

4.4. Use controller to move the stage upwards to align the screw with the stage

4.5. Once the screw is aligned, press FWD on the controller to screw it on (or screw it on manually)

4.6. Once it is screwed on correctly, use controller to move the stage downwards to a measurement of 4 inches.

4.7. Pull the stage apparatus back all the way using the transfer handle

4.8. Use crank to close the isolation valve. It will be fully closed when you hear the valve click.

4.9. Turn off the load lock vacuum and turn on rotating stage.

# Operating Procedure, continued

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## 5. Running the Sputtering Process (Completed on the computer)

### 5.1. Construct layers

- 5.1.1. Click "Program Layers"
- 5.1.2. Enter desired parameters
- 5.1.3. Name and save the layer
- 5.1.4. Repeat for as many layers as needed

### 5.2. Construct a Process

- 5.2.1. Click "Program Processes"
- 5.2.2. Highlight the desired layer and click "add"
- 5.2.3. Repeat until all desired layers are listed under process
- 5.2.4. Save the process list

### 5.3. Run the process

- 5.3.1. Click on "Run Process"
- 5.3.2. Enter the process name file or select "browse"
- 5.3.3. Other information on the screen is NOT necessary.
- 5.3.4. Click "next"
- 5.3.5. When the main chamber has reached the desired vacuum (best is in the -7 range), follow the instructions on the screen to start.

## 6. Unloading the substrate

- 6.1. Open the transfer gate valve
- 6.2. Push the transfer into the main chamber with the transfer handle. Push slowly and steadily until the handle rests against the stop ring. DO NOT TWIST THE HANDLE
- 6.3. While looking through the viewport, bring the hoist "in" using the pendant control
- 6.4. Bring the hoist in until the pins on the transfer ring are just in the slots on the substrate holder. Turn the screw with the knob on top of the hoist assembly to line the slots with the pins
- 6.5. Release the holder from the hoist. Turn the screw with the knob on top of the hoist assembly counter-clockwise to release the holder. Turn the knob until the holder drops from the hoist.
- 6.6. Bring the hoist "out" until the holder is clear of the pins on the transfer
- 6.7. Push the transfer out of the chamber
- 6.8. Close the transfer gate valve. The valve will make a click when it is fully closed

## 7. Removing the substrate

- 7.1. Push the "off" button for the load lock vacuum. The button is on the machine control cabinet

- 7.2. Turn on Nitrogen cylinder.
- 7.3. Put on gloves
- 7.4. Remove the lid from the load lock chamber
- 7.5. Turn off the nitrogen cylinder
- 7.6. Remove the substrate holder.
- 7.7. Remove the substrate from under the clips on the holder and re- tighten the screws
- 7.8. Place the holder on the ring of the transfer. The substrate side will be facing down and the pins on the ring will fit into the slots on the substrate holder
- 7.9. Place the lid on the load lock chamber

Deposition material properties:<sup>1</sup>

Formula	Density	Z-Ratio	Acoustic Impedance	Material Name
Ag	10.5	0.529	16.69	Silver
AgBr	6.47	1.18	7.48	Silver Bromide
AgCl	5.56	1.32	6.69	Silver Chloride
Al	2.70	1.08	8.18	Aluminum
Al <sub>2</sub> O <sub>3</sub>	3.97	0.336	26.28	Aluminum Oxide
Al <sub>4</sub> C <sub>3</sub>	2.36	?		Aluminum Carbide
AlF <sub>3</sub>	3.07	?		Aluminum Fluoride
AlN	3.26	?		Aluminum Nitride
AlSb	4.36	0.743	11.88	Aluminum Antimonide
As	5.73	0.966	9.14	Arsenic
As <sub>2</sub> Se <sub>3</sub>	4.75	?		Arsenic Selenide
Au	19.3	0.381	23.18	Gold
B	2.37	0.389	22.70	Boron
B <sub>2</sub> O <sub>3</sub>	1.82	?		Boron Oxide
B <sub>4</sub> C	2.37	?		Boron Carbide
BN	1.86	?		Boron Nitride
Ba	3.5	2.1	4.20	Barium
BaF <sub>2</sub>	4.886	0.793	11.13	Barium Fluoride
BaN <sub>2</sub> O <sub>6</sub>	3.244	1.261	7.00	Barium Nitrate
BaO	5.72	?		Barium Oxide
BaTiO <sub>3</sub>	5.999	0.464	19.03	Barium Titanate (Tetr)
BaTiO <sub>3</sub>	6.035	0.412	21.43	Barium Titanate (Cubic)
Be	1.85	0.543	16.26	Beryllium
BeF <sub>2</sub>	1.99	?		Beryllium Fluoride
BeO	3.01	?		Beryllium Oxide
Bi	9.8	0.79	11.18	Bismuth
Bi <sub>2</sub> O <sub>3</sub>	8.9	?		Bismuth Oxide
Bi <sub>2</sub> S <sub>3</sub>	7.39	?		Bismuth Trisulfide
Bi <sub>2</sub> Se <sub>3</sub>	6.82	?		Bismuth Selenide
Bi <sub>2</sub> Te <sub>3</sub>	7.7	?		Bismuth Telluride
BiF <sub>3</sub>	5.32	?		Bismuth Fluoride
C	2.25	3.26	2.71	Carbon (Graphite)
C	3.52	0.22	40.14	Carbon (Diamond)
C <sub>8</sub> H <sub>8</sub>	1.1	?		Parlyene (Union Carbide)
Ca	1.55	2.62	3.37	Calcium
CaF <sub>2</sub>	3.18	0.775	11.39	Calcium Fluoride

<sup>1</sup> SQM-160 User's Guide, Version 4.06. Sigma Instruments, Inc. 2000-2008.

Formula	Density	Z-Ratio	Acoustic Impedance	Material Name
CaO	3.35	?		Calcium Oxide
CaO-SiO2	2.9	?		Calcium Silicate (3)
CaSO4	2.962	0.955	9.25	Calcium Sulfate
CaTiO3	4.1	?		Calcium Titanate
CaWO4	6.06	?		Calcium Tungstate
Cd	8.64	0.682	12.95	Cadmium
CdF2	6.64	?		Cadmium Fluoride
CdO	8.15	?		Cadmium Oxide
CdS	4.83	1.02	8.66	Cadmium Sulfide
CdSe	5.81	?		Cadmium Selenide,
CdTe	6.2	0.98	9.01	Cadmium Telluride
Ce	6.78	?		Cerium
CeF3	6.16	?		Cerium (III) Fluoride
CeO2	7.13	?		Cerium (IV) Dioxide
Co	8.9	0.343	25.74	Cobalt
CoO	6.44	0.412	21.43	Cobalt Oxide
Cr	7.2	0.305	28.95	Chromium
Cr2O3	5.21	?		Chromium (III) Oxide
Cr3C2	6.68	?		Chromium Carbide
CrB	6.17	?		Chromium Boride
Cs	1.87	?		Cesium
Cs2SO4	4.243	1.212	7.29	Cesium Sulfate
CsBr	4.456	1.41	6.26	Cesium Bromide
CsCl	3.988	1.399	6.31	Cesium Chloride
CsI	4.516	1.542	5.73	Cesium Iodide
Cu	8.93	0.437	20.21	Copper
Cu2O	6	?		Copper Oxide
Cu2S	Cu2S	5.6	1.58	Copper (I) Sulfide (Alpha)
Cu2S	Cu2S	5.8	1.52	Copper (I) Sulfide (Beta)
CuS	CuS	4.6	1.92	Copper (II) Sulfide
Dy	Dy	8.55	1.03	Dysprosium
Dy2O3	Dy2O3	7.81	1.13	Dysprosium Oxide
Er	Er	9.05	0.98	Erbium
Er2O3	Er2O3	8.64	1.02	Erbium Oxide
Eu	Eu	5.26	1.68	Europium
EuF2	EuF2	6.5	1.36	Europium Fluoride
Fe	7.86	0.349	25.30	Iron
Fe2O3	5.24	?		Iron Oxide
FeO	5.7	?		Iron Oxide
FeS	4.84	?		Iron Sulphide

Formula	Density	Z-Ratio	Acoustic Impedance	Material Name
Ga	5.93	0.593	14.89	Gallium
Ga <sub>2</sub> O <sub>3</sub>	5.88	?		Gallium Oxide (B)
GaAs	5.31	1.59	5.55	Gallium Arsenide
GaN	6.1	?		Gallium Nitride
GaP	4.1	?		Gallium Phosphide
GaSb	5.6	?		Gallium Antimonide
Gd	7.89	0.67	13.18	Gadolinium
Gd <sub>2</sub> O <sub>3</sub>	7.41	?		Gadolinium Oxide
Ge	5.35	0.516	17.11	Germanium
Ge <sub>3</sub> N <sub>2</sub>	5.2	?		Germanium Nitride
GeO <sub>2</sub>	6.24	?		Germanium Oxide
GeTe	6.2	?		Germanium Telluride
Hf	13.09	0.36	24.53	Hafnium
HfB <sub>2</sub>	10.5	?		Hafnium Boride,
HfC	12.2	?		Hafnium Carbide
HfN	13.8	?		Hafnium Nitride
HfO <sub>2</sub>	9.68	?		Hafnium Oxide
HfSi <sub>2</sub>	7.2	?		Hafnium Silicide
Hg	13.46	0.74	11.93	Mercury
Ho	8.8	0.58	15.22	Holmium
Ho <sub>2</sub> O <sub>3</sub>	8.41	?		Holmium Oxide
In	7.3	0.841	10.50	Indium
In <sub>2</sub> O <sub>3</sub>	7.18	?		Indium Sesquioxide
In <sub>2</sub> Se <sub>3</sub>	5.7	?		Indium Selenide
In <sub>2</sub> Te <sub>3</sub>	5.8	?		Indium Telluride
InAs	5.7	?		Indium Arsenide
InP	4.8	?		Indium Phosphide
InSb	5.76	0.769	11.48	Indium Antimonide
Ir	22.4	0.129	68.45	Iridium
K	0.86	10.189	0.87	Potassium
KBr	2.75	1.893	4.66	Potassium Bromide
KCl	1.98	2.05	4.31	Potassium Chloride
KF	2.48	?		Potassium Fluoride
KI	3.128	2.077	4.25	Potassium Iodide
La	6.17	0.92	9.60	Lanthanum
La <sub>2</sub> O <sub>3</sub>	6.51	?		Lanthanum Oxide
LaB <sub>6</sub>	2.61	?		Lanthanum Boride
LaF <sub>3</sub>	5.94	?		Lanthanum Fluoride
Li	0.53	5.9	1.50	Lithium
LiBr	3.47	1.23	7.18	Lithium Bromide

Formula	Density	Z-Ratio	Acoustic Impedance	Material Name
LiF	2.638	0.778	11.35	Lithium Fluoride
LiNbO3	4.7	0.463	19.07	Lithium Niobate
Lu	9.84	?		Lutetium
Mg	1.74	1.61	5.48	Magnesium
MgAl2O4	3.6	?		Magnesium Aluminate
MgAl2O6	8	?		Spinel
MgF2	3.18	0.637	13.86	Magnesium Fluoride
MgO	3.58	0.411	21.48	Magnesium Oxide
Mn	7.2	0.377	23.42	Manganese
MnO	5.39	0.467	18.91	Manganese Oxide
MnS	3.99	0.94	9.39	Manganese (II) Sulfide
Mo	10.2	0.257	34.36	Molybdenum
Mo2C	9.18	?		Molybdenum Carbide
MoB2	7.12	?		Molybdenum Boride
MoO3	4.7	?		Molybdenum Trioxide
MoS2	4.8	?		Molybdenum Disulfide
Na	0.97	4.8	1.84	Sodium
Na3AlF6	2.9	?		Cryolite
Na5Al3F14	2.9	?		Chiolite
NaBr	3.2	?		Sodium Bromide
NaCl	2.17	1.57	5.62	Sodium Chloride
NaClO3	2.164	1.565	5.64	Sodium Chlorate
NaF	2.558	0.949	9.30	Sodium Fluoride
NaNO3	2.27	1.194	7.40	Sodium Nitrate
Nb	8.578	0.492	17.95	Niobium (Columbium)
Nb2O3	7.5	?		Niobium Trioxide
Nb2O5	4.47	?		Niobium (V) Oxide
NbB2	6.97	?		Niobium Boride
NbC	7.82	?		Niobium Carbide
NbN	8.4	?		Niobium Nitride
Nd	7	?		Neodymium
Nd2O3	7.24	?		Neodymium Oxide
NdF3	6.506	?		Neodymium Fluoride
Ni	8.91	0.331	26.68	Nickel
NiCr	8.5	?		Nichrome
NiCrFe	8.5	?		Inconel
NiFe	8.7	?		Permalloy
NiFeMo	8.9	?		Supermalloy
NiO	7.45	?		Nickel Oxide
P3N5	2.51	?		Phosphorus Nitride

Formula	Density	Z-Ratio	Acoustic Impedance	Material Name
Pb	11.3	1.13	7.81	Lead
PbCl <sub>2</sub>	5.85	?		Lead Chloride
PbF <sub>2</sub>	8.24	0.661	13.36	Lead Fluoride
PbO	9.53	?		Lead Oxide
PbS	7.5	0.566	15.60	Lead Sulfide
PbSe	8.1	?		Lead Selenide
PbSnO <sub>3</sub>	8.1	?		Lead Stannate
PbTe	8.16	0.651	13.56	Lead Telluride
Pd	12.038	0.357	24.73	Palladium
PdO	8.31	?		Palladium Oxide
Po	9.4	?		Polonium
Pr	6.78	?		Praseodymium
Pr <sub>2</sub> O <sub>3</sub>	6.88	?		Praseodymium Oxide
Pt	21.4	0.245	36.04	Platinum
PtO <sub>2</sub>	10.2	?		Platinum Oxide
Ra	5	?		Radium
Rb	1.53	2.54	3.48	Rubidium
RbI	3.55	?		Rubidium Iodide
Re	21.04	0.15	58.87	Rhenium
Rh	12.41	0.21	42.05	Rhodium
Ru	12.362	0.182	48.52	Ruthenium
S <sub>8</sub>	2.07	2.29	3.86	Sulphur
Sb	6.62	0.768	11.50	Antimony
Sb <sub>2</sub> O <sub>3</sub>	5.2	?		Antimony Trioxide
Sb <sub>2</sub> S <sub>3</sub>	4.64	?		Antimony Trisulfide
Sc	3	0.91	9.70	Scandium
Sc <sub>2</sub> O <sub>3</sub>	3.86	?		Scandium Oxide
Se	4.81	0.864	10.22	Selenium
Si	2.32	0.712	12.40	Silicon
Si <sub>3</sub> N <sub>4</sub>	3.44	*1000		Silicon Nitride
SiC	3.22	?		Silicon Carbide
SiO	2.13	0.87	10.15	Silicon (II) Oxide
SiO <sub>2</sub>	2.648	1	8.83	Silicon Dioxide
Sm	7.54	0.89	9.92	Samarium
Sm <sub>2</sub> O <sub>3</sub>	7.43	?		Samarium Oxide
Sn	7.3	0.724	12.20	Tin
SnO <sub>2</sub>	6.95	?		Tin Oxide
SnS	5.08	?		Tin Sulfide
SnSe	6.18	?		Tin Selenide
SnTe	6.44	?		Tin Telluride

Formula	Density	Z-Ratio	Acoustic Impedance	Material Name
Sr	2.6	?		Strontium
SrF2	4.277	0.727	12.15	Strontium Fluoride
SrO	4.99	0.517	17.08	Strontium Oxide
Ta	16.6	0.262	33.70	Tantalum
Ta2O5	8.2	0.3	29.43	Tantalum (V) Oxide
TaB2	11.15	?		Tantalum Boride
TaC	13.9	?		Tantalum Carbide
TaN	16.3	?		Tantalum Nitride
Tb	8.27	0.66	13.38	Terbium
Tc	11.5	?		Technetium
Te	6.25	0.9	9.81	Tellurium
TeO2	5.99	0.862	10.24	Tellurium Oxide
Th	11.694	0.484	18.24	Thorium
ThF4	6.32	?		Thorium (IV) Fluoride
ThO2	9.86	0.284	31.09	Thorium Dioxide
ThOF2	9.1	?		Thorium Oxyfluoride
Ti	4.5	0.628	14.06	Titanium
Ti2O3	4.6	?		Titanium Sesquioxide
TiB2	4.5	?		Titanium Boride
TiC	4.93	?		Titanium Carbide
TiN	5.43	?		Titanium Nitride
TiO	4.9	?		Titanium Oxide
TiO2	4.26	0.4	22.08	Titanium (IV) Oxide
Tl	11.85	1.55	5.70	Thallium
TlBr	7.56	?		Thallium Bromide
TlCl	7	?		Thallium Chloride
TlI	7.09	?		Thallium Iodide (B)
U	19.05	0.238	37.10	Uranium
U3O8	8.3	?		Tri Uranium Octoxide
U4O9	10.969	0.348	25.37	Uranium Oxide
UO2	10.97	0.286	30.87	Uranium Dioxide
V	5.96	0.53	16.66	Vanadium
V2O5	3.36	?		Vanadium Pentoxide
VB2	5.1	?		Vanadium Boride
VC	5.77	?		Vanadium Carbide
VN	6.13	?		Vanadium Nitride
VO2	4.34	?		Vanadium Dioxide
W	19.3	0.163	54.17	Tungsten
WB2	10.77	?		Tungsten Boride
WC	15.6	0.151	58.48	Tungsten Carbide

<b>Formula</b>	<b>Density</b>	<b>Z-Ratio</b>	<b>Acoustic Impedance</b>	<b>Material Name</b>
WO3	7.16	?		Tungsten Trioxide
WS2	7.5	?		Tungsten Disulphide
WSi2	9.4	?		Tungsten Suicide
Y	4.34	0.835	10.57	Yttrium
Y2O3	5.01	?		Yttrium Oxide
Yb	6.98	1.13	7.81	Ytterbium
Yb2O3	9.17	?		Ytterbium Oxide
Zn	7.04	0.514	17.18	Zinc
Zn3Sb2	6.3	?		Zinc Antimonide
ZnF2	4.95	?		Zinc Fluoride
ZnO	5.61	0.556	15.88	Zinc Oxide
ZnS	4.09	0.775	11.39	Zinc Sulfide
ZnSe	5.26	0.722	12.23	Zinc Selenide
ZnTe	6.34	0.77	11.47	Zinc Telluride
Zr	6.49	0.6	14.72	Zirconium
ZrB2	6.08	?		Zirconium Boride
ZrC	6.73	0.264	33.45	Zirconium Carbide
ZrN	7.09	?		Zirconium Nitride
ZrO2	5.6	?		Zirconium Oxide