

ATC SERIES UHV MAGNETRON SPUTTERING SYSTEM



MODEL

DESCRIPTION

ATC-2200-UHV

Main Deposition Chamber - 17" high x 22" ID, electropolished, 304 stainless steel vacuum chamber featuring:

Chamber Top - Dished head with differentially pumped viton sealed flange - clamp style
ATC-V systems feature a heavy duty hoist lift mechanism.

Chamber Body - Mating ISO clamp style ring on cylindrical chamber with dished bottom.

CF Ports for the following Components:

- AJA substrate heater (12" CF)
- (6) UHV AJA 3" Magnetron Sputtering Sources (6.75" CF)
- (3) 6" CF viewports with integrated shutters
- vacuum pump(s) / gate valve (10" CF)
- vacuum gauges ((3) 2.75" CF)
- process gas introduction and vent (2.75" CF)
- load-lock
- transfer arm for load-lock system (10" CF)
- angled ellipsometry ports for optical thickness measurement - blanked ((2) 2.75" CF)
- MOS for in-situ stress measurement - blanked (8" CF located bottom center)
- thickness monitor
- RGA (2.75" CF)
- additional spare ports can be found throughout chamber body

The chamber is mounted to a steel frame with:

- integrated instrument rack
- heavy duty casters
- powder coated table top
- leveling feet
- easy access, safety panels
- water manifold with flow sensor

All unoccupied ports are blanked off

Main Chamber Bake Out Systems

Customized bakeout system for ATC-2200 chamber, includes features below

- Combination of permanently mounted external resistive heat pads, and internal retractable heat lamps for external/internal chamber bake out.
- AJA Bake Out System power controller with (3) channel output with TC and display
- Insulating jacket for ATC-2200 chamber

Vacuum Pumping consisting of:

- 1200 l/s HiPace Pfeiffer wide range turbopump with controller, cables and delayed vent valve
- N2 purge on TMP for oxygen plasma processing with pneumatic shut-off valve
- 17 cfm Kashiyama (NeoDry30) Air Cooled Multi Roots Pump, N2 Ballast, and cables

- interconnecting plumbing and hardware
- Brooks CTI-8 straight cryopump with compressor, temperature sensor, all lines and cables.
- roughing / regen valving for cryopumped systems

AJA International Magnetron Sputtering Sources & Source Options as defined below:

- 6 A330-XP UHV magnetron sputtering sources on 6.75" CF flanges. Sources use 3" diameter targets.
- 6 Pneumatic source shutters.
- 6 Gas ring and chimney sets.
- 6 Integral gas injection to source head for reactive sputtering and low pressure operation.
- 6 In-situ tilt gimbals with locking UHV position indicator. Allows source head angle adjustment without breaking vacuum.
NOTE: Mounted on chamber periphery in con-focal orientation

- 1 A330-XP UHV magnetron sputtering sources on 8" CF flanges. Sources use 3" diameter targets.
- 1 Pneumatic source shutters.
- 1 Gas ring and chimney sets.
- 1 Integral gas injection to source head for reactive sputtering and low pressure operation.
NOTE: Mounted on chamber center, normal incidence relative to substrate surface, for direct deposition orientation

MODULAR MAGNET ARRAY: AJA International magnetron sputtering sources 2" and larger feature the unique modular magnet array allowing the end user to configure the source to operate in the balanced, unbalanced and magnetic material modes depending on the application. Magnets are located out of the cooling water for clean, trouble-free operation and access. All AJA UHV sources feature rare earth magnets which are bakeable to 200 C without magnet removal and which are vacuum compatible to 10-11 Torr.

CONFOCAL SPUTTERING with SOURCE HEAD TILTING: AJA International magnetron sputtering sources fitted with either manual or in-situ tilt gimbals are capable of achieving extremely high levels of deposition uniformity when depositing onto a rotating substrate holder with adjustable working distance. Typically +/- 2% thickness uniformity is easily achieved with better than +/- 1% uniformity being possible in certain arrangements. Ideal target diameter for these geometries is typically one half the substrate diameter. The gas ring / chimney option prevents cross-contamination of target materials.

DC and RF Generators & Options as defined below:

- 2 AJA International 1500 Watt DC generator(s) with integral 4-way switchbox and cable set.
- 1 AJA International 600 Watt RF generator(s), auto-matching network and cable set.
- 1 Automated 4-way RF switchbox and cable set.
- 1 AE Pinnacle Plus 5 kW variable frequency (0-350 kHz) pulsed DC generator with cables

- 2 HiPSTER 6 HiPIMS Pulser, specification listed below:
 - Output Average Power: ≤ 6000 W
 - Output Peak Voltage: ≤ 1000 V
 - Output Peak Current: ≤ 600 A
 - Regulation Modes: Voltage, Current, Power, Pulse current
 - Pulse Frequency: 50 to 20 000 Hz
 - Pulse Duration: 2.5 μ s to 1000 μ s
 - Arc control: reaction time < 2 μ s
 - Cooling: Air Cooling
 - Norms: CE marked
 - Includes DC generator (1000V, 1A) and cable set.

- 1 HiPSTER Sync Unit, allows the user to control the pulsing of up to eight HiPSTER HiPIMS power supplies, compatible HiPSTER bias units, or compatible diagnostic hardware. Features Listed Below:
 - Synchronized pulsing of up to eight units in the HiPSTER series
 - Pulse trains with a fixed number of pulses at a fixed frequency
 - **Pulse trains synchronized between multiple units**

- Synchronized and delayed pulses repeated at a common frequency
- Internal trigger available to synchronize other devices
- Can be triggered externally from another device acting as master
- Cooling: Air Cooling
- Norms: CE marked

1 Automated 4-way HiPIMS switchbox and cable set.

Vacuum Gauge Package with cables consisting of:

- Gauge controller - simultaneously displays three gauge head outputs with:
- Nude ion gauge, Convectron gauge and 0.1 Torr Baratron gauge heads.

Quartz Crystal Thickness Monitor(s):

(1) single, low profile, quartz crystal sensor, heat sink, controller, oscillator, cable, feedthrough and 10 crystals. Also includes rotary feedthrough assembly to allow positioning of crystal in substrate position for deposition

SPUTTER DEPOSITION RATE CALIBRATION USING QUARTZ CRYSTAL MONITOR: Unlike e-beam, thermal and other long throw deposition methods, high quality sputtering is typically done at 3"-7" working distances. Due to the proximity of shielding chimneys and swinging shutters to the substrate holder, finding a location for a single QCM sensor head is virtually impossible. Then, with adjustments to the source chimney tuning and substrate Z motion, any adjustment would require re-calibration each time. On the other hand, sputtering is a very stable and predictable process versus evaporation. In con-focal sputter systems the center of the rotating substrate essentially stays in one place. By raising the substrate holder by about 1", swinging a movable QCM into the center position, one is able to get good deposition rate data (as a function of power and source set-up). Once the data has been gathered, the movable QCM is swung out of the way, the substrate is lowered to the same position and manual or automated processing can begin based on this simple test. The rate data gathering can be accomplished in a few minutes without breaking vacuum.

Substrate Holder with the following features:

- accommodates substrates up to 4" diameter
- mounts to top of chamber for sputter up orientation.
- confocal configuration on vertical center axis of chamber
- continuous motorized rotation (0-40 RPM) with controller
- radiant heating to 1000C with SiC element
- water cooled reflector box
- capable of being heated in an O2 environment
- SHQ-15A PID controller with TC input, overtemp protection, +/- 1 degree C temp. stability.
- 4" working distance adjustment via edge welded UHV bellows
- substrate gas distributor
- RF/DC biasing capability while rotating / heating / depositing. Includes dual bias input to allow 150W input power. **Includes (1) AJA International 300 Watt RF generator, auto matching network and cable set**

SUBSTRATE RF BIAS for PRE-CLEANING: AJA International substrate holders are designed with an electrically isolated substrate connected to an integrated, coaxial "N" connector. With this feature, the substrates can be grounded, floating or biased with DC or RF. RF bias prior to deposition is the preferred method of pre-cleaning since it works with conducting substrates, dielectric substrates and conducting substrates with deposited insulating films. Ion energies of 50 to 300 eV can be achieved. At 100 eV, an SiO₂ substrate would etch at approximately 10A per minute. Other pre-clean methods (glow discharge, reverse sputtering and ion beam) bombard adjacent chamber and substrate holder parts thereby contaminating the substrate during the pre-clean process!

SUBSTRATE RF BIAS during SPUTTER DEPOSITION: Applying an RF bias to the substrate during deposition adds energy to mobilize the deposited material resulting in denser, higher quality thin films. This atomic "peening" effect can also be used to tune the index of refraction of optically transparent films and for film planarization. At 100 eV, an SiO₂ film being deposited would be simultaneously back etched at approximately 10A per minute. This is less than 10% of the typical deposition rate. Process pressure, power input and the area ratio of live to ground surface will affect the energy of the ion bombardment. This technique is also used to enhance adhesion and promote uniform alloying when co-depositing multiple materials.

Gas Handling

1 Mass flow controlled gas line (Ar) - 100 sccm with pneumatic isolation valve(s) and filter.

- 1 Mass flow controlled gas line (N2) - 20 sccm with pneumatic isolation valve(s) and filter.
- 1 Ar gas line plumbed to one sputter source (additional sources can be connected as needed)
- 1 N2 gas line plumbed to the substrate gas distributor and (1) sputtering source vis pneumatic diverter valve.

PLUMBING OF INERT PROCESS GAS: Argon (inert gas) can be admitted directly into the chamber or via the sputter source gas rings of any sources which are sensitive to "poisoning" or are being used to sputter "gettering materials" (eg. Ti). Since it is desirable to "pre-sputter" target surfaces with the shutter closed, "gettering" materials can reduce the pressure within the isolation chimney to a level where the plasma goes out. Injecting the Ar gas into the source's gas ring / isolation chimney keeps the pressure in this area at a sufficient level to sustain a plasma discharge. AJA recommends that only one source (eg. Ti) is plumbed to the Ar initially since unnecessary plumbing is expensive, extends pump down time and complicates the service area. Plumbing Ar to additional sources if needed can be easily done by the customer as required using standard parts.

PLUMBING OF REACTIVE PROCESS GASSES: Reactive process gases should ideally be admitted near the substrate holder via a gas ring around the substrate holder or gas distributor opposite the main vacuum pump. This configuration delivers the reactive gas directly into the plasma near the growing film and away from target surfaces which are subject to "poisoning". One exception is for Titanium Nitride deposition where the Ar/N2 gas mixture is injected into the sputter source's gas ring - in this case the TiN film is conductive and does not poison the target surface

Pressure Control / Vacuum Valves

VAT Series 64-UHV closed loop, automatic pressure control / isolation gate valve. Includes controller with pressure and position presets and battery pack which closes valve within 3 seconds in the event of a power failure. Includes metal sealed bonnet and differentially pumped double shaft seal (10" CF size)

VAT Series 10 UHV Pneumatic Gate Valve for cryopump isolation. (10" CF size)
- includes safety interlocks for transfer arm position and vacuum pressure differential

Manual vent valve.

Automatic venting via turbo delayed vent valve.

DOWNSTREAM PRESSURE CONTROL - SIGNIFICANT ADVANTAGES: AJA International, Inc, deposition systems utilize only downstream pressure control for deposition processing for several reasons including maximizing turbopump life, better gas flow resolution for reactive processing, less gas consumption, simplicity and convenience. Keeping the gas load down on a turbopump by downstream throttling to achieve desired pressures reduces heat of compression, subsequent expansion of materials and results in improved bearing life. It also keeps deposited material out of the turbopump since a throttled turbopump's valve is typically 80% closed. With cryopumps it results in less frequent regeneration and less Argon incorporated in the water vapor condensing on the first stage array.

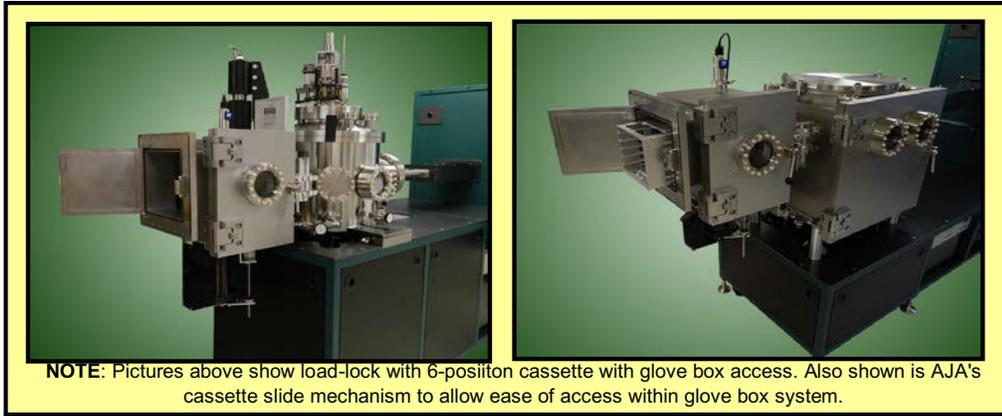
For some reactive processes the percentage of reactive gas to Argon can be very critical and require high resolution, properly matched MFC's and gas selection. Controlling pressure by upstream gas flow control limits the choices of MFC's since they must be matched to the high vacuum pump's speed. For a typical 3 mTorr process pressure, 75% less gas is consumed in a downstream, throttled configuration. Finally, being able to simply select the process and plasma strike pressures with a closed loop automatic pressure control gate valve simplifies operation and computer controlled recipe design. This saves time and results in less mistakes.

Load-Lock as described below:

- 1 **Load-Lock Mounted Between ATC-2200 Chamber and Customer Supplied Glove Box** as described below:
 - Custom "Box Style" stainless steel chamber body.
 - Pneumatic valve located between load-lock and main deposition chamber.
 - Magnetic transfer arm with custom susceptor for transferable substrate carrier.
 - (2) large hinged doors to allow glove box in right angle or linear orientation, unused door will allow atmospheric access.
 - MKS Full range gauge with display.
 - 260 l/s HiPACE Pfeiffer wide range turbopump with controller, and cables
 - 8.8 cfm Kashiyama (NeoDry15) Air Cooled Multi Roots Pump, N2 Ballast, and cables
 - interconnecting plumbing and hardware
 - (2) viewports

Manually Actuated Load-Lock Cassette as defined below:

- 6 position substrate cassette elevator with removable cassette
- cassette mounted on slide mechanism for ease of access from glove box system
- 6" UHV bellows lift mechanism with manually actuated hand wheel
- (6) transferable substrate carriers with universal insert adaptors to allow mounting of various and irregular sized substrates.



VACUUM LOAD LOCK - SIGNIFICANT ADVANTAGES: Adding a vacuum load-lock to your deposition system has two major advantages, throughput and film quality. With the main chamber at base vacuum, samples can be introduced via the low volume load-lock and processing can begin within 10-12 minutes after substrate introduction (vs. hours of waiting for similar base vacuum conditions if the chamber is vented every time for substrate introduction). As a result, throughput can be 5-10 times higher with a vacuum load-locked system. The other advantage is film quality - when the deposition chamber base vacuum is poor before beginning the deposition process, there is more residual water vapor present which breaks down in the plasma and results in oxygen and hydrogen incorporation into the film chemistry. This can cause major problems with film quality and research results when impatient users with no load-lock start depositing before a sufficient base vacuum has been reached. This is even more important in environments with high humidity in the lab. For an option that costs between 8% to 17% of the total price, this is an exceptional value and deserves serious consideration.

Power Distribution / Pump Control

- 1 **EMOC / PD30A-360-208V** rack mounted master three phase power distribution box with:
 - Mains power switch
 - Emergency OFF button
 - Hoist up/down momentary switch with 4 pin output connector
 - Main contactor with time delay for water interlock shutdown
 - water and vacuum interlock inputs
 - (4) 30A, 208/220 VAC single phase outputs (for PD-30S, heater control, Shimadzu or cryo units)
 - (2) interlocked 220 VAC receptacles
 - (2) non-interlocked 220 VAC receptacles for TMP and MP
 - (1) non-interlocked 220 VAC receptacles for general accessories
 - (1) 30A, three phase (or single phase) output (for Pinnacle Plus Generator, Cryopump, Shimadzu, etc)
 - Wieland mains power input (60A per leg + neutral + ground) with mating connector

- 1 **PD-30S** rack mounted slave power distribution box with:
 - Mains Power Breaker
 - 220 VAC, 30 A, 1 phase input
 - water cooling / vacuum interlock input
 - interlocks enabled output connector
 - (2) interlocked 220 VAC receptacles
 - (1) non-interlocked 220 VAC receptacle
 - (2) non-interlocked 220 VAC receptacles for TMP and MP
 - Integral TMP/MP on/off breaker (for load-lock pumps)

Pneumatic Controls

4-Way Solenoid & Manifold Assembly (for systems equipped with computer control) to actuate the following pneumatic devices:

- (7) source shutters
- (3) gas line isolation valves
- (1) load-lock isolation valve
- (5) future pneumatic devices

Computer Control

Phase II-J Computer Control

AJA International, Inc. developed, Labview based, Phase II-J Sputtering System control software.

Compact PC on heavy duty sliding drawer in instrument rack with ethernet connection, large, flat color display and CD burner.

7" x 19" rack mounted Phase II-J hardware module with fully wired IO to allow quick and simple field retrofits such as the addition of sputter sources, gas lines, power supplies, etc. after system delivery.

Interfaces with (5) DC & (4) RF generators for control of output mode, setpoint, ramping & plasma detection

Capable of interfacing with (1) 4 way DC switchbox and (1) 4 way RF switchbox

Interfaces directly with solenoid pneumatics manifold, for control of shutters, gas isolation valves & spares

Interfaces with VAT valve for: open / closed / throttle position

Interfaces with AJA SHQ-PID heater controller for: on / off / temp. setpoint / T/C temp. feedback

Interfaces with AJA substrate rotation controller (**On/Off Mode**)

Interfaces with up to (4) MFC's for control of: gas correction factor / flow setpoint / flow feedback

Define and stack process layers to create processes

Monitoring and data logging kW hrs in Phase II-J software:

Store and run processes

104 separate password protected accounts for process layer & process security

Auto shutdown of power supplies if: plasma not detected

Auto abort of process if: plasma not detected / gas flow setpoint or temperature setpoint not reached

Displays and data logs: shutter position / DC power feedback / Pulse Frequency and Reverse Time / DC bias feedback (for RF) / plasma verification / process pressure / gas flow feedback / T/C temperature feedback / target kW hours / Abort Notifications

In-Situ Analytical Equipment:

- 1 FS-1 Banded Wavelength Ellipsometer System, includes 4-wavelength LED light source unit, no moving parts ellipsometric detector unit, frame for mounting sample with manual height adjustment, reference sample, wall plug power supply, cables, and documentation.
 - In-situ mounting adapter pair for FS-1. Mounts to 2-3/4" conflat flange
- 1 MKS Instruments 835 VQM (0-145 amu) Vacuum Quality Monitor, as described below:
 - 835 System, w/ a Controller for single gauge, 1-145 Range Mass Detection (AMU)
 - 835 Software Suite CD includes the 835 Viewer Application, Installer, Executable, Read Me, License Agreement, Revision History.
 - Differential Pumping "T" adaptor with ports available for turbopump, RGA, and isolation valve
 - Pfeiffer HiCube 80 l/s turbo/mechanical pump station, turbopump will be directly coupled to "T" adaptor.
 - manual 2.75" CF gate valve with size 3 orifice with operating pressure range from 1 Torr to 10-9 Torr.
 - pneumatic 2.75" gate valve with interlock box for power failure and main chamber venting
 - support leg for RGA (red in color for awareness)

NOTE: Cannot be run on AJA laptop, must be run on separate computer to avoid LabVIEW interference.

Re-Circulating Water Chiller:

- 1 17,400 BTU/HR Closed-Loop Chiller for AJA Deposition Systems
 - Temperature setting range 5C to 40C
 - Cooling Capacity up to 5100W
 - Temperature stability +/- 0.1 C
 - Pump Capacity up to 60 PSI (0.42MPa)
 - Flow Rate up to 28 L/min
 - Tank capacity approximately 5 L
 - Noise level 60/61 dB

- Configured for single phase, 200-230 VAC (50/60 Hz) allowable voltage range +/-10%
- *(Includes installation package)*

GUARANTEES:

1. Con-Focal Deposition Uniformity: better than +/- 1.5% over a 4" diameter wafer - 5 mm edge exclusion with RF deposited SiO₂ or reactively deposited TiN (measured optically with AJA reflectometer)
2. Base Vacuum: better than or equal to 5.0×10^{-9} Torr with vacuum pumping system

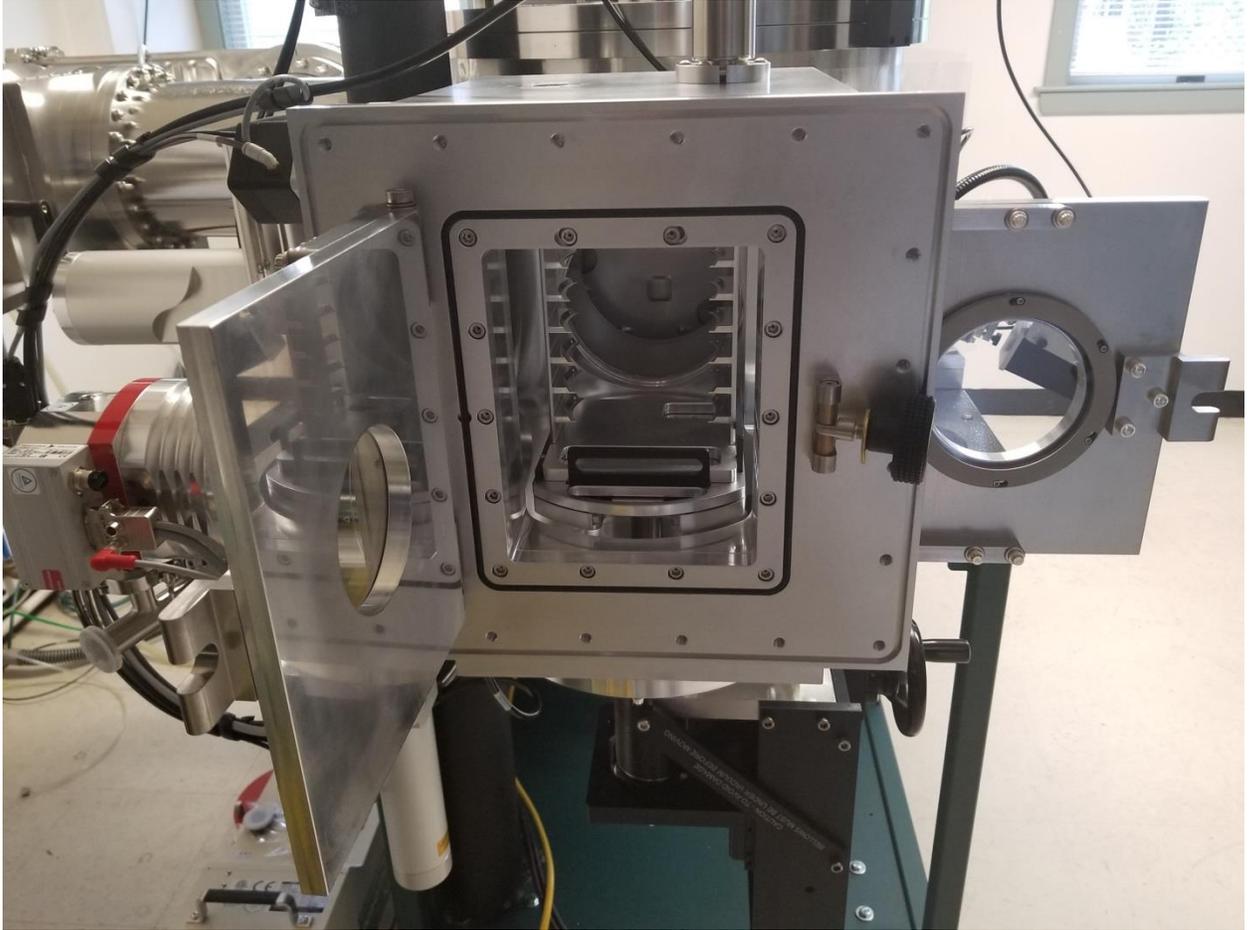
1.

main chamber



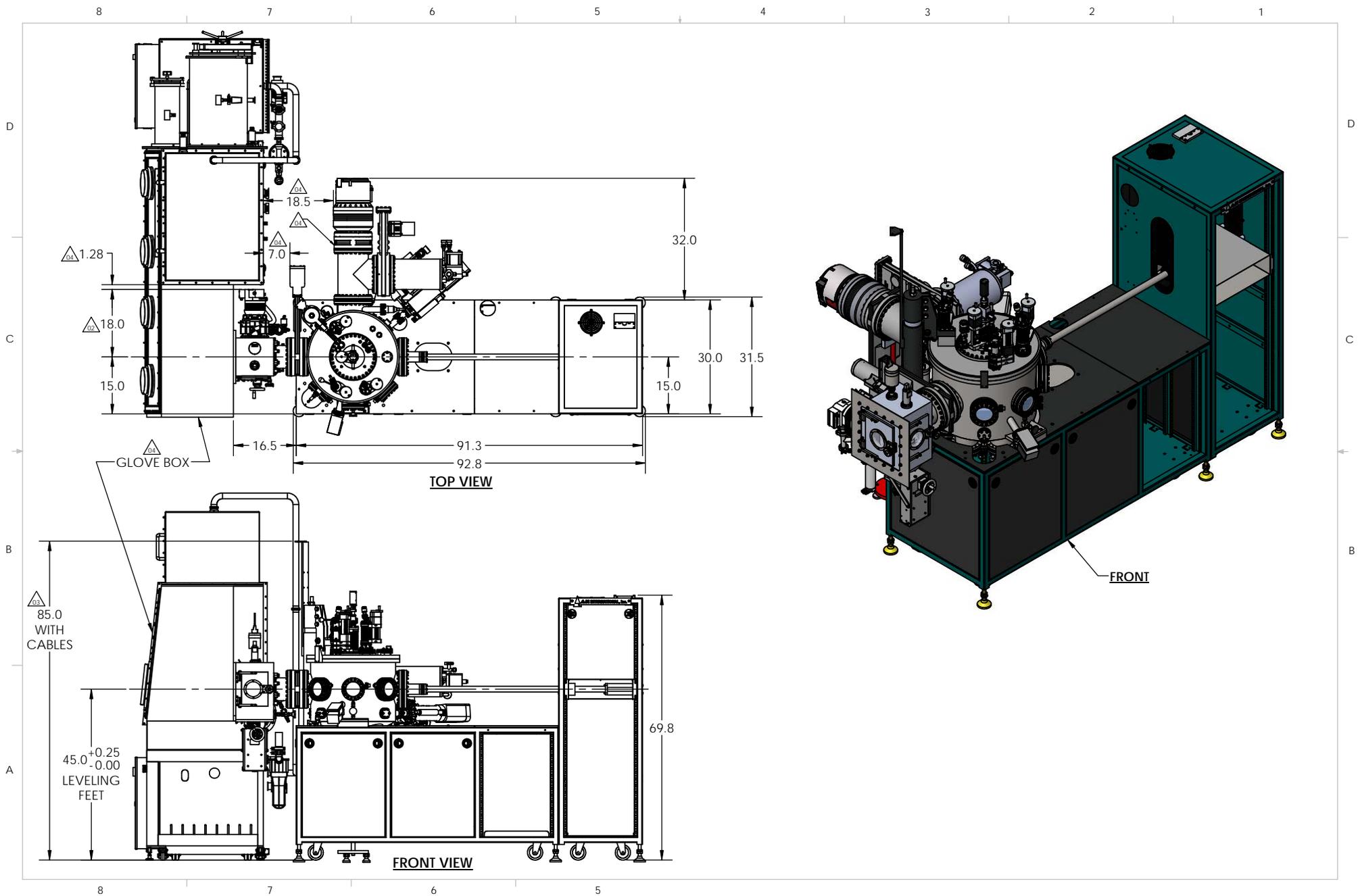
2. Loadlock





Left side view





8 7 6 5 4 3 2 1

D

C

B

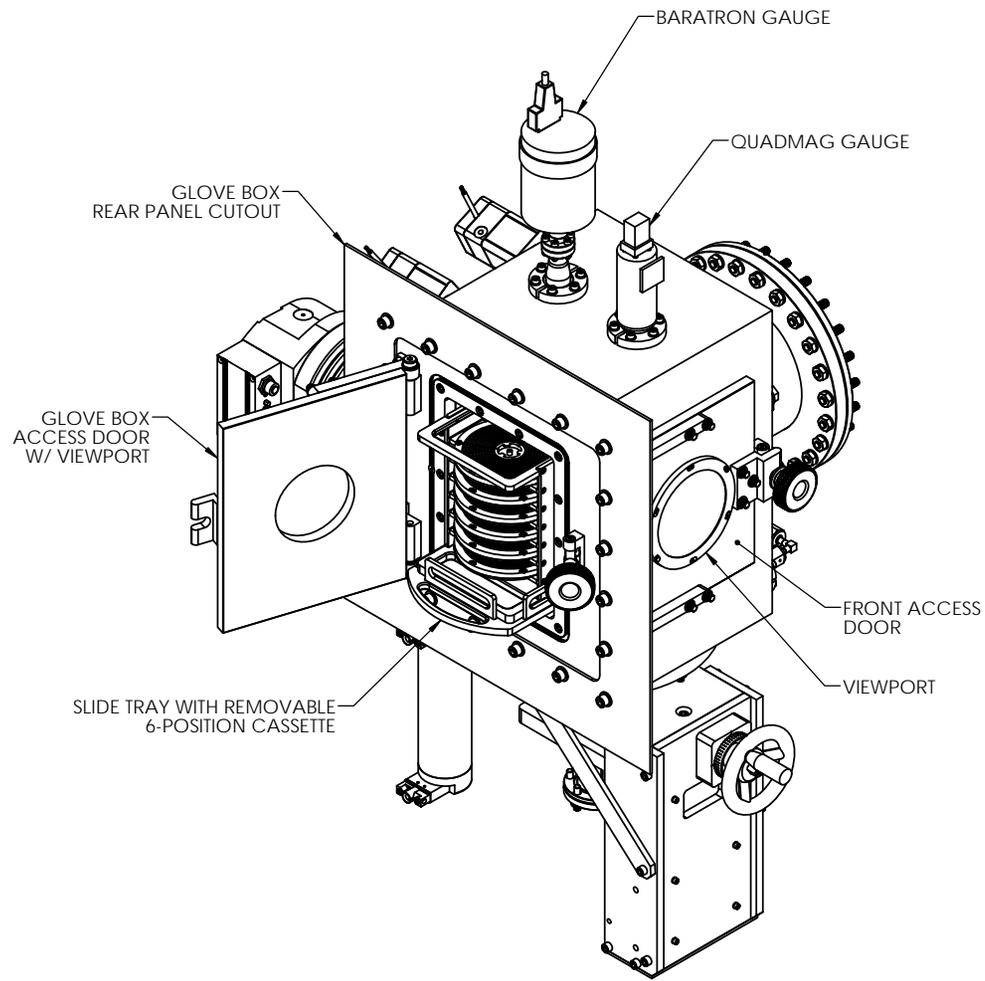
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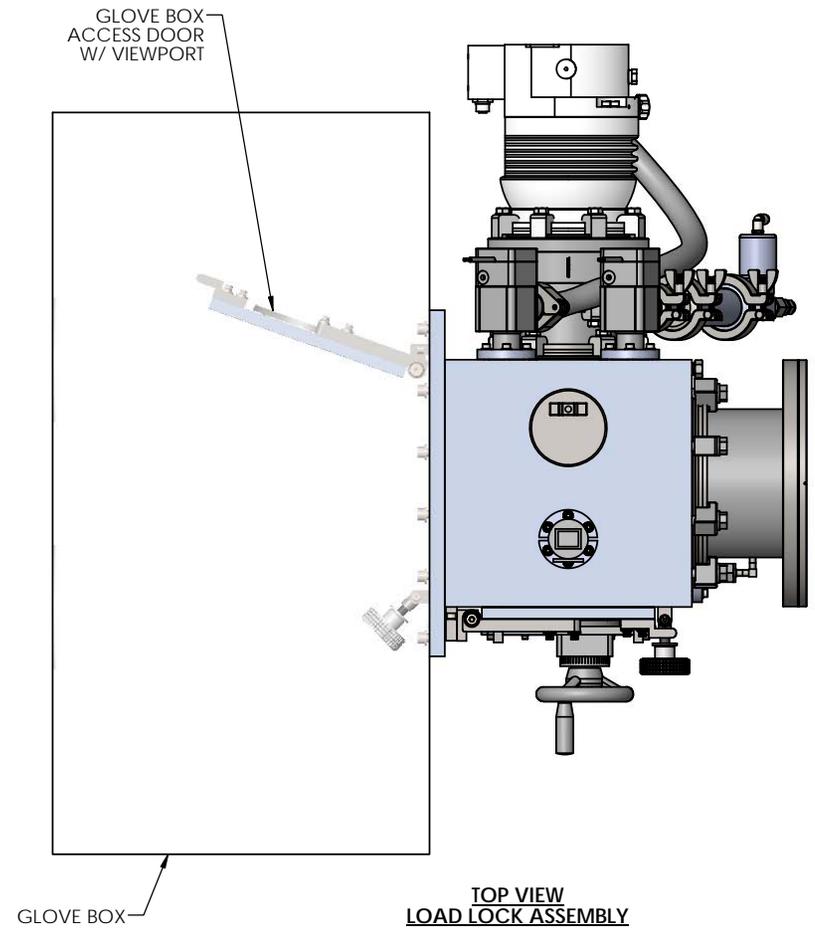
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LOAD LOCK ASSEMBLY



8 7 6 5 4 3 2 1

