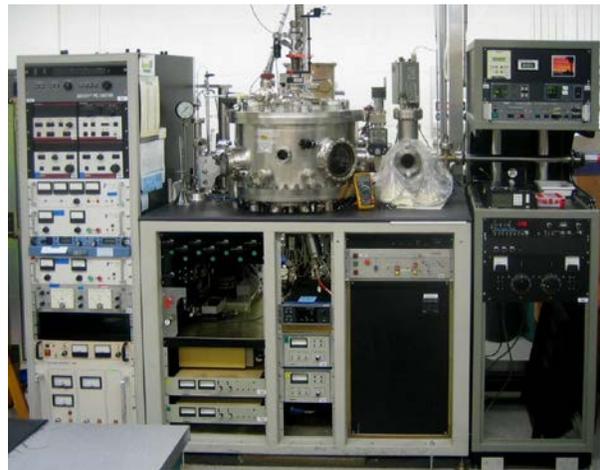




Thin Film Deposition Capabilities

Windows Group Coatings Lab (building 70)

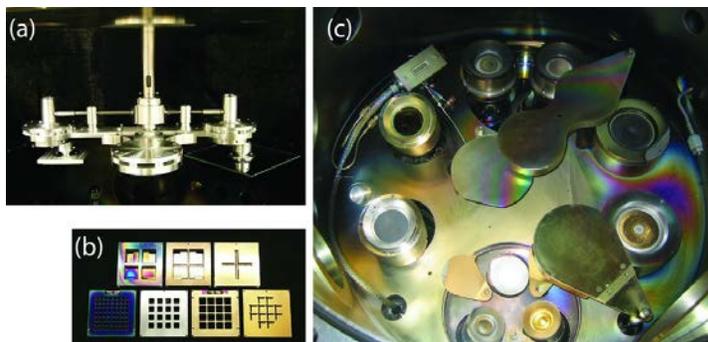
IBEX Physical Vapor Deposition System is the primary electrochromics deposition chamber capable of binary and ternary sputtering. It has ports to house up to eight round sputter sources which are grouped in four clusters on the chamber floor. The planetary substrate holder allows for film uniformity over 73 mm × 73 mm for multilayer devices or 89 mm × 89 mm for single layer. Substrate masking and combinatorial synthesis capabilities are also possible. This system can operate in single and dual magnetron reactive deposition mode, with industry-standard dual magnetron and mid-frequency sputtering supplies (Advanced Energy), industry-standard mass flow controllers (MKS), differentially pumped partial pressure analyzers (SRS), and a custom load lock and glass sample cleaning station.



IBEX Deposition Chamber

Attributes and Capabilities:

- Typical base pressure is 1.0×10^{-7} Torr. Assortment of DC, 40 kHz, RF power supplies.
- Load lock maximum possible passage size is 96 mm.
- Substrate maximum size without masks = 89 mm square; 87 mm x 89 mm coated.
- Substrate maximum size with cartridge-mask system is 73 mm square, 66 mm square coated.
- Cartridge-mask system allows multiple deposited layers without breaking vacuum.
- Absolute maximum rotated sample size is 150 mm square.
- Substrate heating could be added with non-rotating carousel.



(a) Planetary substrate holder

(b) Substrate masks

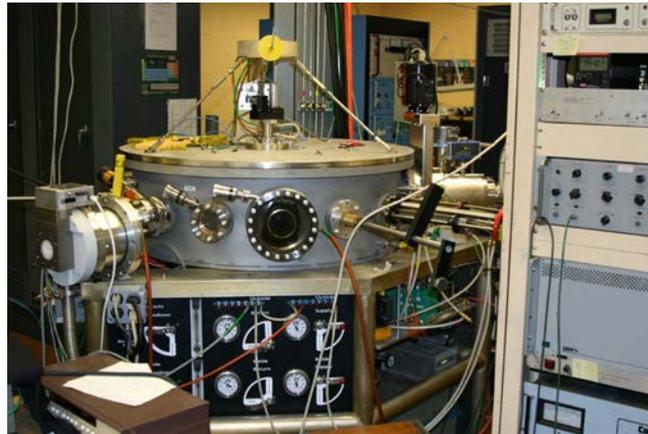
(c) Multiple sputtering sources on the chamber floor as seen from the top of the opened chamber.



Thin Film Deposition Capabilities

Plasma Applications Coatings Lab (building 53)

Chamber 1 Vapor Deposition System is a universal research and development deposition system primarily for advanced magnetron sputtering including High Power Impulse Magnetron Sputtering (HiPIMS). This chamber is equipped with industry-standard mass flow controllers for multiple gas injection, residual gas analyzer (SRS) and Hiden EQP Mass and Energy Analyzer¹ for Plasma Diagnostics. The chamber has a motorized substrate holder capable of rotating the substrate to various positions. Planar magnetrons from 1.5" to 3" and 2 linear magnetrons with target size 178 mm × 38 mm are available.



Chamber 1

Attributes and Capabilities:

- Base pressure is 2.0×10^{-7} Torr
- Various power supply including Advanced Energy (Pinnacle and Pinnacle Plus) and Melec SPIK 2000A for HiPIMS
- Rotating substrate holder capable of multilayer deposition using multiple sputtering.
- Various sputtering guns for different size target.
- Substrate heating up to 500°C.



HiPIMS without any gas: Pure Self-Sputtering of Cu in vacuum



Negative Ion Filter for oxide deposition

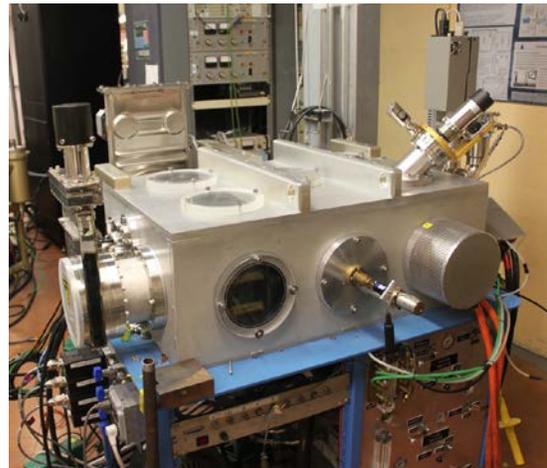
¹ Owned by UC Berkeley



Thin Film Deposition Capabilities

Plasma Applications Coatings Lab (building 53)

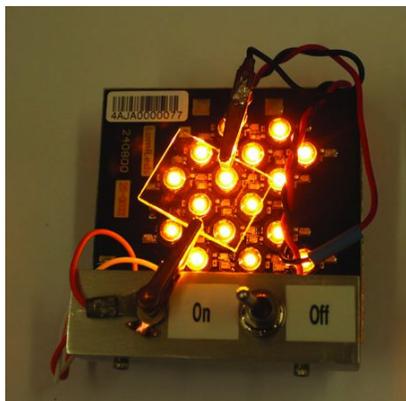
Chamber 2 Vapor Deposition System is a research and development chamber primarily used for cathodic arc deposition (both continuous and pulsed). It is also the system for depositing thin films of zinc oxide and related materials. Substrate treatment such as biasing and substrate heating up to 500°C are possible. This chamber has a residual gas analyzer (RGA by SRS) and a Raytek IR temperature sensor to monitor the substrate temperature. Industry-standard mass flow controllers are used and in conjunction with the RGA, a feedback loop controlled by LabView™ allows the gas pressure and flow rate to be regulated during deposition to ensure consistent partial pressure during deposition.



Chamber 2

Attributes and Capabilities:

- Typical base pressure is 2.0×10^{-6} Torr; the cryo-pump has a custom cool trap for zinc vapors.
- The pressure and flow of gas is regulated by LabView™ to maintain control of partial pressures during deposition.
- LabView control of the sequence of up to three cathodes during pulsed cathodic arc deposition.
- Substrate biasing and heating up to 500°C.



Transparent conducting aluminum zinc oxide thin film deposited on glass.



Arc plasma travelling through a magnetic filtered during a cathodic arc deposition



Material Characterization Facilities

Dektak 150 Surface Profiler²

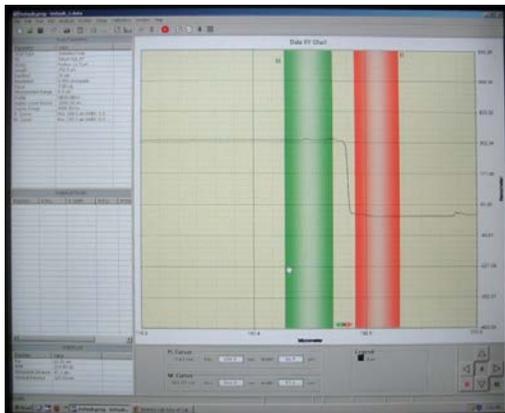
The Dektak 150 contact probe is used to measure the thickness of thin films grown in our physical vapor deposition chambers. This characterization process allows for the calculation of deposition rates and subsequent growths of films and device stacks to specified layer thicknesses.

Attributes and Capabilities:

- Two dimensional contact surface profile measurements
- Vertical resolution down to 1 nanometer
- 10 cm x 10 cm X-Y stage range; vertical capacity to 9 cm
- Option available to allow for automated 2-D large area scans
- Three step height resolution ranges, up to a maximum of 524 μm .



Veeco Dektak 150



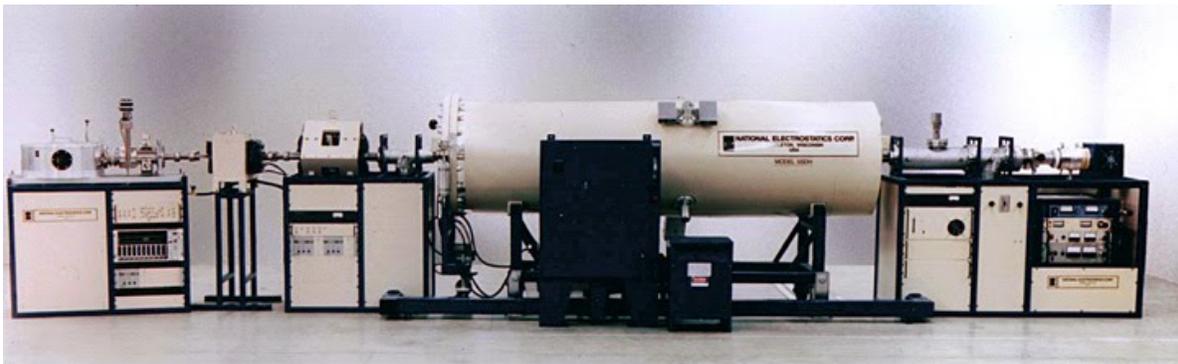
Step profile of a deposited thin film

² Shared with the Battery Group



Material Characterization Facilities

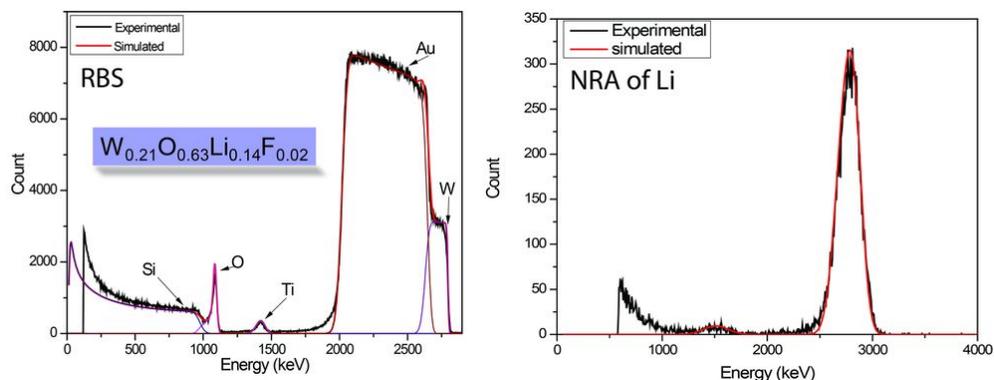
Pelletron³



The Pelletron is a 1.7 MV tandem electrostatic ion accelerator made by the National Electrostatic Corporation (NEC) for ion beam analysis of materials such as Rutherford Backscattering Spectrometry (RBS), Nuclear Reaction Analysis (NRA), Ion Beam Channeling, Elastic Recoil Detection Analysis (ERDA) and Particle Induced x-ray Emission (PIXE).

Attributes and Capabilities:

- Energetic alpha beam up to 5.1 MeV can be generated with a terminal voltage of up to 1.7 MV.
- The target chamber is evacuated by a turbo pump; sample changing can be done through a special feedthrough in the lid of the chamber; a 5-axis goniometer allows for channeling experiments.
- Nuclear Reaction Analysis can be done in conjunction with Rutherford Backscattering Spectrometry on exactly the same sample position.



RBS analysis of lithiated WO₃ deposited on Au/Ti. W-O quantify with RBS and Li quantify with NRA

³. This facility is jointly operated with the Material Sciences Division (MSD)



Lawrence Berkeley National Laboratory

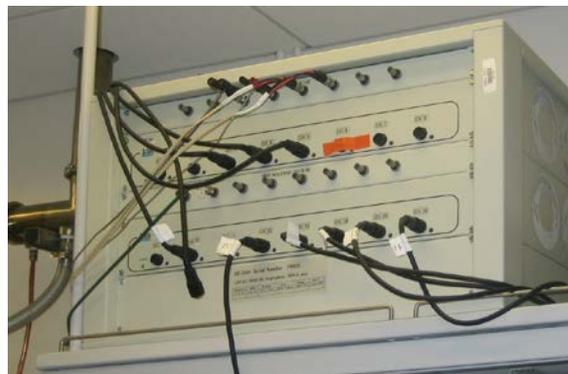
Environmental Energy Technologies Division

Material Characterization Facilities

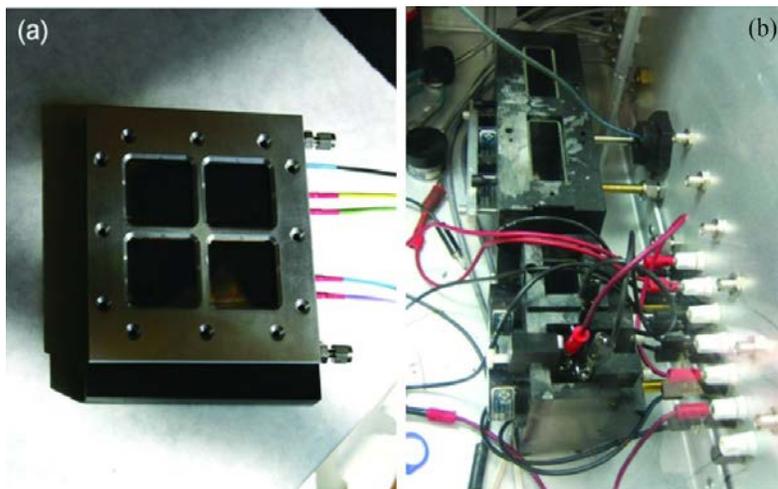
Arbin Instruments BT-2430 16 Channel Cycler⁴ was developed for the battery research community. The electrochemical similarities between batteries and electrochromic devices make it an ideal test and data acquisition instrument for prototype electrochromic window systems.

Attributes and Capabilities:

- Sixteen Channel Device Cycler with Integrated Data Acquisition
- Programmable to continuously cycle electrochemical devices at fixed or evolving parameters.
- Auxiliary input allows optical feedback loop, allowing cycling voltages, ramp times, and hold times to evolve with optical cycling behavior.
- Capable of all standard potentiostat functions for typical electroanalytical experimentation.



Arbin Instruments BT-2430 16 Channel Cycler



(a) A Transition Metal Switchable Mirror four channel test cell with integrated gas reservoir is controlled during cycling by the Arbin BT-2430.

(b) opto-electrochemical test cells inside a glovebox are controlled by the Arbin BT-2430.

⁴ Shared with the Battery Group.