Telemark Product Training

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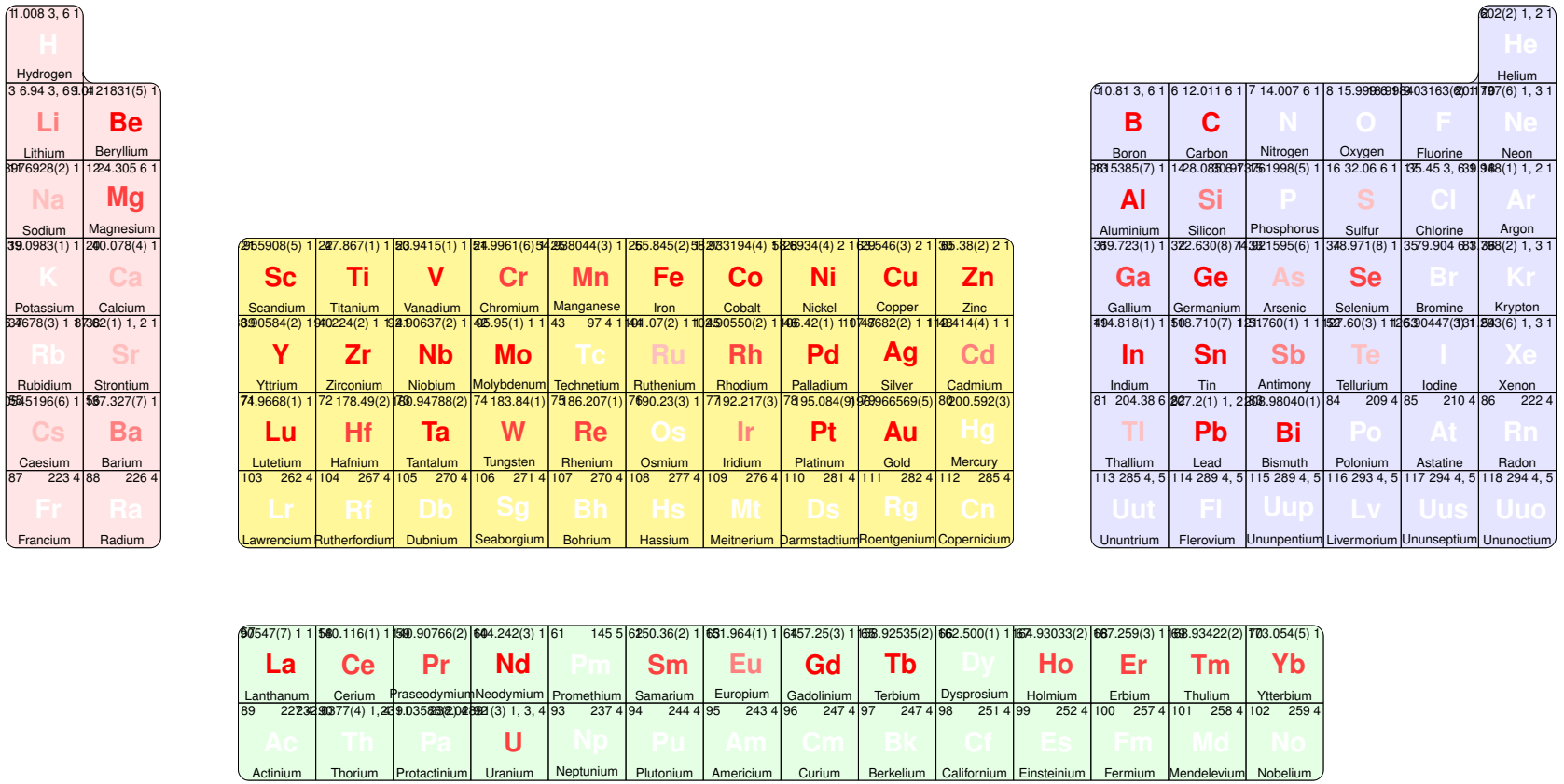
E-beam: Versatile Thin Film Technique



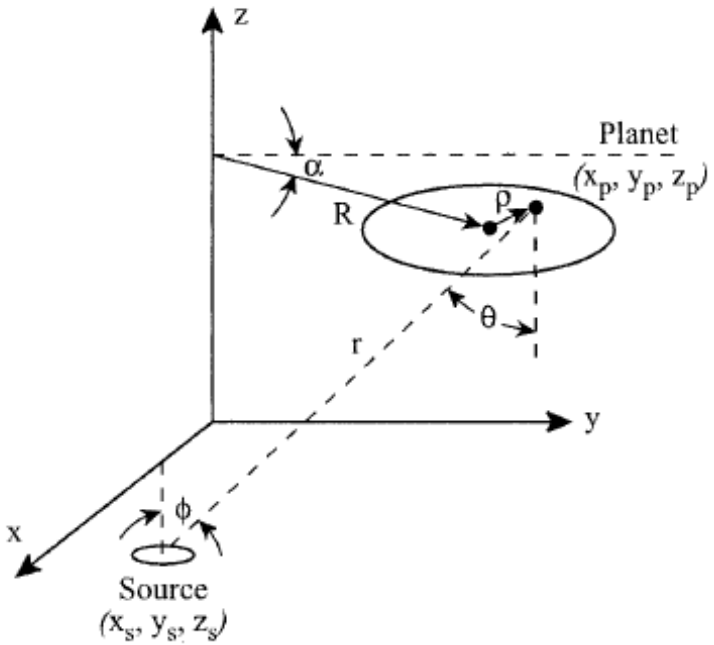
Process Drives Equipment Selection

How do process requirements and deposition materials drive equipment selection?

Typical process requirements

- Film Uniformity
  - → Drives Throw Distance
- Film Thickness
  - → Drives Pocket Size
- Deposition Rate
  - → Drives Power Supply Selection

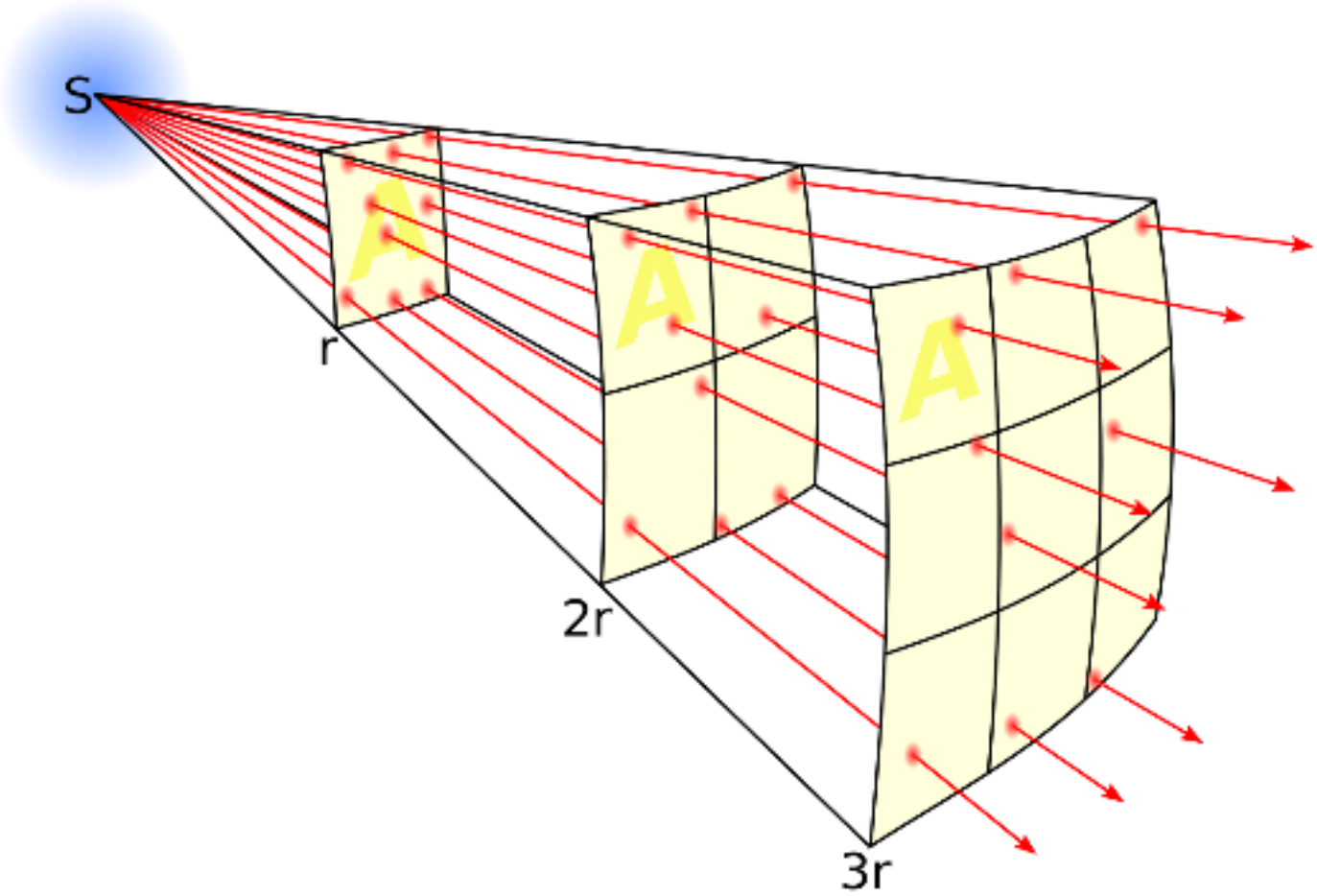
Calculating Distribution/Uniformity



Planetary?
Single-spinner?
Dome?
Tri-Dome?
Web?
Masking?
Uniformity can be complicated. . . We're happy to consult with you!

$$\int \frac{(z_p - z_s)^n}{\left((x_p - x_s)^2 + (y_p - y_s)^2 + (z_p - z_s)^2\right)^{n/2+1}}$$

Inverse Square Law

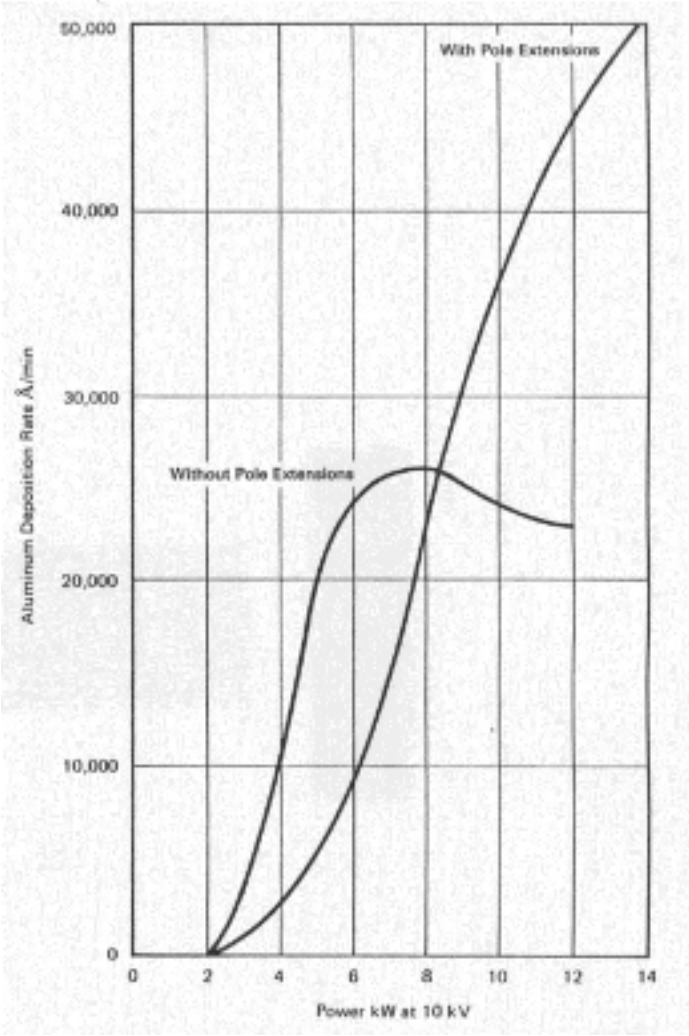


Different material have different concerns

- Sublimating materials (many metal oxides) are difficult out of large pockets (>40cc)- use multiple small pockets
- Metals often need larger pockets with a liner to achieve higher rates

Different material have different concerns

- Sublimating materials (many metal oxides) are difficult out of large pockets (>40cc)- use multiple small pockets
- Metals often need larger pockets with a liner to achieve higher rates
- Aluminum
- Refractory metals



Material Consumption

5-6 micron per cc at 25 cm above source (static)
Scales with r^{-2}
(e.g. only 300 nm to 375 nm at 1 m)
Don't forget to consider crucible liner$\rightarrow$ shrinks pocket volume...

Also consider motion of parts (tooling factor)

Pocket Filling

- Granular materials 0.6-0.8 packing density
- Overfilling pocket can lead cross-contamination or liner cracking
- Don’t evaporate all of pocket (striking bottom of pocket)
- Leaves ≈50 % of pocket volume for evaporation

Do I need a liner?

Liners:

- Provide thermal isolation from hearth
- Keep e-beam source clean(er)
- Keeps material from bonding to the hearth

Liner Selection

TELEMARK

Crucible Liner Recommendations for E-Beam Evaporation

Element	Symbol	Melting Point °C	Bulk Density g/cm³	Acoustic Impedance Ratio (z) (880)	Acoustic Impedance g/cm²·s (860, 861)	Temperature °C @ Vapor Pressure 10^{-5} mbar	Temperature °C @ Vapor Pressure 10^{-4} mbar	Recommended Crucible Liner(s)	Sweep	Remarks
Aluminum	Al	660	2.7	1.05	8.41		1010	Re-infiltrated	none	
Aluminum Oxide (Alumina)	Al_2O_3	2045	3.96	0.36	24.53		1550	Graphite, Re-infiltrated, Mo	large	
Beryllium	Be	1283	1.85	0.55	16.05	710	1000	Vit. Carbon		Powder very toxic. Wets W/Mo/Ta.
Beryllium Oxide	BeO	2575	3.01				1900		large	Powder very toxic. No decomposition from EB.

https://telemark.com/wp-content/uploads/Thin-Film-Evaporation-Guide.pdf

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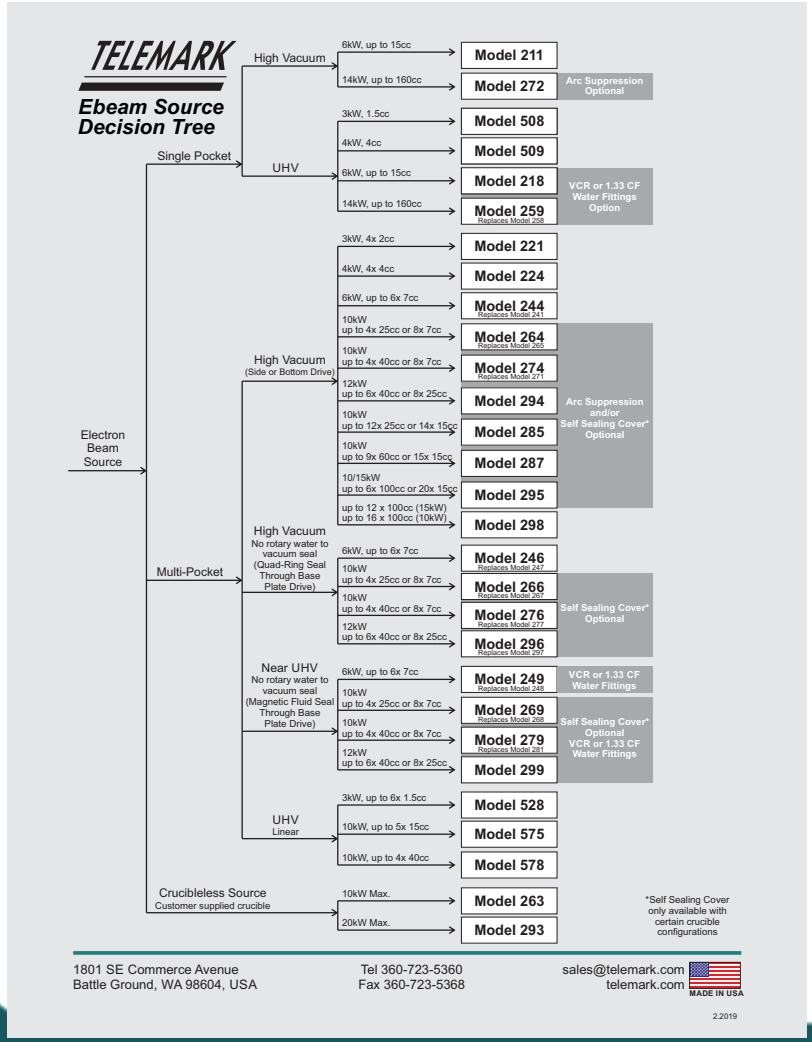
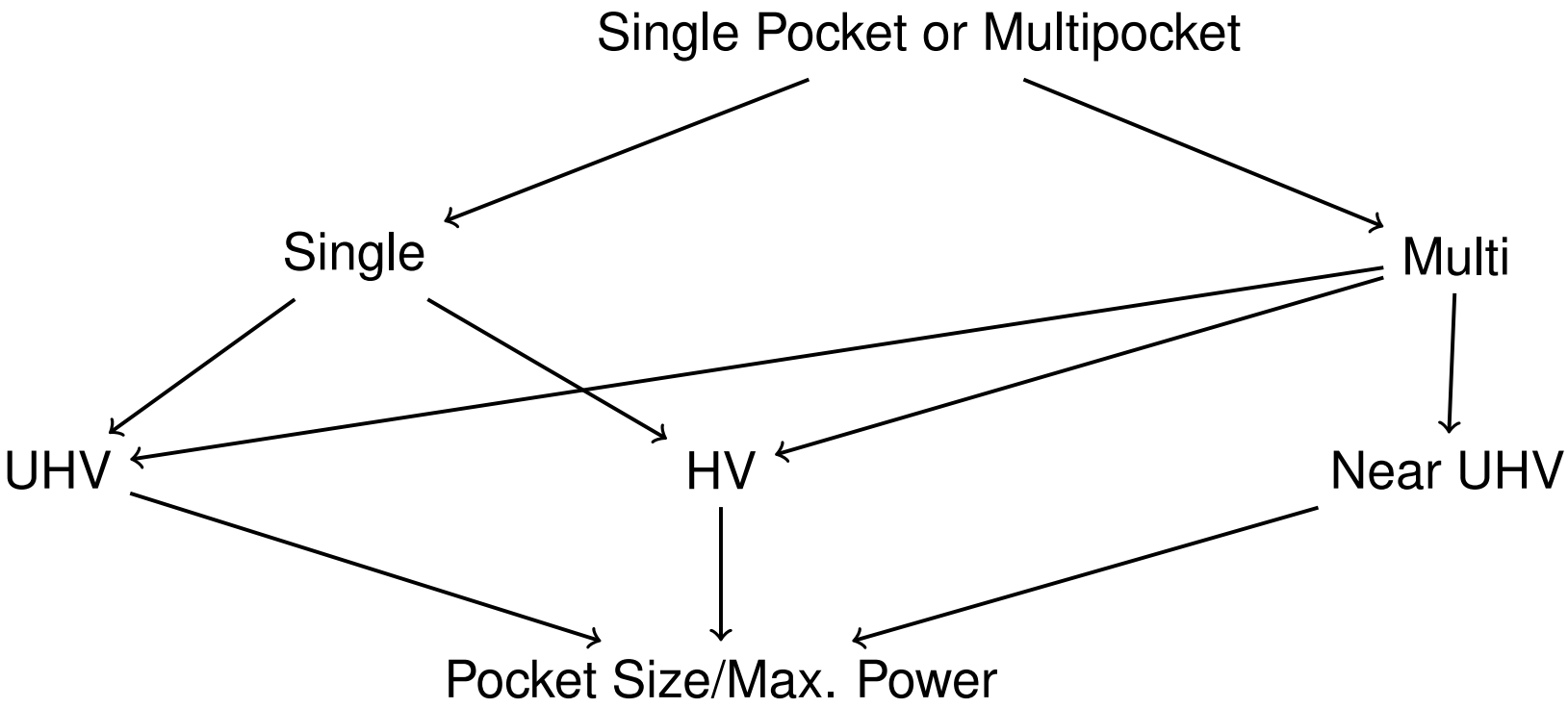
Source Selection



https://telemark.com/wp-content/uploads/telemark-e-beam-source-model-tree.pdf

General Source Selection Process



Multipocket Sources

HV		Near UHV	UHV
Rotary Water-to-Vacuum Seal	No Rotary Water-to-Vacuum Seal	Magnetic Rotary	Linear Bellows
221			528
224			
244	246	249	
264	266	269	575
274	276	279	578
285			
287			
294	296		
295			
298			

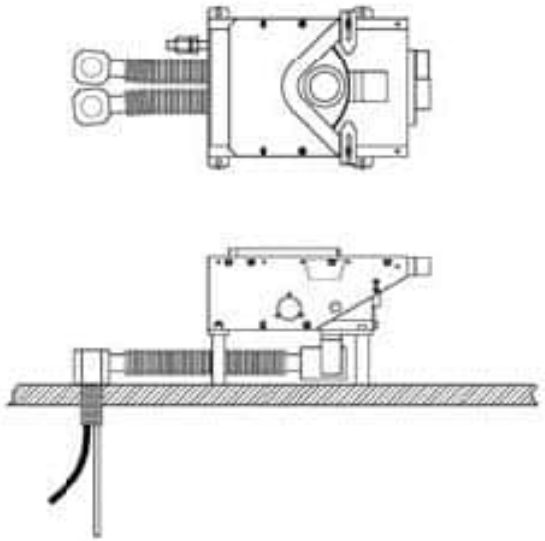
Source Options

- Arc Resistant Emitter
- Self Sealing Cover
- In-Pocket Switch
- VCR or 1.33CF water fittings
- Flange mounted

Arc Handling

Telemark primarily uses three methods to reduce arcs:

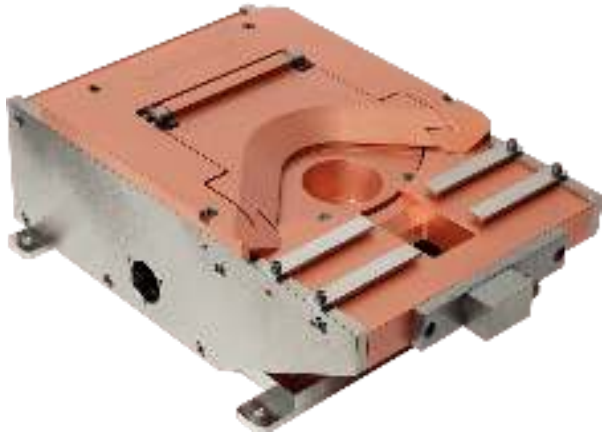
- Power Supply Design
- Arc Suppression Emitter Design (264/266/269/273/274/276/279/294/296/299)
- Arc Suppression Upgrade (264/271/272/273/274/294/295)



Arc Resistant Emitter

- Can operate in hostile, high particulate environments
- Do not react to ion sources or other discharges
- Operate at vacuum levels of >5x10-3 Torr
- Have longer crucible life and enable better evaporation of material
- Employ a durable emitter assembly for increased filament life and simple maintenance

Self-Sealing Cover



- No in-vacuum pneumatics or motor required
- Protects materials from cross-contamination
- Excellent for Gold or Indium deposition
- Available on only certain crucible configurations of the models 264, 266, 269, 271, 273, 274, 276, 279, 294, 295, and 296

Periodic Maintenance

- Hearth cleaning
- Filament replacement
- Seal maintenance
- Magnet gauss

Hearth Cleaning

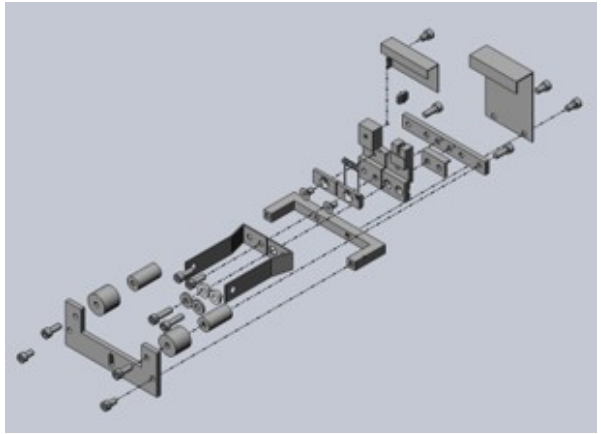
- Wire brush (brass or stainless) or scotch-brite pad between runs
- Periodic bead blasting of hearth
- Semi-annual Factory rebuild

Emitter Removal

- In normal practice the emitter is extremely hot after operation
- Remove nuts and bolts holding HV leads
- Remove Allen screw holding Emitter
- Pull the emitter assembly straight out the front

Emitter Cleaning

- Needed Equipment: Alcohol, Wire, Bead-blaster, Gloves
- Clean and vapor dry the parts after bead-blasting
- Discard any cracked or broken ceramics
- Discard screws that hold down the filament clamps and the beam former

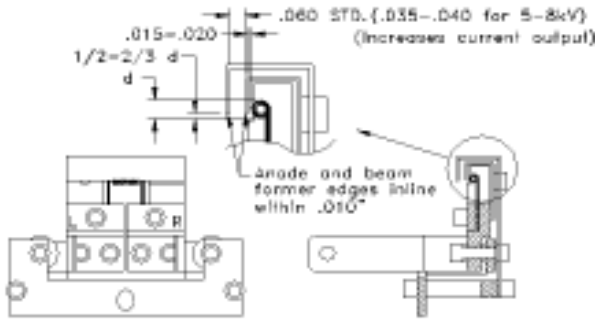


Emitter Reassembly

- 90% of source problems relate to the EB source emitter
- Close attention to the emitter assembly is of the utmost importance to trouble free runs
- In particular, pay meticulous attention to the following:
  - Length of screws
  - The relative position of the anode plate, beam former, and filament
  - Filament leads
  - HV leads

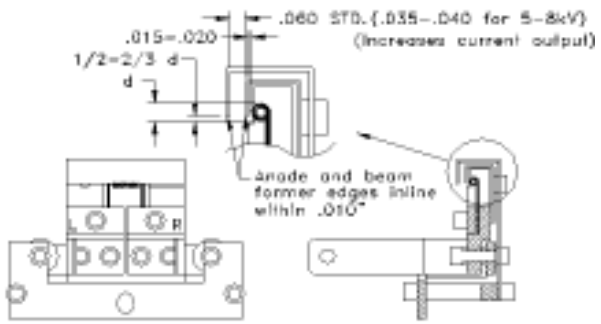
273 Emitter

1. Assemble the mounting bracket, the left hand cathode block, and the left hand buss using two #6 x 3/8" screws
2. Add the following to the assembly: the L insulator, the right hand cathode block and the right hand buss bar, using two #6 washers, two collar insulators, and two #6 x 1/2" screws
3. Mount the cross insulator and the beam former using one #6 x 1/4"



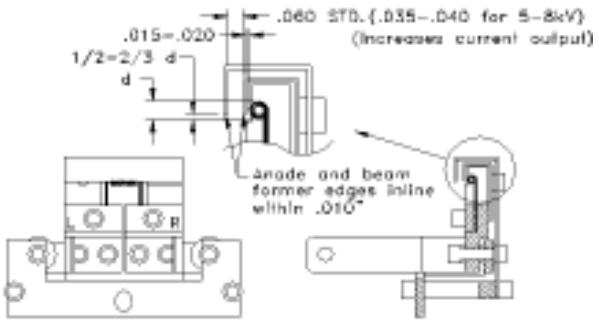
273 Emitter

4 Stand this assembly up on a flat surface, with the buss bars facing away from you. Gently tap the beam former into place, and snug the screw down. Turn the assembly so the buss bars are facing you. Press down gently on the beam former, and gently snug the screws on the right hand buss bar. Check the gap between the two cathode blocks, making sure that they are parallel. Snug the left hand buss bar screws.



273 Emitter

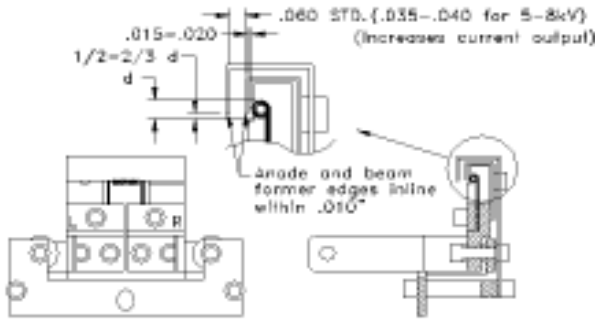
5 Install the new filament, making sure that the filament orientation is correct. Using new #6 x 1/4" screws, loosely mount the filament clamps in place. Gently tap the emitter assembly on a flat surface to settle the filament into place. Slide the filament clamp on the right cathode block until it is flush with the right side of the block. Snug the right #6 x 1/4" screws. Gently push the left hand clamp into place. NOTE: Sliding this clamp can cause the filament to warp or bow. Snug the left #6 x 1/4" screws. Now check the alignment of the filament to the beam former.



273 Emitter

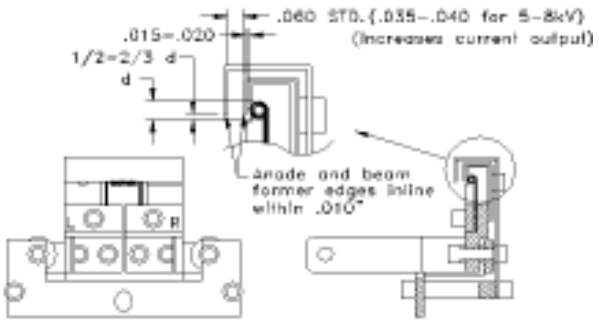
6 Loosely mount two HV Insulators and two HV Shields to the emitter support bracket with two #6 x 3/8 screws.

7 Mount the Anode to the U Bracket using two #6 x 1/4" screws.



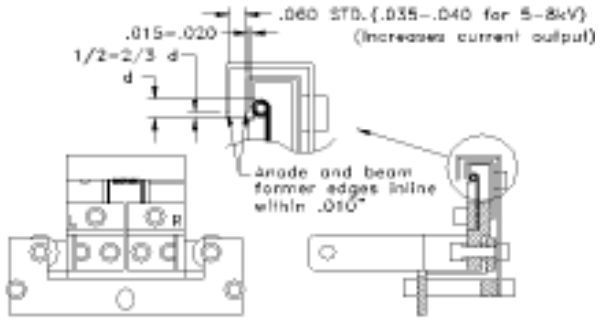
273 Emitter

8 Attach the emitter support bracket assembly to the mounting bracket assembly, using two #6 x 1/4" screws. Place this assembly on a flat surface with the emitter support hanging over an edge. Gently push down on the support bracket and tighten the two #6 x 3/8 screws into the HV insulators. Next, carefully reach around and tighten the two #6 x 1/4" screws into the HV insulators. Now mount the U bracket assembly to the support bracket using two #6 x 1/4" screws. Gently push down on the mounting bracket, and tighten the two #6 x 1/4 screws.



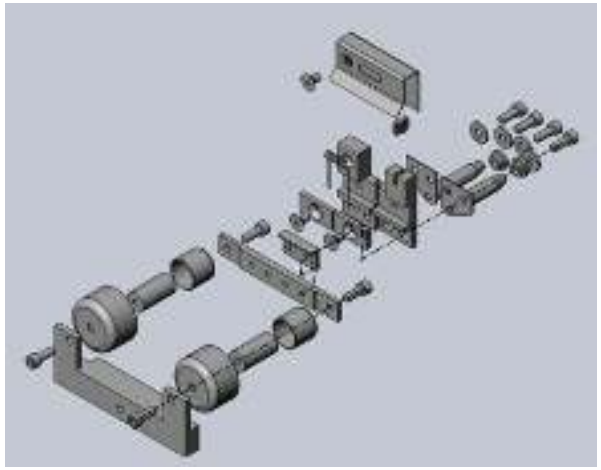
273 Emitter

9 Push down on the Anode and tighten the last two #6 x 1/4 screws. Check the alignment of the Anode to the beam former. The rebuilt emitter assembly is now ready to be installed back in the E-source.



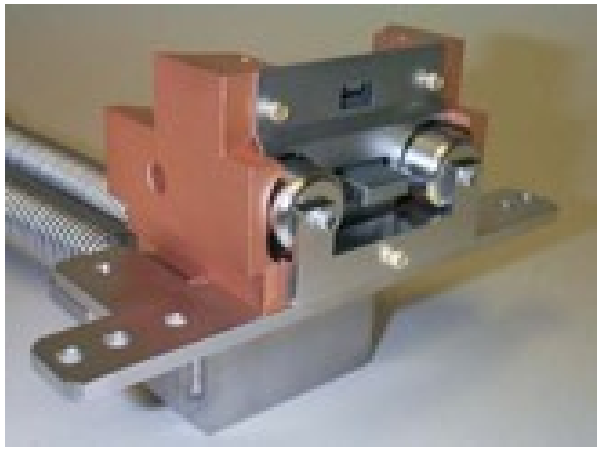
Arc-Resistant Emitter

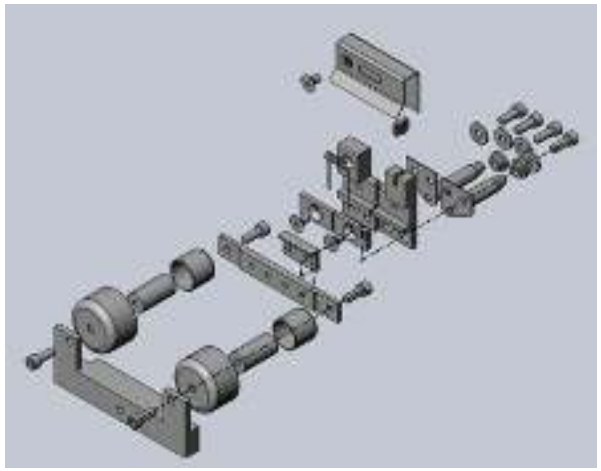
1. Assemble the mounting bracket without cut outs facing down, to the left hand cathode block, and the left hand buss bar using two #6 washers, and (1) #6x 3/8 screw (Ti) and (1) #6-32 x 1/2 screw (Ti) to attach Ion Trap.
2. Add to the assembly the L insulator, the right hand cathode block, and the right hand buss bar, using two #6 washers, two collar insulators, and one #6 x 3/8 screw (Ti) and (1) #6-32 x 1/2 screw (Ti) to attach Ion Trap. Adjust gap between the two cathode blocks to Max. Allowed by the screws. Snug all the screws down at this time.



Arc-Resistant Emitter

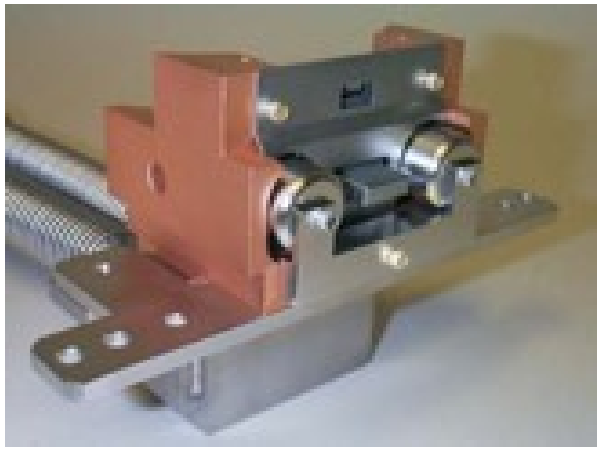
3 Install the new filament making sure that the filament orientation is correct (dog leg to the right side, from the front view). Use (2) #6 x 1/4 (Ti) flat head screws, loosely mount the filament clamps in place. Gently tap the emitter assembly on a flat surface to settle the filament into place. Slide the filament clamp on the left cathode block until it is flush with the left side of the block. Snug the left #6 x 1/4 screw. Gently push the right hand clamp into place. NOTE: Sliding this clamp can cause the filament to warp or bow. Snug the right #6 x 1/4 screw.

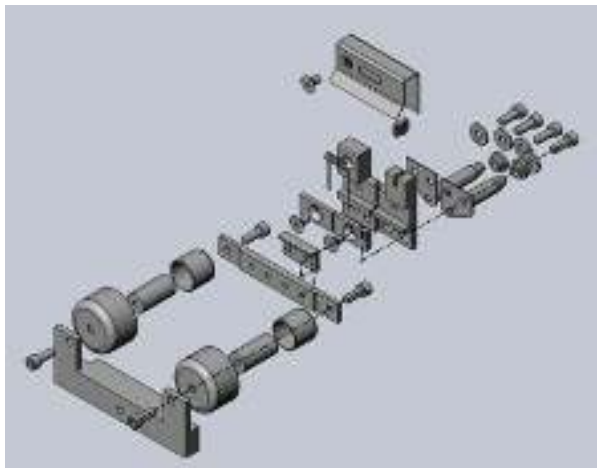




Arc-Resistant Emitter

4. Next mount the cross insulator and the beam former using one #6 x 1/4 (Ti) flat head screw.
5. Now check the alignment of the filament to the beam former. Adjust filament so as to be centered in window, ie: left to right.
6. Loosely mount two HV Insulator and two HV Shield, Inner to the emitter mounting bracket cut-out side with two #6 x 3/8 (silver plated) screws.

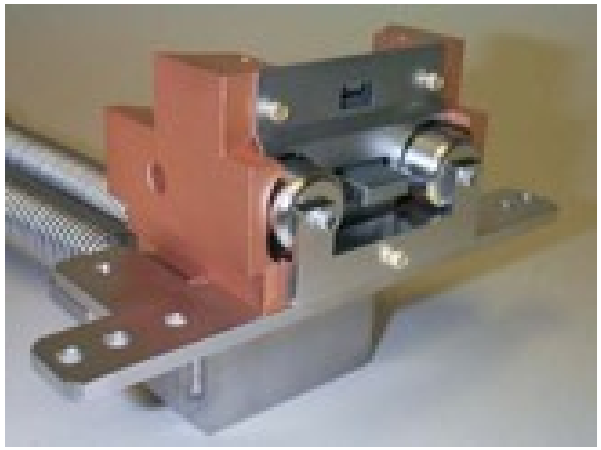


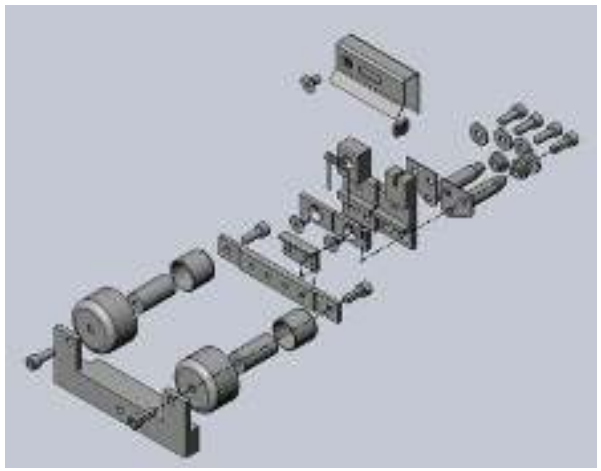


Arc-Resistant Emitter

7 Next attach (2) HV Shields, Outer, and the Emitter support bracket with (2) #6-32 x 3/8 (silver plated) screws.

8 Rotate the assembly 180 degrees, now snug the remaining (4) #6-32 x 3/8 (silver plated) screws.





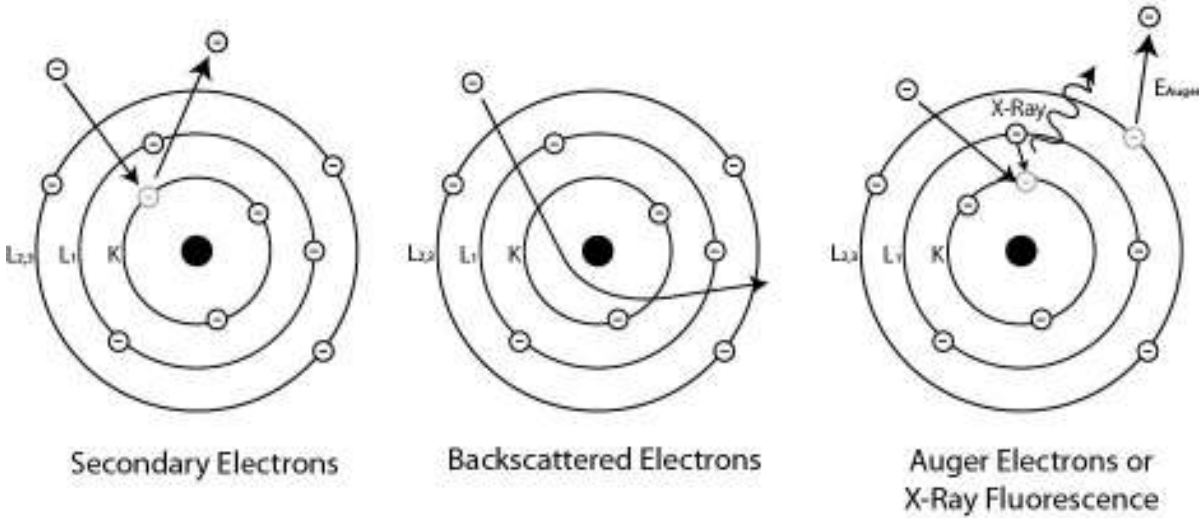
Magnet Gauss

- Permanent magnet is gaussed to center beam in pocket at factory
- Heat or Impact will weaken magnet $\rightarrow$ shift beam center
- Taking apart source can reduce magnet field strength by 20 %
- Periodically check voltage that centers beam, have regaussed if required

Selecting a Gauss Value

- Metals: 10 kV $\rightarrow$ Better melt penetration
- Dielectrics: $<$8 kV $\rightarrow$ Less dissociation (e.g. SiO_2 $\rightarrow$Si,SiO)
- Sources gaussed for higher energies can be shunted lower

Secondary Electrons



- Electrons ejected from melt towards substrate, or reflected off melt surface
- Source permanent magnet helps capture these electrons

Mitigating Secondary Electrons

Secondary electron problems:

- Substrate damage
- Resist hardening
- "Pin-holes" and flakes

Solutions:

- Longer throw distance ($>$20in)
- Use optional rear-mounted trap
- Maintain source gauss
- Large rotary multi-pocket sources have the longest magnet arm extension

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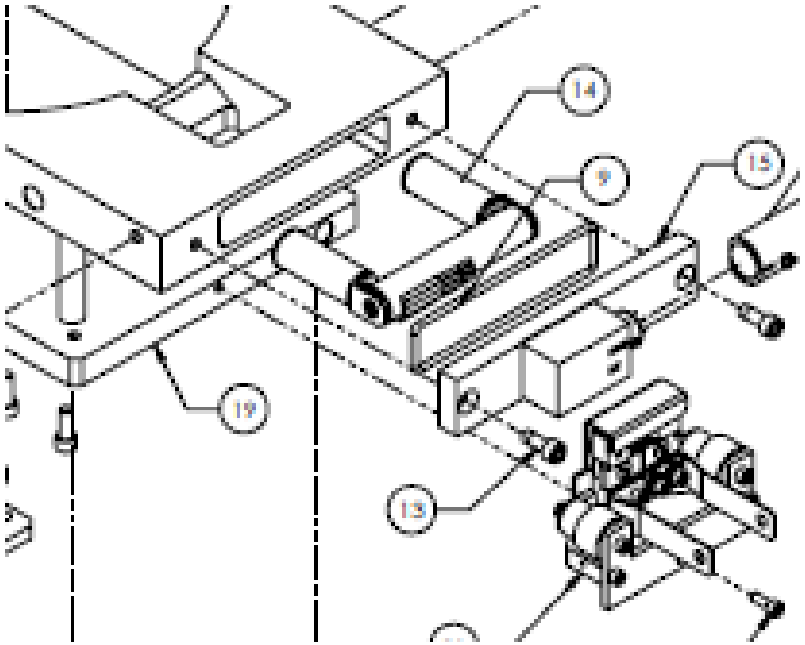
Why Sweep the beam?

If the evaporant cannot dissipate the beam energy by evaporation, conduction, or radiation, spitting occurs



Sweep the beam to distribute the power and avoid spitting

Sweep Comparison

Digital

8 Memory Slots
5 Pt. Pocket Setup
5 Preset Shapes

Programmable

32 Memory Slots
9 Pt. Pocket Setup
6 Preset Shapes
32 Custom Shapes
Pattern Rotation
Profiling
PatternMaker Software

Sweep Suggestions

For metals or melting materials:

- Small sweep amplitude during deposition
- Use sweep to precondition material to avoid explosions/spitting
- Telemark Digital Sweep is an excellent economical choice

For Dielectrics or sublimating materials:

- Sweep the entire crucible
- Sweep Profiling can greatly improve evaporant utilization in the crucible (avoid digging)
- The Telemark Programmable Sweep's advanced features allow for longer runs and better material utilization

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Source Indexing

- Manual rotation (knob)$\rightarrow$ prone to errors
- Rotary sources $\rightarrow$ 396/398
  - 396 for smaller sources (24x and below)
  - 398 for larger sources (26x and above)
- Linear sources $\rightarrow$ 397
- Source Mounted in-pocket switch prevents mis-rotation

Feedthroughs

Telemark offers a wide variety of power, rotation, and instrumentation feedthroughs with o-ring or metal seal as well as an excellent line of cost-competitive ferrofluidic feedthroughs

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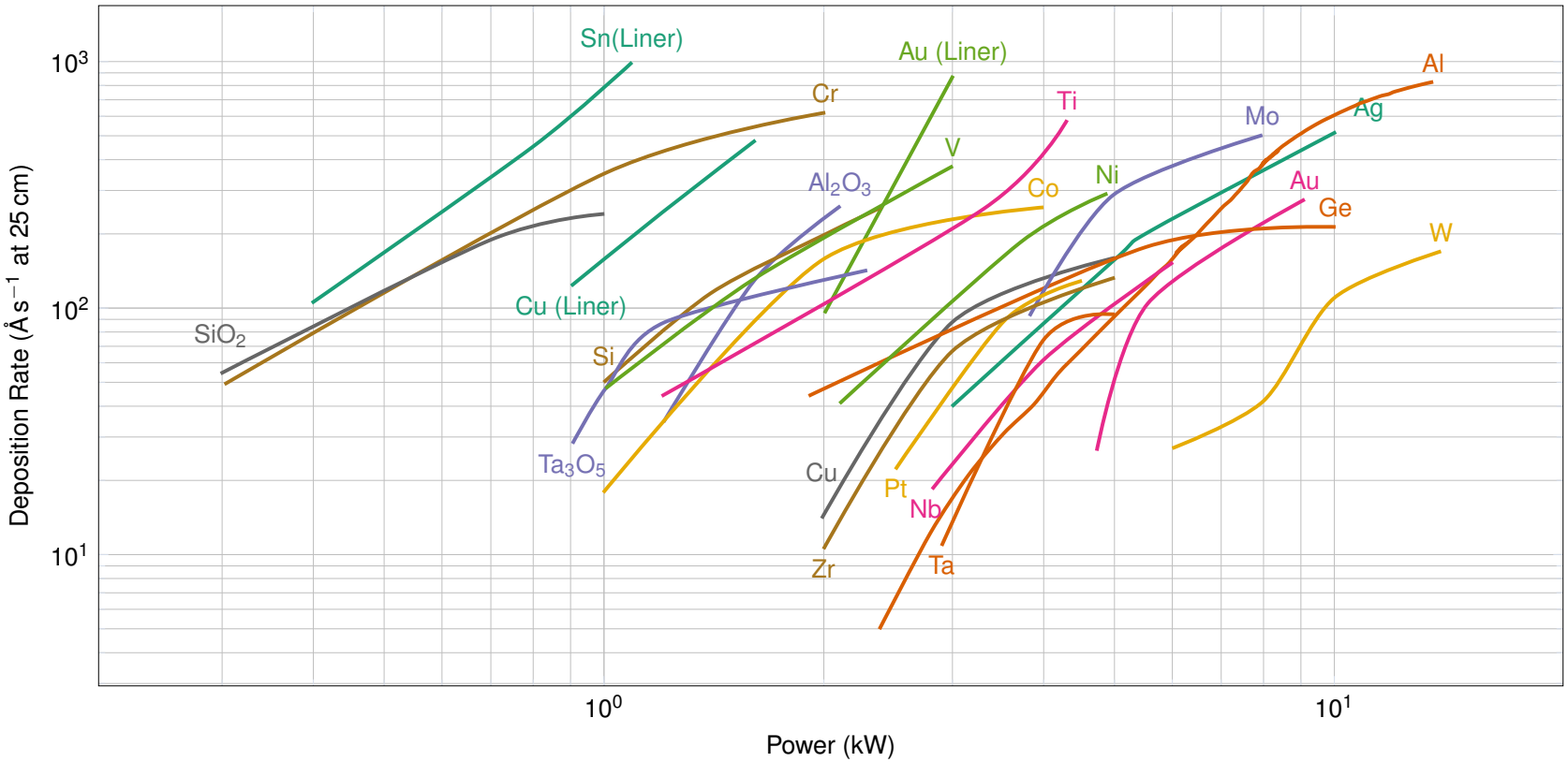
Power Supply Selection

How do I select an appropriate Power Supply?

Material Evaporation Rates



Process/through-put drives power requirement

TT vs ST

TT

- Easier Serviceability
- Higher Power Available

ST

- Lower Ripple
- Higher Efficiency
- Smaller Footprint
- Better Arc Handling

Power	TT-1	TT-2	TT-3	ST-1	ST-2
4 kW				○	
6 kW	○			●	
8 kW				●	●
10 kW	●	●	●	●	●
12 kW				●	●
15 kW	●	●	●		
20 kW	●	●	●		

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How do I control rate and process?

Time and Power?

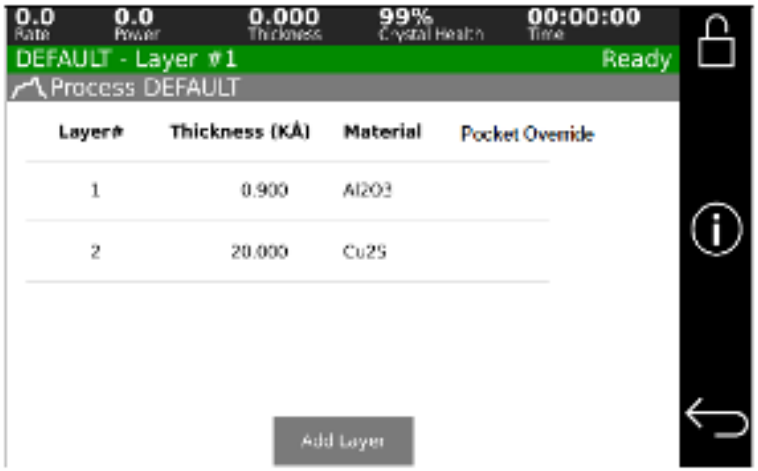
- Inconsistent
- Operator intensive
- Error-prone

Better: Deposition Controller with Quartz Crystal Microbalance

Quartz Crystal Monitoring

- Small piece of driven quartz oscillates via piezeoelectric effect
- As thin film deposits on crystal face $\rightarrow$ mass increases
- As mass increases $\rightarrow$ oscillation frequency decreases
- By measuring oscillation frequency we can infer deposited film thickness

Process Management



- A `Process` is one or more `Layers`
- Each `Layer` is defined as a `Material` with a defined thickness
- Each `Material` has a set of material properties (density, acoustic impedance, crucible number, rate, ramp/soak, etc.)

Advanced Process Management

Programmable and expandable I/O allows for integrating other process equipment (such as shutters, heaters, SCRs, MFCs, Ion Source, etc.)

PLC Integration

A variety of protocols for integrating 861 with system controller:

- Telemark standard protocol
- 360C protocol
- ASCII Checksum protocol
- ASCII No Checksum protocol
- Mixed ASCII protocol

Allows user to remotely:

- Update process/material properties
- Remotely operate 861 controller (start/stop process)
- Stream thickness/rate data

Telemark provides DCM software for easy remote interface, as well as material/process management and backup/restore

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Common process problems

- "Why doesn’t my film index match the bulk material index?"
- "Why does my film drift out of spec overnight?"
- "Why does my film not stick to or pop off my substrate?"
- "How do I get rid of these pin-holes in my film?"
- "How do I remove this native oxide layer on my substrate?"

Bad Film Index or Drifting film

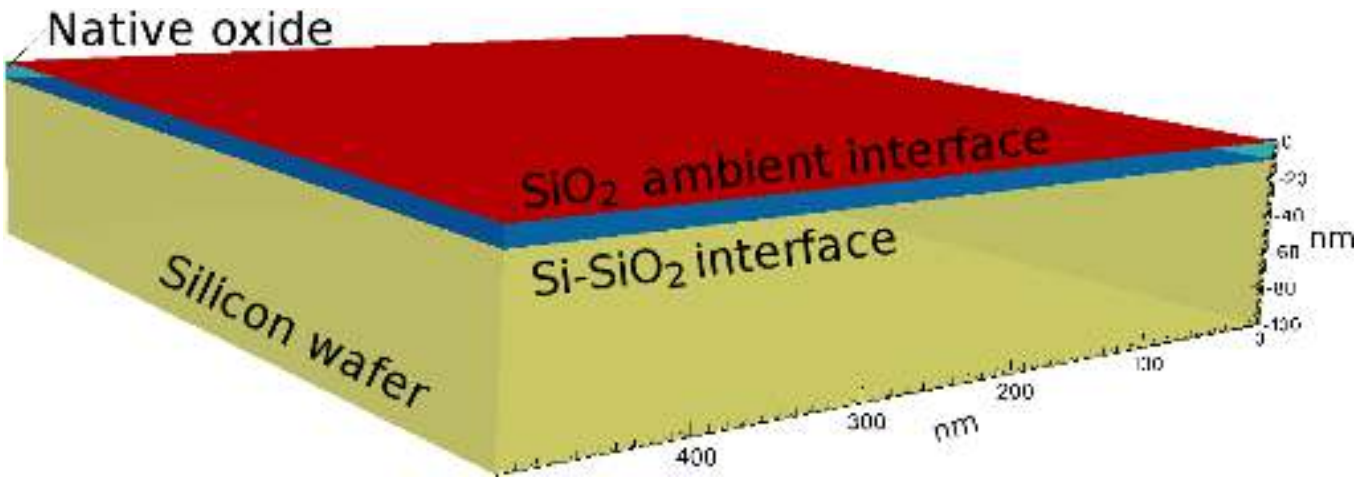
- Film is not dense enough
- Film can absorb humidity
- Solutions:
  - Heat
    - Parts have to cool before handling
    - Chamber has to cool for worker safety
    - Incompatible with some materials (e.g. plastics, resist)
  - Ion Assisted Deposition (IAD) via Ion Source

Bad Film Adhesion or Pin-Holes

- Substrates not clean
  - Improve cleaning practices
  - Improve Cleanroom
  - Ion Source Pre-clean
- Excessive film stress causes delamination
  - Change process materials to balance coating stress (usually not an option)
  - Heat
  - Ion-Assisted Deposition with Ion Source

Native Oxide Removal

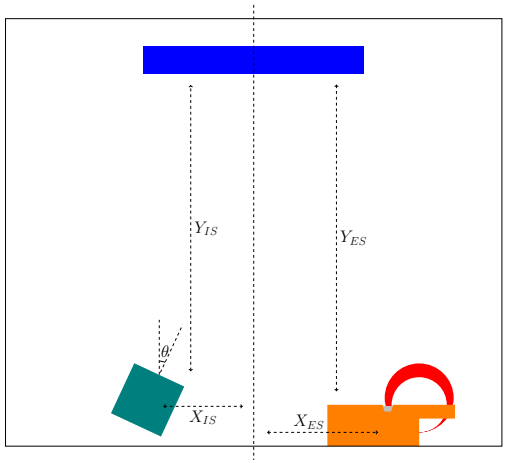
- Use separate ion etch tool and keep under vacuum or N_2
- In-situ Ion Etch using Ion Source

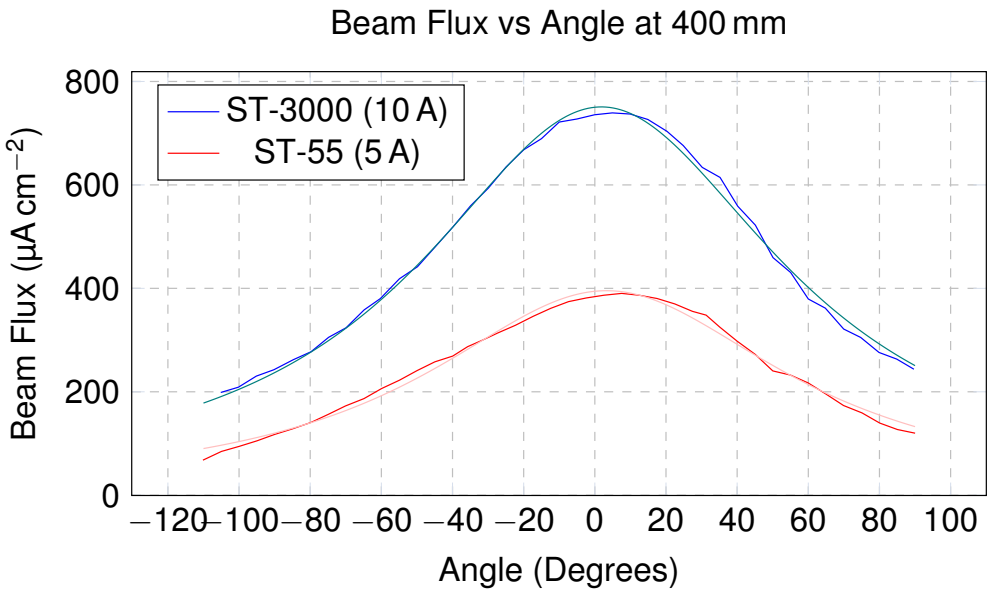


ST Ion Sources

Model	Mini UHV	XIAD	ST-55	ST-3000
Power	800 W	1 kW	1.5 kW	2.5 kW
Beam Current	3 A	4 A	7 A	15 A
Energy	200 eV	225 eV	225 eV	300 eV

Sizing Ion Source





Ion Assisted Deposition

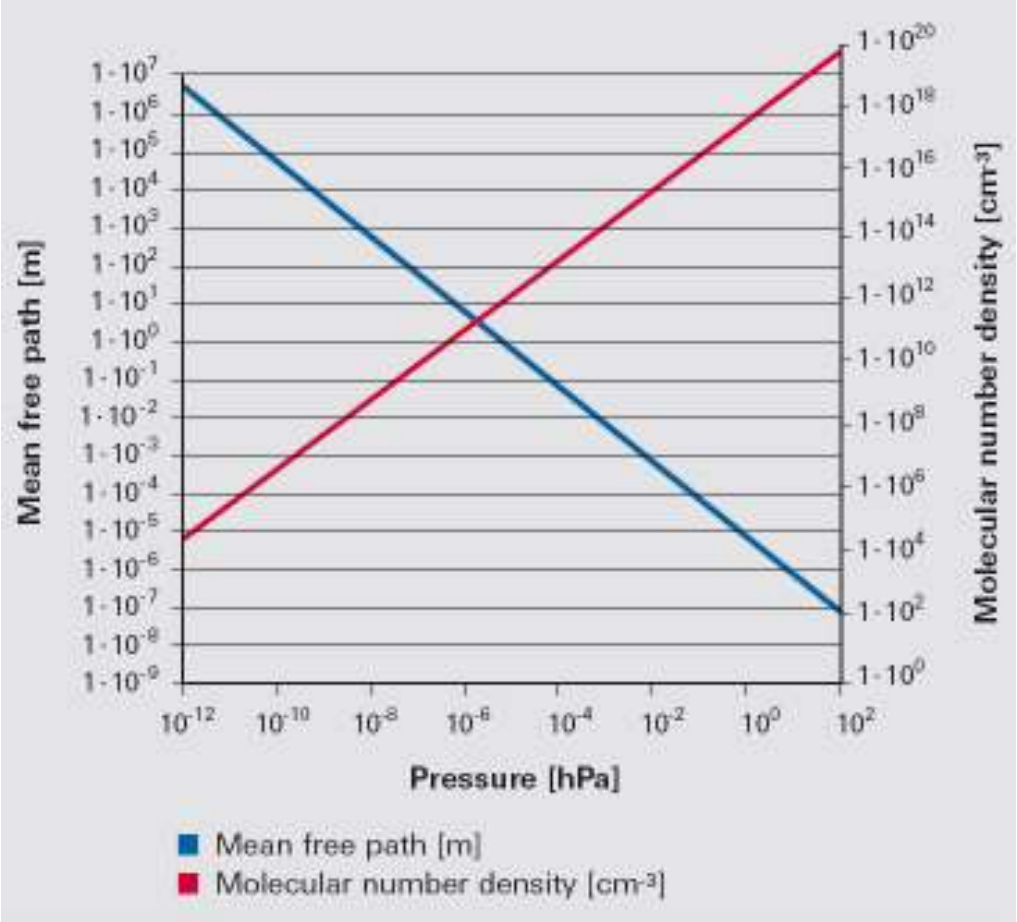
- Coating densification
- Improved index of refraction
- Better environmental stability
- Lower coating stress
- Higher Throughput than IBS

Proper Dosing

- Low Power $\rightarrow$ Low Dose
- High Power + High Pressure $\rightarrow$ Short MFP $\rightarrow$ Low Dose
- High Power + Low Pressure $\rightarrow$ High Dose $\rightarrow$ Substrate Damage

ICM allows proper dosing without substrate damage

Mean Free Path



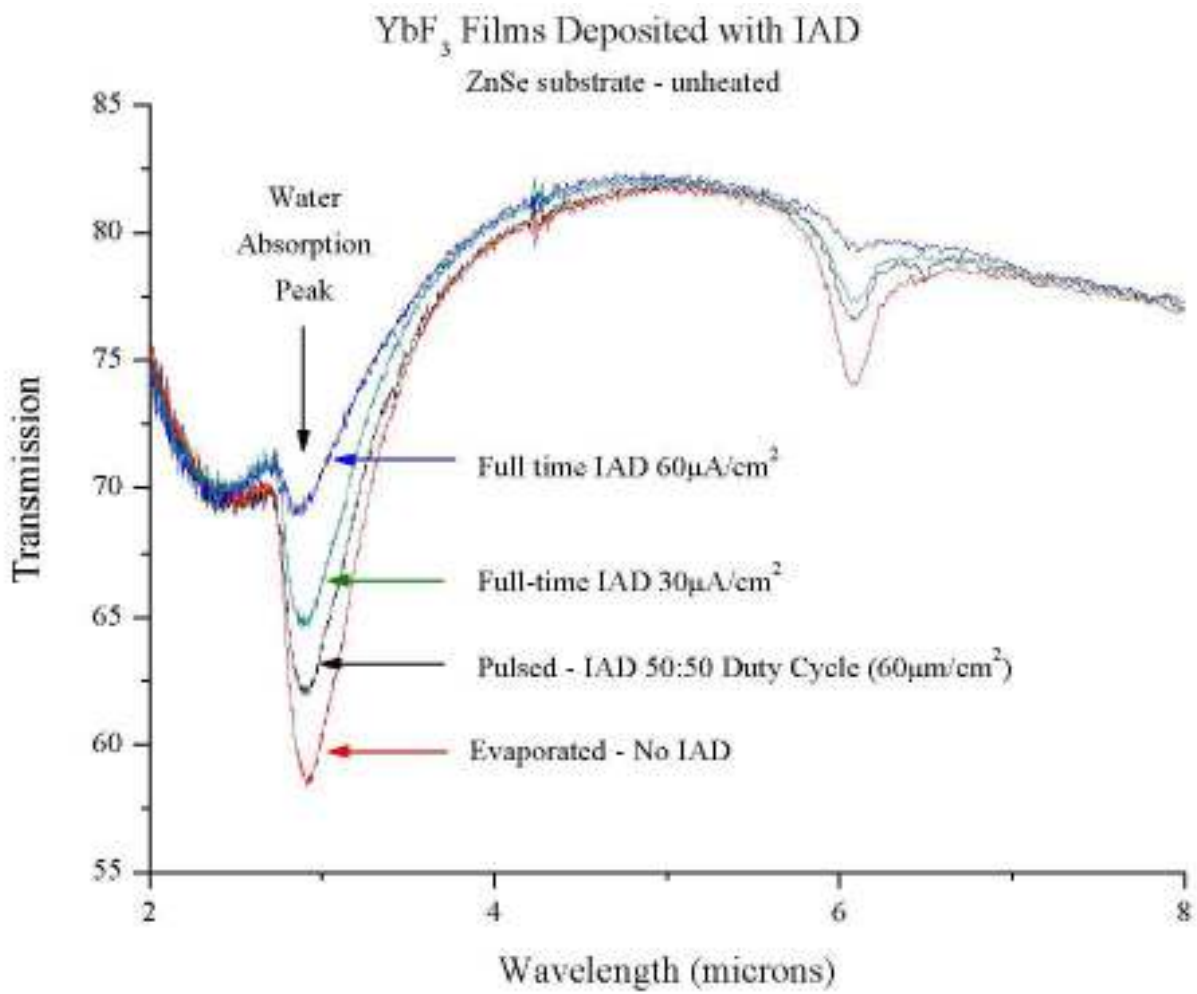
5×10^{-5} Torr$\rightarrow$1 m MFP

Telemark Ion Current Monitor

Explode View

Easy to Clean after In-situu Use

Exp. Example


YbF3 Films Deposited with IAD
ZnSe substrate - unheated
Water
Absorption
Peak
Full time IAD 60μA/cm2
Full-time IAD 30μA/cm2
Pulsed - IAD 50:50 Duty Cycle (60μm/cm2)
Evaporated - No IAD
Transmission
Wavelength (microns)
85
80
75
70
65
60
55
2
4
6
8

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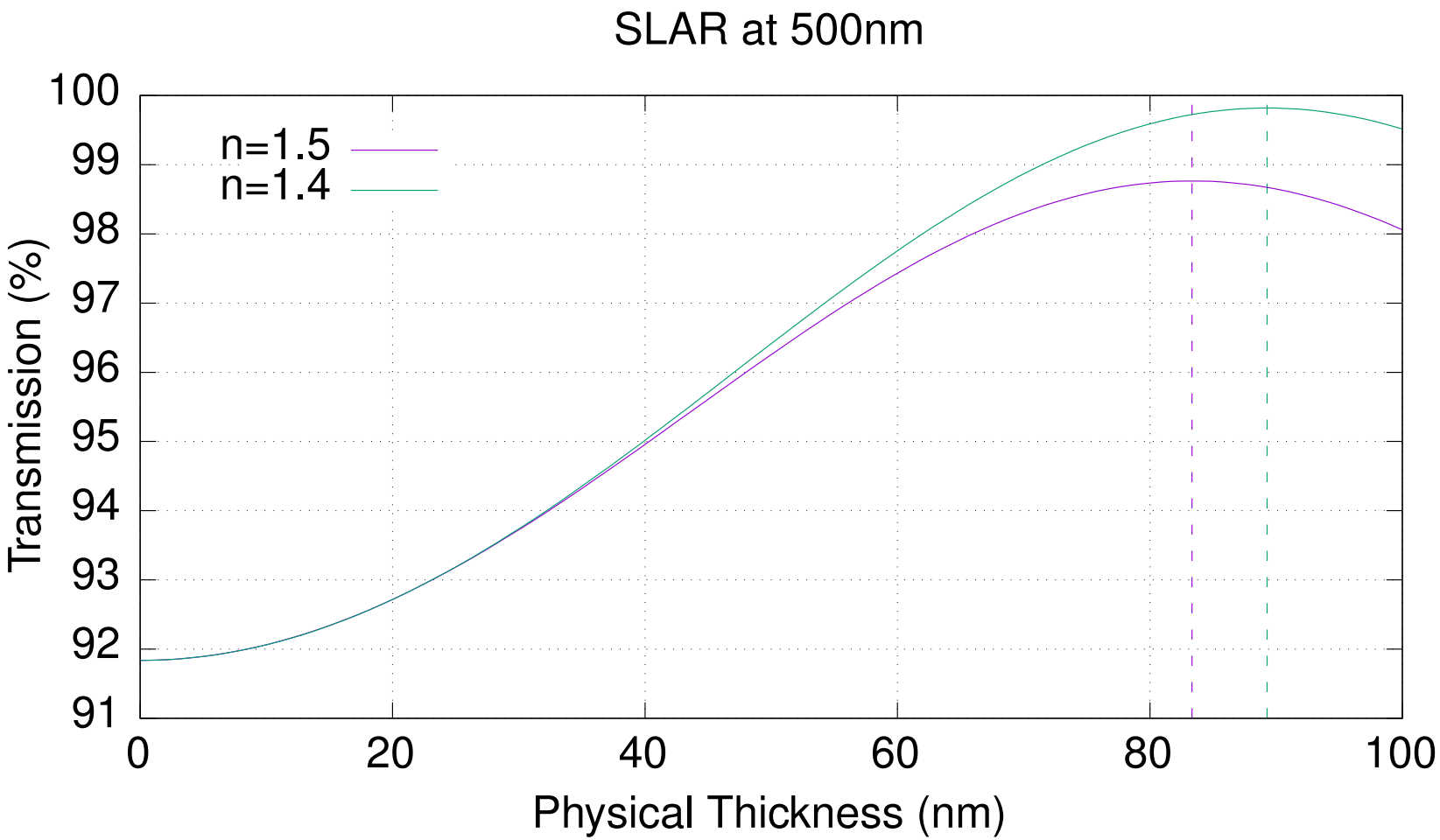
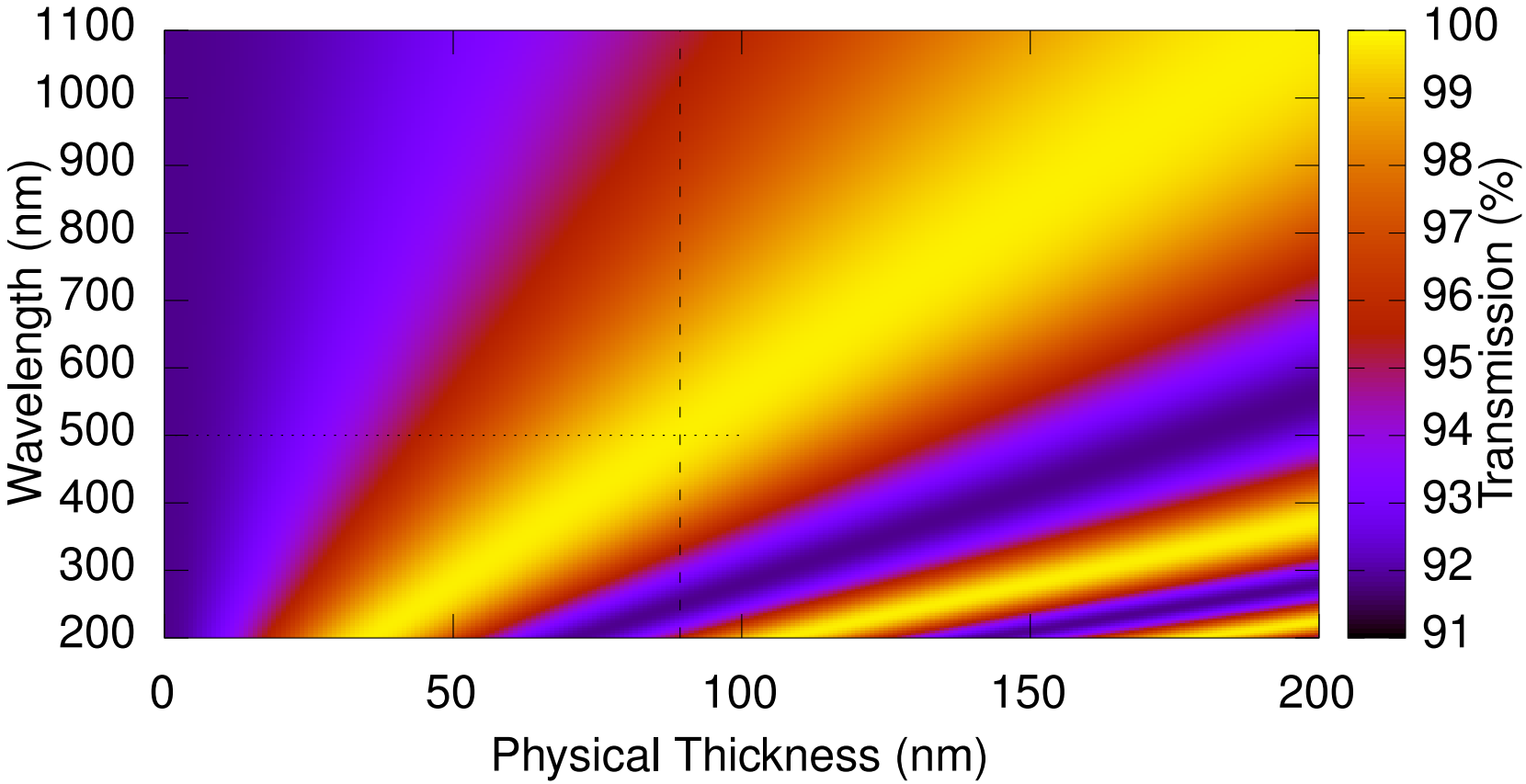
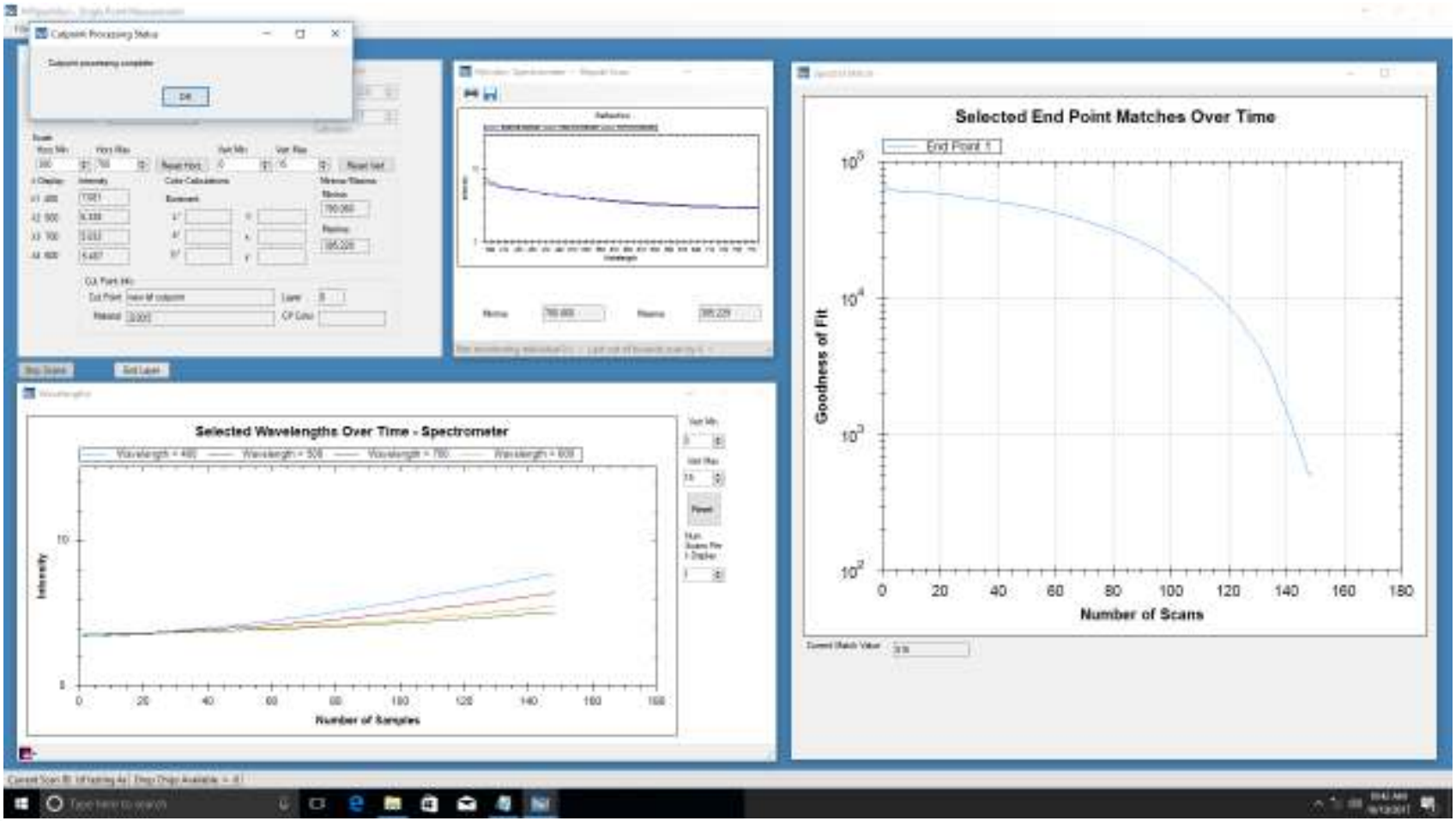
Physical Thickness vs Optical Thickness



Single Layer Anti-Reflection Example



Optical Monitor



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Cryochiller Sizes

Telemark provides 5 Cryochiller sizes, with cooling capacities from 1200W to 3600W

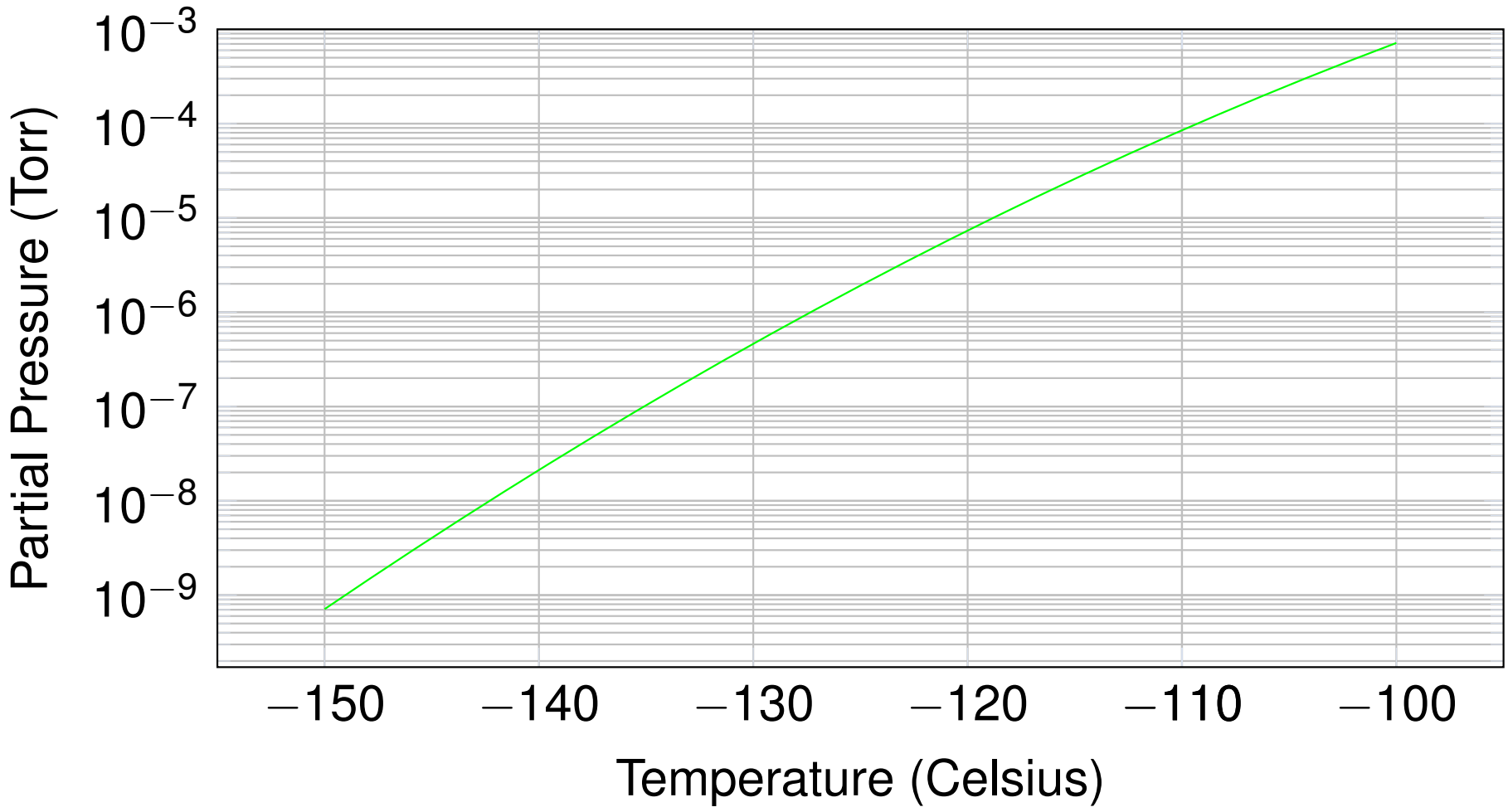
Which one?

How do I select the right size Cryochiller for my process?

Why do I need a cryochiller?

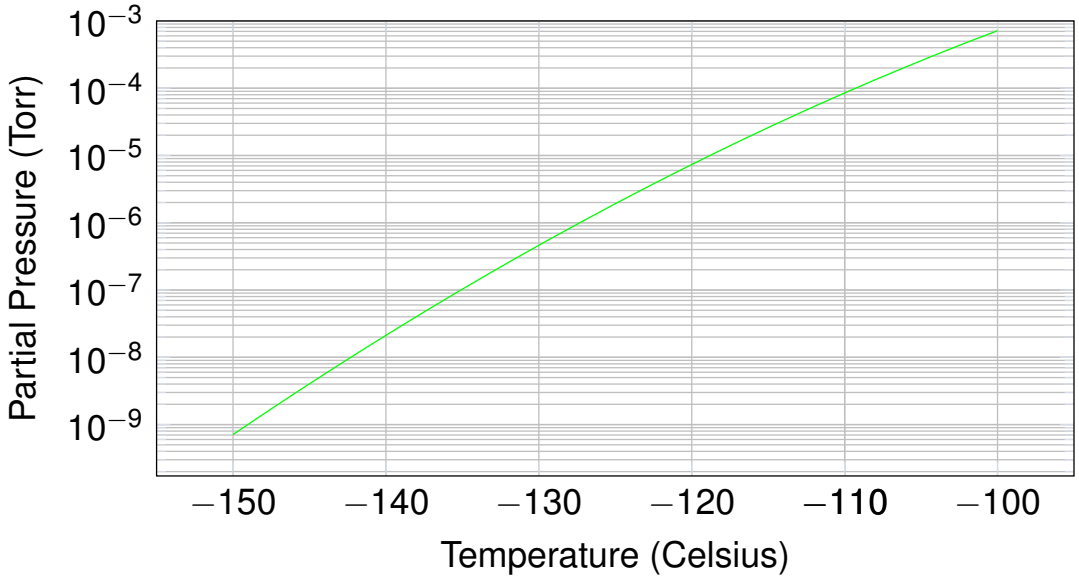
- Most processes require a minimum background vacuum pressure for success
- 90% of species in chamber is H_2O
- Initial Capital Costs:
  - Turbopump: $\sim$\$8/L/s
  - Cryopump: $\sim$\$2/L/s
  - TVP: $\sim$\$0.2/L/s

Water Vapor Pressure vs Temperature



Water Vapor Pressure vs Temperature

Process Requirement drives required coil temp...



Heat Load

The other important question:
What's the heat load on the system?

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- Distance between Cryochiller and Chamber (26 $\mathrm{W\,m^{-1}}$ of insulated piping)

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- Cryocoil surface area (375 $\mathrm{W\,m^{-2}}$)
- Additional radiant heat on coil (IR heaters, etc.)

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- Distance between Cryochiller and Chamber (26 $\mathrm{W\,m^{-1}}$ of insulated piping)
- Cryocoil surface area (375 $\mathrm{W\,m^{-2}}$)
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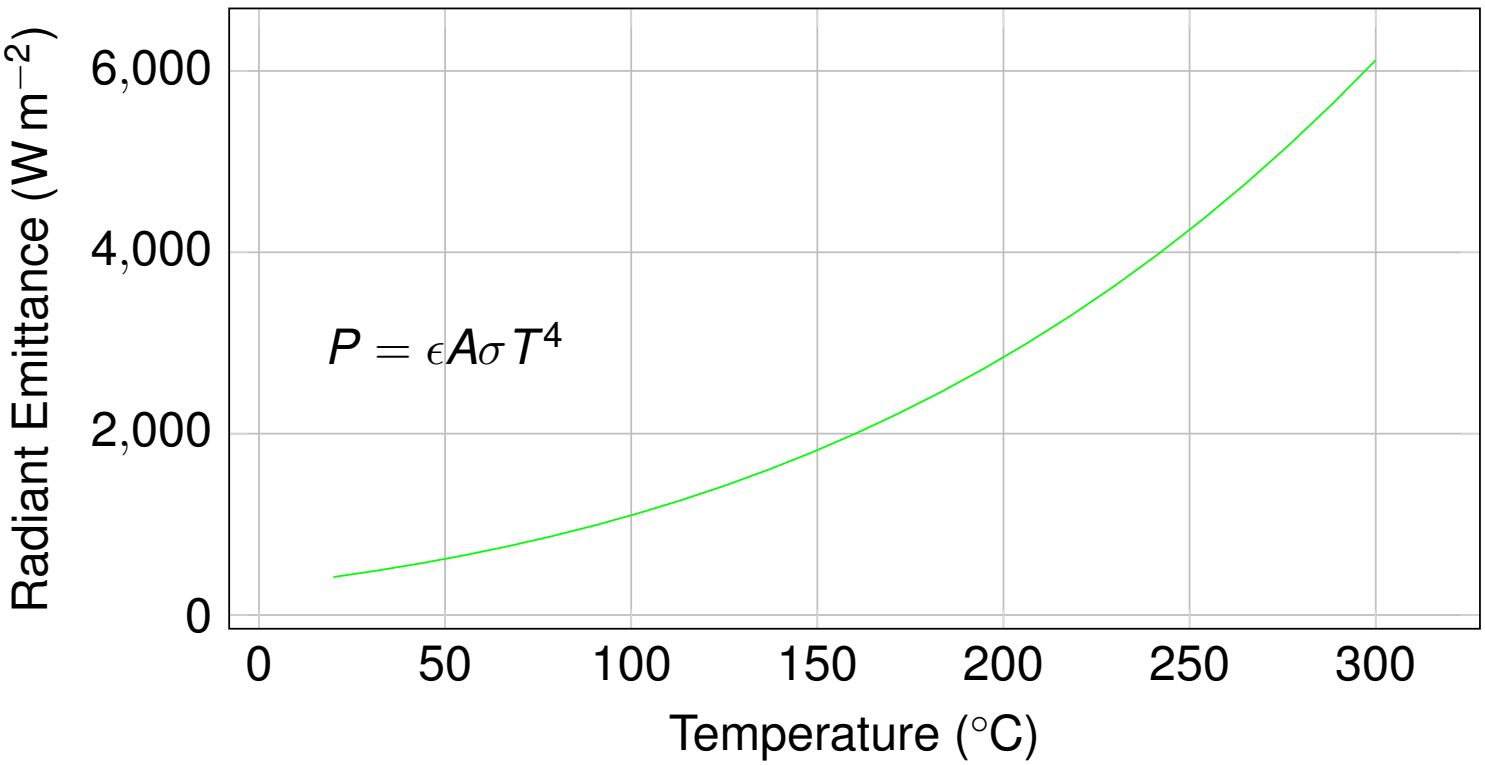
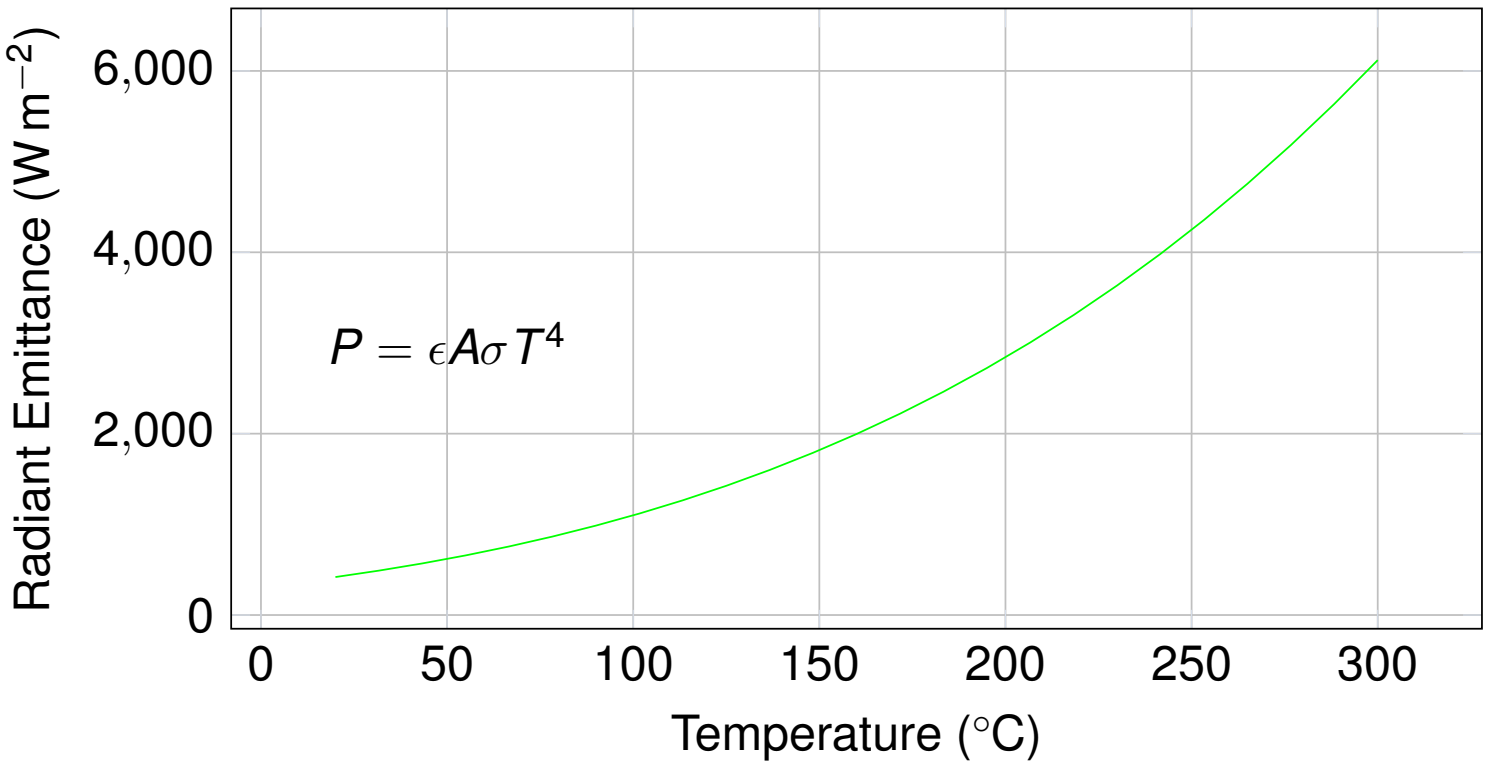
Telemark can help estimate this!

Elevated Temp. Heat Load

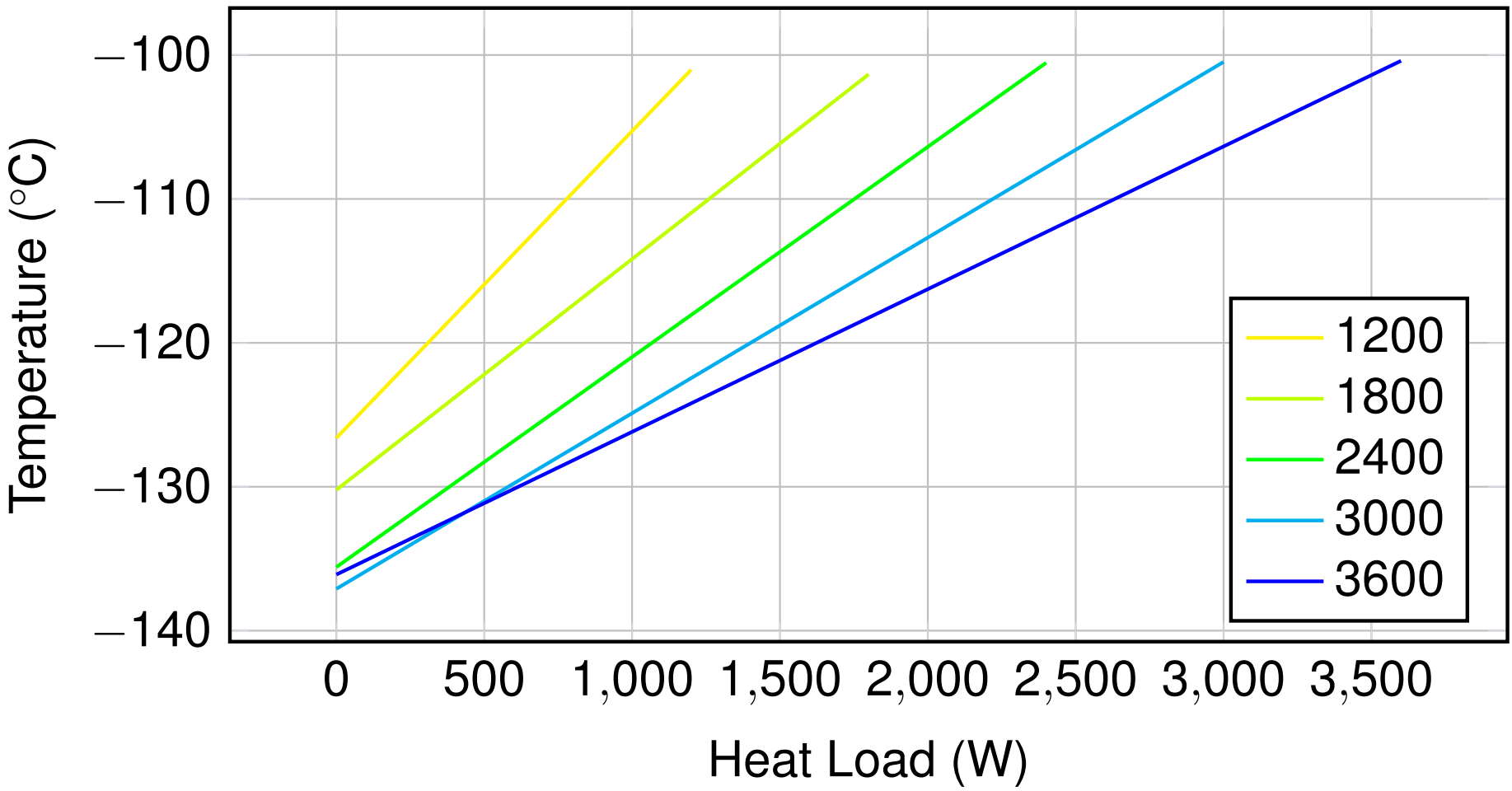


Elevated Temp. Heat Load



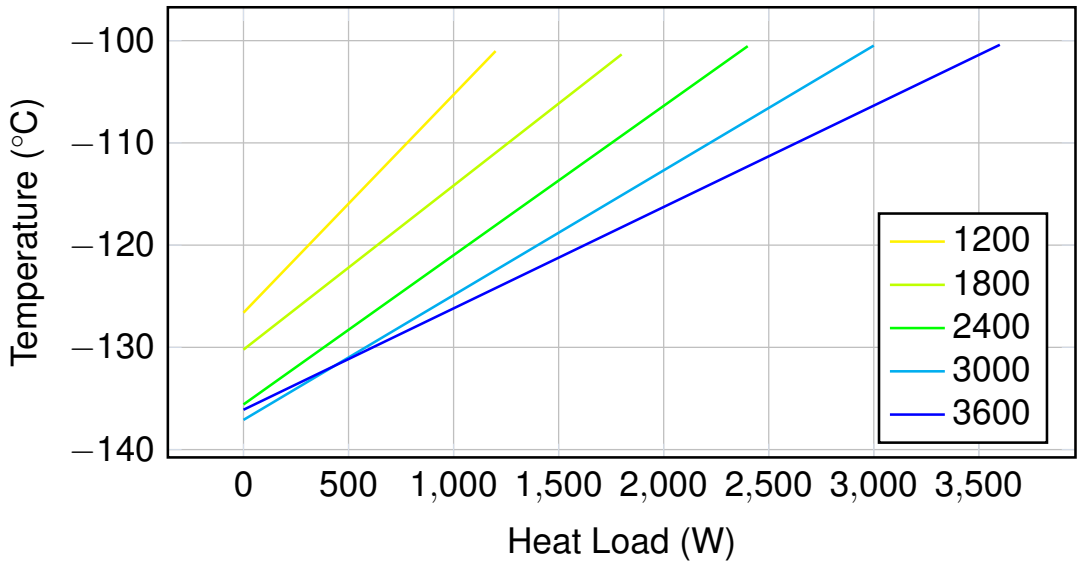
Radiation Shielding is *very* important for hot processes!
Telemark can assist with design and consultation.

Heat Load vs Cryochiller



Heat Load vs Cryochiller

Custom gas mixtures can reach −160 °C, with reduced capacity



High Temperature Applications

Telemark Cryochillers can also be used for higher temperature applications:

- Food Processing
- Essential Oil extraction
- Cannabis processing

As well as more classic applications:

- Fast-cycle batch coating
- Large area/web coating
- In-line processing

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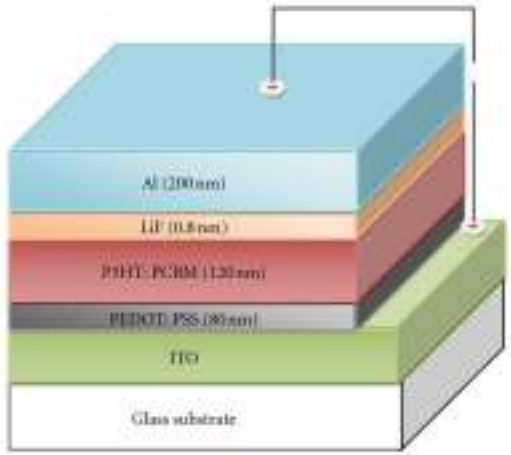
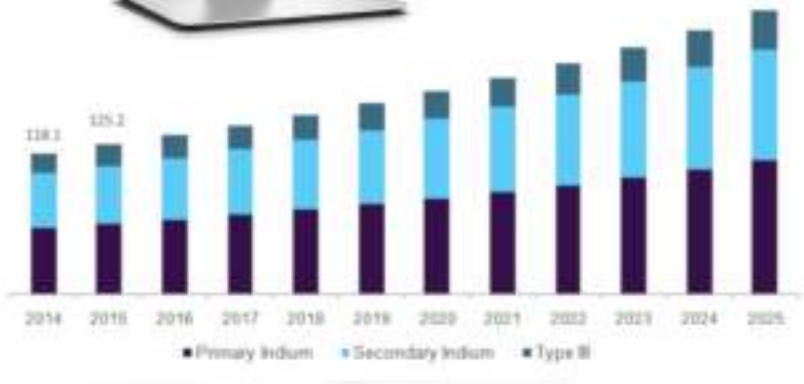
Increasing TCO Market





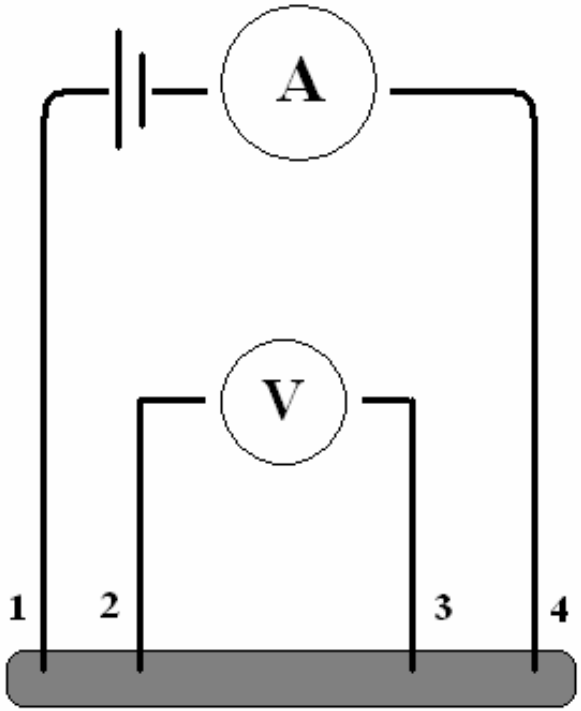
Grand View Research GVR-1-68038-820-6
Etan J. Tal
Ashley Pomeroy

In-Situ Sheet Resistance Monitoring

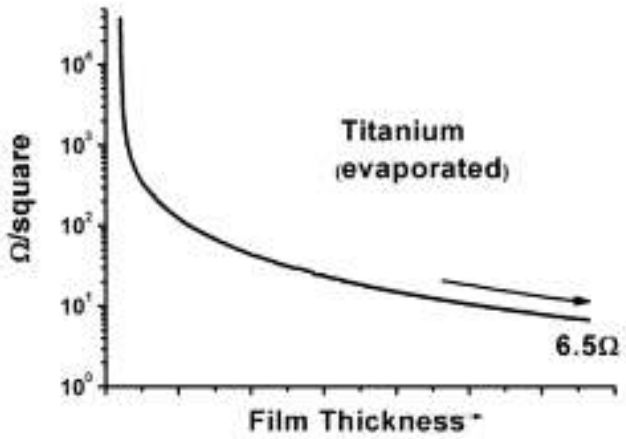
- 4-point probe technique
- 200 kΩ to 0.2 Ω range
- ±0.5% accuracy
- FR4-based sensor card

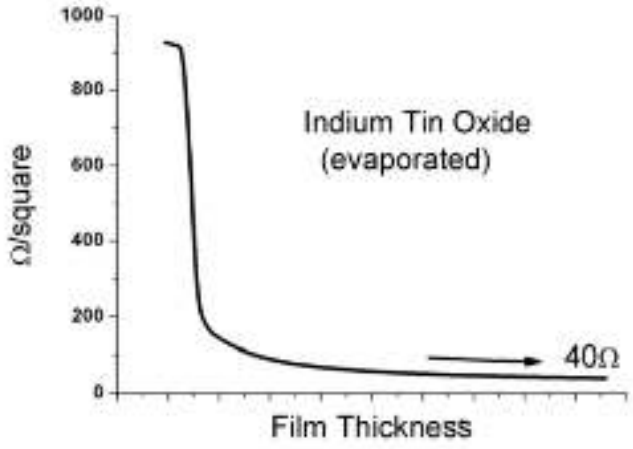
4-Point Sensing

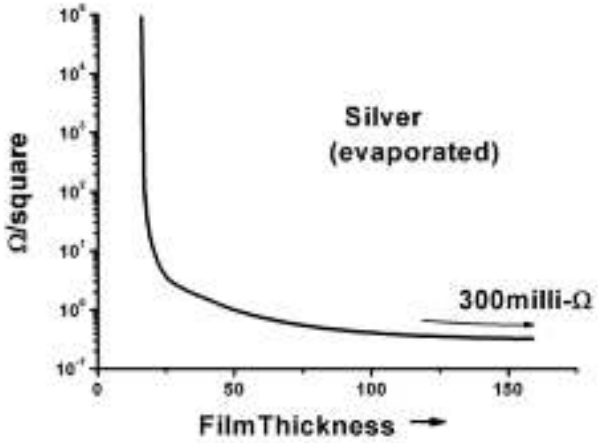
- Outer electrodes supply current I
- Inner electrodes sense voltage V
- Ohm's Law $\Omega = \frac{V}{I}$ provides accurate film resistance
- Eliminates wire lead and contact resistance from measurement

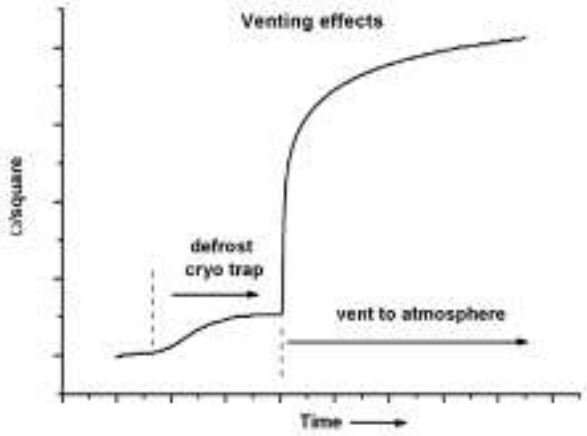


SRM Examples









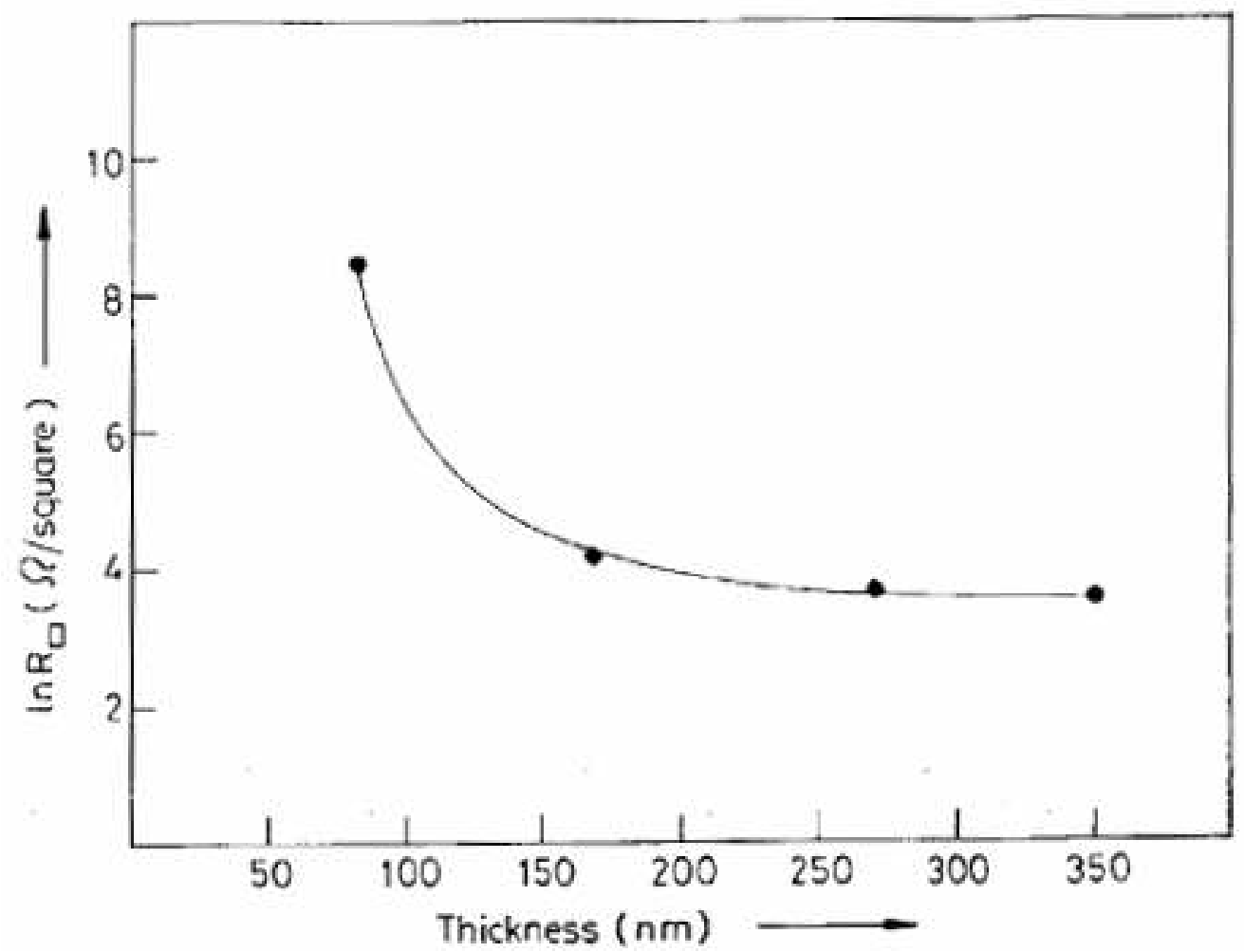
Electron Beam Advantages

- High Deposition Rates
- Excellent Material Utilization
- Easily incorporate multiple materials for multilayer coatings

Electron Beam ITO Difficulties

- Difficult ITO stoichiometry control
- In_2O_3 & SnO_2 evaporate at individual vapor pressures
- Post-deposition 250-400 °C air bake recommended

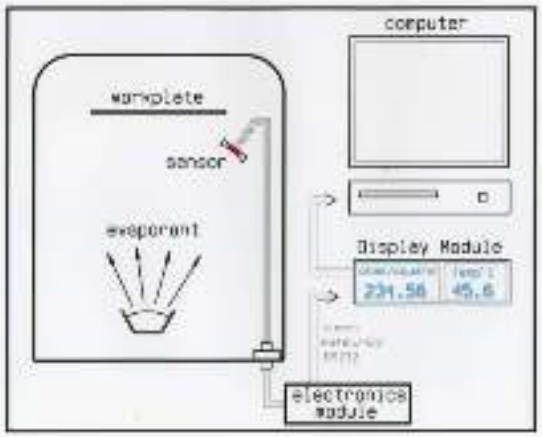
ITO Ω/□ vs Thickness



Benoy, M.D. et al Braz. J. Phys. (2009)

Deposition Equipment

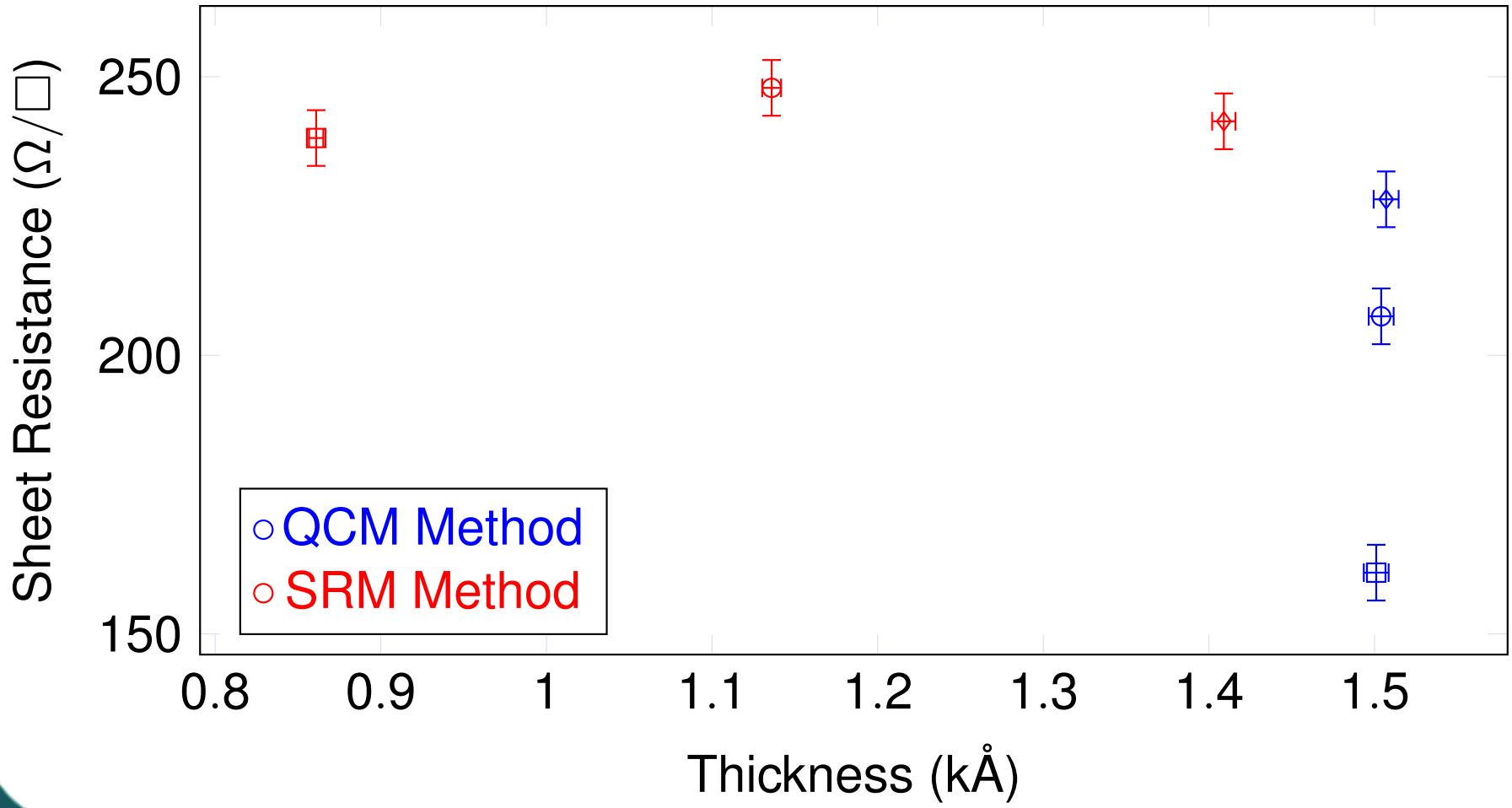
- CA-50 Chamber
- Telemark Model 274 4x40cc
- Telemark 861 Dep Controller
- 6MHz Quartz Crystal Sensor
- Sheet Resistance Monitor



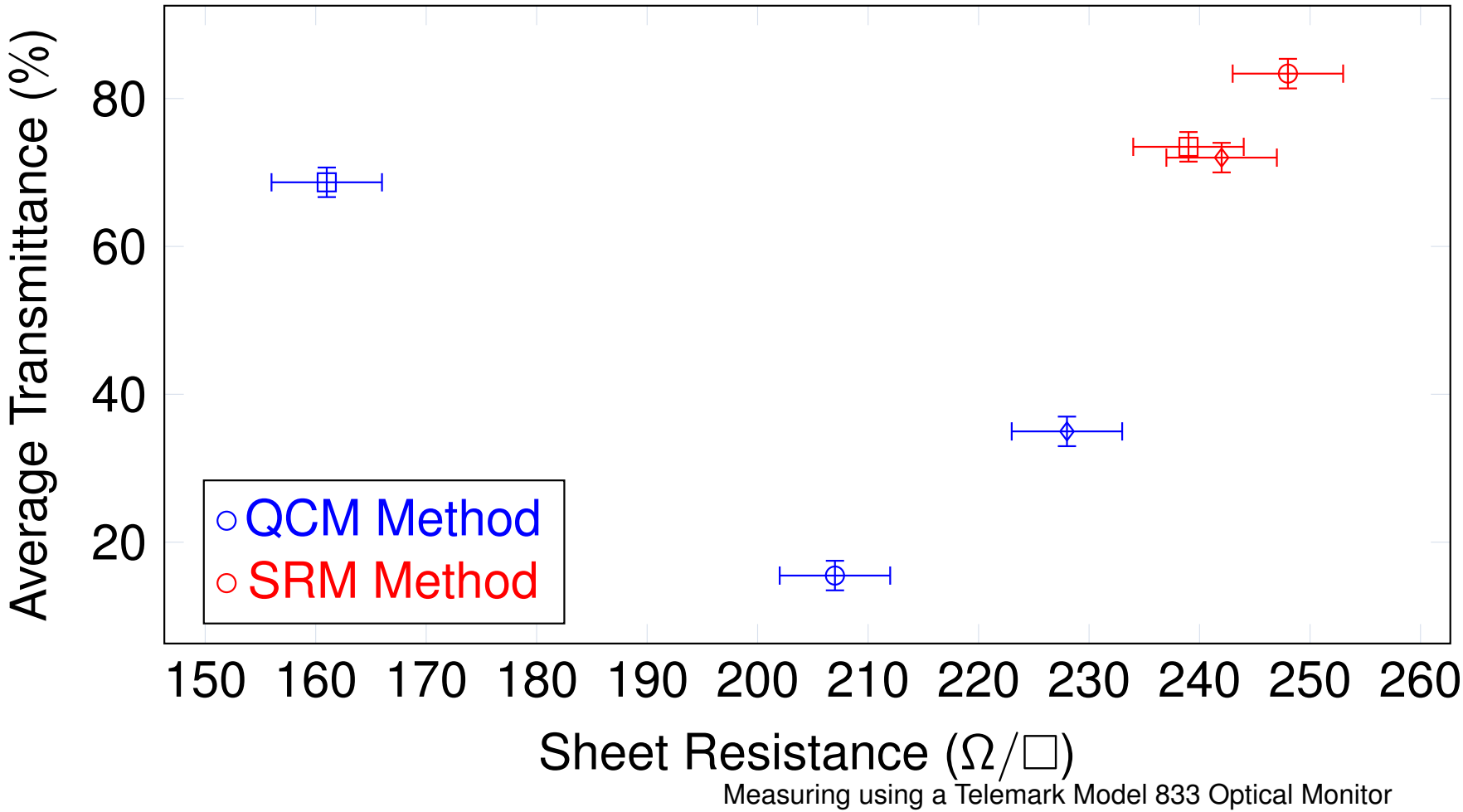
Experimental Approach

- Evaporate ITO (In_2O_3/SnO_2 90/10 WT%) at $5\,\text{Å}\,s^{-1}$
- Stop via QCM at 1.5 kÅ
- 5×10^{-5} Torr O_2 partial pressure
- 1 h in-air post-deposition bake at 300 °C
- Measure sheet resistance & optical transparency
- Repeat for (3) runs to establish run-to-run variation
- Repeat procedure using Sheet Resistance Monitor as stop criteria

Resistivity Results



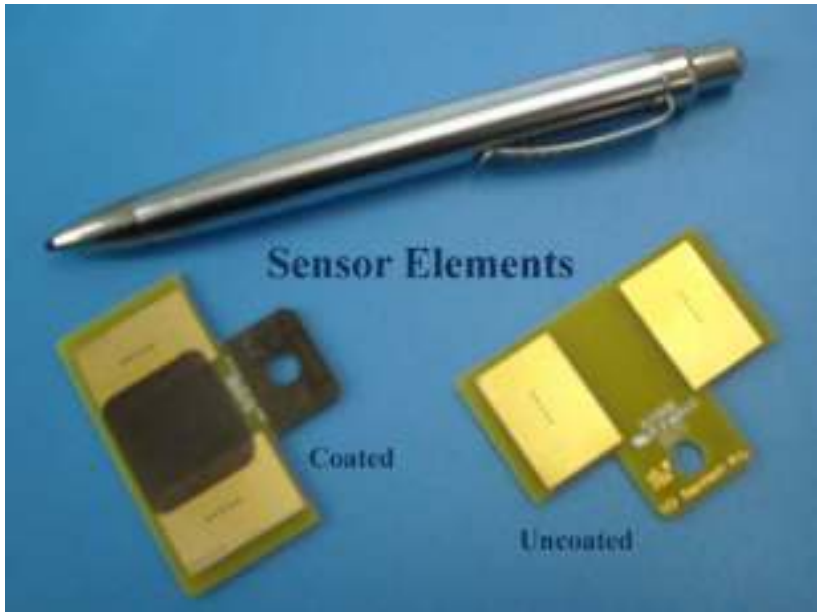
380-780 nm Optical Transmittance Results



Measuring using a Telemark Model 833 Optical Monitor

Conclusions

- In-situ sheet resistance monitoring improved resistance run-to-run variation from 20% to 5%
- Currently developing high temperature SRM sensor cards for >150 °C



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TELEMARK

Model 575/578 UHV Linear Multi-pocket Electron Beam Sources

FEATURES

- **Mounted on 10” CFF (DN200CF) flange (575) or 12” CFF flange (578) with all feedthroughs (optional CF flange configurations available)**
- **Pumps down to 10^{-11} torr**
- **Automatic motorized indexer available as an option**
- **Electro-pneumatic shutter available as an option**
- **Water-cooled cryo-shield available as an option**
- **Integral sealed XY Sweep coils**
- **Designed for ease of use and maintainability**
- **Long filament life with 270° beam deflection**
- **Emitter assembly secured by single screw for easy filament replacement**

APPLICATION

The 575/578 are precise, efficient UHV multi-pocket electron beam sources, ideal for research and development, as well as for small production applications.
The models 575/578 are unique for their compact size and the capability to take up to five 15cc or four 40cc crucibles. This, combined with a 8/10kW power rating, makes the 575 and 578 the most versatile multi-pocket UHV electron beam sources available in the market place.
These models also incorporate all the unique design features that have made the Telemark electron beam sources the most widely used E-beam evaporation sources in the world.

SPECIFICATIONS

Electron Beam . . . . . 270° hidden filament
Power Rating 8kW (575), 10kW (578)
Max High Voltage . . . . . -10kV
Cooling Water. . . . . 1.5 gpm (6l/min)
Bake Out Temperature . . . . . 220°C
Distance from flange to center of the pocket
575-01, 575-02, 575-03 . . . . 11”(280mm)
All other models . . . . . 14.5”(356mm)
(custom lengths available as an option)

MODELS

575-01	5 pocket 4cc
575-02	4 pocket 7cc
575-03	3 pocket 15cc
575-04	7 pocket 4cc
575-05	6 pocket 7cc
575-06	4 pocket 15cc
575-07	9 pocket 4cc
575-08	7 pocket 7cc
575-09	5 pocket 15cc
578-01	2 pocket 40cc
578-02	3 pocket 25cc
578-03	4 pocket 40cc
578-04	4 pocket 25cc

The 6kW model 568 source is available for applications where a 8” CF flange mounted source is required.

Optional Source Rail Guide Assembly

Model 528 UHV Compact 3kW Linear Multi-pocket Electron Beam Source

The model 528 is mounted on a 2.75 inch CF flange with 1.5cc pockets, no sweep coils, available in 3, 4, 5, and 6 pocket configurations.

1801 SE Commerce Avenue
Battle Ground, WA 98604, USA

Tel 360-723-5360
Fax 360-723-5368

sales@telemark.com
telemark.com

MADE IN USA

TELEMARK

Near UHV Multi-Pocket and UHV Single Pocket Electron Beam Sources

6kW

Model 249

Near UHV Multi-pocket
Capacity up to 6x 7cc
Magnetic Fluid Rotary Feedthru
to pump into -10 torr Range

Model 218

UHV Single pocket

High Performance in a Small Package with Crucible Volumes up to 15cc.

- Rated at 6kW of power when operated at voltages from -6 to -10kV.
- Compact design for use in small research and development systems or wherever space is an important consideration.
- Sweep coils sealed in stainless steel cans are standard.

10kW

Model 269/279

Near UHV Multi-pocket
up to 6x 15cc pocket (269)
up to 6x 25cc (279)
Magnetic Fluid Rotary Feedthru
to pump into -10 torr Range

- **ROTATABLE HEARTH IS REMOVABLE FOR EASY CLEANING OR CHANGING OF CRUCIBLES**
- 270° beam deflection (Hidden Filament)
- Proprietary water cooling design means longer crucible life and more consistent evaporation of material

3kW

Model 508

Ultra compact UHV Single pocket source

- Unmounted or mounted 2.75” CF flange
- No beam sweep
- 1.5cc pocket
- 5kV max.

15kW

Model 259

UHV Single pocket up to 160cc

Large Capacity Source
Performance Proven in High-Power Production and MBE Applications

- Available in crucible volumes up to 160cc for long, uninterrupted evaporation, for long intervals between breaking vacuum, or processes requiring large area source

4kW

Model 509

Ultra compact UHV Single pocket source

- Mounted on 4.5” or 6” CFF for direct replacement of K-cells
- No beam sweep
- 4cc pocket
- 5kV max.
- Integrated Dual HV feedthrough option

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sales@telemark.com
telemark.com

MADE IN USA

2.2018

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Loyalty Program

	STANDARD PRICING	LOYALTY REWARDS PRICING
E-Beam Components listed here-in	Prices Listed	10% Discount from Prices Listed
Quartz Crystals	$25/ten	$22.50/ten
Cryochiller Refrigerants	Prices Listed	10% Discount from prices listed
E-Beam Source Services		
Standard Regauss	$350	$300
Source Rebuild	$1350	$1200
Source Rebuild and Upgrade to latest design, including four new pole pieces	$1750	$1600
Other Factory Repairs		
Hourly Rate	$125/hr.	$110/hr.
Turnaround Time	2-4 Weeks	Target 1 Week or less
Field Service		
Technicians	$1650/day	$1500/day
Engineers	$2000/day	$1800/day
Telephone Service and Process Consulting	$150/hr.	No charge within reasonable time limits

(1) Customers who purchase all the consumables they require from Telemark, including quartz crystals, liners and emitter parts, are eligible for Loyalty Pricing and expedited service.

Contact the Telemark Factory or your local Telemark Sales Representative to enroll in this great savings program

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Conclusion

Thank You!

Stop by Booth 100!