The ONYX- Revolution

Angstrom Sciences-
Cylindrical Magnetrons
BACKGROUND:

- In business for over 20 years
- Comprehensive IP including US Patents on:
  - Profiled Magnets
  - Turbulent water flow
- Complete Cylindrical Cathodes
  - TCO, Reactive, and Metal Applications

For more info . . .
www.angstromsciences.com
THE SOLUTION: ONYX-REVOLUTION

- 85% or greater bulk target tube utilization
- Highest Vapor Flux Efficiency
- Tunable thickness control

RESULTS:

- Average 20% increase in Dynamic Deposition Rate (DDR)
- Increased *overall* material efficiency
- Best achievable thickness uniformity
- Reduced maintenance and system downtime due to shield cleaning
THE SOLUTION: ONYX-REVOLUTION

- Advanced profiled Magnetic Design for optimal utilization and uniformity
- Gas Integration Options
  - Argon and Reactive gas inputs
- DC, Pulsed DC and MF Power
- Vertical and Horizontal mounting options
- Recommendation for Optimal Uniformity
  - Magnet bar length: 6” overhang on each side of substrate
  - 2”-4” source to substrate

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ONYX-REVOLUTION

*Magnetics:*

Profiled magnets naturally conform to the curvature of cylindrical target; reducing distance between racetracks and increasing field at target surface.

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Rotating Cylindrical Magnetron Configurations:

Drop-In / Flange Mount Dual Rotatable. Vertical or Horizontal mounting.
Rotating Cylindrical Magnetron Configurations:

"Through the Wall"
Straight-thru cylindrical magnetron solutions. For vertical and horizontal applications

Drive shaft custom sized to place target "centered" over substrate

Target/Magnet Array length sized to customers substrate width.

Drive Block and target ends standard for all ASI "Straight-Thru" cylindrical magnetrons
Fundamentals of Cylindrical Cathode Design and Operation

Robust Mechanical Design:

The rotatable cathode must fulfill 3 fundamental operations:

• Dynamically seal air – water - vacuum
• Effectively deliver power to the cathode
• Provide smooth concentric target rotation
Cathode Drive Overview:

- 1/2 HP Drive Motor
- Drive Belt Safety Cover
- Chamber Interface
- Drive Shaft Shield
- Water Seals Section
- Drive/Power Section
- Vacuum Seals Section
Cathode Drive Overview:

- Double Row Angular Bearings SKF 3211A
- Vacuum Seals (Primary and Back-Up)
- Magnet Array Alignment Key
- Water Inlet Chamber
- Water Outlet Chamber
- Power Buss (>400A Rating)
- Water Seals (Primary and Back-Up)
- Drive Rotation Sensor
Target Assembly Overview:

- Target Clamp (2 Bolts)
- Axial Alignment Support
- Target Material
- Debris Shields (Electrically Floating)
Target Assembly Overview:

- Debris Shield
- Electrical Isolation
- Remove 4 Screws and Circ-clip to Remove Debris Shields
- Static Water / Vacuum Seal
- Magnet Array Assembly
- Axial Support
- Water OUT
- Magnet Support Shaft Centering Bushing
- Water IN
- Magnet Support / Water Inlet Tube
Power Transmission Overview:

- C70600 (CuNi)
- Best matched material for *
  - Hardness
  - Electrical Conductivity
  - Thermal Conductivity

- No o-rings to reduce thermal conductivity
- No multi-lam materials used to support electrical conductivity
- Copper/Brush Assembly
- Full 360° contact around shaft
- Rotating Shaft
Fundamentals of Cylindrical Cathode Design and Operation

Corrosion/Water-resistant Magnet Bars:

- Deep drawn and welded, non-magnetic, stainless steel enclosures
- Epoxy filled to prevent magnet shifting and additional corrosion protection
ANGSTROM ADVANTAGE:
MODULAR MAGNET DESIGN

Magnet Assemblies have “interchangeable” turnaround designs that may be manufactured to your specific type of target.
Fundamentals of Cylindrical Cathode Design and Operation

**Optimized magnetics:**

- Modular construction with optimized “turn-arounds” and “straight-away” elements
- Support tube designed to facilitate “tilt” and external shunting for thickness uniformity enhancement
- Minimized distance between adjacent racetracks to enhance “line-source” behavior (Vapor Phase Efficiency)
3D Magnetic Field Modeling for optimized “turn-around” erosion:
ERODED TARGET: 85%+ BULK TARGET UTILIZATION
Impact of Tilting and Shunting:

Shims are used for small adjustments due to "local" effects which might be caused by gas flow, anode amplifications, ... . Up to 5% changes can be made.

Shunts can be custom trimmed to length, placed anywhere along magnet array length, on 1 or 2 sides of the magnet pack, 1/2" height adjust.
Uniformity Adjustment – Addressing “Tilt”:

2D Model (FEMM) of magnet array shows the effects on the magnetic field of inserting spacers.

Spacers or mechanical adjustment is used to raise or lower the magnet array at specific locations.
Uniformity Adjustment – Addressing “Local” Effects by shunting:

To eliminate “local” uniformity effects, 1 or more shunts may be cut to length and used for tuning over the magnet array length.

Depending on the size of the uniformity anomaly, shunts may be used on one or both sides of the magnet array.
The highly concentrated magnetic field at the target surface eliminates any magnetic cross talk between adjacent target tubes in a twin tube configuration.
Applying shunting and tilting to optimize thickness distribution < +/- 2.0% on a 3.2 m wide substrate (3.5 m long magnet array)
Vapor Flux Efficiency:

What is V.F.E. --&gt; Vapor Flux Efficiency

V.F.E. is defined as the amount of material sputtered vs. the amount of material which actually arrives to the substrate

\[
\text{V.F.E. } \propto \frac{1}{\text{shields to cathode distance}}
\]

\[
\text{V.F.E. } \propto \frac{1}{\text{shields to substrate distance}}
\]

\[
\text{V.F.E. } \propto \frac{1}{\text{pressure}}
\]

\[
\text{V.F.E. } \propto \frac{1}{\text{angular flux (±10.5 d.)}}
\]

VFE is affected by the distances between:
- Shields - Substrate
- Shields - Cathode

Angular Flux

\[\cos^3 \text{ flux distribution}\]

ASI uses 85% as a "typical" value
More material is directed to the substrate, dramatically reducing build-up on shields and resulting in a cleaner and more stable process that requires less power to achieve a specific deposition rate!
Cylindrical Magnetron
Magnetic Field Model

Magnet Array Spaced 0.080" away from target ID

"Angles may vary based on spacing distance!"

102.68 = Tang. "Peak"

Normal "Zero" Crossing 77.92°

Normal "0" crossing and Tang. "Peak" show balanced magnetics

77.32°

Yields ~ +/- 12.1° angle between racetrack centers

Angle about Target Surface (deg.)

Magnetic Field (Gauss)
Normalized Deposition Profile For a Dual Rotatable Magnetron

ASI cylindrical racetrack separation of 12.1 degrees results in ~14% of material deposited on shields.

"Typical" conventional cylindrical racetrack separation of 14.7 degrees results in ~21% of material deposit on shields.
Impact of Vapor Flux Efficiency on “Realized” Materials Utilization:

Analysis of Material Available to Substrate

Translates to:  
15% - 25%  
Cost of Materials Advantage

Material Available (in³)

Vapor Flux Efficiency

90% Target Utilization
85% Target Utilization
80% Target Utilization
ASI
Competitors
Translates to:
15% - 25%
Cost of Materials Advantage
CONCLUSIONS:

Angstrom Sciences has developed cylindrical magnetron technology that embody:

- Robust mechanical and electrical construction
- Corrosion resistant and modular magnet bars
- Optimized magnetics to maximize bulk target erosion and deposited film uniformity
- Profiled magnetics to reduce the separation distance between adjacent racetracks (Vapor Phase Efficiency)

RESULTING IN:

- Average 20% increase in Dynamic Deposition Rate (DDR)
- Increased overall material efficiency
- Best achievable thickness uniformity
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