



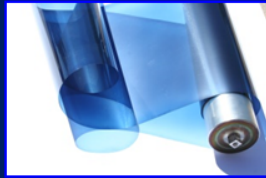
High Value Roll-to-Roll Workshop (HVR2R)

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Taking Technologies from Lab to the Marketplace Employing R2R Processing



Scalable, low-cost, high volume roll-to-roll Processing



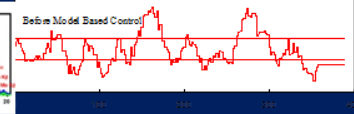
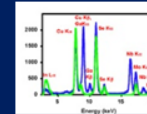
Equipment design, fabrication, and implementation from R&D to Manufacturing



Model Based Control and New Sensor Developed with Predictive Models

With Model Based Control

Before Model Based Control

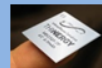


Intelligent, sensor based controls

Thin Film PV



Thin Film Battery



Window Films



Fuel Cells and Membranes



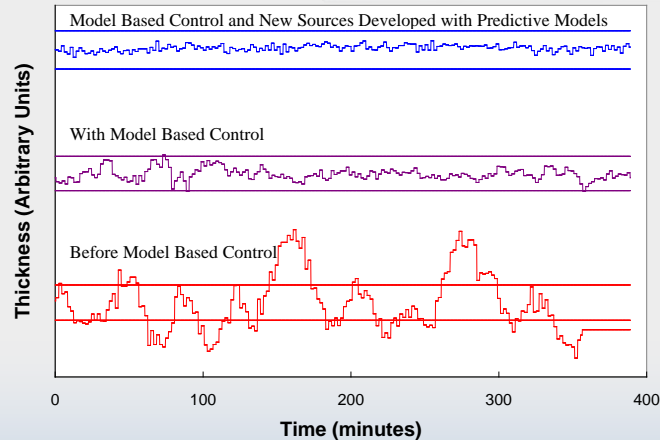
Applications for High Value R2R

- Next Generation Batteries
 - Increased Energy Density, Cycle Life, and Safety with All Solid State Lithium Batteries
- Low-Cost Window Films Compatible with Retrofit
 - Dynamic Electrochromic Window Coatings
 - Low-e Window Films with Added Function
- Separation Membranes
 - Water Purification
 - Flow Batteries
 - Membrane Reactors, e.g. Biofuels Synthesis
- Multifunctional Technologies
 - Smart, Wearables: Electronic Textiles with Sensors, Power, and Communications Integrated in Fabric for Health Monitoring, Security, etc.
 - Power Integrated into Structure: BIPV, Defense & Space (Power on wing of MAV), etc.
- Next Generation Solar/Energy Harvesting
 - Rectenna Based Energy Harvesting of Waste Heat

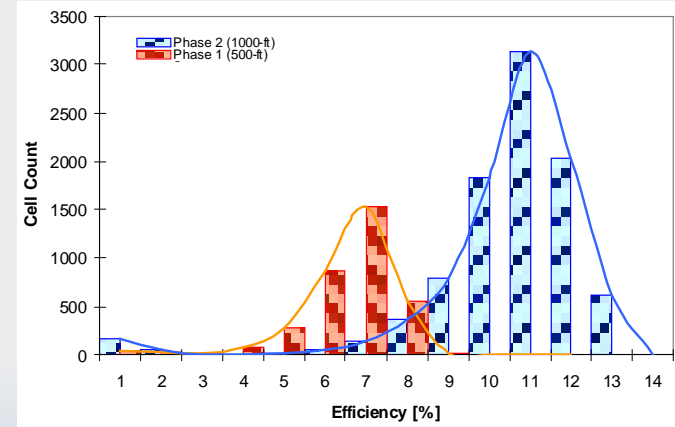
Challenges for HVR2R Development

In-Line Sensors and Sensor Based Controls: Development from R&D to Manufacturing

Model Based Controls Enables Uniform, Reproducible Film Quality



Enabling Improvements in Performance and Yield in a Manufacturing Environment

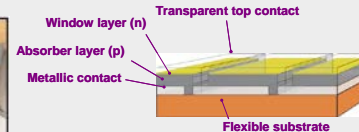
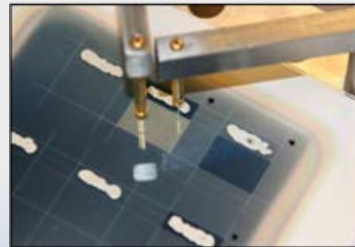


Challenges for HVR2R Development

- Nanodimensional Control of Materials to Enhance Performance
- Low-Cost Flexible Substrates
 - Mechanical Integrity with Thin Substrates (<2 mil)
 - Moderate to High Temperature Compatibility
 - Optimized Coatings/Materials Properties without High Temperature Processing/Anneal for Polymeric Substrates
- Alternatives to Lithography to Pattern Large Area Devices
 - Particularly with Reactive and Transparent Materials

Monolithic Integration

- Blanket Deposition of Films
- Laser Scribing to Devices
- Inkjet Insulating and Conductive Vias



Summary

- Many Industries Benefit from Roll-to-Roll Processing
 - Smaller Footprint Equipment for Large Area Devices
 - Flexible Substrates Provide Enhanced Versatility for Product Integration
 - Economies of Scale
- Challenges are Similar Across Technology Space
 - Intelligent Process Controls Provide the Required High Throughput and High Yield to Realize Economies of Scale
 - Nanodimensional Control of Materials is Required for Performance Optimization
 - Mechanically Stable, Durable Low-Cost, Thin Substrates
 - Minimizing Temperature Required to Optimize Performance
 - Patterning of Materials into Devices, Particularly for Reactive and Transparent Materials