Product Commercialization using Roll-to-Roll manufacturing

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EASTMAN BUSINESS PARK
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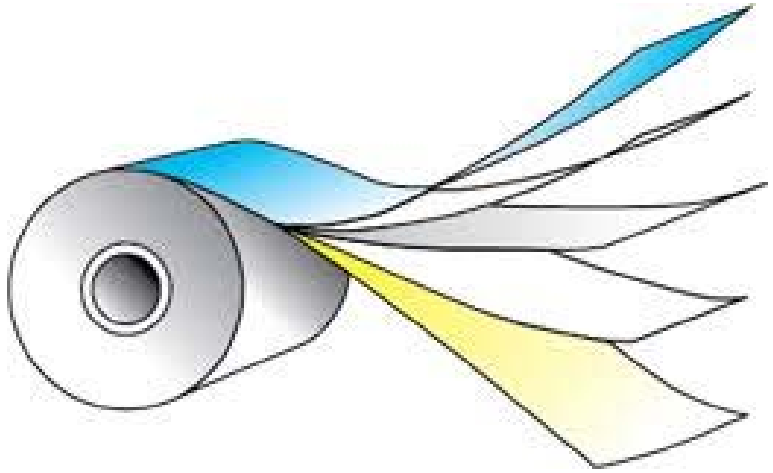
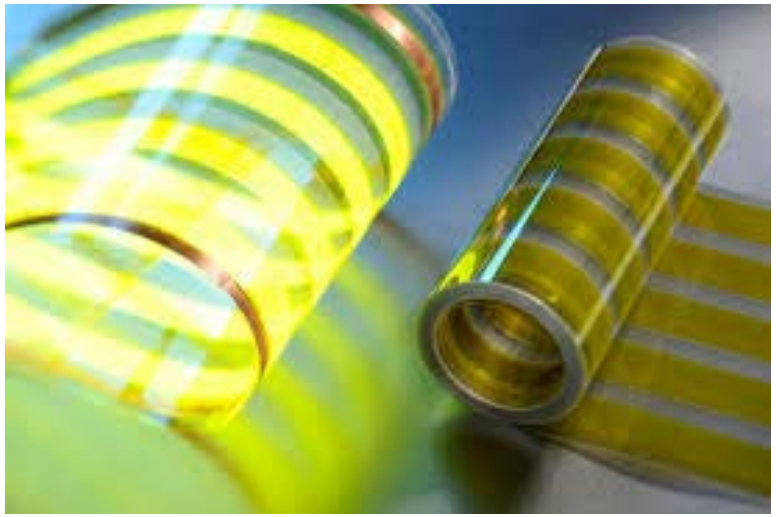
Kodak Pilot Commercialization Center

OBJECTIVES

Scale-up new materials from lab / bench to production using low cost roll-to-roll processes

- **Flexible** – customized formats and processes
- **Accessible** – rapid learning cycles
- **Robust** – market-ready quality
- **Scalable** – rapid expansion to high volume

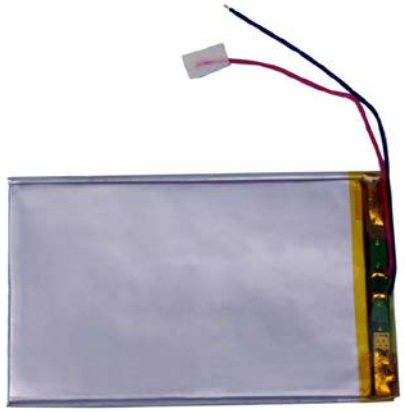




Roll-to-Roll Manufacturing

Principle advantages

1. Product performance
   a) Flexible format
   b) Multi-functional/Composite films
2. Low manufacturing cost
   a) Low material waste
   b) High production speed
   c) Minimize manufacturing process steps



Roll-to-Roll Manufacturing

Energy Product Applications

Energy storage

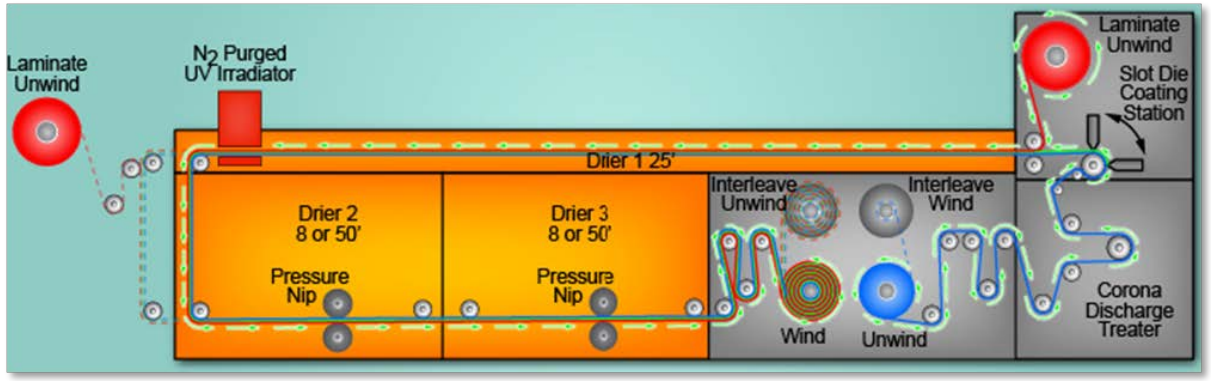
- Novel electrode development and manufacture
- Custom cell design and assembly

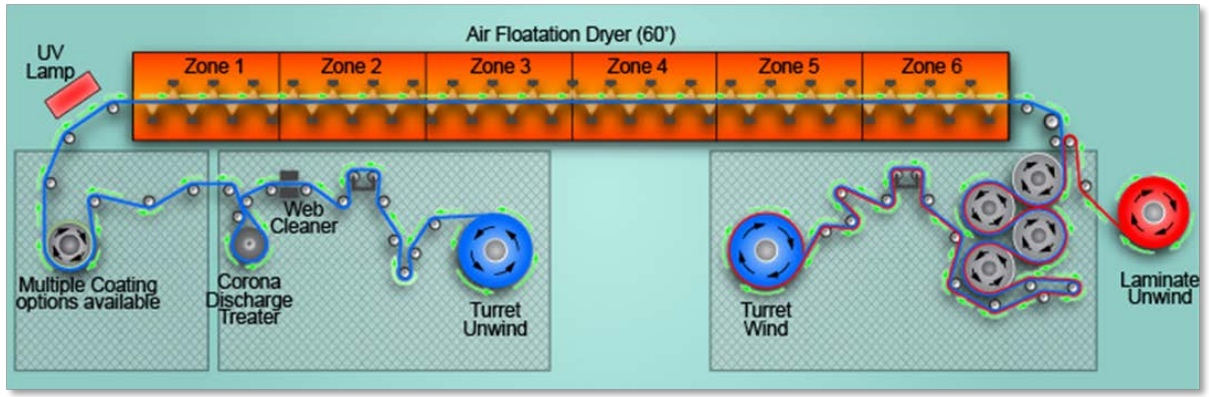
Energy generation

- Photovoltaics
- Window films

Roll-to-Roll Manufacturing

Critical capabilities



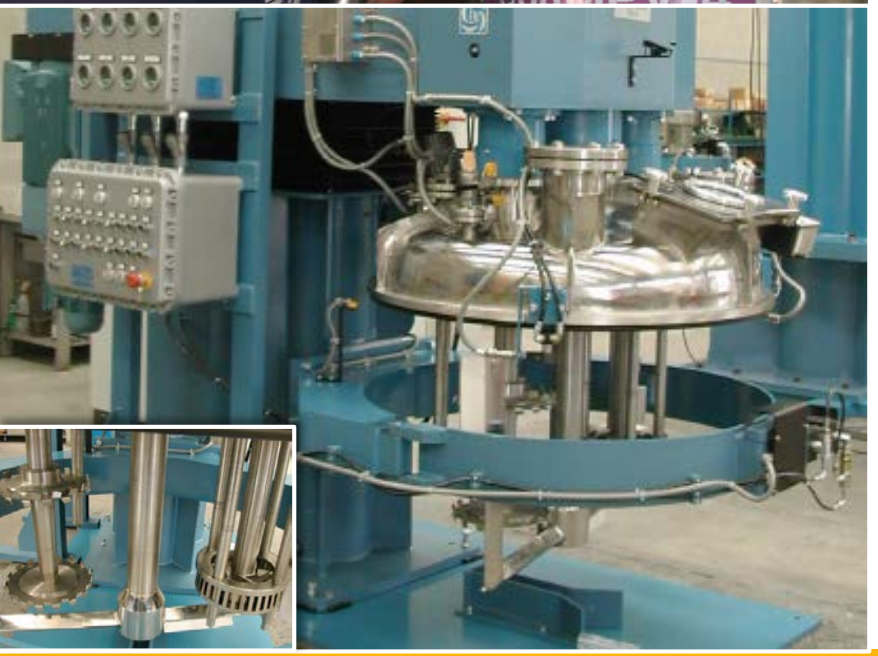


1. Layer uniformity/print quality
2. Patterned deposition
3. Thin substrates
4. Multi-layer products
5. Lamination – wet and dry
6. Drying/curing technology

Roll-to-Roll Manufacturing

Key scalability areas

1. Solution preparation
   a) Particle size distribution
   b) Mixing efficiency
2. Coating/deposition
   a) Rheology
   b) Interfacial science
3. Drying/Curing
   a) Stress induced defects
   b) Custom material properties (e.g. crystal growth)



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Solution preparation

Critical requirements

- Mixing options for dispersing a wide range of particle sizes and shapes
- Handling nanoparticulates and other HSA materials
- Control of the mixing environment

Future opportunities

- Reduced mixing cycle times
- Maintaining dispersions with low binder

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Coating/deposition

Critical requirements

- Patterned deposition
- Precision line/edge control
- Lamination – wet and dry

Future opportunities

- Complex patterning of thick layers
- Substrate treatment for wetting/adhesion
- In-line diagnostics and closed-loop control

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Drying/Curing

Critical requirements

- Controlled drying profiles
- High temp curing/sintering
- UV/photonic curing
- Calendaring/compression

Future opportunities

- High rate drying with minimal internal stress
- Shorter cure times/in-line curing
- In-line measurement of extent of cure

Commercialization Challenges

Technical

- Develop Materials / Process to fit within existing RTR capabilities
- Develop Materials / Process to enable high throughput rates
- Develop Materials / Process to enable more precise product specs

Financial

- Capital to build or modify RTR processes
- Availability of funding to complete commercialization experiments
- Availability of funding to purchase materials and process time to make first production runs

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Critical Success Factors

- Leverage the existing RTR install base to eliminate the capex barrier
- Develop materials that are compatible with the needs and constraints of RTR processes
- Develop process technology that can be added to existing RTR coating machines to enhance output and quality

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Driving low UMC

- Higher line speeds without capex
- Multi-layer/composite structures
  - Simultaneous, multi-layer coating
  - Multi-station in-line coating machines
  - Lamination
- Higher yield through in-line measurement and control

Roll-to-Roll Manufacturing
Funding considerations

- Increased use of shared-use facilities to commercialize the product and initiate production without capex
- Provide funding to develop material and process technology that enhances the existing install-base
- Availability of up-front funding for commercialization and initial production activities

Roll-to-Roll Manufacturing

Conclusion

- US-based RTR coating operations can be leveraged to drive on-shore manufacturing of new products in the energy storage and generation markets
- Being cost competitive will require these operations to be able to produce at higher speeds and with increased in-line functionality
- Material technology that is designed to fit within existing install-base is most likely to get to market first at a globally competitive cost
- Funding will be needed to provide seed money to enable emerging companies to finish their commercialization efforts and complete their initial production events

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Thank You