Electron Beam Technology for Converting Applications

Stephen C. Lapin, Ph.D.
PCT Engineered Systems, LLC
Davenport, IA

PCT
Engineered Systems, LLC

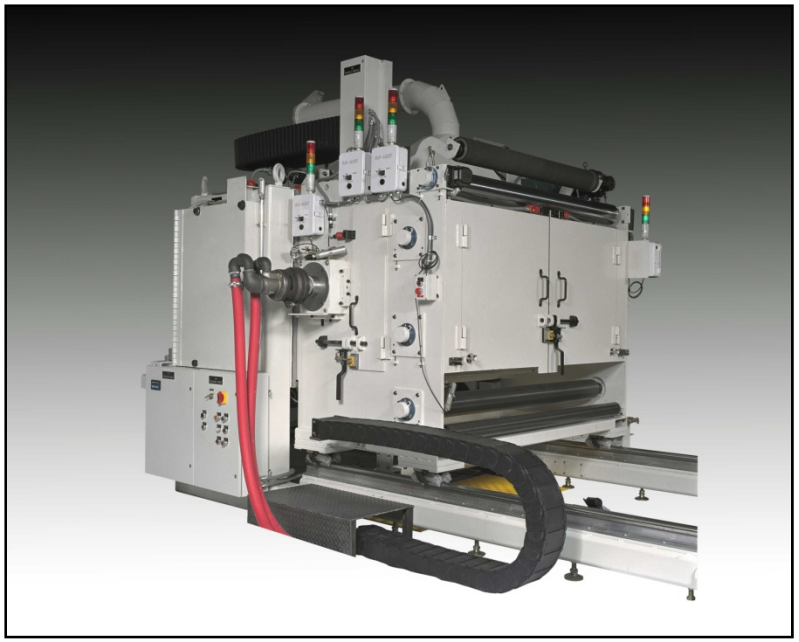
Background: Electron Beam Technology

- Accelerated electrons generated by electrically operated filaments
- Energy of electrons determined by acceleration potential
  - Low voltage typically defined as less than 300 kV
  - Penetration determined by voltage and substrate density
- Electrons will ionize most organic and polymer materials
- Making and breaking of chemical bonds is the basis for crosslinking and curing (polymerization)
- Typical applied energy (dose)
  - Crosslinking: 25 to 150 kGy (2.5 to 15 Mrads)
  - Curing: 20 to 40 kGy (2 to 4 Mrads)

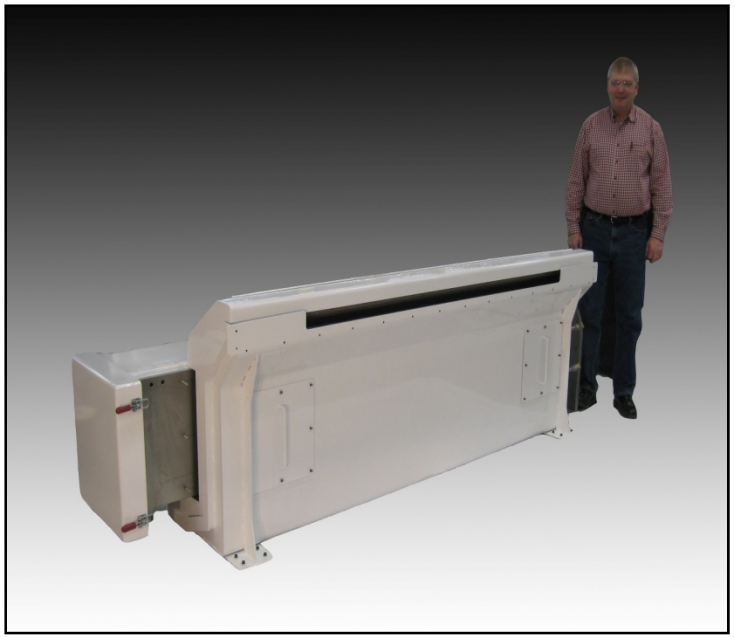
Background: Electron Beam Equipment

- Industrial processors
  - In use for more than 30 years
  - Operates up to 300 kV
  - Web widths up to 130 inches
  - Throughput up to 5000 MRFPM (5 Mrads @ 1000 ft/min)
- New generation lower voltage processors
  - Operates at 70 to 125 kV
  - Lower cost and smaller size compared to original industrial equipment
  - Ideal for many printing, packaging, and converting applications
  - Throughput up to 3600 MRFPM (3 Mrads @ 1200 ft/min)
- New compact modular processors
  - Modular 10 and 16 inch wide emitters
  - Operates at 70 to 150 kV
  - Permanent vacuum
  - Surface sterilization applications
  - Potential for narrow web applications
- Scanning beam processors – limited use in web applications

Electron Beam Equipment



Industrial Electron Beam Processor



New Generation Low Voltage
Electron Beam Processor

Electron Beam Advantages

- Lower energy usage compared to thermal drying
- Small footprint
- Near zero VOCs
- Instantaneous curing
- High line speeds
- Consistent output
- Improved product performance

UV/EB Comparison

UV

- Photoinitiator required for curing
- Surface curing in air or inert atmosphere
- Light penetration needed for curing
- Multiple lamps needed for wide/high speed processing
- High heat output from mercury lamps
- Output variation with age and across width of lamp

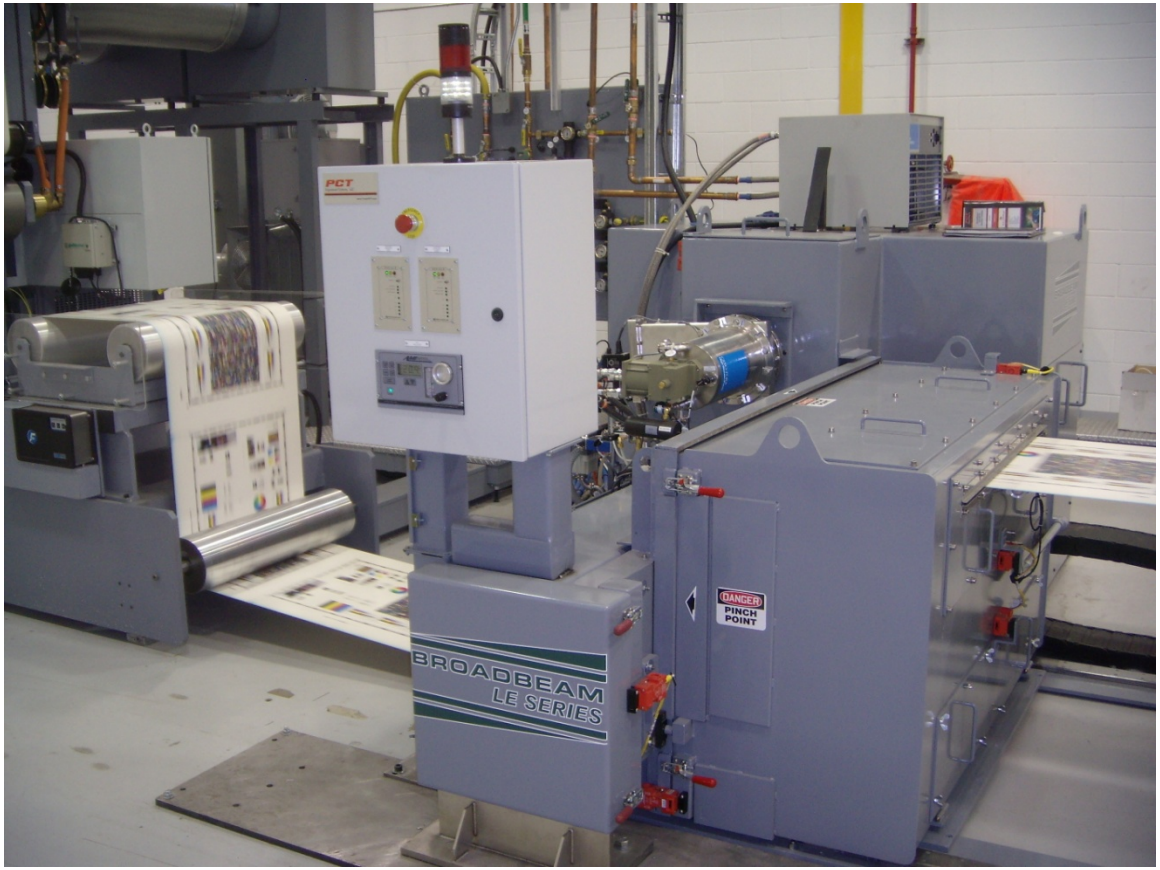
EB

- No photoinitiator needed
- Surface curing requires inert (N_2) atmosphere (not need for laminate processes)
- Penetrates opaque materials
- Single EB unit will cure >100 inches wide at >1000 ft/min
- Cooler, more energy efficient process
- Consistent output and uniformity

Low Voltage Electron Beam Applications

- Printing and Packaging Applications
  - Ink curing: web off-set, flexo (Wetflex™)
  - Overprint Coatings: laminate replacement, cold seal release, multi-wall paper bags, outdoor film bags
  - Laminating Adhesives: folding cartons, flexible packaging
- Converting Applications
  - Non-printing applications
  - May include converting of substrates that are subsequently printed

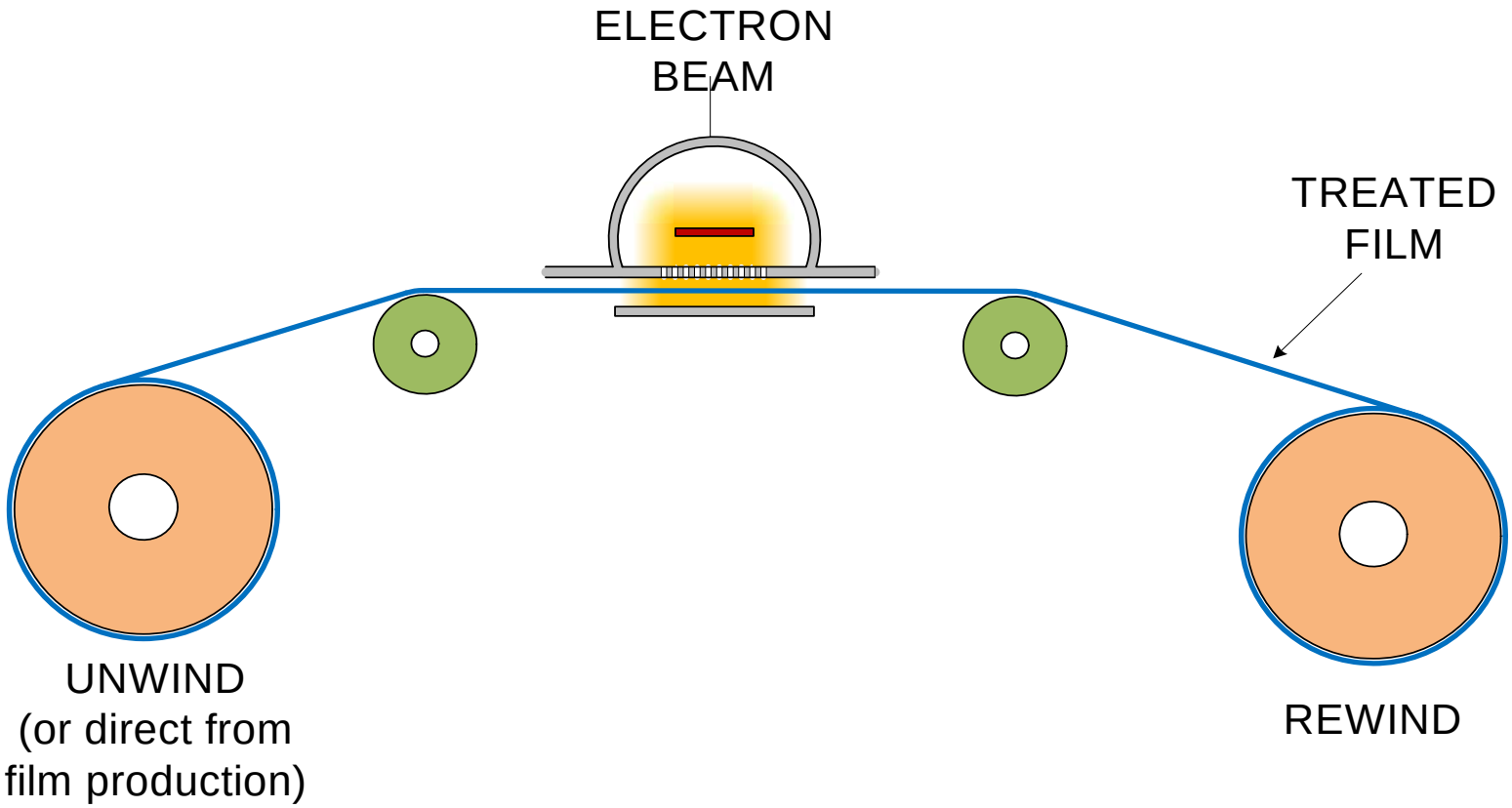
Electron Beam Ink Curing
Web Offset Carton Production



EB Converting Applications

- Film Crosslinking
- Pressure Sensitive Adhesive Crosslinking
- Direct Coating
- Laminating
- Transfer Coating
- Backside Embossing
- Topside Embossing

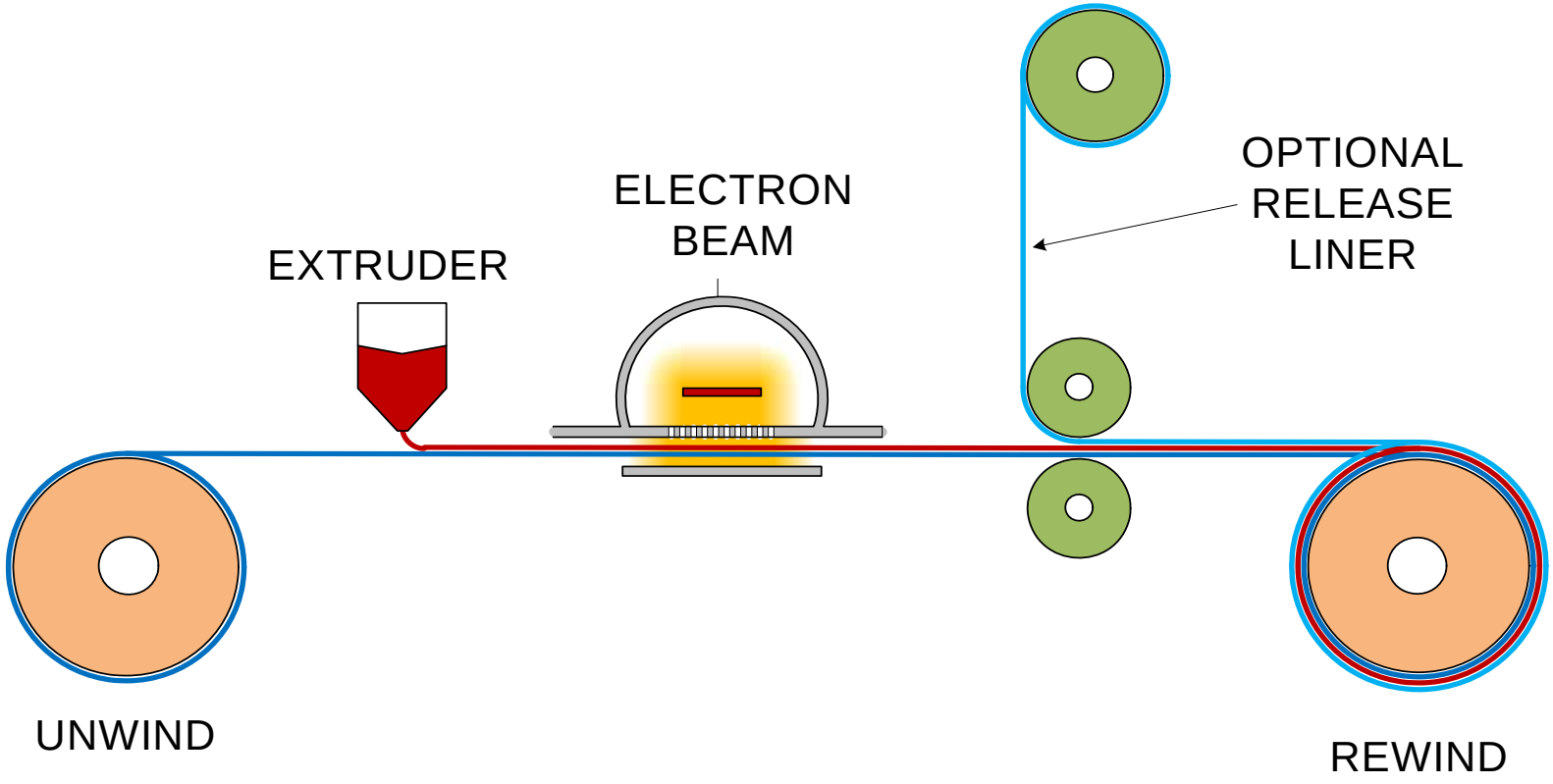
Film Crosslinking



Film Crosslinking

- Largest single EB application
- Polyethylene and polyethylene copolymers are well known to undergo crosslinking upon EB irradiation
- Other polymers may undergo chain scission or a combination of scission and crosslinking depending on the polymer
- Most common use of polymer crosslinking is to create heat shrinkable films
- Crosslinking is also be used to modify the physical and thermal properties of various films

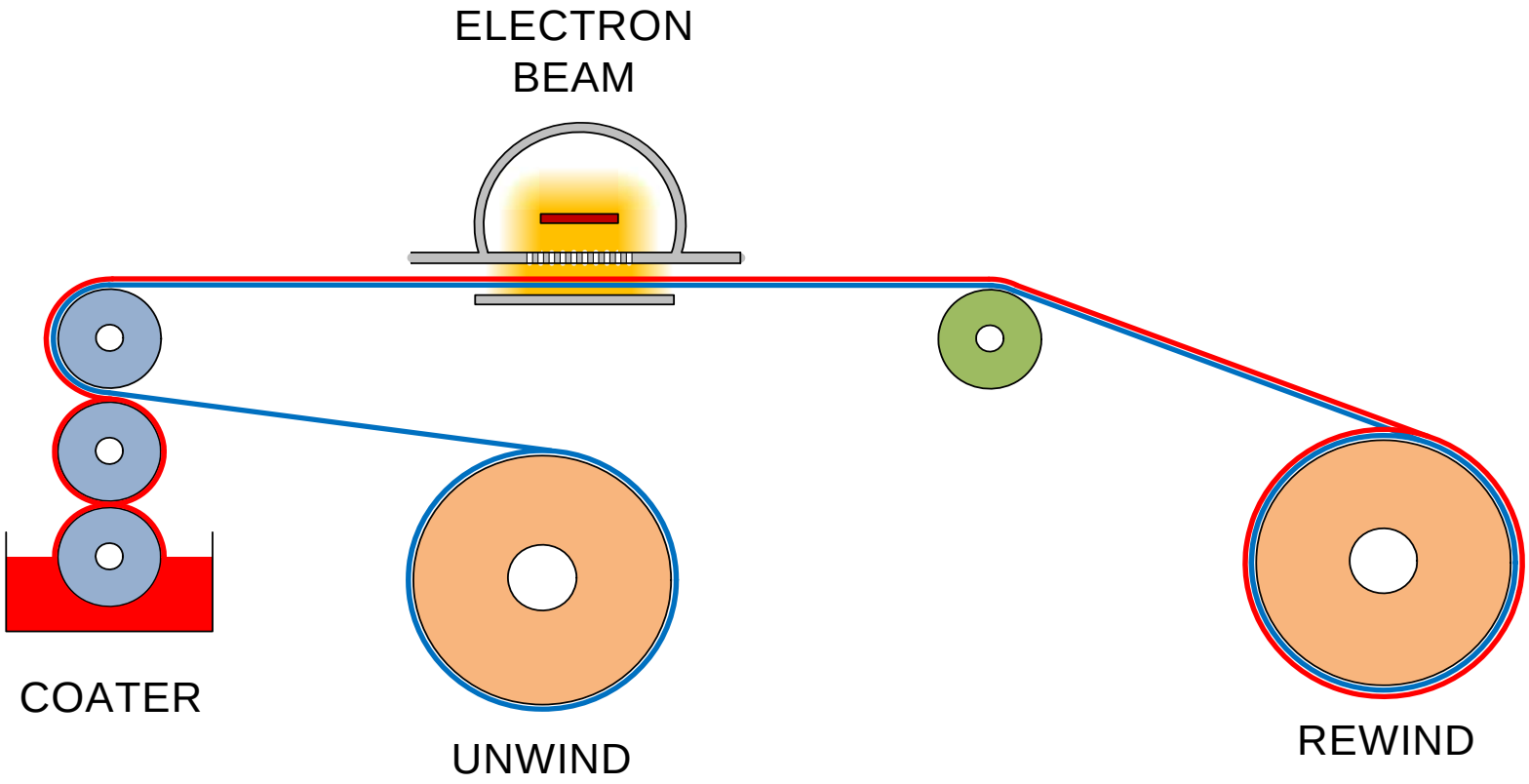
Pressure Sensitive Adhesive Crosslinking



Pressure Sensitive Adhesive Crosslinking

- Hot melt, syrups, solvent, and water based PSA's may be EB crosslinked
- EB Crosslinking of hot melt adhesives improves sheer, heat, and chemical resistance
- EB crosslinked hot melt PSAs provide alternative to solvent acrylic PSAs
- Applications include free film adhesives, high performance tapes, and label stock

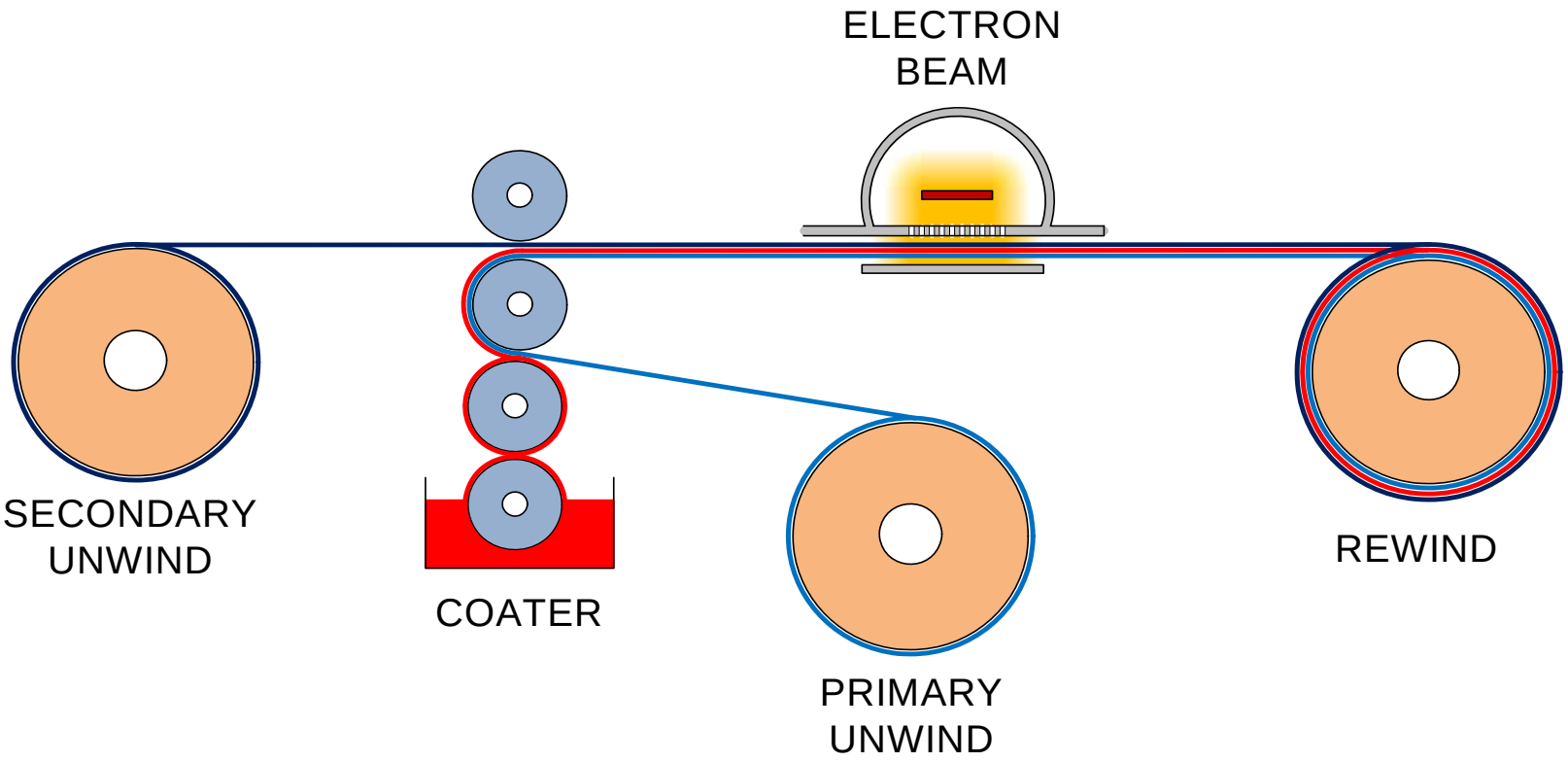
Direct Coating



Direct Coating

- Release coatings
  - Premium silicone release liners for PSAs
  - Industrial release coatings (silicone and non-silicone)
- Coatings for vacuum metallization
  - Premetallization primers
  - Metal protective coatings
    - Enhance/preserve barrier properties
    - Corrosion protection
- Protective coatings
  - Furniture and countertop laminates
  - Crosslinking provides stain and scratch resistance
- Pigmented and filled coatings
  - EB penetrates opaque coatings
  - Examples: magnetic media, abrasive binders

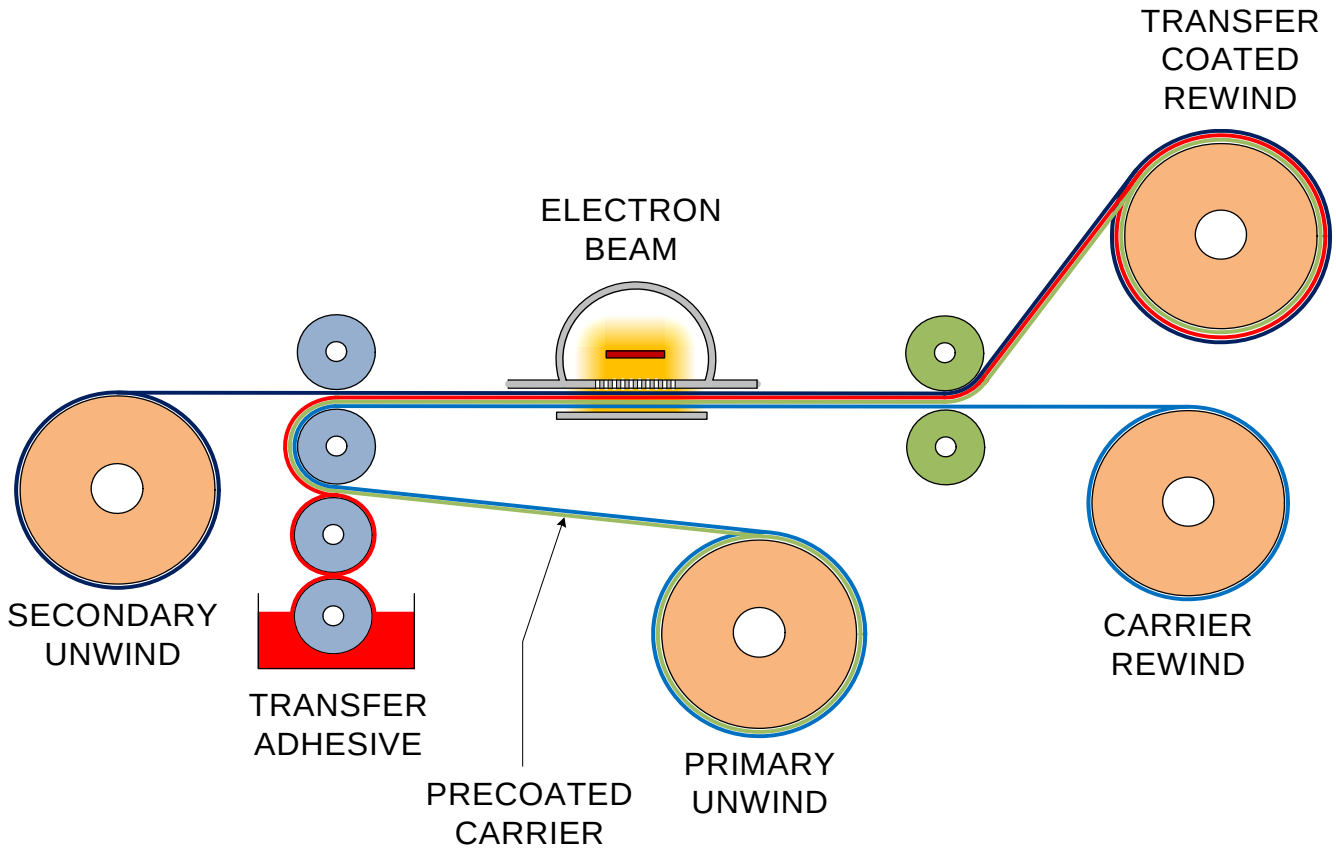
Adhesive Laminating



Adhesive Laminating

- EB advantages
  - Stable one component adhesives
  - Room temperature application
  - Will cure through opaque films
  - Instant bonding – immediate QC, slitting, die cutting, shipping
- Current commercial packaging applications
  - Flexible packaging (film-to-film and film-to-paper)
  - Folding cartons (film-to-paperboard)
- Converting applications
  - Paperboard and plastic card stock - lamination of metalized, holographic, and specialty films
  - Paper, film, and foil – prelaminated packaging and industrial substrates
  - Instant bonding enable in-line laminating with other converting processes

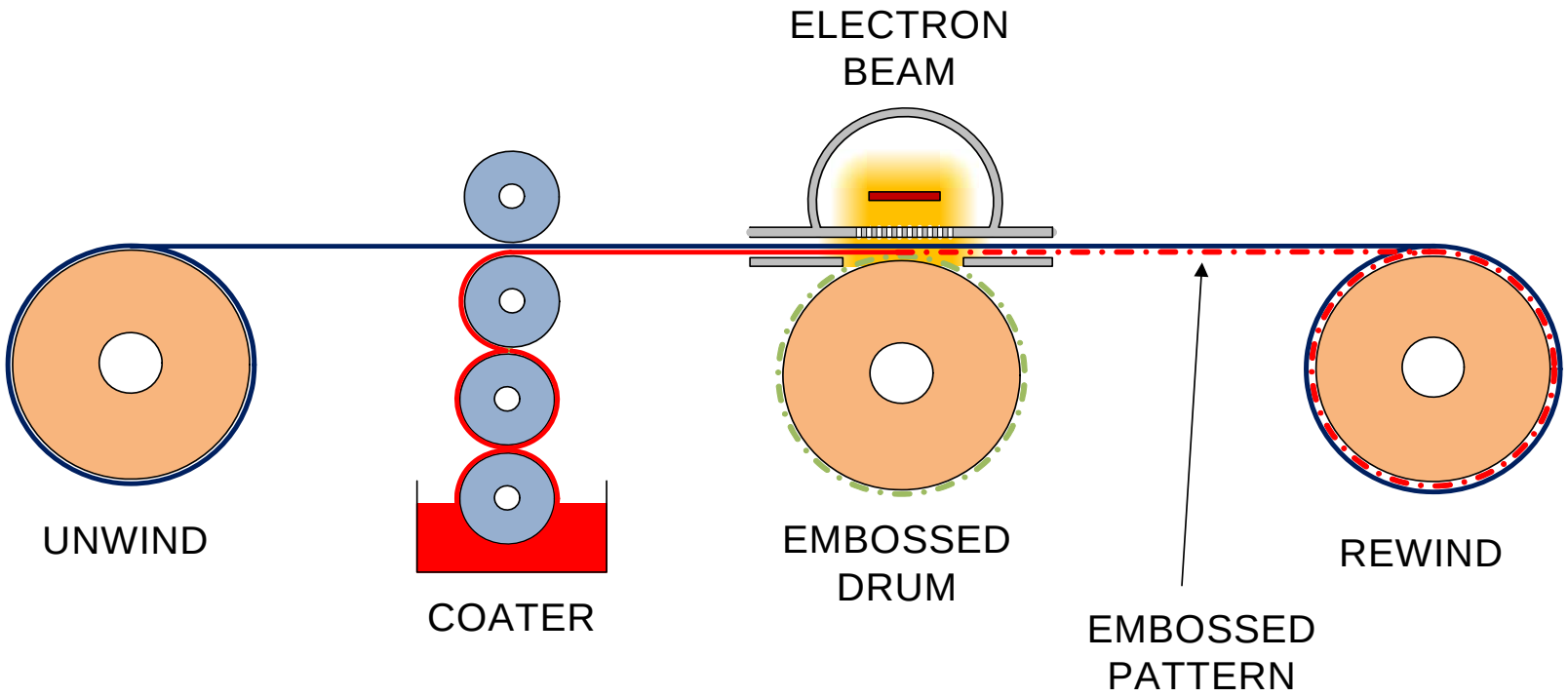
Transfer Coating



Transfer Coating

- EB advantages
  - No solvent or water to dry
  - Cool process allows transfer to heat sensitive substrates
  - Low adhesive weights
  - Instant curing
  - Permanent bond
- Applications
  - Transfer metalliztion
  - Decorative and specialty transfer coatings
  - Pattern printing of adhesive produces transfer pattern (no stamping dies required)
  - Highly uniform surface defined by casting on the original carrier film

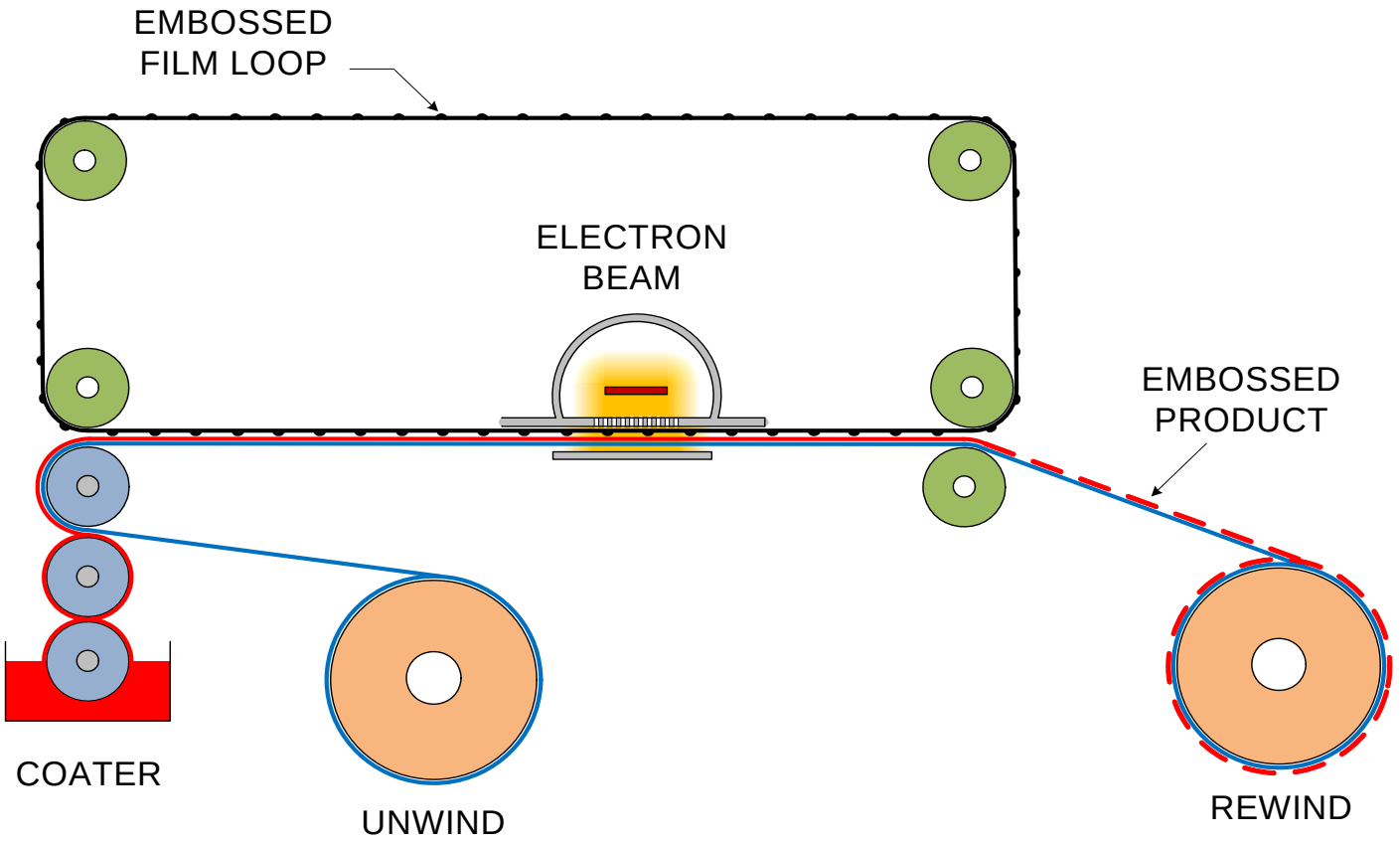
Backside Embossing



Backside Embossing

- EB advantages
  - No solvent or water to dry
  - Cure through opaque materials including paper
  - Clean release from embossed metal drum
  - Pattern reproduction more accurate than thermal embossing
  - Wide feature size (from microns to inches)
  - Crosslinks EB coatings have high chemical and thermal resistance
- Applications
  - Casting papers
  - Unique tactile effects
  - Unique optical effects
    - Holograms
    - Reflective materials
    - Lenticular

Topside Embossing



Topside Embossing

- EB advantages
  - No solvent or water to dry
  - Pattern defined by “parent” film (roll or loop)
  - Cure through clear or opaque parent film
  - Clean release from select parent film materials
  - Parent film may be registered to printed web
  - Wide feature size (from microns to inches)
  - Crosslinked EB coatings have excellent durability
- Applications
  - Decorative packaging
  - Unique tactile effects
  - Unique optical effects

Conclusions

- EB may be used in wide variety converting applications
- EB provides environmental and energy saving advantages compared to thermal curing processes
- The nature of EB technology can enable unique converting processes
- The development of smaller, lower cost equipment, makes EB an attractive technology for expanded use in converting applications

Thank You

Questions?

Steve Lapin
PCT Engineered Systems
SCLapin@TeamPCT.com

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