Electron Beam Technology for Converting Applications

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UV/EB Technology Selection

- UV and EB are complementary, not competing technologies
- UV and EB have some similarities and fundamental differences
- Selection of UV or EB should be based on the best fit for the process and application
- Best fit considerations may include:
  - Enabling of end-use
  - Capital cost
  - Operating costs
  - End-use properties
  - Fitness for food packaging
  - Substrate considerations

Energy

UV

- Energy in the form of photons
- Wavelength determines energy; typically 250 to 450 nm
- Energy unit conversion; 350 nm photon = 3.5 eV
- Total applied energy typically 0.1 to 0.5 J/cm2

EB

- Energy in the form of accelerated electrons
- Accelerating voltage determines energy; typically 80 to 180 kV
- Typical electron energy at substrate; 70,000 eV
- Total applied energy typically 20 to 40 kGy
  - 1 kGy = 1 J/gram
  - For 50 gram/meter^2 layer = 0.1 to 0.2 J/cm^2

Energy

UV

- Energy not sufficient to directly initiate polymerization (non-ionizing)
- Photoinitiator must be used

EB

- Will ionize any organic material
- No photoinitiator needed

Penetration

UV

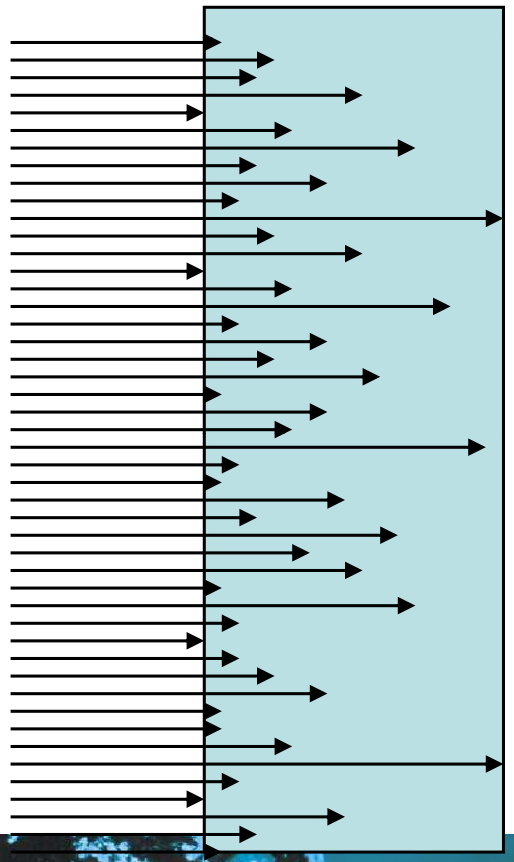
- Penetration depends on the optical density of the material
- Penetration is controlled by the peak irradiance (power and focus) of the UV source
- Good penetration into clear materials
- Limited penetration into pigmented, filled, and opaque materials
  - Effective curing of thin ink films
  - Effective curing of thick coatings with low pigment loading
  - Lamination of clear materials

EB

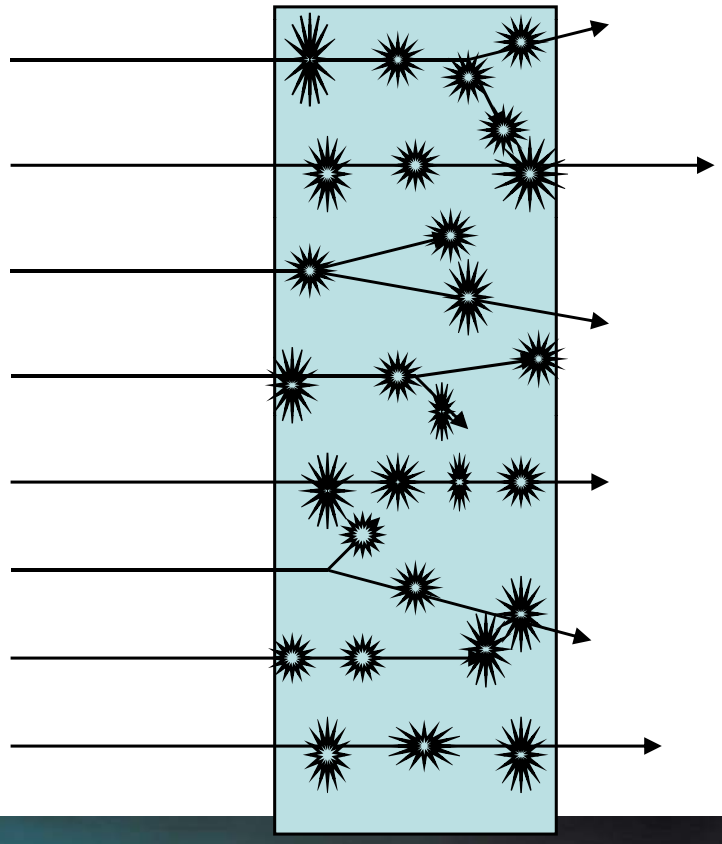
- Penetration depends on the mass density of the material
- Penetration is controlled by acceleration potential (voltage) of the beam
- Easily penetrates into clear, pigmented, filled, and opaque materials
  - Can cure thick and/or heavily pigmented or filled inks and coatings
  - Enables lamination of opaque materials

Penetration/Energy Deposition

UV Photons



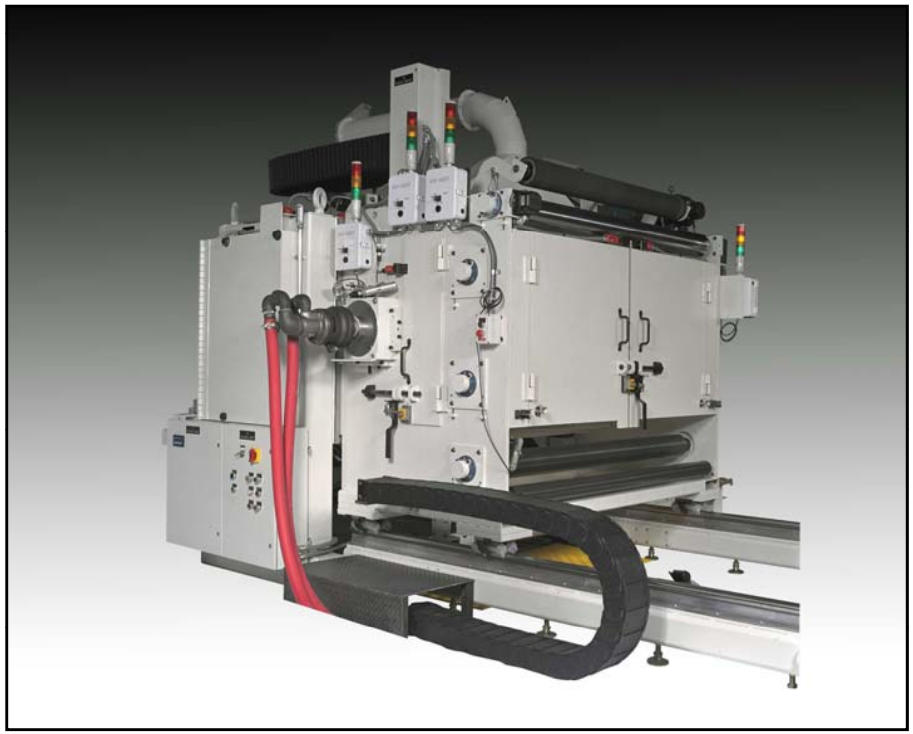
EB Electrons



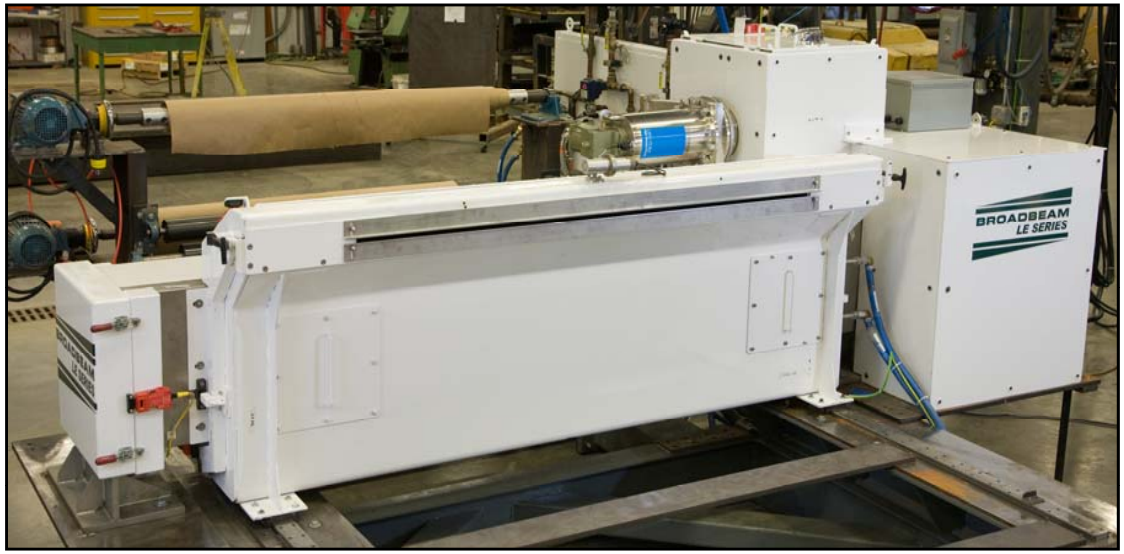
New Generation Low Energy EB Equipment

- Introduced about 10 years ago
- Focus on 80 to 150 kV portion of the low energy spectrum
- Effective penetration up to about 100 g/m^2 (100 microns at density = 1 g/cm^3)
- High throughput (30 kGy at 400 m/min)
- Up to 1.7 m wide
- Ideal for most printing, packaging, and, converting applications
- Reduced cost compared to 150 to 300 kV Industrial equipment

Electron Beam Equipment

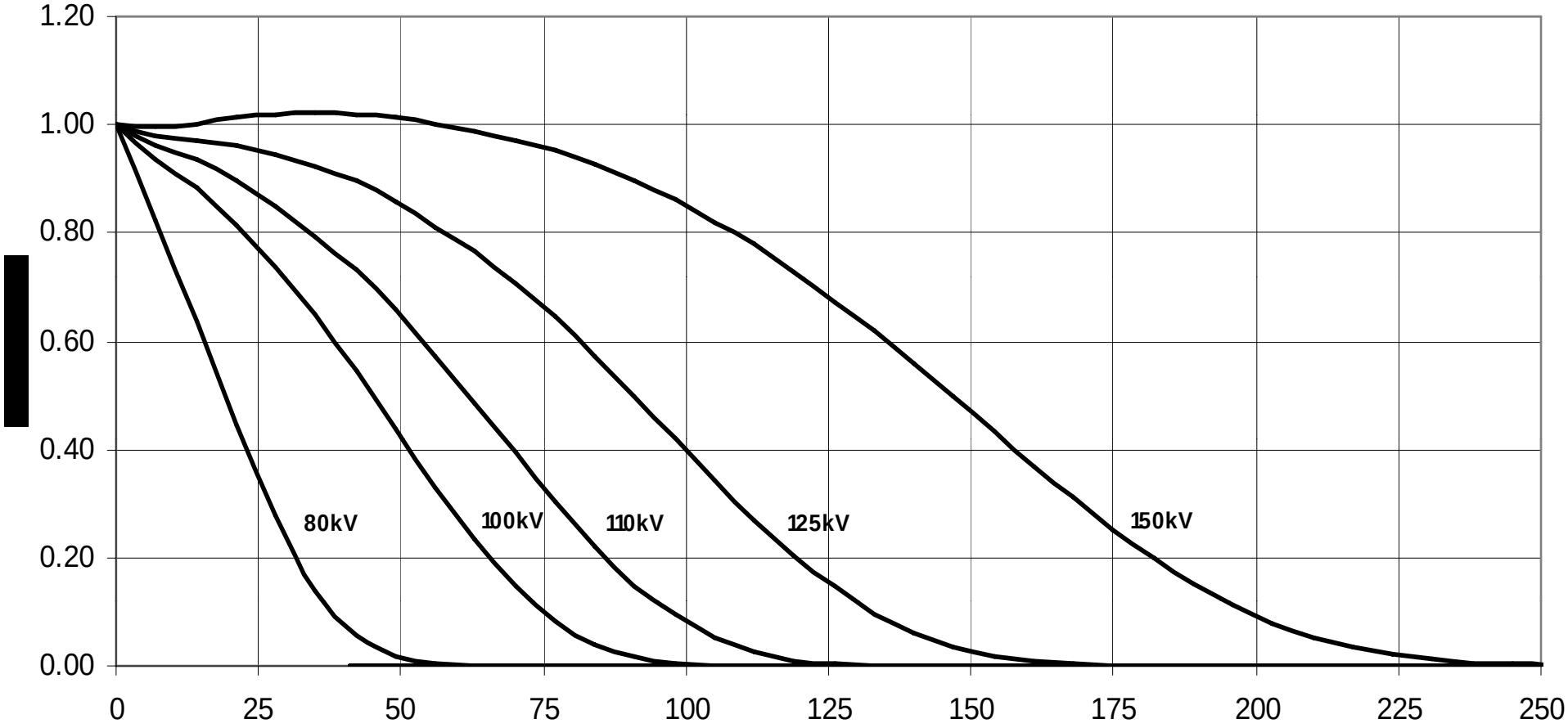


Industrial Electron
Beam Processor
150 to 300 kV



New Generation
Low Energy
Electron Beam Processor
80 to 150 kV

BroadBeam LE Depth/Dose Profile



Unit Conversions:

For unit density g/m² = microns

1 g/m² = 0.613 lbs/3000 ft²

Low Energy Electron Beam Applications

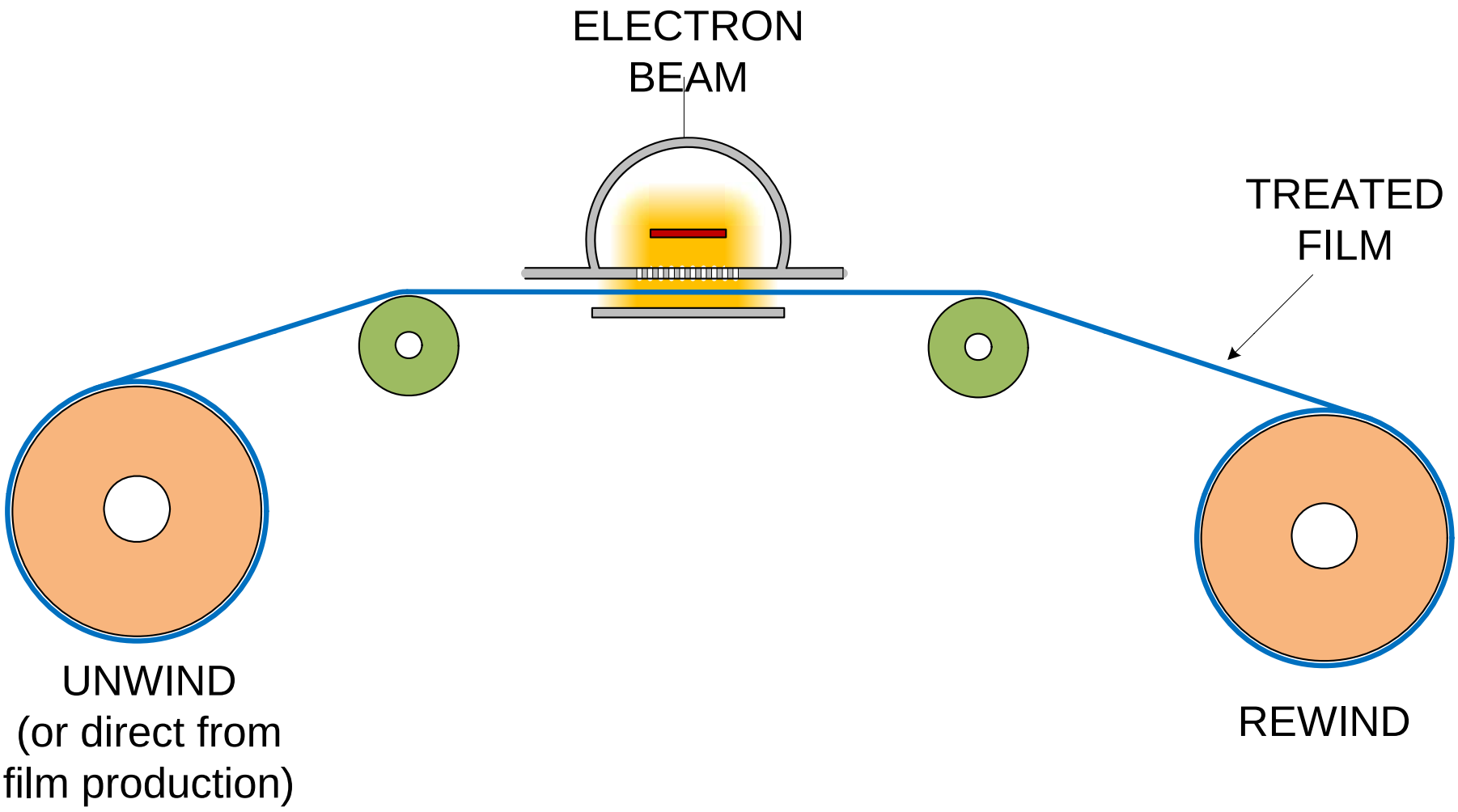
- Printing and Packaging Applications
  - Ink curing: web off-set, flexo (Wetflex™)
  - Overprint Coatings: laminate replacement, cold seal release, multi-wall paper bags, outdoor film bags
  - Laminating Adhesives: folding cartons, flexible packaging
- Converting Applications
  - Non-printing applications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

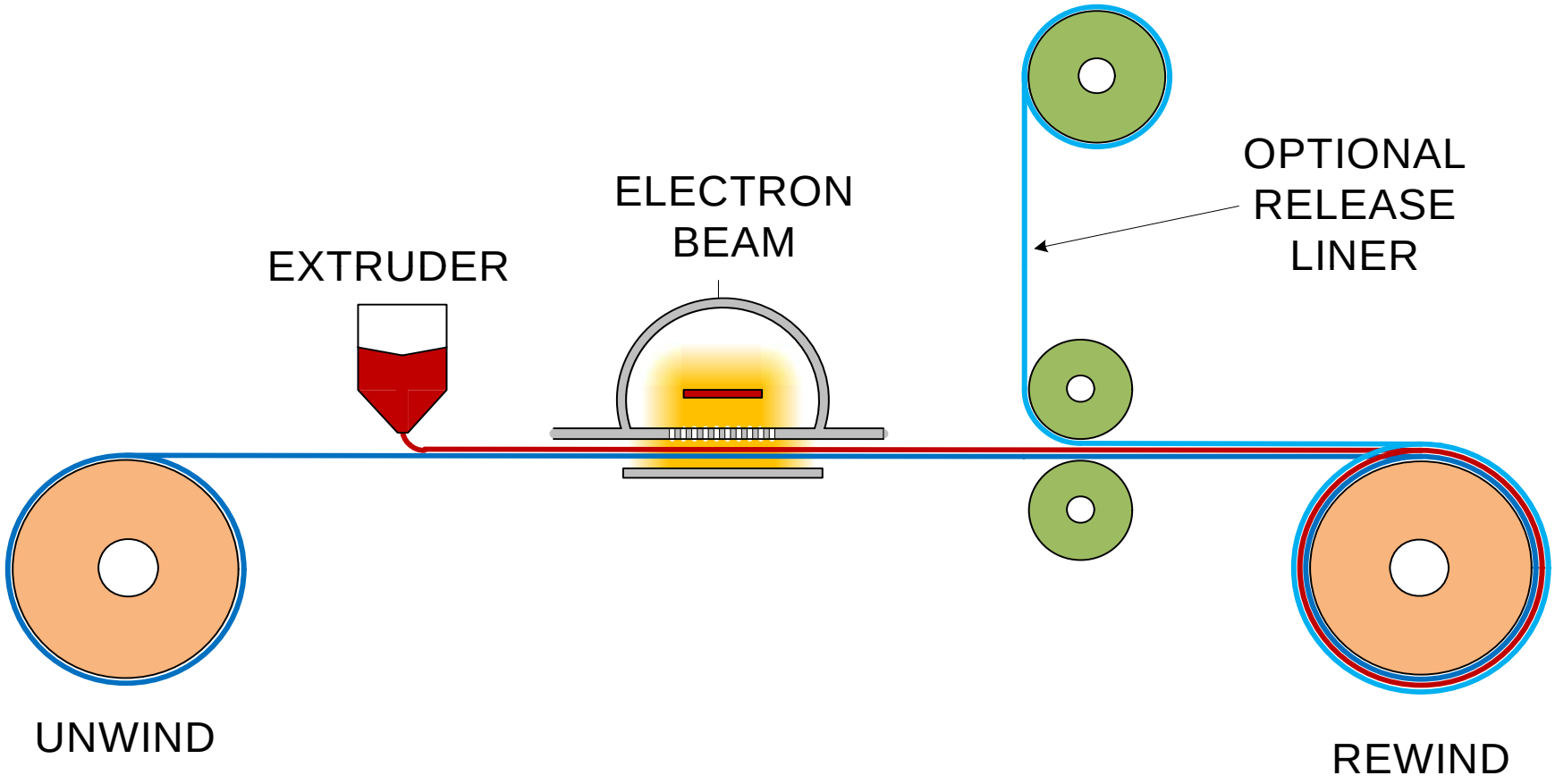
Film Crosslinking



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

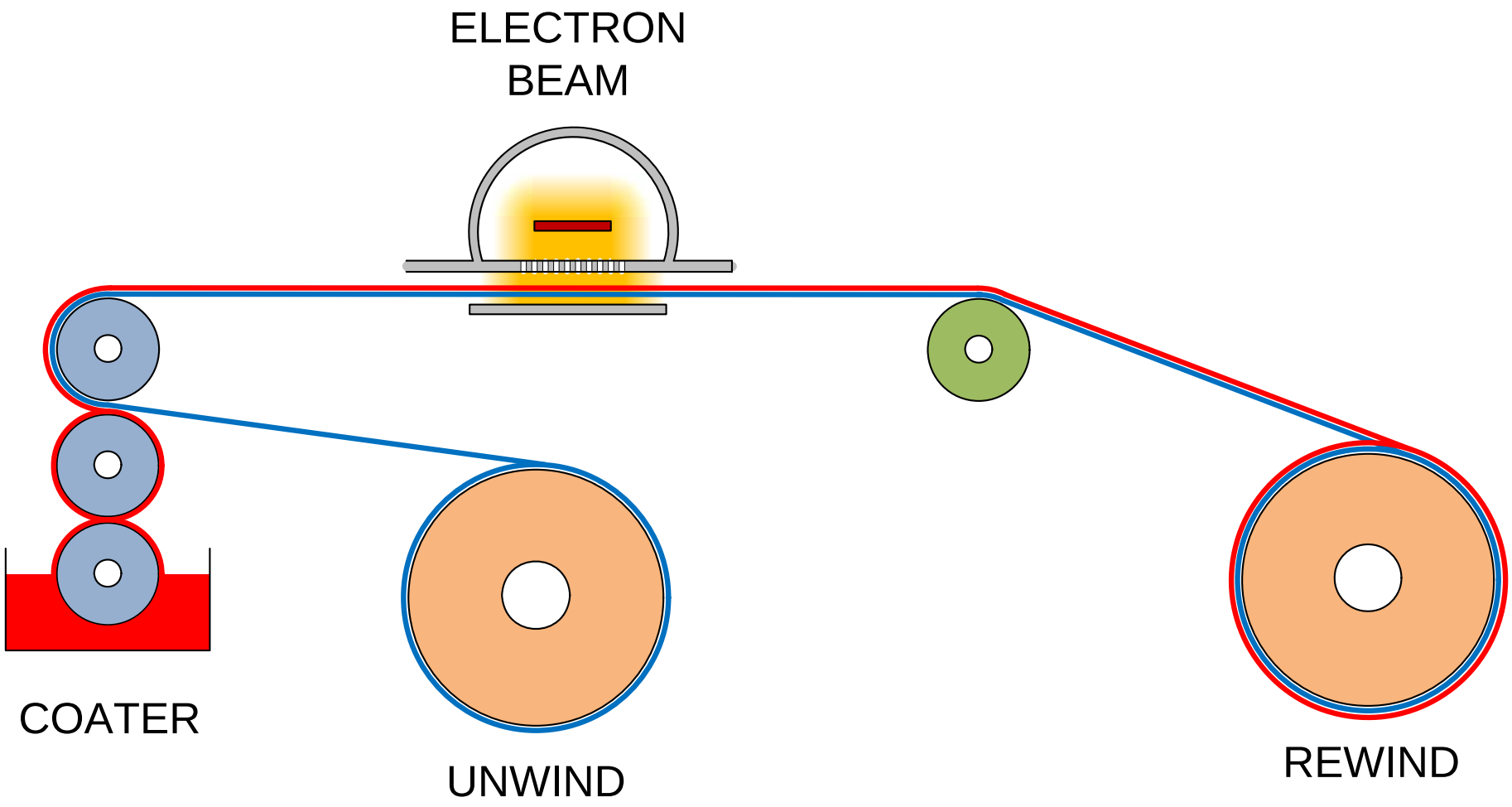
Pressure Sensitive Adhesive Crosslinking



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

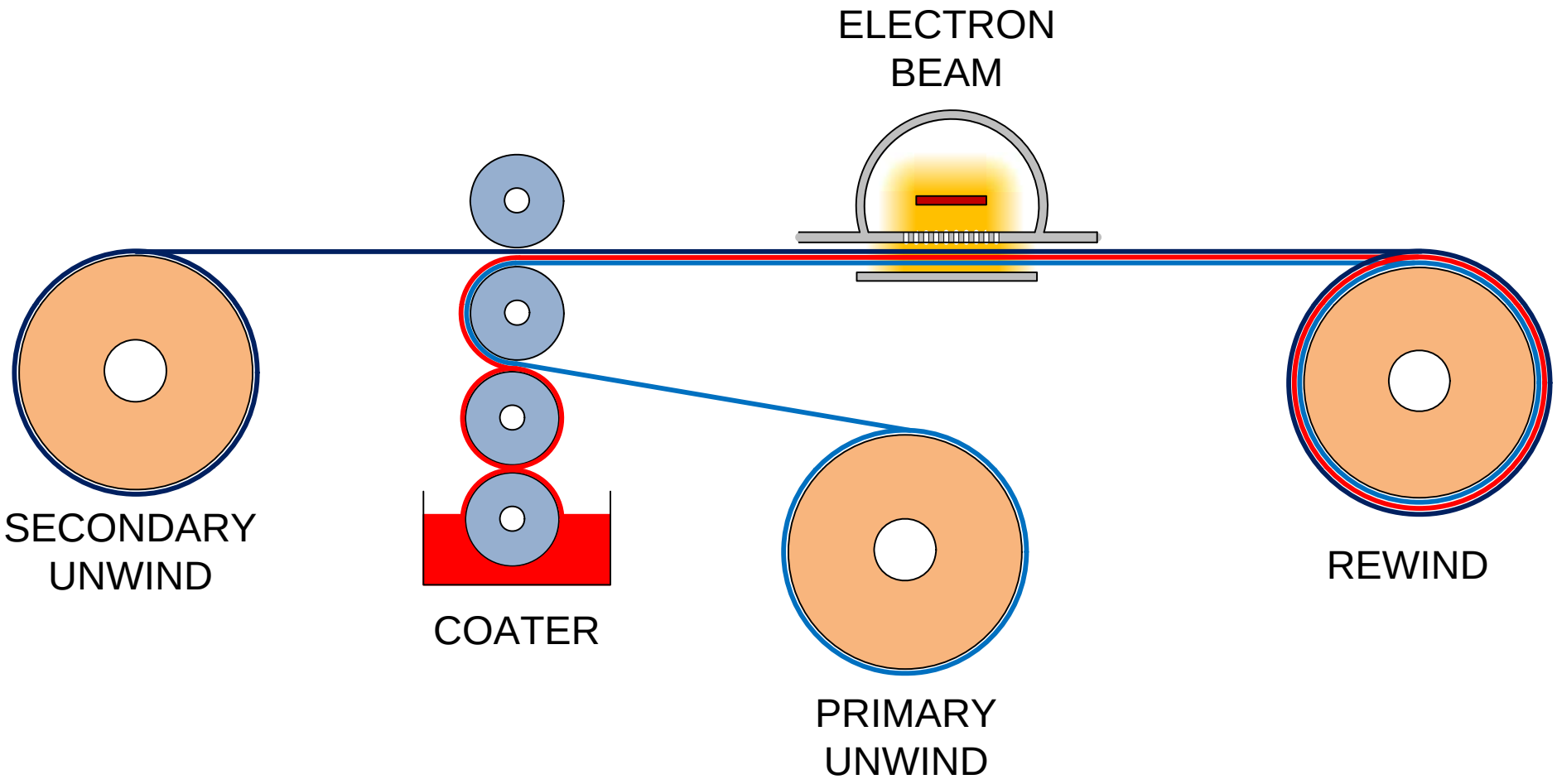
Direct Coating



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

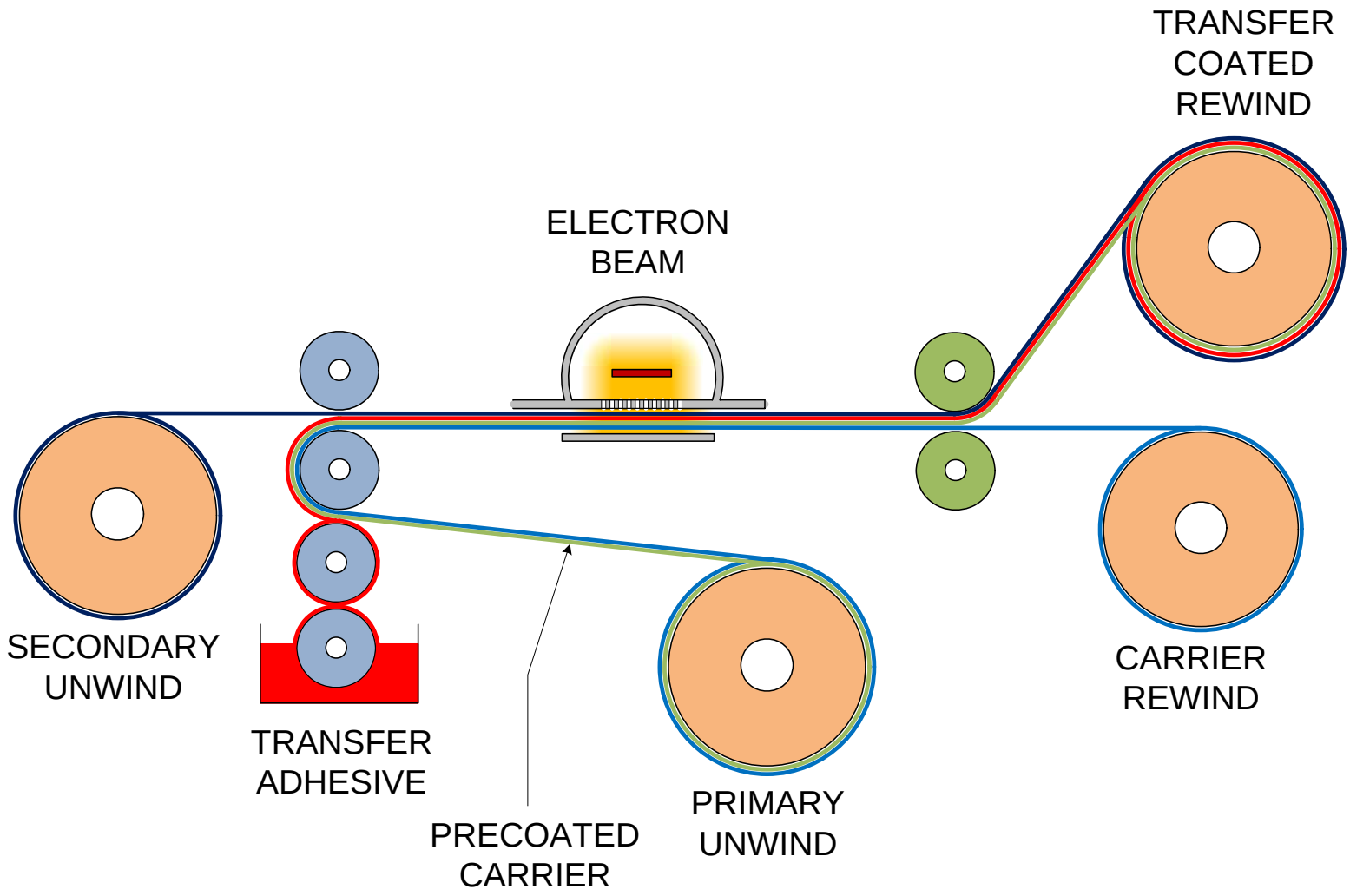
Adhesive Laminating



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

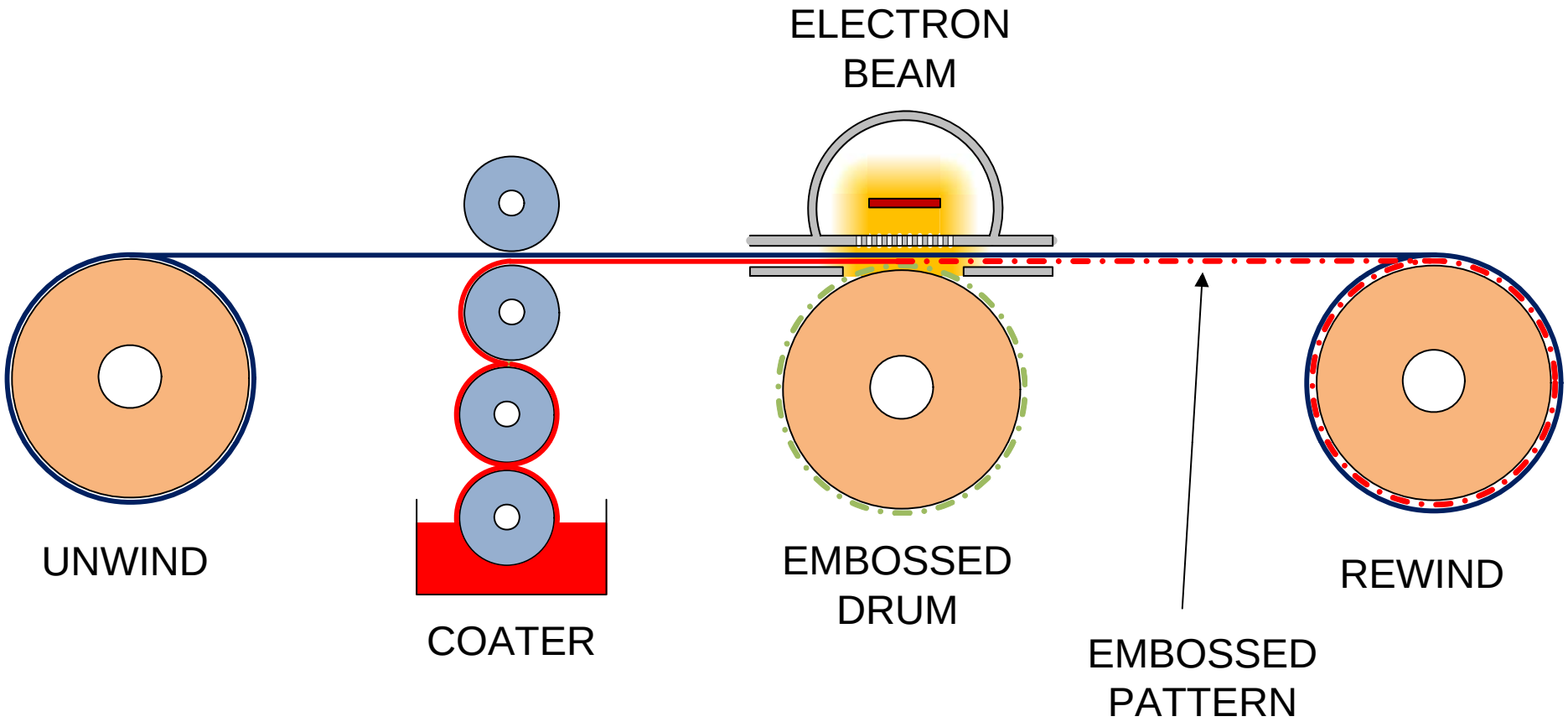
Transfer Coating



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

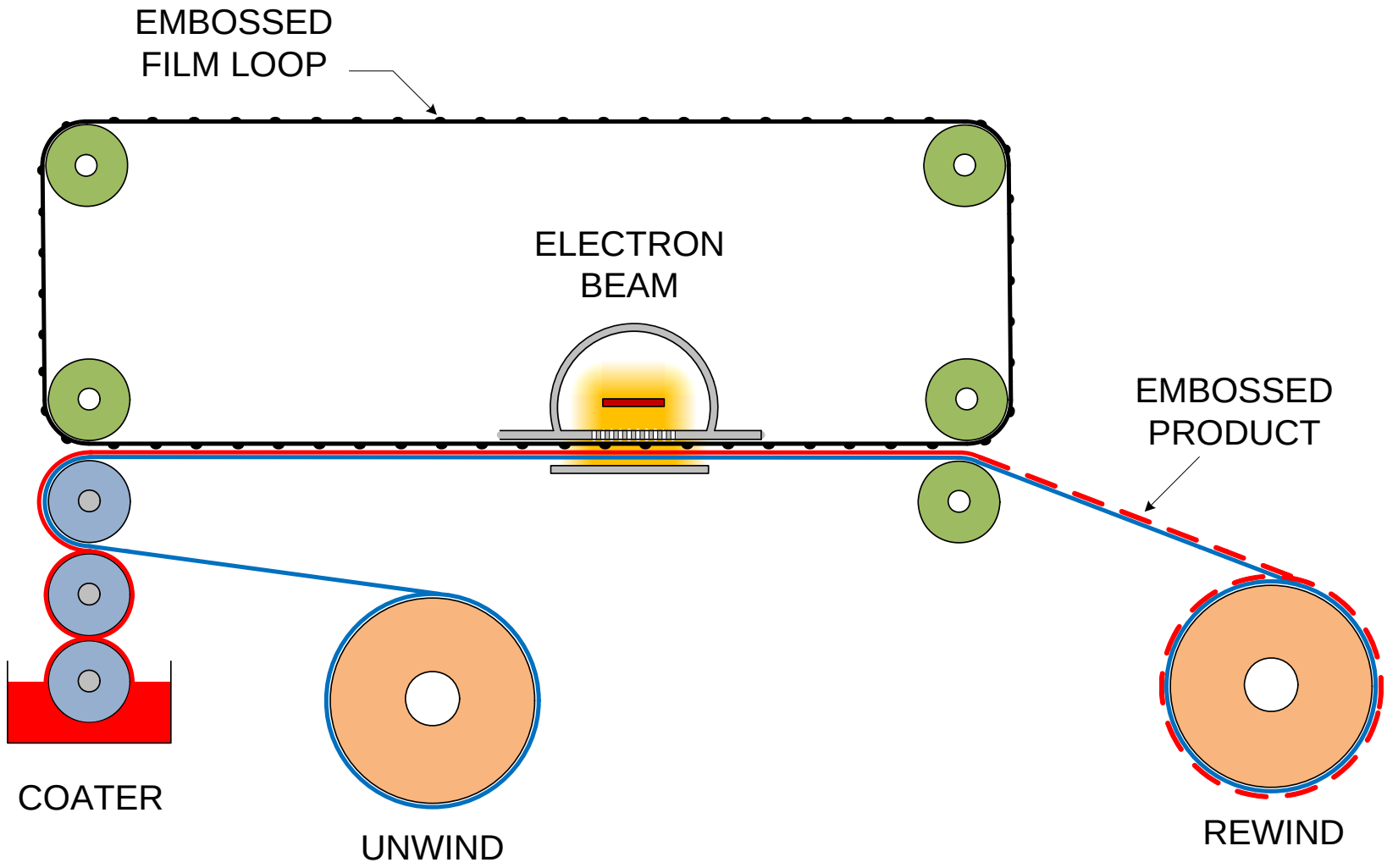
Backside Embossing



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?

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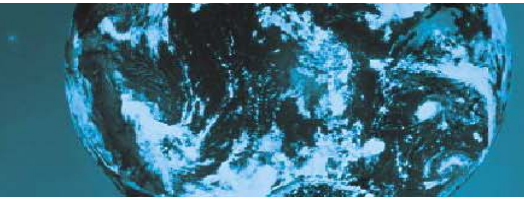

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