Electron Beam Technology for Converting Applications

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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

UNWIND (or direct from film production)

ELECTRON BEAM

TREATED FILM

REWIND
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

EXTRUDER

ELECTRON BEAM

OPTIONAL RELEASE LINER

UNWIND

REWIND
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
  - Premetalization 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

SECONDARY UNWIND

COATER

PRIMARY UNWIND

REWIND

ELECTRON BEAM
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

- 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 metallization
  - 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

- **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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