RADTECH UV+EB 2018
TECHNOLOGY EXPO AND CONFERENCE
May 7-9, 2018
Hyatt Regency, O'Hare - Chicago, Illinois
The world's largest event dedicated to the educational, technical, and scientific advancement of ultraviolet (UV) and electron beam (EB) technologies.

Low voltage EB equipment development to meet the challenges of the fast growing packaging market

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Energy Sciences

Radtech NA 2018

Chicago Ill USA

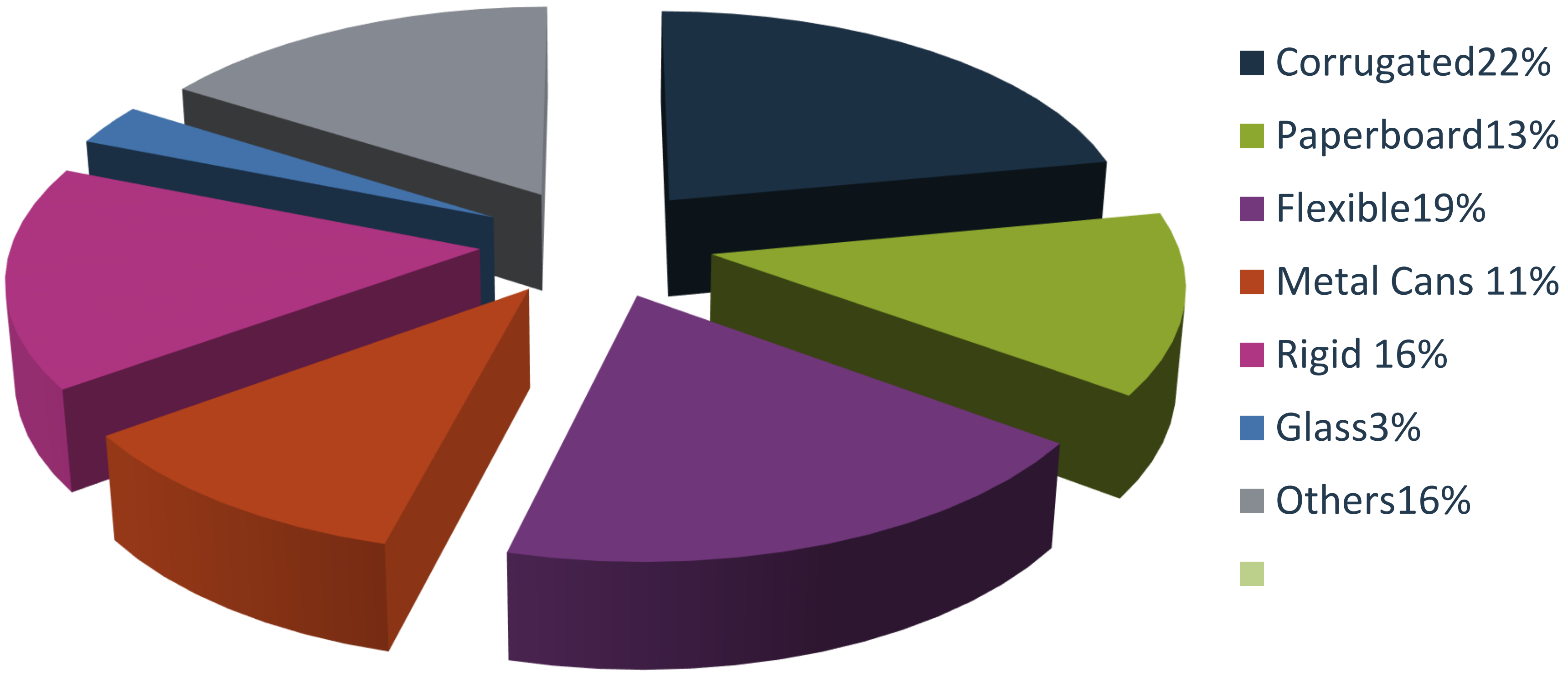
Agenda

- **Markets for Packaging**
- **Packaging Market Trends and demands from end users**
- **Chemistry and resin supplier challenges**
- **EB equipment developments to meet the market trends**
- **Conclusions**

EB Applications

	Coating	Ink	Adhesive	Crosslink
Packaging	☑	☑	☑	☑
Converting	☑		☑	☑
Films				☑
Silicone	☑			
Tapes			☑	
Tires				☑
Furniture	☑			
Flooring	☑		☑	

Total NA Packaging Market US$ 164 Billion
Flexible Packaging Largest Growth (US $31 Billion)
FPA 2016



Flexible Packaging Growth

FPA 2016

Growth	2000	2006	2016
Total Flexible Packaging Industry	$19.7 B	$24.9 B	$31.2 B
$ Growth Year	3.7%	5.1%	3.4%

Challenges Faced By the Flexible Packaging Industry Today

- **Driving Technology in:**
  - Portioned / Single Serve Packages
  - Customize preparation (food, cosmetic, supplement…)
  - Customize printing. Shorter Runs

- **Driving Technology in:**
  - Barrier Materials
  - Scavenging Technologies
  - Shelf life extensions
  - Increased Environmental Awareness Low to NO VOC
  - Reuse, reduce, recycle, bio-base resins
  - Reduce Carbon Footprint

Challenges Faced By the Flexible Packaging Industry Today

- **Driving Technologies In:**
    - Environmentally Friendly Energy Cured Ink Technology
    - Resin & film technology to meet the challenges
    - Energy Cured Coating Technology to eliminate laminates
    - Printing Press and other equipment technology to print higher viscosity energy cured inks
    - Curing equipment technology to meet the above mentioned challenges
    - Plates and other printing methods

Applications of EB Curing in Packaging

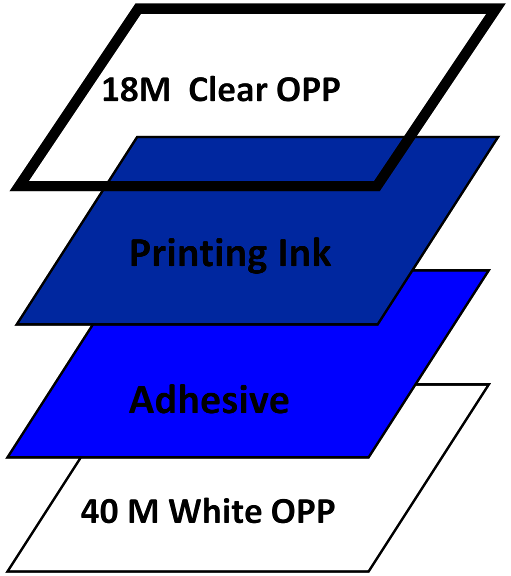
- **Coatings replacing laminates**

- **EB Curing of Inks**
  - **EB Offset Inks**
  - **EB CI-Flexo Inks**
  - **EB curing digital inks**

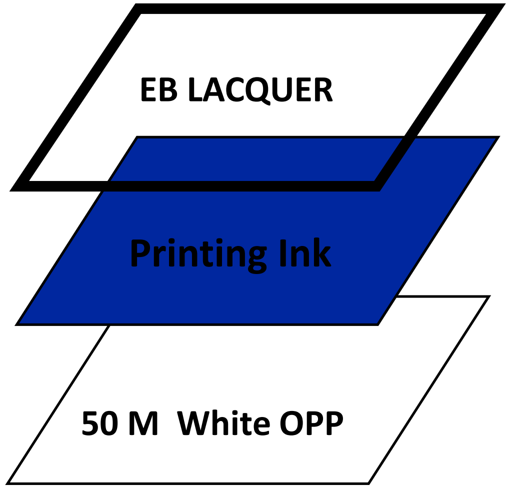
- **EB X-linking**
  - **High Barrier Shrink Films**
  - **Vacuum Skin Packaging**

Laminate Replacement with EB Lacquers Concept

CONVENTIONAL LAMINATION



MONO-FILM WITH EB LACQUER



Challenges To Meet the Laminate Replacement

- Film & Resin Suppliers to Meet the Packaging Requirements with Monolayer.

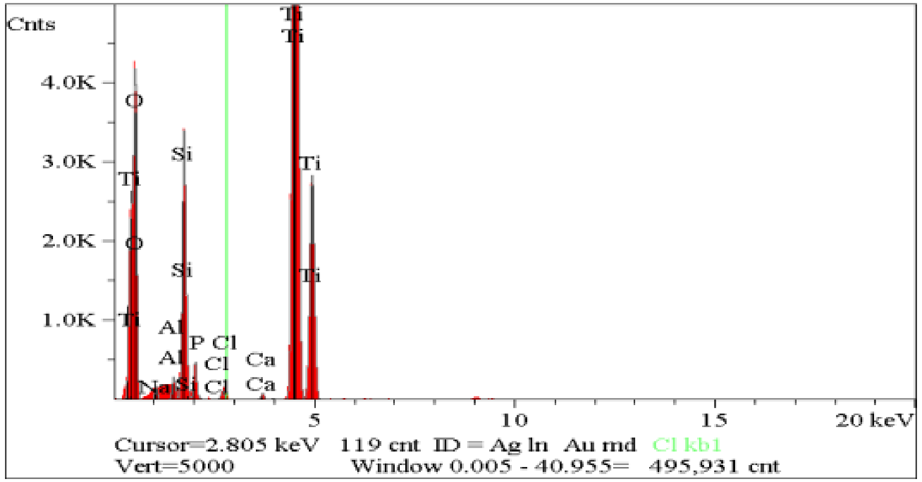
- Coating Supplier Challenges
  - Meet the Film Properties With a EB Cured Coating
  - Matte and Gloss Properties as Provided By Film
  - Soft Touch and other Properties
  - Abrasion and Scuff
  - COF
  - Temperature resistance

Challenges to Meet Laminate Replacement

- EB equipment Supplier Challenges
  - Wide Width Ranges 24 – 108 inches
  - High Speed 1500 feet\min
  - Continuous Operation with Minimum Downtime
    - Robust Window Foil Technology to Resist Chemicals From Coatings

Pre-Mature Foil Failure

EDX analysis



EB Offset Inks

- Not That Much Development from Ink and EB Equipment
- Good Development from Press supplier to Meet Flexible Packaging Challenge. (Print Various Substrates)

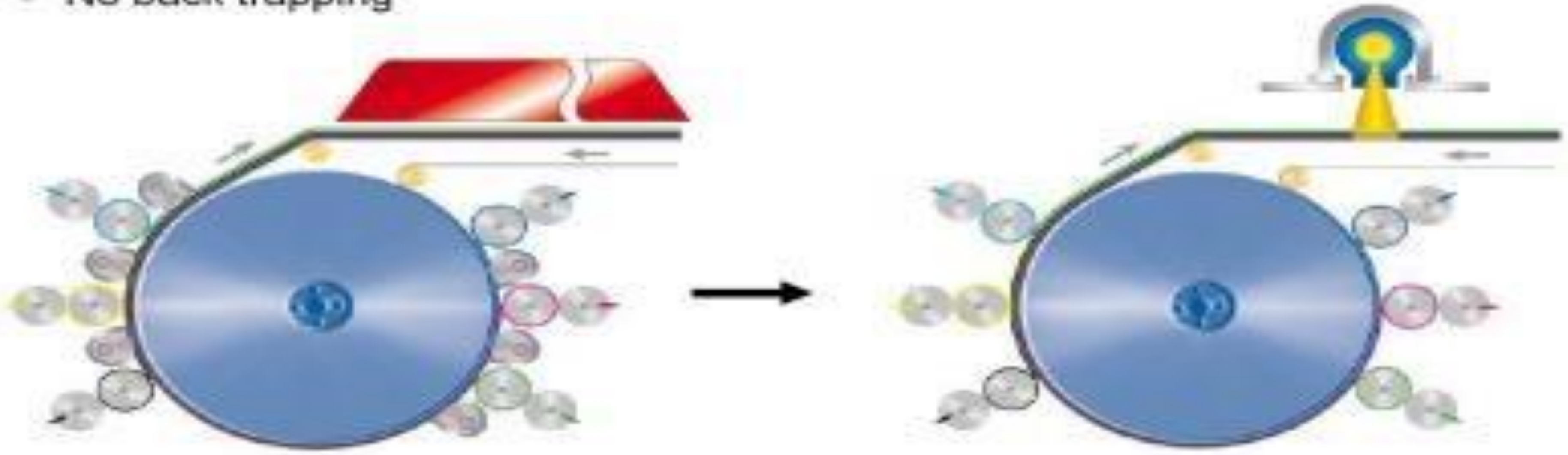
EB CI-Flexo Inks
Major Printing Method for Flexible Packaging

Print Type	2010	2013	2015
Flexo	64%	63%	66%
Gravure	9%	11%	15%
Offset & Other	1%	3%	4%
Digital	n/a	<1%	<1%
Unprinted	26%	22%	15%

EB CI-Flexo Process

EB Flexo Requirements:

- **Only one EB curing station at end**
- **No inter-station curing or drying**
- **Wet-on-wet printing**
  - No turn bars - Central Impression (CI) Press
  - Transfer of ink over wet ink
  - No back trapping



Challenges to Meet EB CI-Flexo

- Ink Suppliers Major Challenge
  - **WETFlex:** Wet Trapping achieved by evaporating a non-reactive diluent and increasing the viscosity of the applied layer.
  - **GELFlex:** Wet Trapping achieved by evaporating a non-reactive diluent and adjusting the Hansen’s solubility parameter to form an organo gel in the applied layer.
  - **ELEX-ONE:** Wet Trapping achieved by adjusting the surface tension of the applied layer.

Challenges to Meet EB CI-Flexo

- **CI-Flexo Press Manufacturers:**
  - Pumps and Mixers for High Viscosity Energy Cured Inks
  - Doctor Blades
  - Temperature and Rheology Control
- **EB Equipment:**
  - Wide Web
  - High Speed Up to 1500 feet\min
  - Continuous Operation, minimum downtime

Advantages of Digital Printing with EB Curing

- Very High Print Quality
- Very Cost Effective for JIT Printing and Short Runs
- Better Properties
  - Gloss
  - Solvent & Temperature Resistance
- In-Line Coating and laminating Possible
- Food Packaging Compliant

Digital Printing With EB Curing

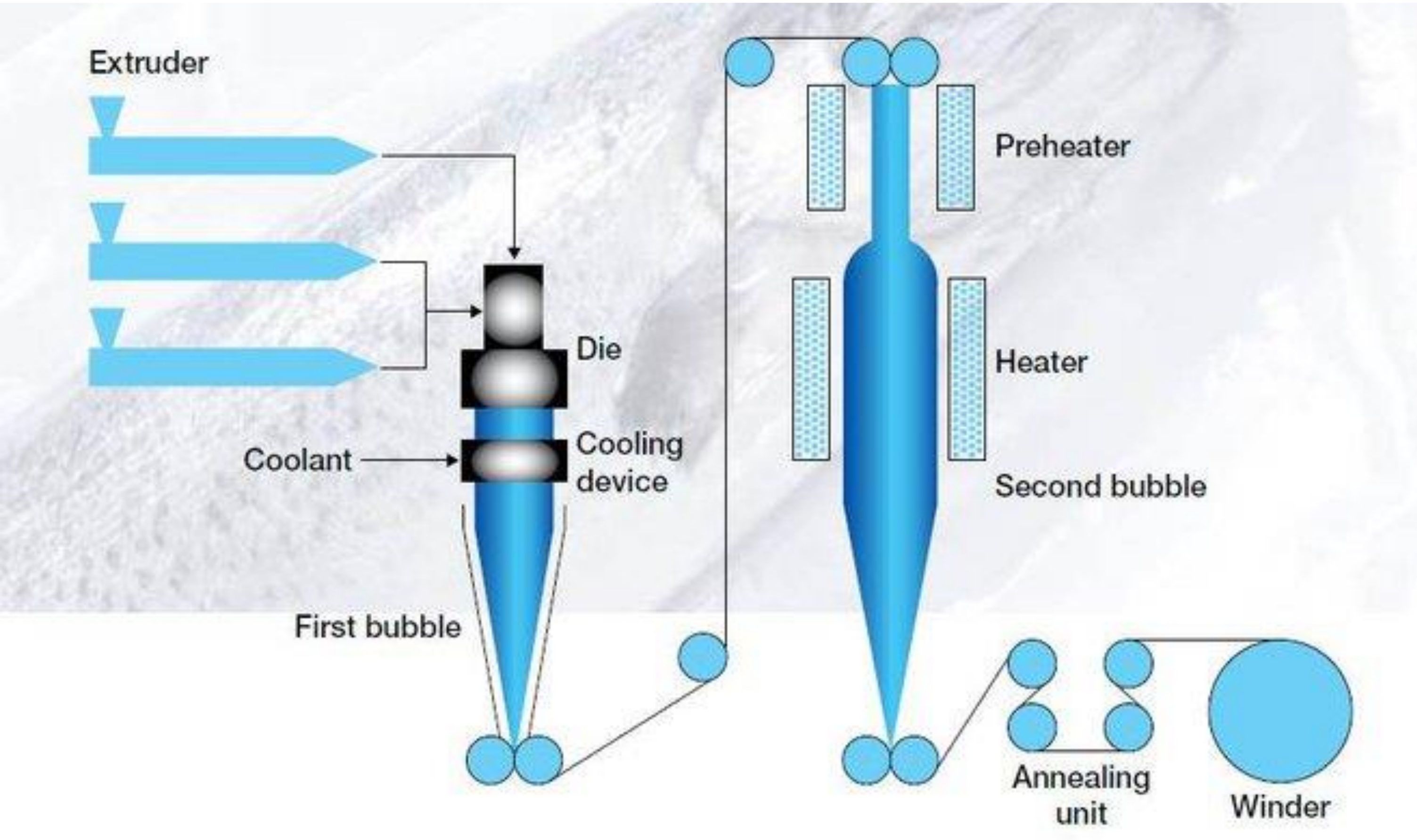
- Crosslinking of HP Indigo Inks To Obtain Better Resistance Properties
  - Temperature resistance up to 175-200 C Important for Heat Sealing

- EB Curing of Inks applied By Digital
  - Higher Gloss
  - Better Chemical Resistance
  - Temperature Resistance

Challenges To Meet with EB-Digital Printing

- **Ink Suppliers**
  - **Viscosity of Inks**
  - **Wet on Wet Printing**
- **Press Suppliers**
- **EB Equipment**
  - **Cost Effective Equipment**
  - **Small Size**
  - **Low Speed. (400-600 feet\min)**

High Barrier Shrink Film Bags Double Bubble Process Using 3-Layers



Structure of High Barrier Shrink Film Bags

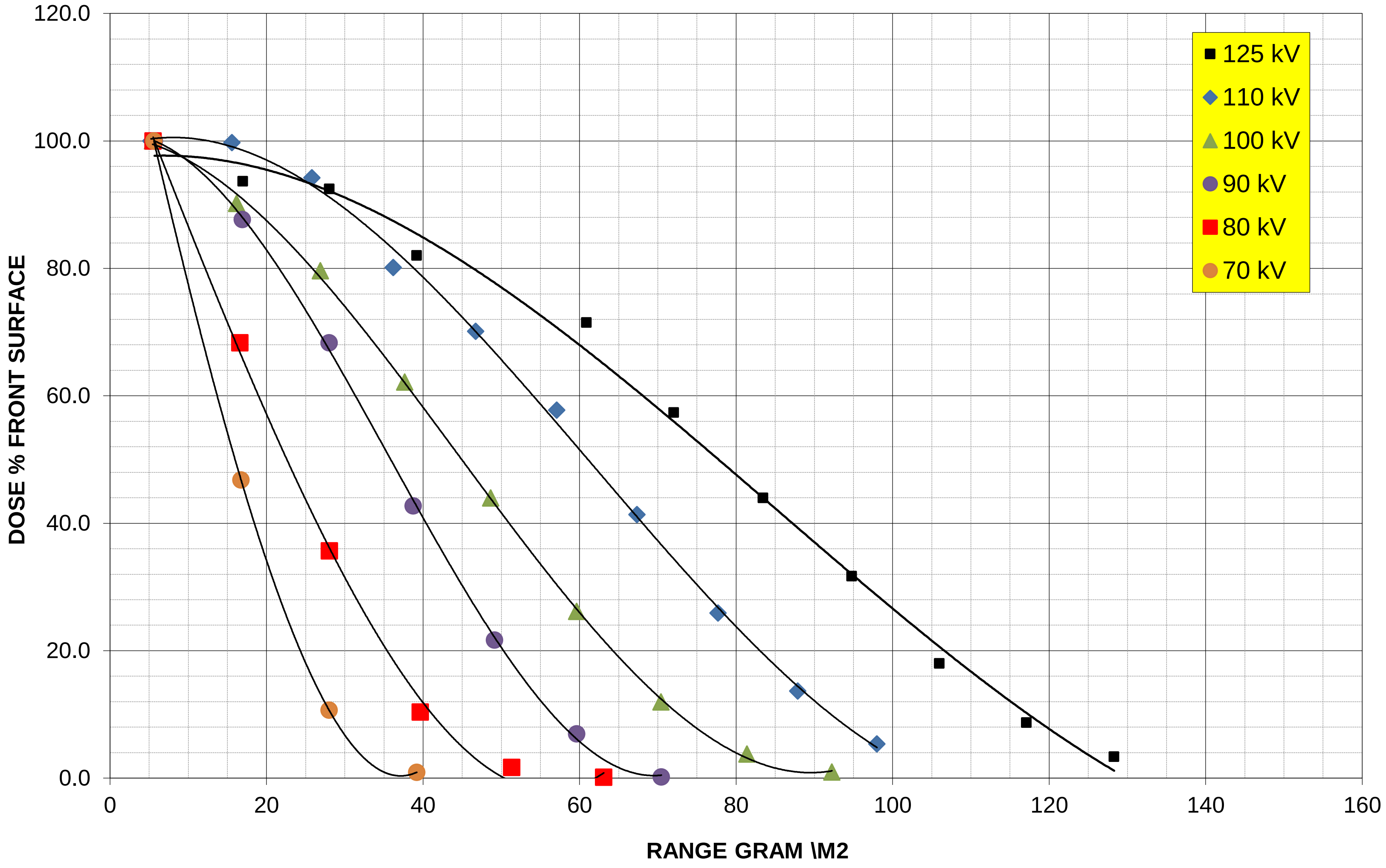
Structure: Total wall thickness about 65 Microns.

- Outer Layer = 48 microns (18% EVA + LDPE)
- Middle Layer = 7 microns (PVDC) O_2 Barrier (7 – 9 cc/m^2 / 24 Hrs)
- Inner Layer = 8 microns (18% EVA + LDPE)

Typical EB Conditions for this Application

125-70 kV, 50-80 kGy Double Pass

Typical Non-Drum EB System



Vacuum Skin Packaging (VSP)

The Vacuum Skin Packaging (VSP) process uses a tray and special films that gently surround the product and seal over the entire surface of the pack like a second skin, preserving shape, texture and product integrity for a premium retail presentation

Appealing shelf presentation

- Reduced packaging size and volume takes up less shelf space, cheaper to transport
- Reduced purge, increased shelf life lowers food waste, improves stock management
- Shelf life increased to 2-6 weeks vs MAP trays (6-10 days)

Typical Structure of VSP Film

Structure: Typical 80 – 150 microns (5 layers)

Outside

Surlyn Ionomer Provides Puncture, and other properties

Tie Layer

EVOH 44% Provides O_2 Barrier < 10 cc/m^2/24 hrs

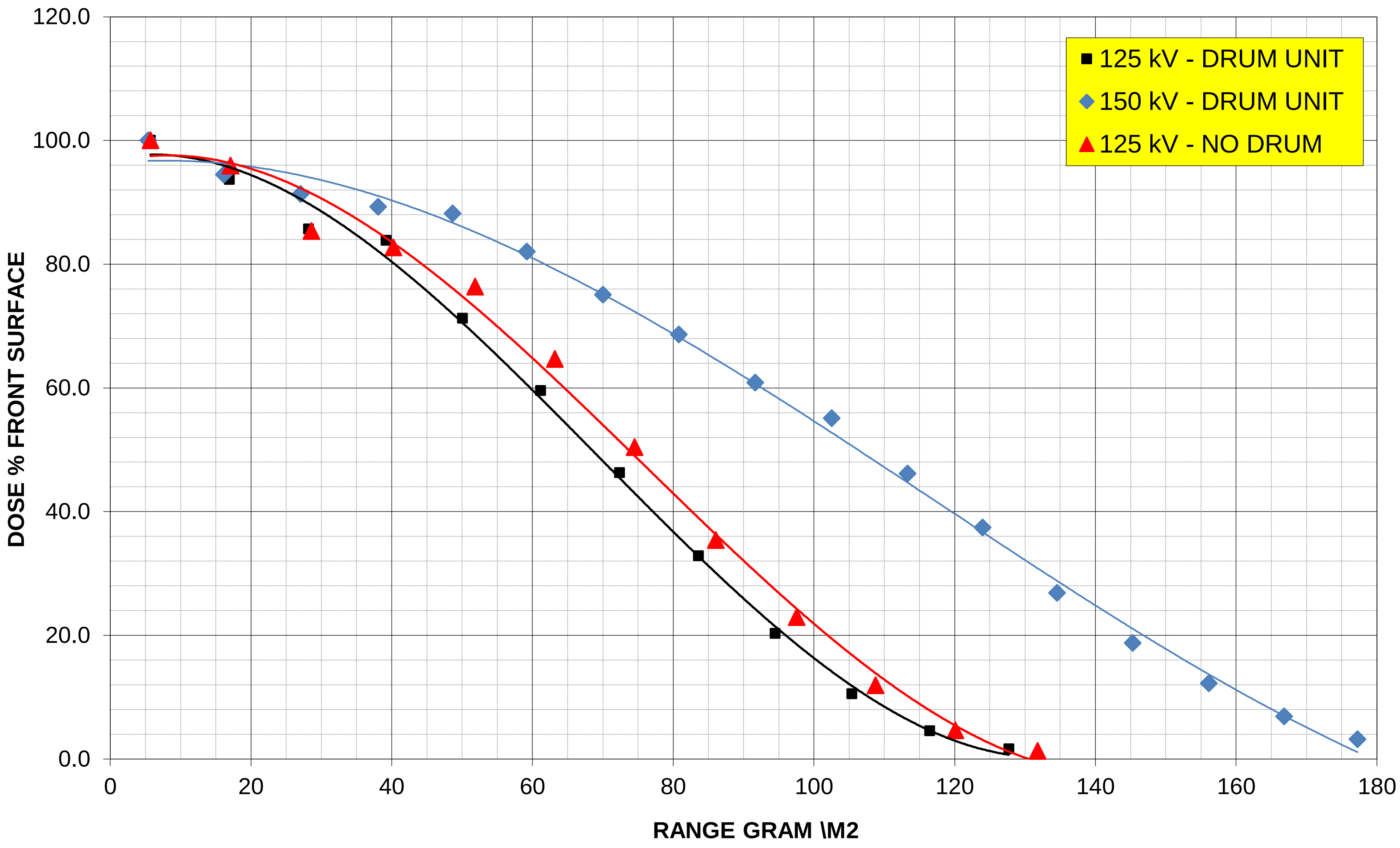
Tie Layer

Inside Sealant layer (LDPE/EVA)

Typical EB Conditions for this Application

125 kV, 120-150 kGy Chill Drum Preferred

150 kV with Chilled Drum Optional



Challenges to Meet with EB-Crosslinking

- Resin Suppliers:
  - Use Co-agents to achieve desired crosslink density at lower dose so can go higher in speed

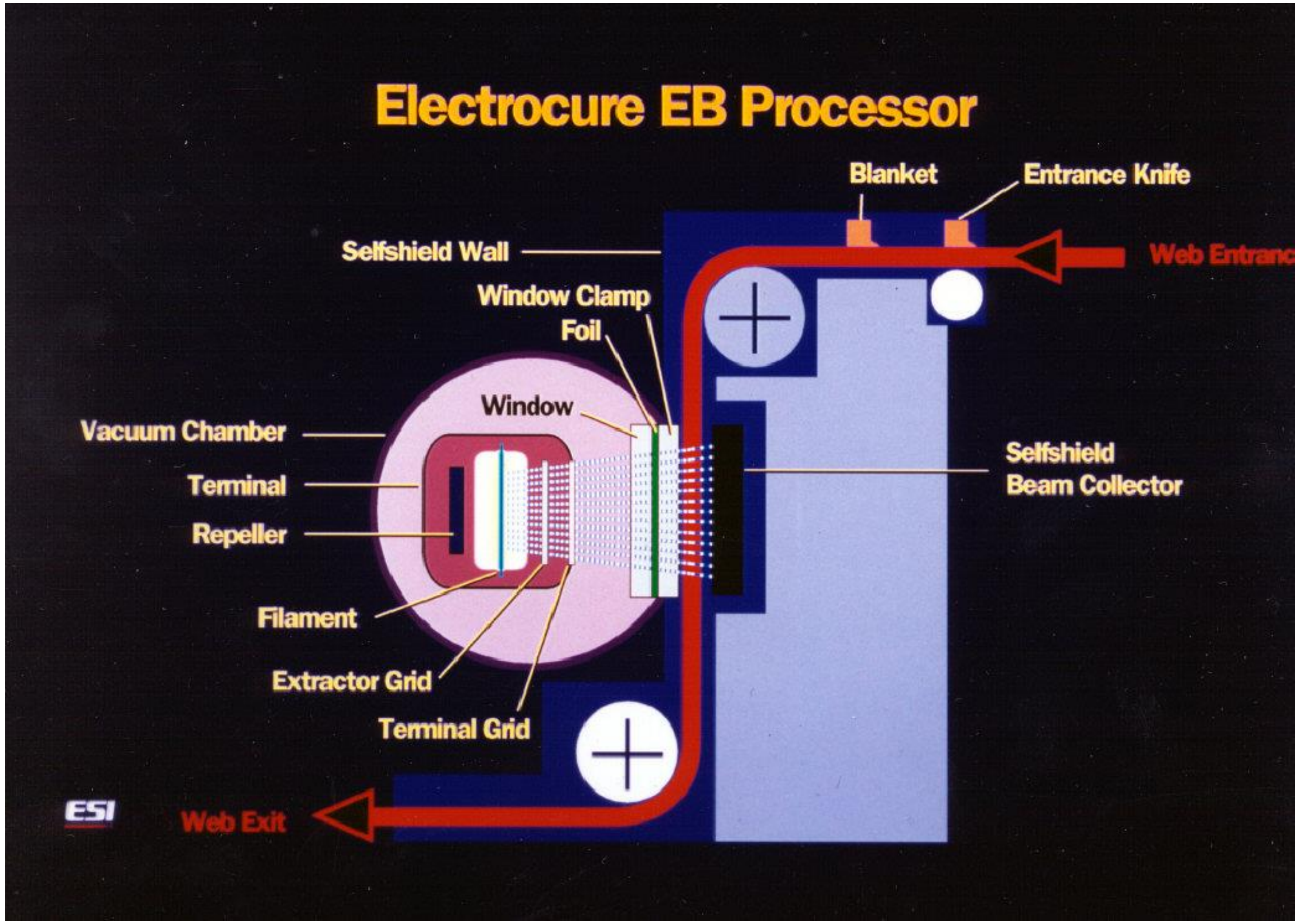
- EB Equipment Supplier:
  - Higher Speed at Lower Voltages (Around 80 kV)
  - Higher Dose Speed at 125 kV

EB Equipment Challenges to Meet Market Requirements

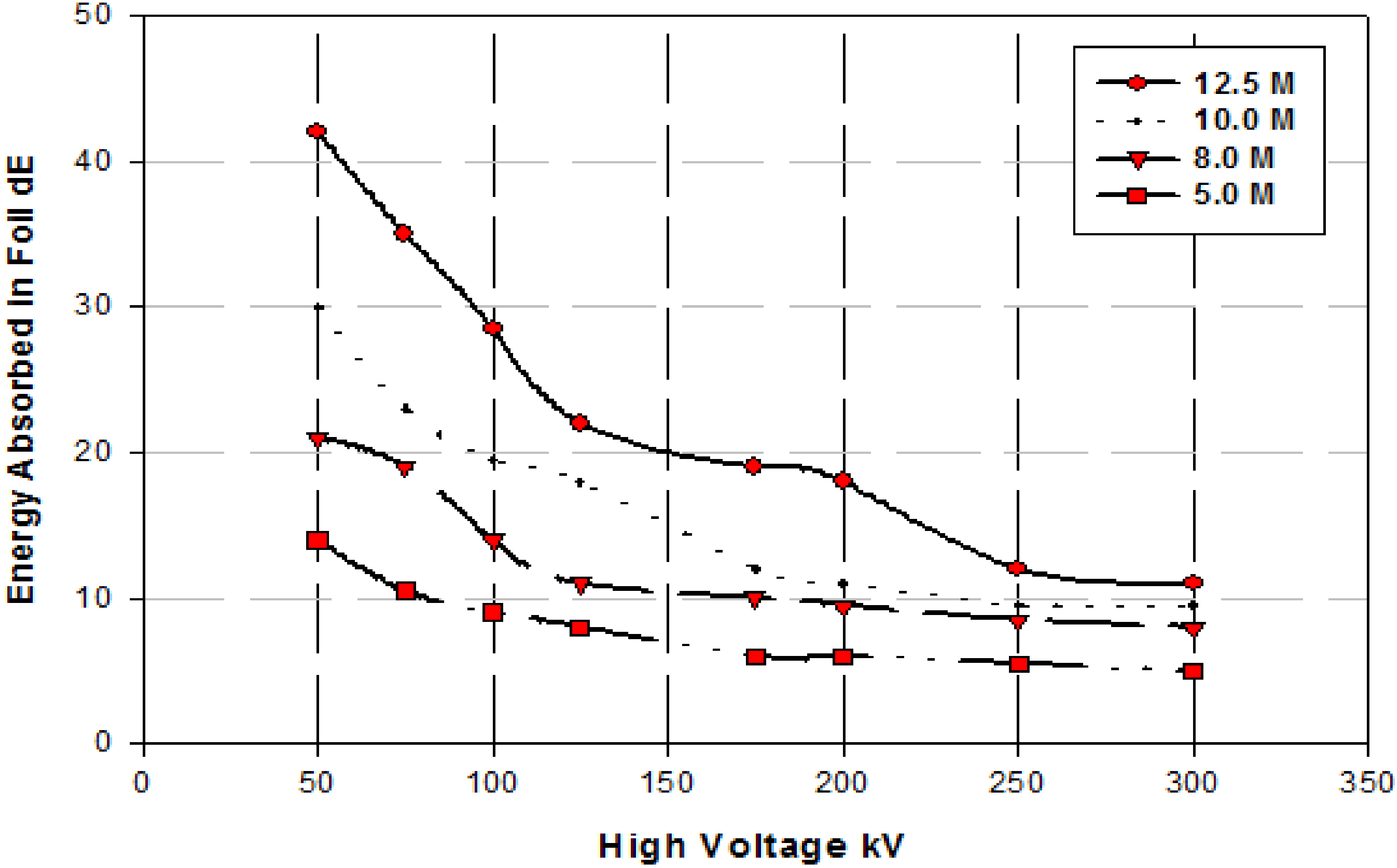
- Foil Passivation: Resist Reactions with Coating Effluents like Si Resulting in Pre-Mature Foil Failure
- Improve Heat Transfer of the Foil to Meet High Speed requirements For EB Coatings and EB CI-Flexo Applications
- Window Body Development To Allow High Speeds Up to 1500 Feet\Min
- Small Size Cost Effective EB Units For Digital Printing
- Increase Speed Rating at 80 kV for High Barrier Shrink Film Applications

How Does An EB Work?

- FILAMENTS EMIT ELECTRONS.
- ELECTRONS ARE ACCELERATED USING HIGH VOLTAGE.
- ELECTRONS PASS THROUGH THE WINDOW FOIL AND STRIKE THE PRODUCT.
- ELECTRONS CAUSE MOLECULAR CHANGES IN THE PRODUCT.



Energy Absorbed By Various Thickness Titanium Foils as a Function of High Voltage



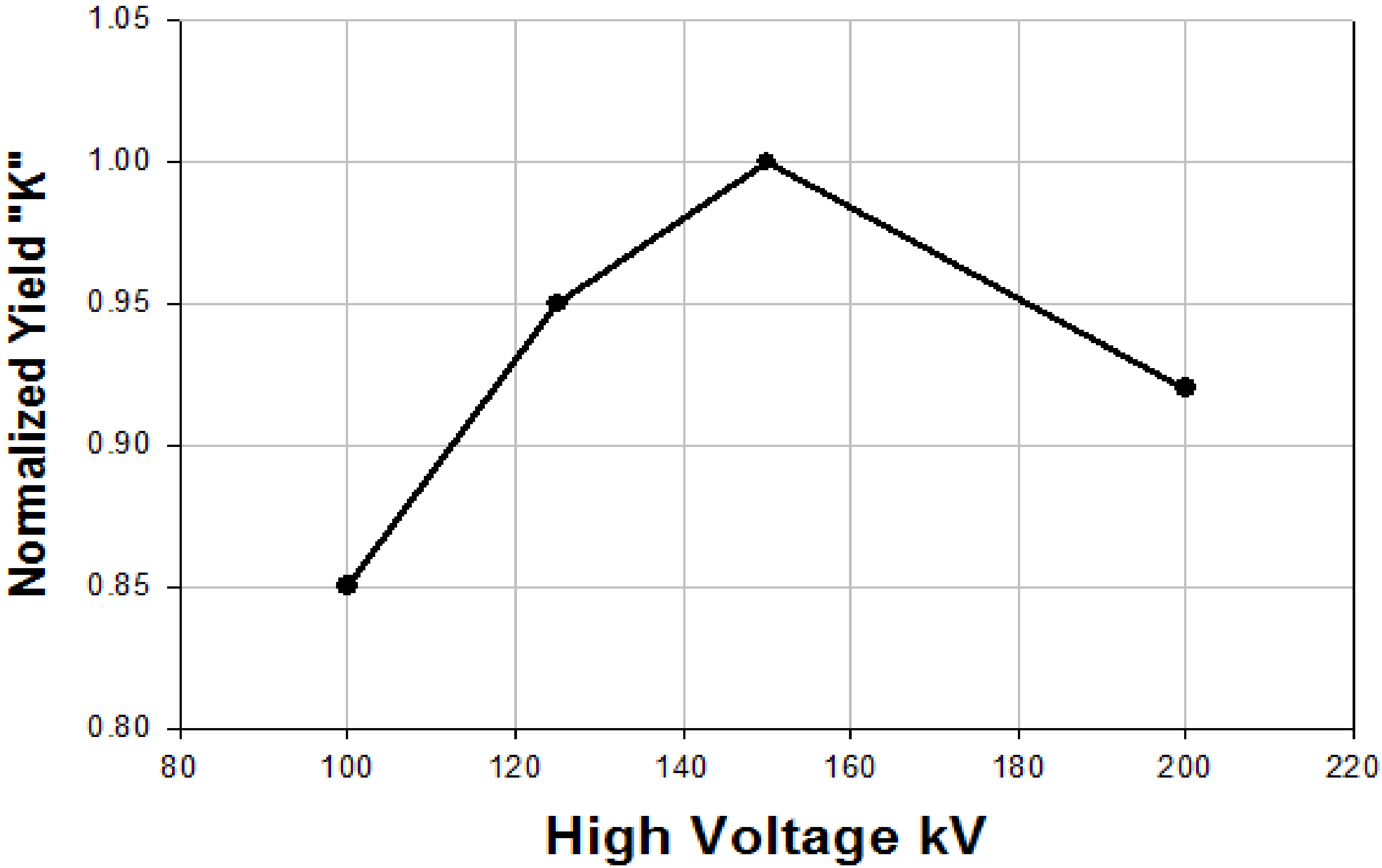
Heat Energy Deposited In Foil

Power kW =

High Voltage Absorbed dE (kV) X Beam Current I (mA)

Note: It is Imperative to keep the Foil Temperature < 450 C to Prevent Pre Mature Foil Failure.

Typical Machine Yield As A Function Of High Voltage For 12.5 Micron Titanium Foil



Dose Speed Relationship

Dose (kGy) = K X I (mA) / S (mpm)

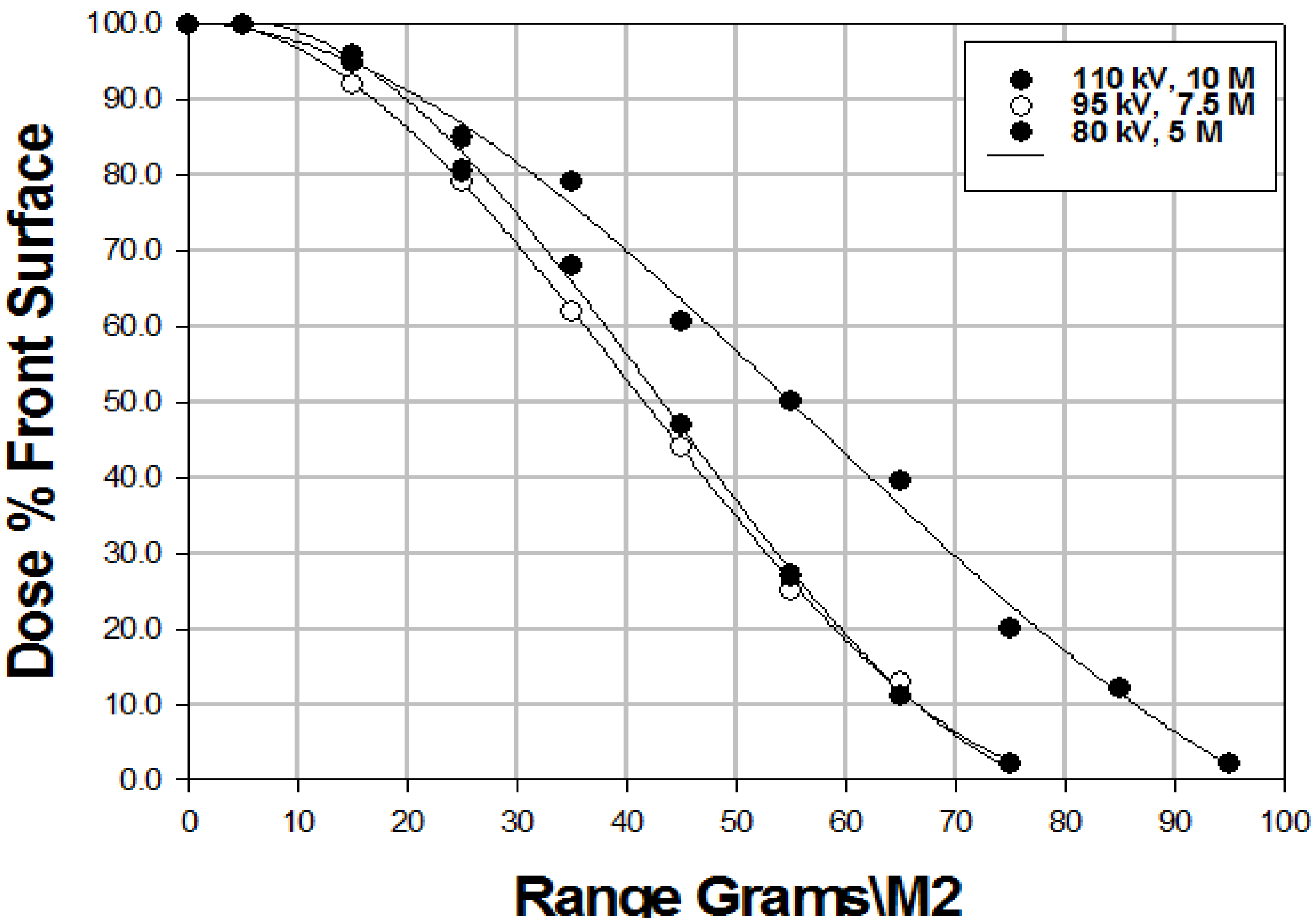
Machine Yield at Various Foil Thickness at its Optimum Operating Voltage

Machine Width 1200 mm

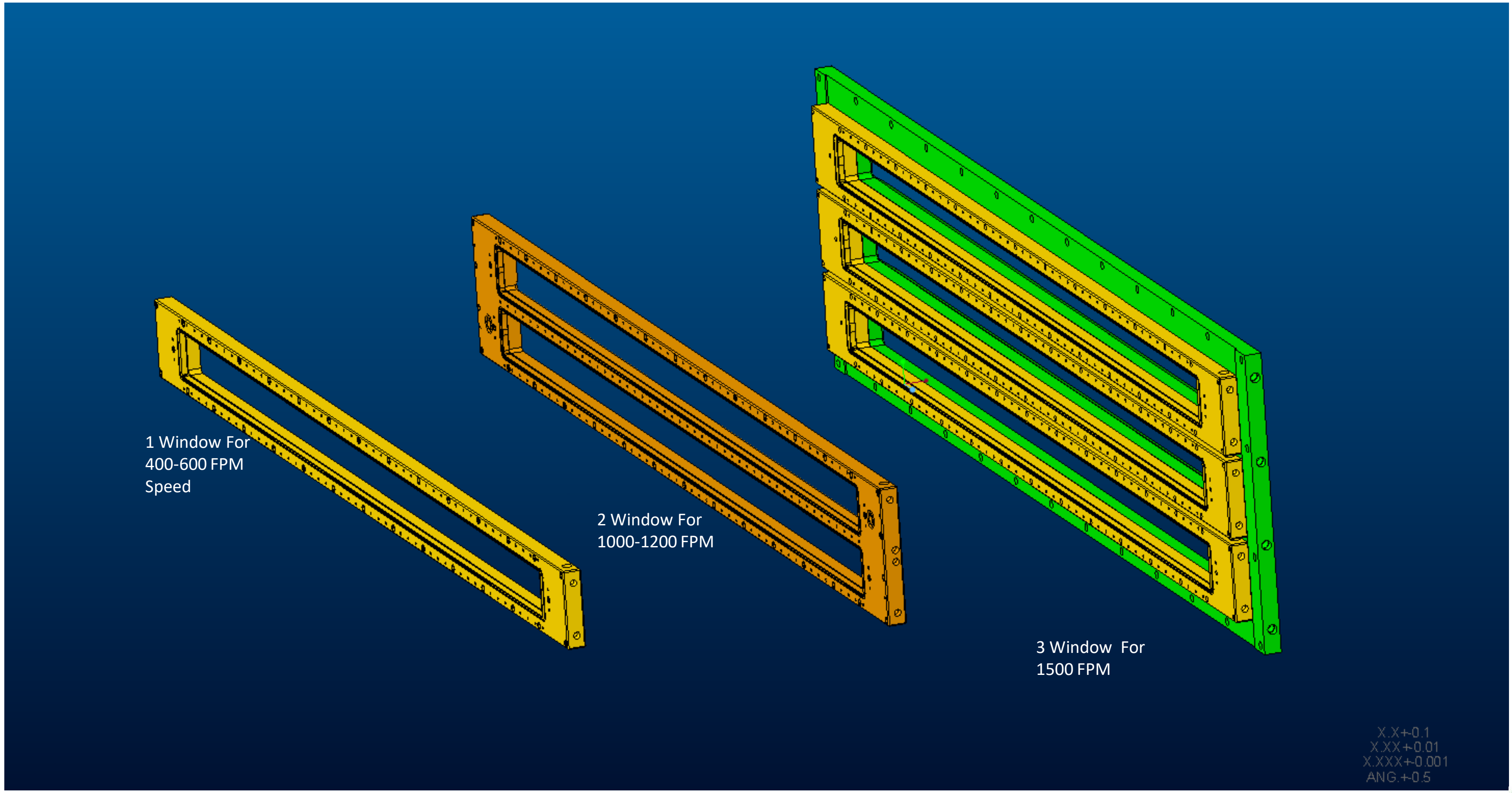
High Voltage kV	Titanium Foil Thickness Microns	Machine Yield “K” Mrad/fpm/mA	Machine Yield “K”kGy/mpm/mA
150	12.5	7.30	22.0
110	10	8.45	26.0
95	7.5	9.71	29.6
80	5.0	10.50	32.0

Depth Dose Profiles of EB Equipment at its Optimum Operating Voltage as a Function of Titanium Foil Thickness

Product Gap = 10 mm



Window Body Improvements For Different EB Equipment



Conclusions

- **Flexible Packaging Has the Largest Growth**
- **Energy Curing in Particular EB Curing Shows Good Promise**
- **Chemistry Development and EB Development Continues to Meet the Challenges**

Thank You
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