Industrial Electron Beam Processing

Overview of the Document

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Industrial Electron Beam Processing

Document sources:

1 – IAEA Industrial Irradiation of Polymers: Status and Prospects Report – August 2005

2 – Industrial Applications of Electron Accelerators: CERN Accelerator School – 24 May to 2 June, 2005

3 – IAEA Consultants Meeting – July 2008
## Industrial Irradiation Processing

**Status and Prospects – 2004**

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### Heat Shrinkable Products
- Principles of technology
- Food packaging
- Materials
- Trends and needs
- Electrical, electronic, and telecommunication
- Materials
- Trends and needs

### Tires
- Materials and formulations
- Trends and needs

### Surface Coatings – Inks, Coatings and Adhesives
- Materials and formulations
- Trends and needs

### Medical Product Sterilization
- Materials concerns
- Trends and needs

### Food Irradiation
- Trends and needs

### Niche Applications
- Grafting
- Hydrogels
- Depolymerization
- Pollution prevention

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Industrial Irradiation Processing of Polymers
Status and Prospects

REPORT
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Industrial Applications of Electron Accelerators

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Ion Beam Applications

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Industrial Electron Beam Processing

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Major Sections

1. Introduction
2. Electron Beam Accelerators
3. Materials Effects
4. Process Dosimetry
5. Major End-use Applications
6. Other Application Areas
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Low-energy Accelerators

Coolidge Early Developments
High-vacuum X-ray tube
First External EB tube
ESI Elongated Cathode
RPC/PCT Multiple Cathode
NHV Curetron™
AEB Sealed Emitter
Early EB Accelerators

Coolidge’s First High-vacuum, Hot-cathode X-ray Tube
US Patent Application Filed May 9, 1913
Early EB Accelerators

Coolidge’s Electron Tube with Foil Window
First External Beam Electron Accelerator
US Patent Application Filed April 28, 1925
ESI Elongated Cathode
RPC/PCT Multiple Cathode
NHV Curetron™
AEB Sealed Electron Emitter

- Window
- Support
- Grid
- Factory
- Evacuated
- Acceleration
- Chamber

27 cm diameter

33 cm height

~15 kilos

27 cm diameter
AEB Sealed Electron Emitter
Medium-energy Accelerators

Philips N.V. Cockcroft-Walton
GE Resonant Transformer
IBA/RDI Dynamitron
HVEC Insulating Core Transformer
D. V. Efremov Institute (NIIEFA)
Budker Institute ILU and ELV
NHV Corporation Cockcroft-Walton
Cockcroft-Walton Accelerator
GE Resonant Transformer
HVEC Insulating Core Transformer
Budker Institute Single Cavity ILU
NHV Balanced Cockcroft-Walton

3 MeV, 150 kW
High-energy Accelerators

Varian Associates Linac
CGR MeV (Getinge Linac)
Mevex
Titan Scan (L3 Communications)
IBA Rhodotron
Budker Institute ILU
CGR MeV (Getinge Linac)

10 MeV, 20 kW
IBA Industrial Rhodotron®

10 Pass, 10 MeV, 200 kW
IBA Industrial Rhodotron®

6 Pass, 7 MeV, 700 kW
Budker Institute ILU
3. Material Effects

3.1 Polyethylenes
3.2 Polypropylenes
3.3 Halogenated Plastics
3.4 Engineering Thermoplastics
3.5 Elastomers
3. Material Effects

3.6 Thermoplastic Elastomers
3.7 Monomers and Oligomers
3.8 Water Soluble Polymers
3.9 Natural Polymers
3.10 Living Matter (DNA)
Polyethylene Crosslinking

Polyethylene – amorphous region

PE with reactive free radical

\[ 2 \left[ \begin{array}{c} \text{C} \\ \text{H}_2 \\ \text{C} \\ \text{H}_2 \\ \text{C} \\ \text{C} \\ \text{H}_2 \\ \text{H}_2 \end{array} \right] + e^- \rightarrow \begin{array}{c} \text{C} \\ \text{H}_2 \\ \text{C} \\ \text{H}_2 \\ \text{C} \\ \text{C} \\ \text{H}_2 \\ \text{H}_2 \end{array} \]
DNA Scissioning
4. Process Dosimetry

4.1 Alanine

4.2 Polyethylene
Low-energy EB Concerns

*Monte Carlo 80 keV EB Penetration through 6 µm Ti Window into 144 µm Alanine Coating*
ATR FTIR Absorbance
at 965 cm\(^{-1}\) in 38 µm LDPE Film

Multiple passes at 3.0 MV
5. Major End-use Applications

5.1 Wire and Cable Insulation
5.2 Heat-Shrinkable Tubing
5.3 Heat-Shrinkable Food Packaging Films
5.4 Closed Cell Polyethylene Foams
5.5 Automobile Tire Components
5.6 Inks, Coatings and Adhesives
5.7 Hydrogels
Wire and Cable and Tubing
Under-beam Handling
Closed Cell PE Foam
Pigmented Coatings

Low-energy EB Cured Coating after 1000 hours Salt-spray Test
5. Major End-use Applications

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Medical Packaging Decontamination

Getinge Linac STERSTAR™ System
Three 200 keV Triangulated Beams
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Cured in the Mold at 30 kGy
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North and South America 18
Western Europe 24
Asia-Pacific and Elsewhere 11

Total 53
Document Summary

104 Pages
13 Tables
108 Figures
269 References
20.8 MB MS Word File
13 EB Manufacturers