Low Energy Electron Irradiation (LEEI) for novel Applications in medical Production and Pharma

ICARST 2017 – April 24 – 28, 2017; Vienna (A)

Frank-Holm Rögner
Head of Department
Electron Beam Processes
Fraunhofer Institute for
Organic Electronics, Electron Beam and Plasma Technology
FEP
Dresden, Germany
frank-holm.roegner@fep.fraunhofer.de
Content

Short Introduction

Low Energy Electron Beam Technology – Basics

New Concept of toroidal shaped Electron Source

Virus Inactivation for novel Vaccine Production
Content

Short Introduction

Low Energy Electron Beam Technology – Basics

New Concept of toroidal shaped Electron Source

Virus Inactivation for novel Vaccine Production
Facts and Figures – Fraunhofer FEP

Core Competencies

- ELECTRON BEAM
- SPUTTERING
- PLASMA ACTIVATION
- HIGH-RATE PECVD
- ORGANIC ELECTRONICS
- IC AND SYSTEM DESIGN

Research Facilities and Laboratories
Content

Short Introduction

Low Energy Electron Beam Technology – Basics

New Concept of toroidal shaped Electron Source

Virus Inactivation for novel Vaccine Production
Basics of Electron Beam Processes

- The kinetic energy of the electrons interacts with the substrate.
- Different kind of interactions of the accelerated electrons with matter.
- Each interaction is technological applied.
- Electron emitters accelerate electrons up to a speed of $10^8$ m/s.
Advantages and limits of **low energy** electrons

Limited penetration depth

- Energy of electrons
- Density and thickness of material

**Low energy range**

**High energy range**

Related to:

- Energy of electrons
- Density and thickness of material

## Basics of Electron Beam Processes

<table>
<thead>
<tr>
<th>Parameters of the Process</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Acceleration voltage</strong> (electron energy)</td>
<td>The higher the acceleration voltage, the higher the penetration depth</td>
</tr>
<tr>
<td><strong>Beam current</strong> (number of electrons per time)</td>
<td>The higher the beam current, the higher the transferred energy per time (dose rate)</td>
</tr>
<tr>
<td><strong>Product speed</strong> (throughput)</td>
<td>The higher the product speed, the lower the transferred energy (applied dose)</td>
</tr>
</tbody>
</table>
Advantages and limits of low energy electrons

- Low energy range (150 – 200 keV)
- Compact and self shielded
- Integrable into production facilities
- Internal logistics only
- Adaptable to different products and materials
- Scalable equipment cost
- Well adapted to surface treatment

Content

Short Introduction

Low Energy Electron Beam Technology – Basics

New Concept of toroidal shaped Electron Source

Virus Inactivation for novel Vaccine Production
Electron treatment of surfaces

- Treatment of seed or bulk goods
- Surface sterilization of medical products
- Lacquer curing on 3D-products

It would be nice to have an all-round source for homogenous dose application onto 3D-surfaces.
Electron treatment of surfaces

Treatment of seed or bulk goods

Surface sterilization of medical products

Lacquer curing on 3D-products
High power toroidal gun – Basics

Scalable Prototype

Central Axis

Electrons

Ions

Insulator
Cathode
Plasma
Ion extraction grid
Electron exit window
Anode wires
Toroidal EB source with Wire Anode Discharge Plasma Numerical Simulation

- Electron trajectories ⇒ Trapping
- Ion density distribution ⇒ Localization
- Distribution of electric potential ⇒ Repelling ions off the wires

Supply Voltage: 1 kV
Treatment of granules with toroidal source
Content

Short Introduction

Low Energy Electron Beam Technology – Basics

New Concept of toroidal shaped Electron Source

Virus Inactivation for novel Vaccine Production
Inactivation of **virus suspensions** with low energy electron irradiation for vaccine production

**Novel Methodology of virus inactivation**

**SAFE**
- **Inactivation by damaging RNA/DNA**
- > 50% loss of antigens

**FAST**
- minutes to hours
- > 80% conservation of antigens
- + **EFFECTIVE**
Low Energy Electrons – Dose distribution

Doses Distribution 200 keV

Relative Doses in %

Penetration Depth in g/m²

- Titanium
- Air gap
- Packaging material
- Vaccine

200 keV
- 15 μm Titanium Film
- 5 cm Air Gap
- 70 μm PET-PE
- 100 μm Liquid
Inactivation of virus suspensions with low energy electron irradiation for vaccine production*

- Successful proof-of-concept with influenza A
- Vaccination of mice with LEEI inactivated H3N8 -> efficiently protected
- Low-priced vaccines
- New types of vaccines
- Inactivation of biological hazards

* Fertey et al., Viruses 2016(8):319; doi:10.3390/v8110319
3 IP applications
Challenges for Low Energy Electron Inactivation

- **Dose distribution** within the liquid film
  - Limited penetration depth
  - Velocity distribution within the thin liquid film
  - -> **new dosimetry** for liquids necessary (ongoing development)

- **Liquid film handling**
  - Precisely film thickness
  - Controlable fluid speed
  - Safe transport

bag based model
Summary

➢ Low energy electron processes are ready for new challenging application

➢ New electron source concepts can widen fields of industrial usage

➢ Customized technology development is basis for efficiency application

➢ New concept of toroidal electron source opens new applications

➢ LEEI inactivation will change vaccine production
Low Energy doesn't mean less Development. It shows best Results with optimized Effort!

To learn more, visit us at the exhibition in the Rotunda Building!