Industrial Inline Control for Advanced Vacuum Roll to Roll Systems

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Web inspection - surface Quality control 7.4 - 7684
Industrial Inline Control for Advanced Vacuum Roll to Roll Systems

Outline

- High productive layers for packaging
- Copy protect layers by high rate electron beam evaporation
- Ultra high barrier layers for solar and OLED FED
- Inline ellipsometric control for solar and OLED
High productive layers for packaging

Plasma Metallizing process
Uncoated Metallized Substrate
Inline layer uniformity control

Gas
Cathode Power
OD measurement
High productive layers for food packaging

World Largest Al boat system by Applied Materials with 4.5 m coating width

Al boat evaporators for Food Packaging
Effective evaporation system

- Annual output up to 11,000 t for 4.45 m coating width
- High coating uniformity
- Patented staggered boat arrangement
- Optical inline thickness control by measurement of the absorption at a single wavelength
Copy protect layers by high rate electron beam evaporation

Fabry Perot color shift layer system (e.g. Al - Al₂O₃ – Al *)
for copy protection of banknote, medical packaging and decorative coatings

*patented
Fabry-Perot-Filter with color shift effect

Fabry Perot layer system (Al - Al₂O₃ – Al)

Colour related to middle layer thickness

Due to a new process control technology implemented in the TOPBEAM™ system colour shift reflection layers can be produced with a productivity rate which is twenty times higher compared to the standard sputter web coating technology.
Copy protect layers by high rate electron beam evaporation

Fabry Perot layer system (e.g. Al - Al₂O₃ – Al) for copy protection of banknotes and decorative coatings
High rate evaporation with Electron Beam

Closed loop layer control - data feedback from multiple head sensors to beam scanning unit
Uniformity for evaporation down to +/- 2 % possible
Electron Beam evaporation system

with one or two EB guns

Crucible with evaporation material

EB with 2100 mm coating width

→ 2 Electron beam guns
Inline control of the layer thickness

Spectral reflection measurement of the Al₂O₃ layer along web width

Inline control by ESCOSYS®

new EB power distribution

uniform layer

• Registered trademark
Best coating technology depending on the application and customers need

**sputtering**
- best quality
- less particles
- variable composition
- “low rate“ (order m/min)

**evaporation**
- Boat or Electron Beam
- less dense layers
- less variable composition
- high rate (order m/s). Up to 25 times lower cost / m²

E.g. copy protection for banknotes
Color shift layer Al – AlO – Al

Coating cost: 18 $ / m² 0,8 $ / m²
Ultra high barrier layers for solar and OLED FED

Flexible Packaging Requires:
- Optical Transparency
- Easy Processing
- Desirable Mechanical Properties
- High Barrier Properties
  (Low permeability for $O_2$, $H_2O$ & $CO_2$)

Flexible Electronic Devices
Encapsulation Concept in r2r

Encapsulant (Flexible polymer layer)

Encapsulated FEDs

Functional Thin Film electronic modules (ITO layers, electron transport layers, organic emitters, etc.)
Functional Layers for FED*:

Multi-layer stack for ultra high barrier films for display and solar applications

Inorganic layers: Al$_2$O$_3$, SiO$_x$:

- **Electron Beam evaporation**: high rate, reasonable cost, web speed e.g. 10 m/s
- **Flexible solar – medium lifetime**

- **sputtering, PECVD**: best quality, higher cost, e.g. 2 m/min - 0.03 m/s
- **Flexible solar, OLED**

Cross-linked layer inline in vacuum or off-line at air*

*e.g. ORMOCER by ISC/FhG

*FED: Flexible Electronic Devices
Modular Roll Coater

- Unwind Module
- Process Module
- Rewind Module

1 Process Module with 3 Process Stations

e.g. sputtered Al$_2$O$_3$ for barrier layers

2 Process Modules, 6 Process Stations
SMARTWEB™
2 Process Modules, 6 Process Stations
Sputter Deposition Sources
planar and rotatable cathodes for Metals, TCO, Oxides
Ellipsometric inline control for electron beam and sputtering systems

Ellipsometry offers new possibilities:
  separate:
  - \( n, k \)
  - **Absorption** (SiO\(_x\))
  - **Layer thickness**
  - Possible relations to:
    - Density
    - Layer-properties

Photometry
Utilization of an ellipsometer in a sputter system

For single layers and multilayer systems (future)
Ellipsometer installed in a modular sputter system

lamp and modulator of the UFMWE*
*(Ultra Fast Multi Wavelength Ellipsometer by Jobin)

Chamber with roller for stable measurement

Monochromator of ellipsometer receiver
Advanced inline measurement by ellipsometer in a high speed electron beam evaporation system

Installation of the ultra fast multi-wavelength ellipsometer in a high rate evaporation electron beam system

„Dangerous life“ - 3 m above ground for the Ellipsometer staff
Electron beam inline process control with the ellipsometer

SiO$_x$ barrier layer on PET film with 12 µm thickness
Ultra high barrier for encapsulation

- The development of roll to roll inline control is supported by the EU project: FLEXONICS* (Ultra high barrier for r2r encapsulation of flexible electronics)

- Multilayer-system:
  - Inorganic layer: $\text{Al}_2\text{O}_3$, SiO
  - Cross-linked layer: on air by ORMOCER lacquer (SiO$_2$ network)

- first results r2r - 4 layer stack: water vapor and oxygen permeation in the order of $1 \times 10^{-4}$ ** for sputtering and evaporation

*Partners: University Thessalonica, Jobin/Horiba, IVV/ISC/FhG, Alcan, Applied Material, Isovolta, Siemens, Konarca, Uni. Graz,
Conclusion

Advanced vacuum coating technology and the use of latest developments of inline measurement and control techniques offers new solutions for flexible solar, OLED and copy protect markets.
Thank you

Danke

Kansha!

Merci

Gracias

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