



# Industrial Inline Control for Advanced Vacuum Roll to Roll Systems

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Web inspection - surface Quality  
control 7.4 - 7684

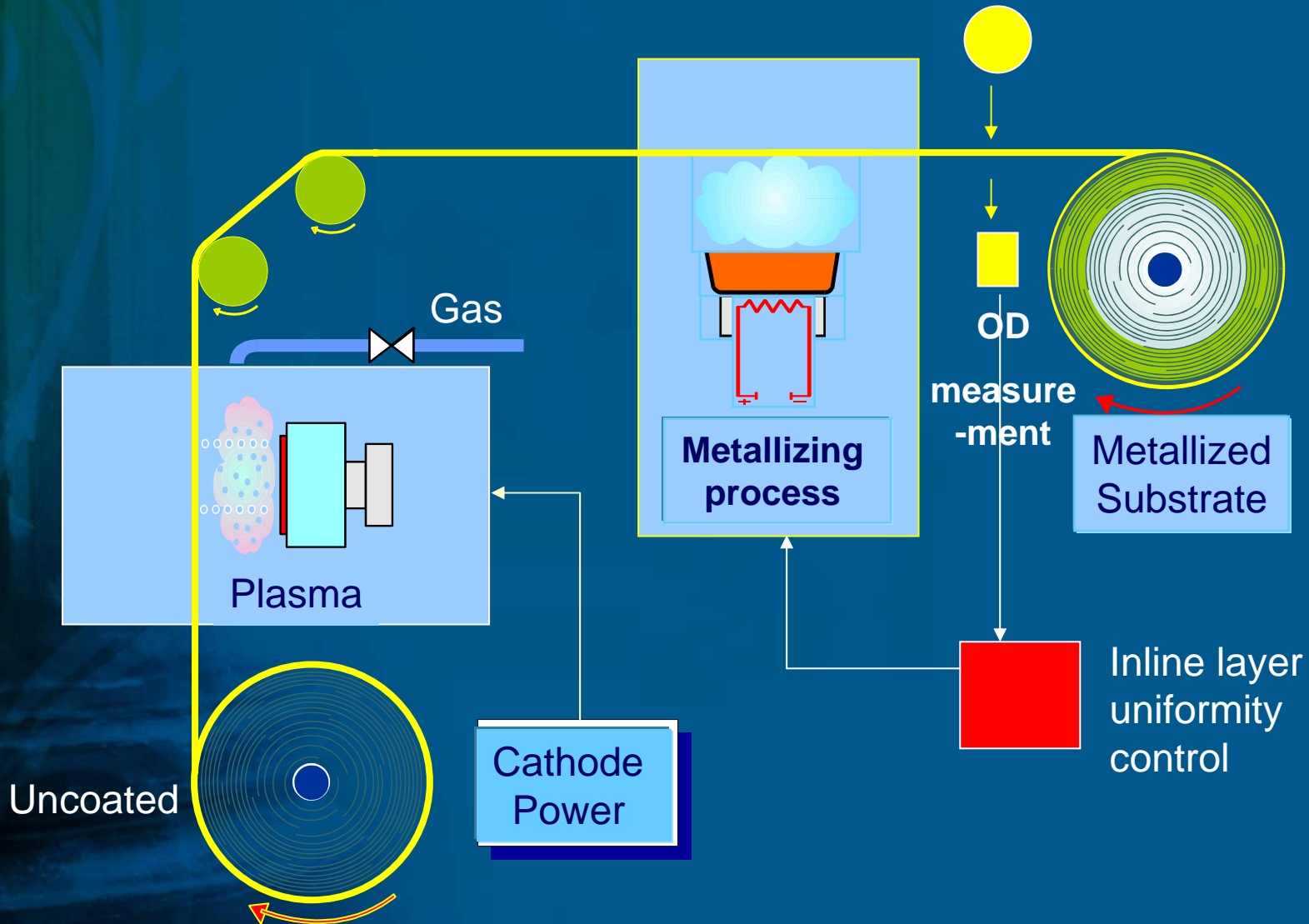
# Industrial Inline Control for Advanced Vacuum Roll to Roll Systems

## 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



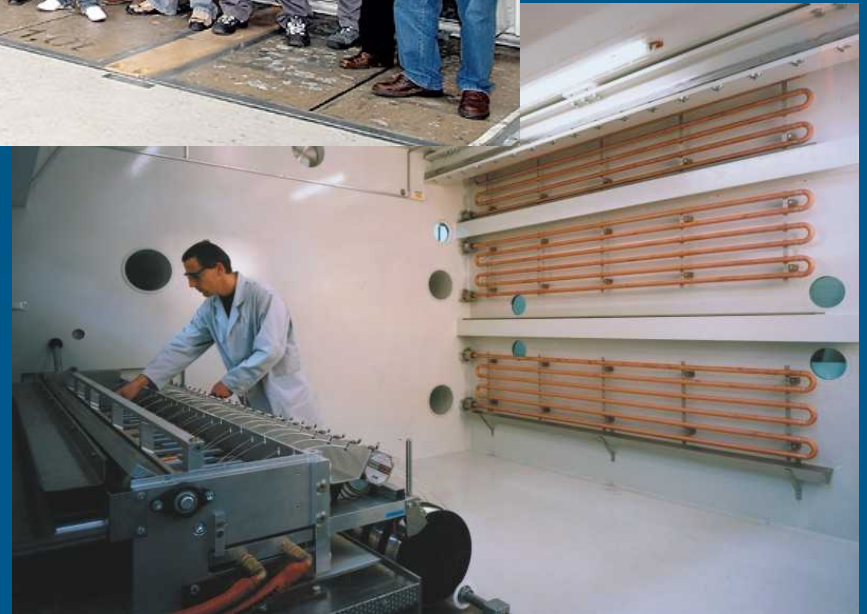
# High productive layers for packaging





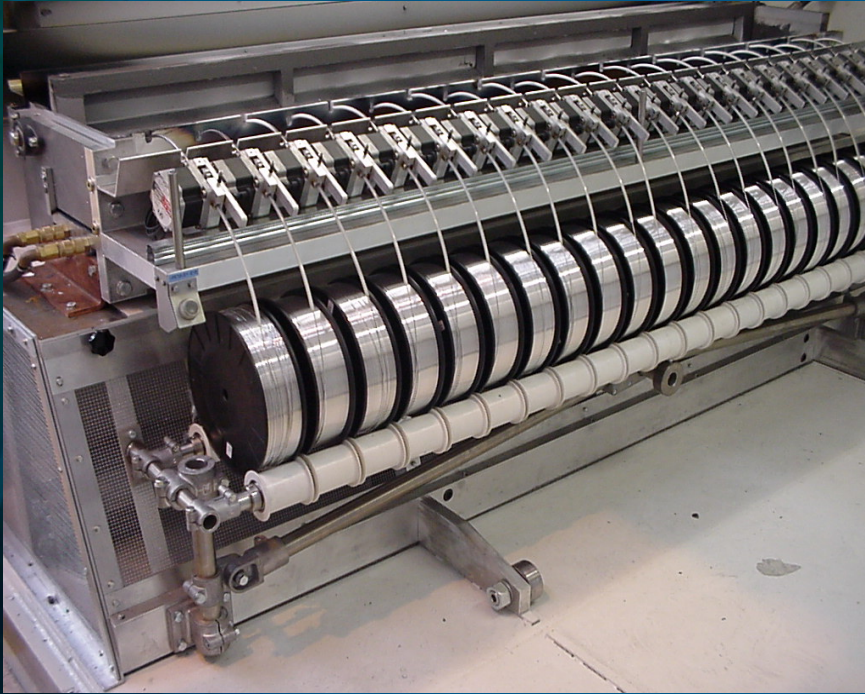
High productive layers for food packaging  
World Largest AI boat system by  
Applied Materials with 4,5 m coating width

AI 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 - Al<sub>2</sub>O<sub>3</sub> - Al \*)  
for copy protection of banknote, medical packaging and decorative coatings



in future with color shift

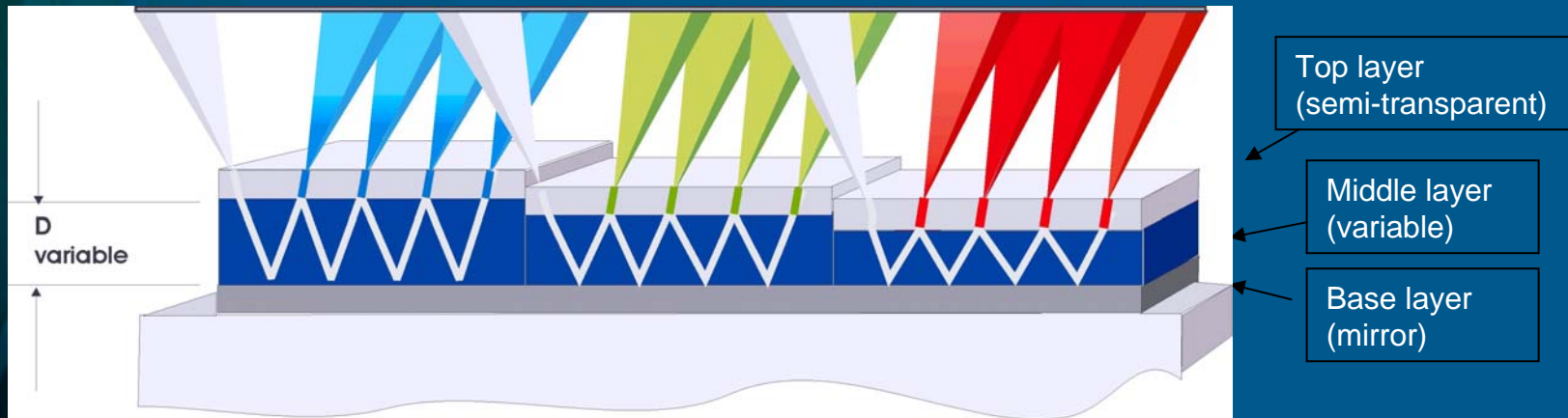


\*patented



# Fabry-Perot-Filter with color shift effect

Fabry Perot layer system (Al - Al<sub>2</sub>O<sub>3</sub> - Al)

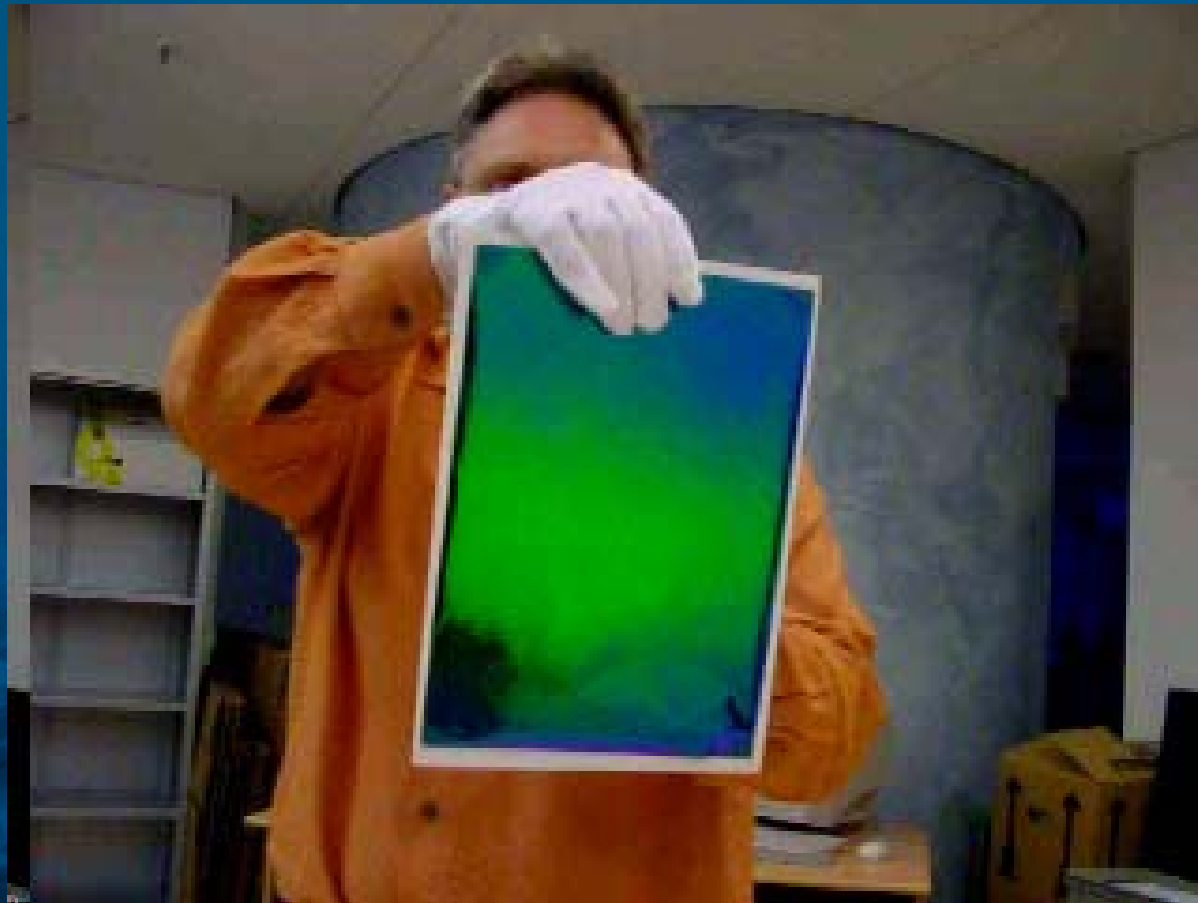


Colour related to middle layer thickness

**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.**

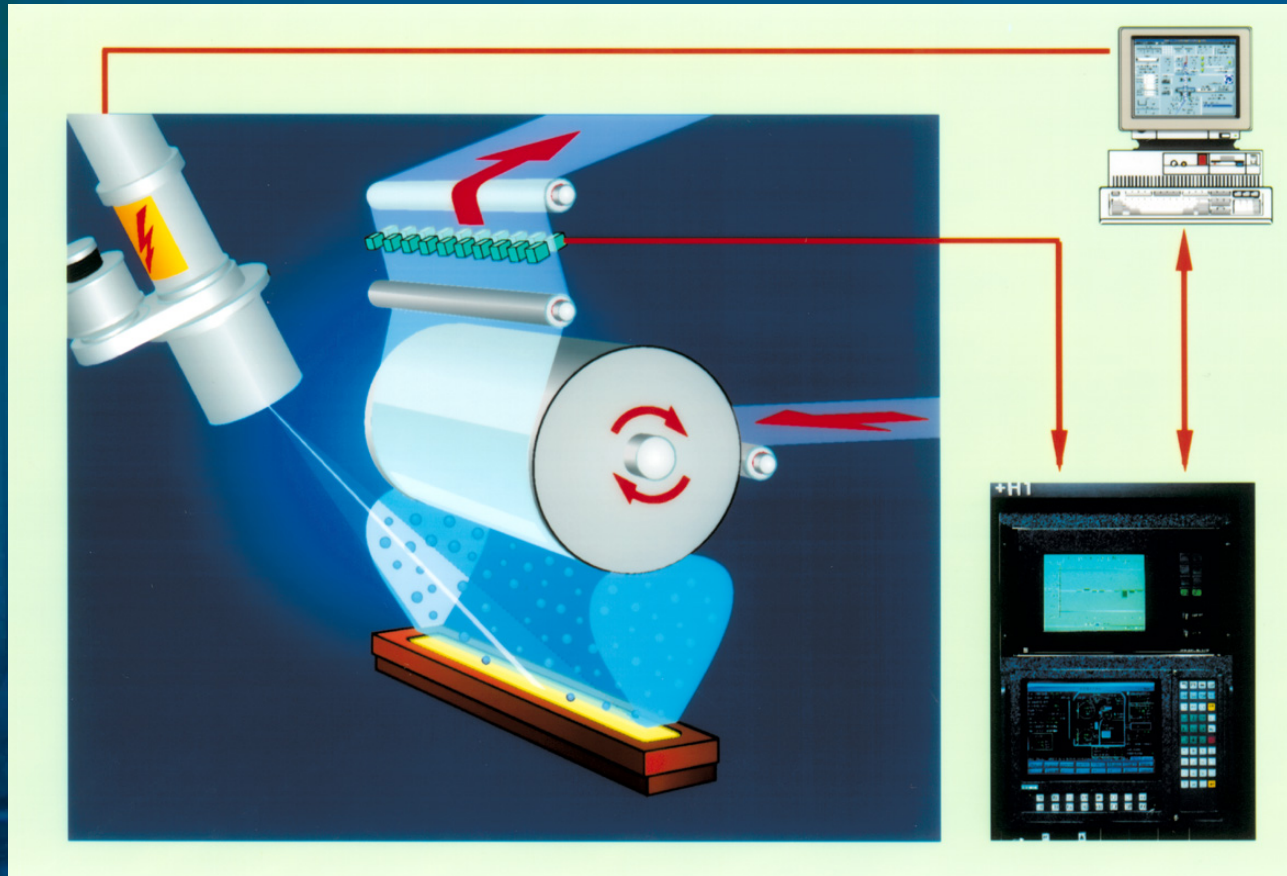
# Copy protect layers by high rate electron beam evaporation

Fabry Perot layer system (e.g. Al - Al<sub>2</sub>O<sub>3</sub> - 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  $\pm 2\%$  possible

# Electron Beam evaporation system with one or two EB guns

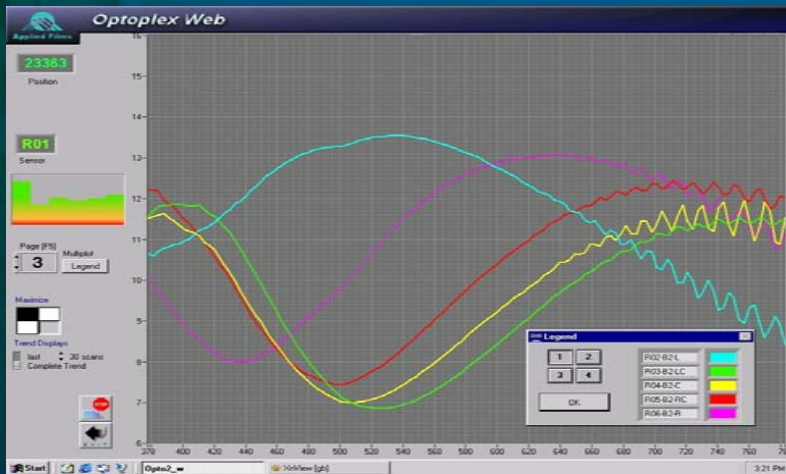


EB with 2100 mm coating width  
→ 2 Electron beam guns

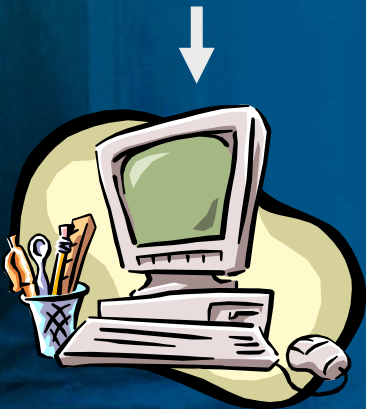
Crucible with evaporation  
material



# Inline control of the layer thickness



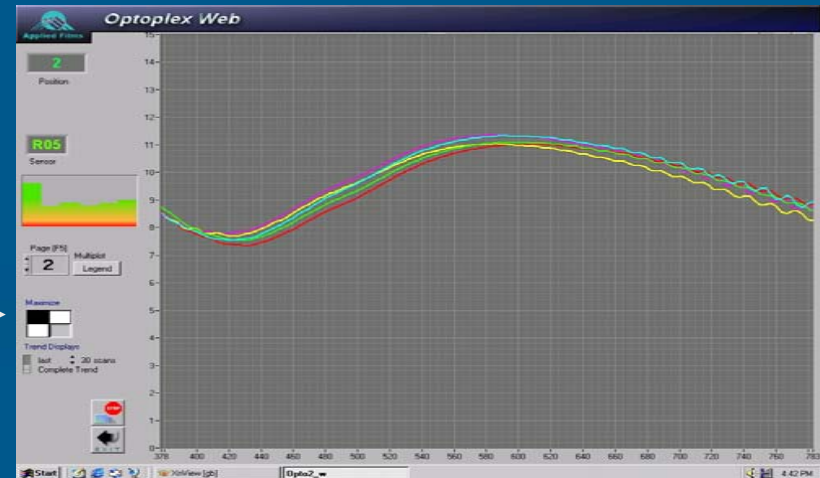
Spectral reflection measurement of the  $\text{Al}_2\text{O}_3$  layer along web width



Inline control by ESCOSYS\*



new EB power distribution



uniform layer



# 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 / m<sup>2</sup>

e.g. copy protection for banknotes  
color shift layer Al – AlO – Al

Coating cost : 18 \$ / m<sup>2</sup>

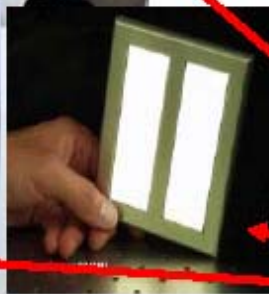
0,8 \$ / m<sup>2</sup>

# 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<sub>2</sub>, H<sub>2</sub>O & CO<sub>2</sub>)

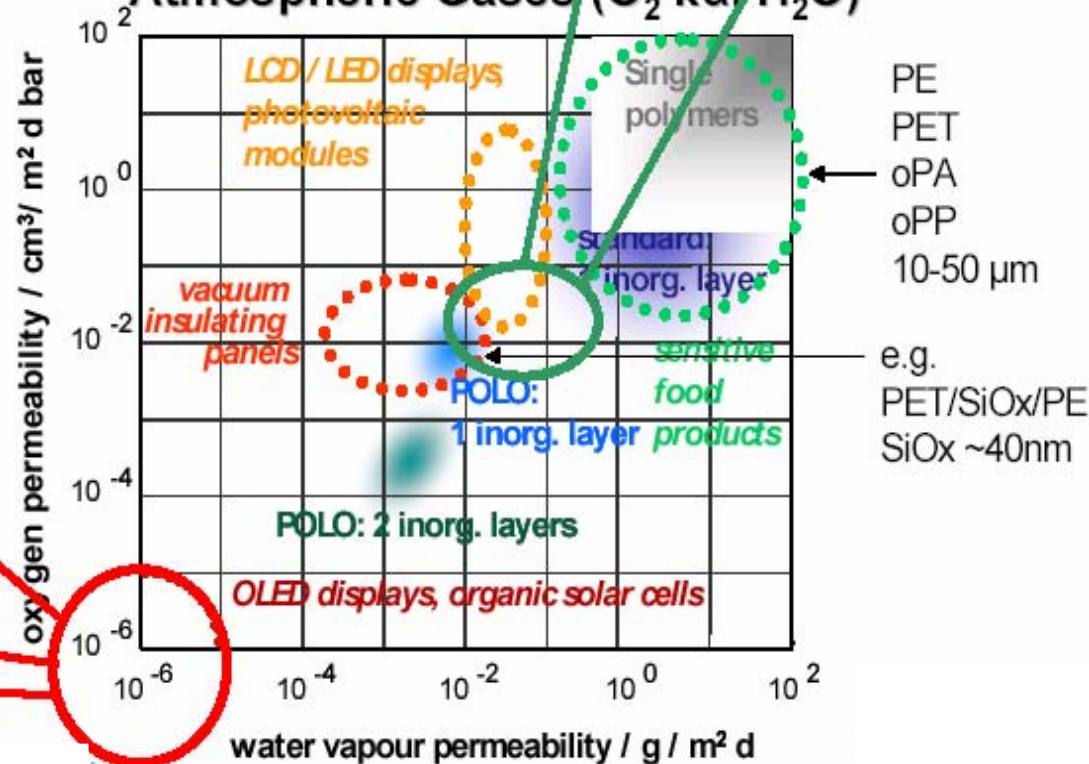
## Flexible Electronic Devices



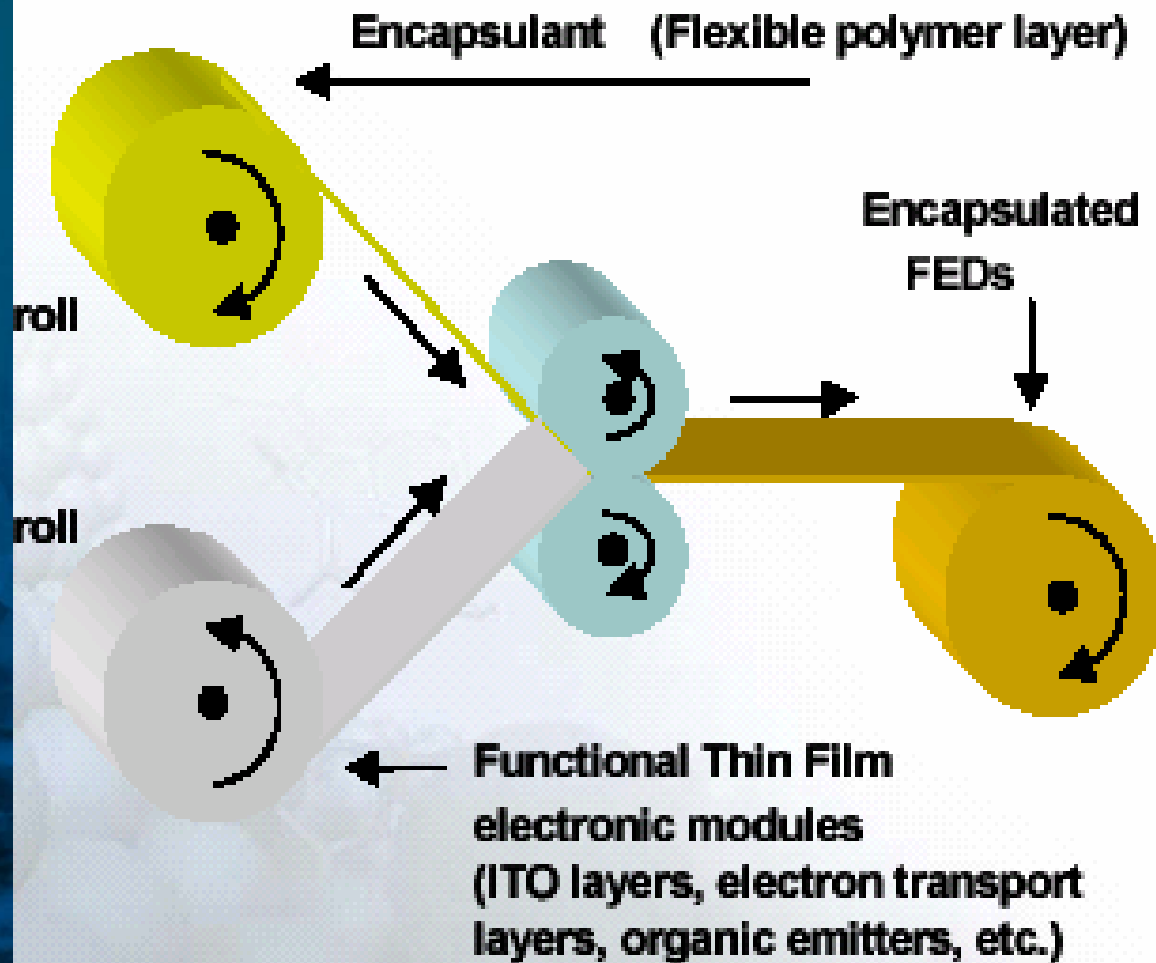
## Food & Beverage Packaging



## Permeability of Atmospheric Gases (O<sub>2</sub> και H<sub>2</sub>O)



# Encapsulation Concept in r2r





# Functional Layers for FED\* :

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

Inorganic layers :  $\text{Al}_2\text{O}_3$  ,  $\text{SiO}_x$ :

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\*



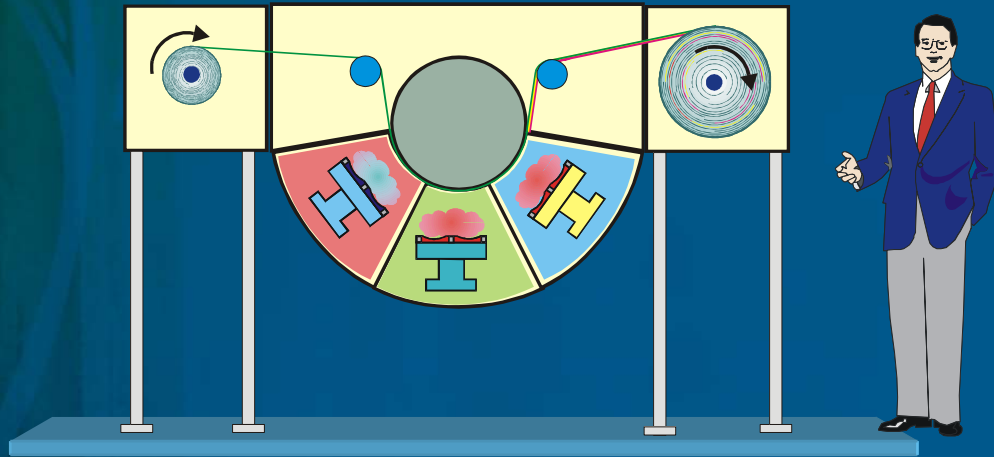
PET

\*e.g. ORMOCER by ISC/FhG

\*FED : Flexible Electronic Devices

# Modular Roll Coater

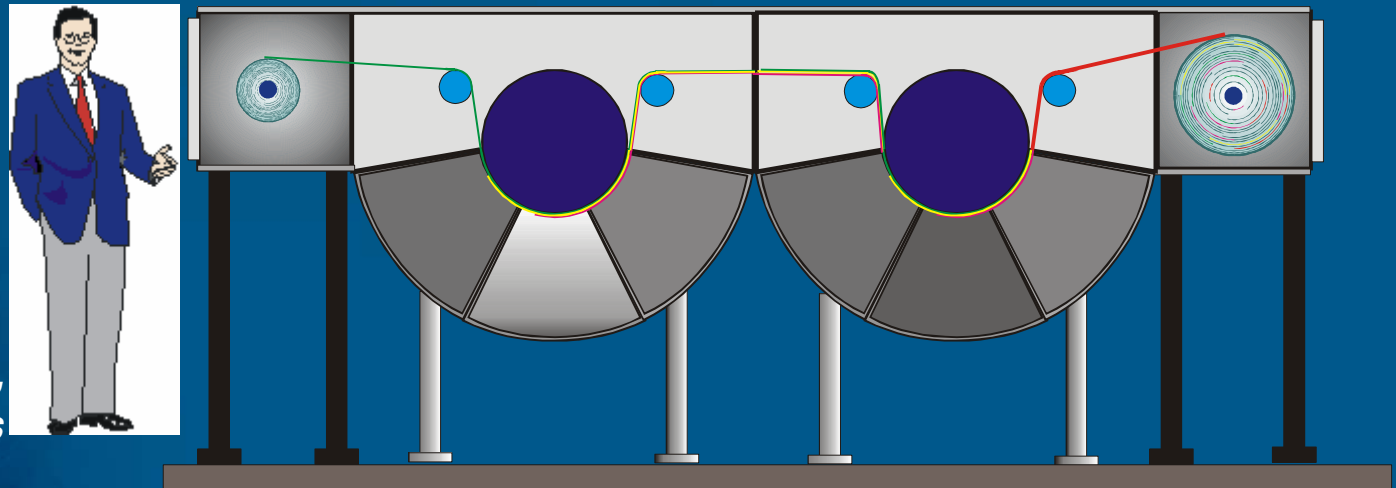
Unwind Module    Process Module    Rewind Module



*1 Process Module with 3  
Process Stations*

*e.g. sputtered  $Al_2O_3$  for  
barrier layers*

Unwind Module    Process Module 1    Process Module 2    Rewind Module



*2 Process Modules,  
6 Process Stations*

**SMARTWEB™**

*2 Process Modules, 6 Process Stations*





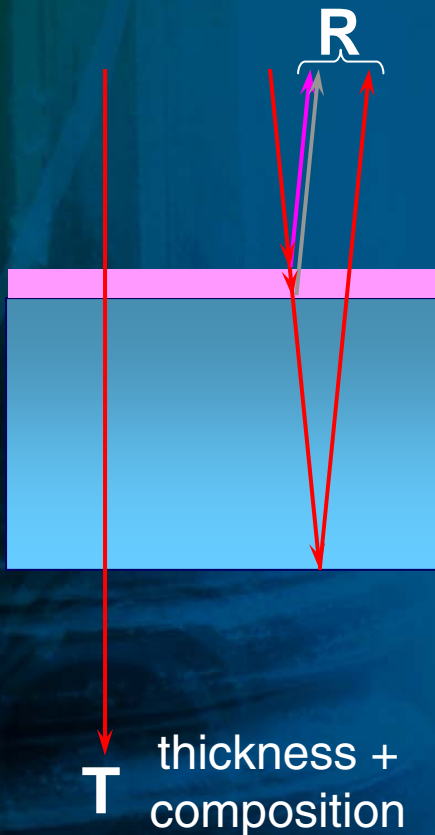
# Sputter Deposition Sources

planar and rotatable cathodes for Metals, TCO, Oxides



# Ellipsometric inline control for electron beam and sputtering systems

## Photometry

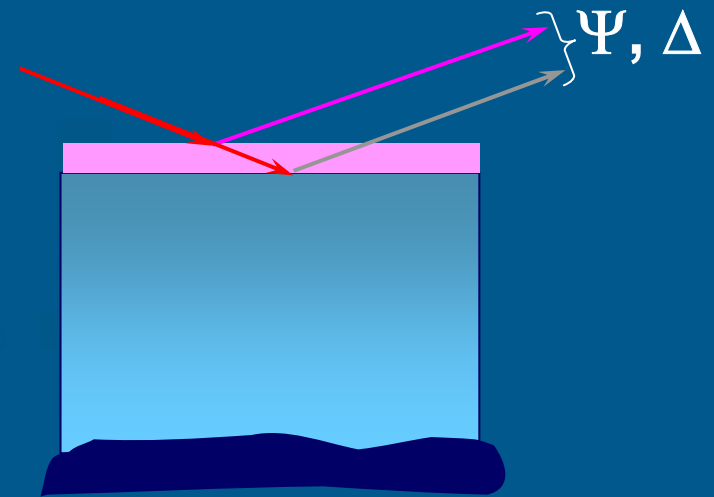


## Ellipsometry offers new possibilities:

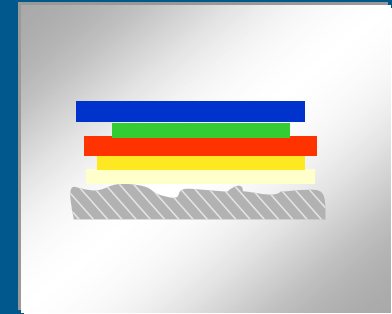
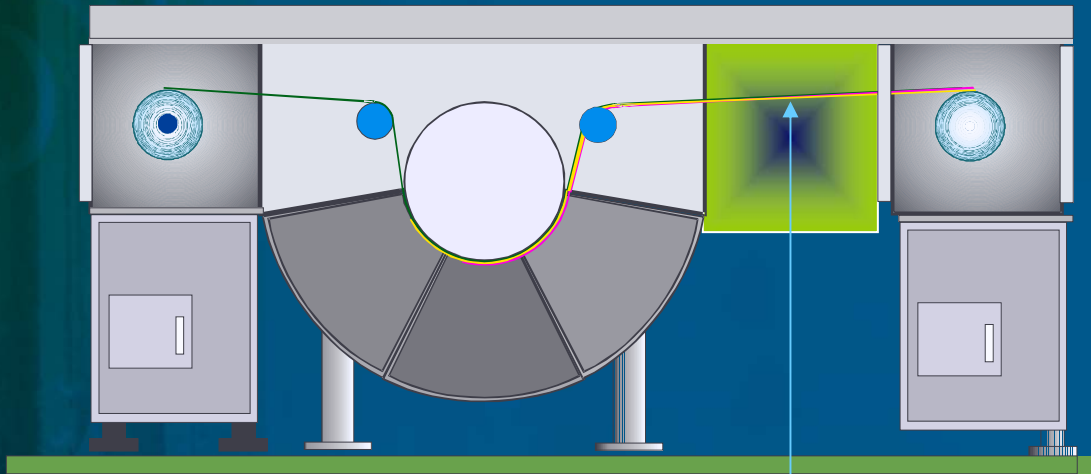
separate :

- $n, k$
- Absorption (  $\text{SiO}_x$  )
- Layer thickness
- Possible relations to :
- Density
- Layer-properties

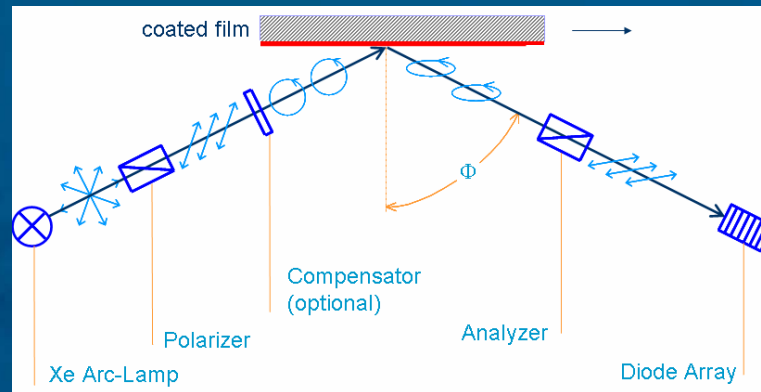
## Ellipsometry



# Utilization of an ellipsometer in a sputter system

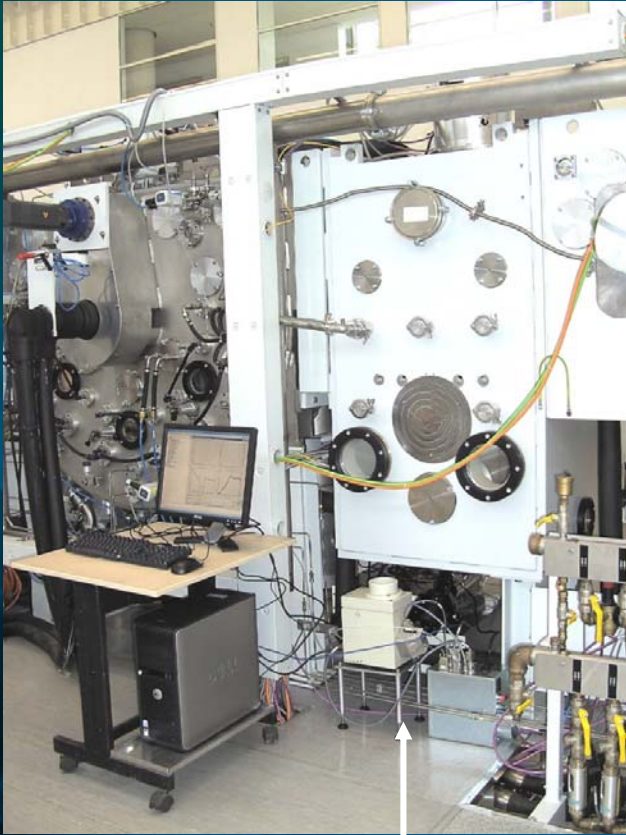


For single layers  
and multilayer  
systems (future)





# 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

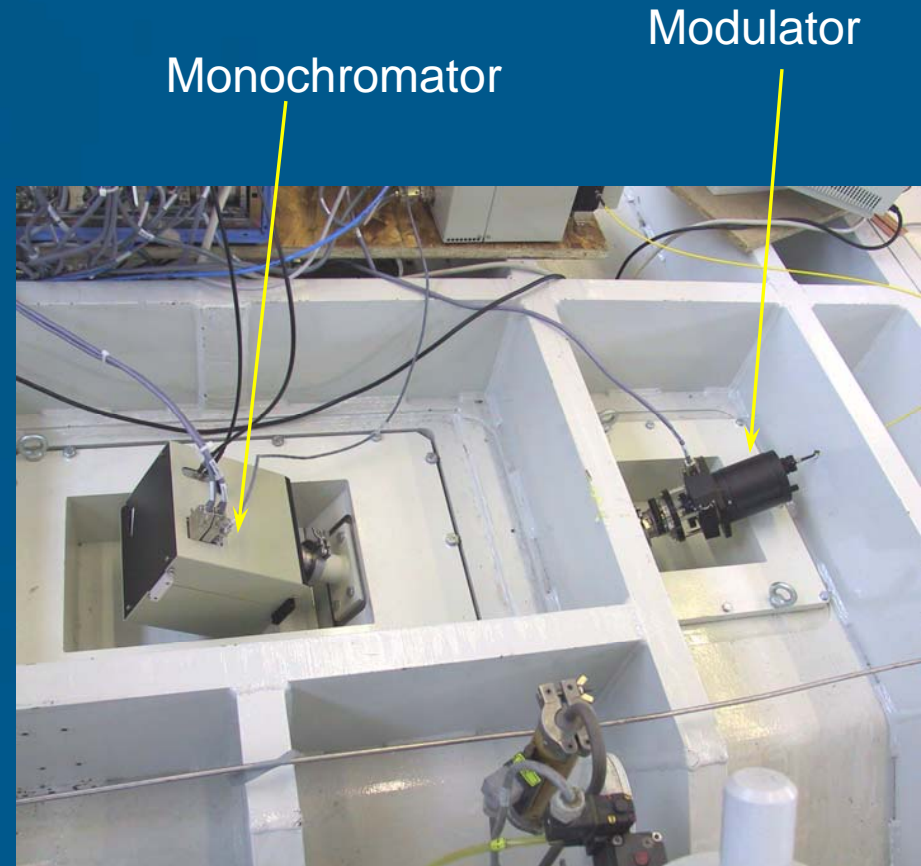
Monochromator of ellipsometer receiver

# 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

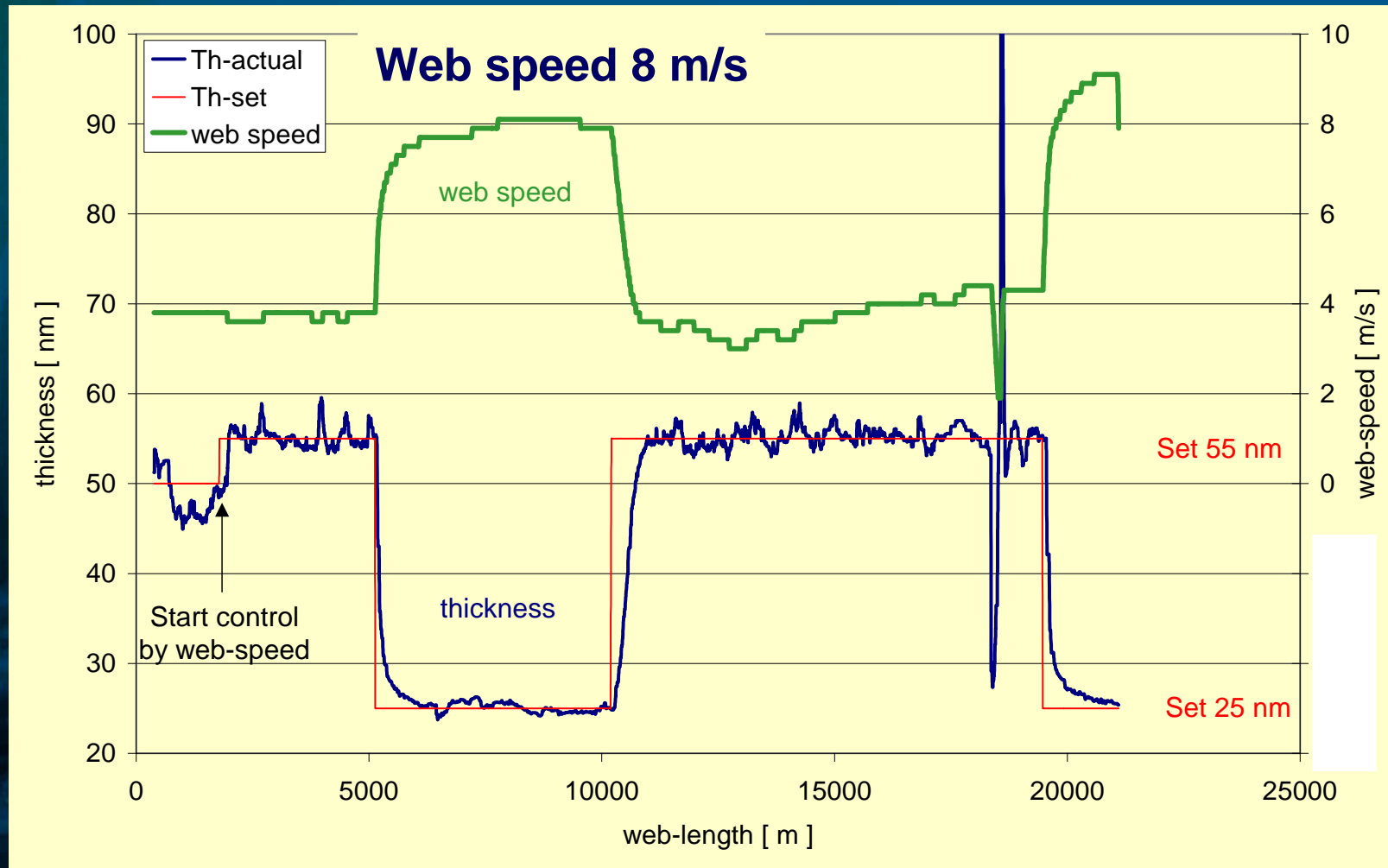


„Dangerous life“ - 3 m above ground  
for the Ellipsometer staff



# Electron beam inline process control with the ellipsometer

SiO<sub>x</sub> 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 :  $\text{Al}_2\text{O}_3$  ,  $\text{SiO}$
  - Cross-linked layer : on air by ORMOCER lacquer (  $\text{SiO}_2$  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,

\*\*  $\text{g/m}^2/\text{day}$  –  $\text{cc/m}^2/\text{day}$

Alcan, Applied Materiall,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

# 謝謝

*Thank you*

「感謝」

***Kansha!***

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御参加頂き  
ありがとうございました。

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