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# Large Area Coating for Glazing

IOP Vacuum Symposium –  
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Off-Line Coatings Technology Group

Pilkington European Technology Centre

# NSG Group



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- Pilkington a member of NSG Group from June 2006
- Equal largest flat glass producer
- Main business areas; Building Products, Automotive Products, Speciality Glass
- Sales c. €5.7 billion
- 31,500 employees worldwide
- Manufacturing operations in 29 countries
- Sales in 130+ countries
- Annual R&D spend c. €81 million

# A typical installation

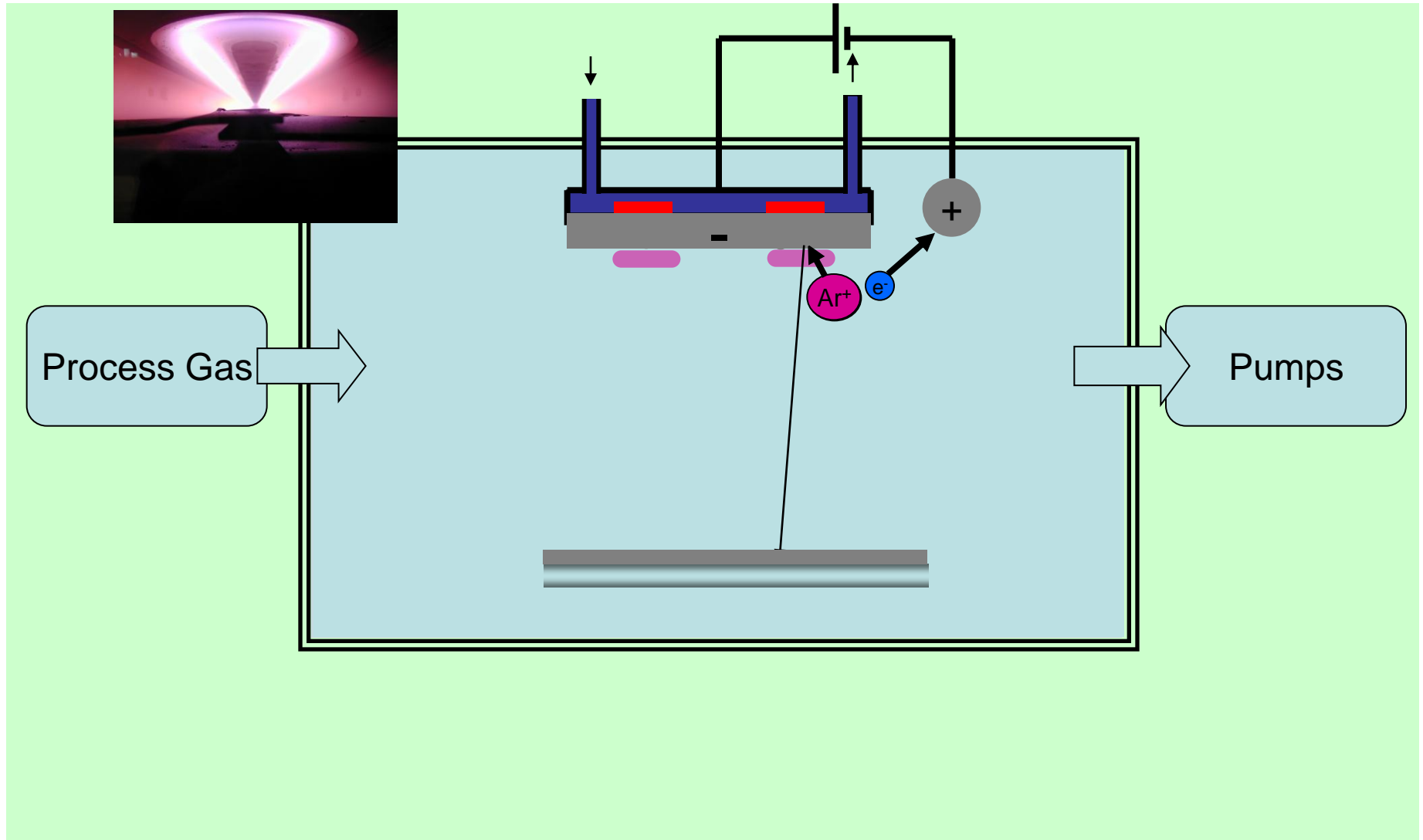


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# The Sputtering Process

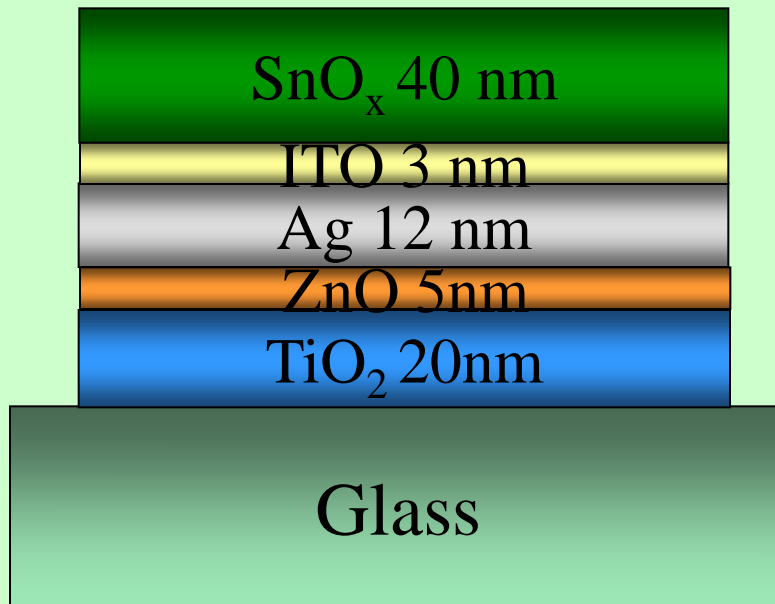




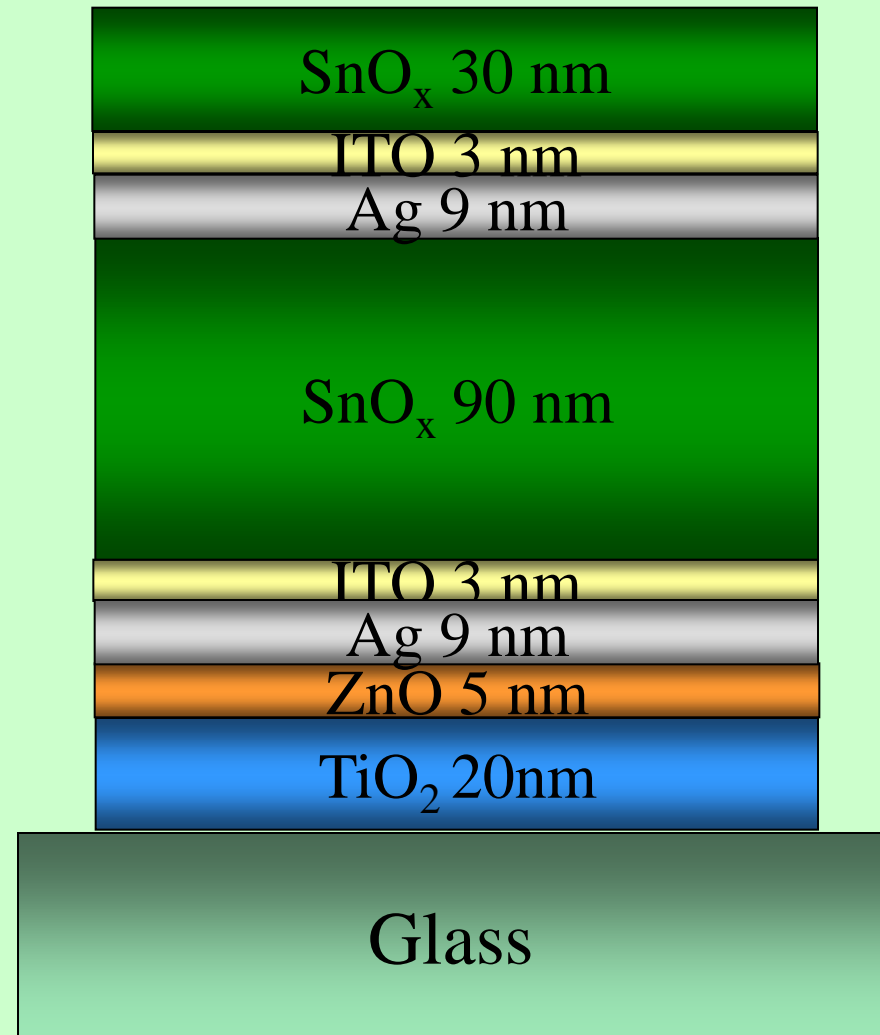
# Typical Stacks

To get the properties we want we have to make complicated coating stacks!

## Low-e



## Solar Control





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...in large sizes...



The standard glass size is the “Jumbo” – this is 6 x 3.2 m in size. The appearance of the coated glass must be acceptably uniform across the whole plate and from plate-to-plate



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# Product Attributes





# Insulation and U-value

•U-value is a measure of building insulation.

•Low numbers are better!

•To achieve good insulation windows need to be multiple glazed and coated.

Construction Element	U-Value $\text{Wm}^{-2}\text{K}^{-1}$
Outer Wall	0.35-0.7
Ground Floor	0.25-0.7
Insulated Roof	0.25-0.35
Solid Timber External Door	2.2-3.3
Single Glazed Window UPVC	5*
Double Glazed Window	2.6
Double Glazed Ag Low-e Window	1.1*
Triple Glazed Ag Low-e Window	1.0-0.5*

Source: The Building Regulations 2000 Approved Document L1A (2006 Addition) & Calcs\*



# Other important criteria

- Visible Light Transmittance, Reflectance
- Colour
- Solar Energy Transmittance and Reflectance
- Emittance (linked to U-value)



# Business Targets

- Product Attributes are a given
- Maximise Profit
  - Low cost
  - Higher Value (but may not be much over cost for commodity products)
- Low Capital Spend (cheapest equipment to do job in reliable way)
- High Volume Production (as Capital and Variable costs must be covered)



# Process Targets

- For high volume production
  - Large area coating with low manning level
  - High deposition rate
  - Low downtime
    - long production campaign
  - High quality
    - low defect rate
- Flexibility to make different coatings
- How do we achieve these targets and what are the problems?



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# Problems & Solutions



# High Volume Manufacturing

- Large Area Coating
  - Large vacuum plant handling largest glass sheets
  - High throughput – continuous coating
  - Flexible plant configurations that allow different coating stacks to be made on the same plant
  - High depositions rates



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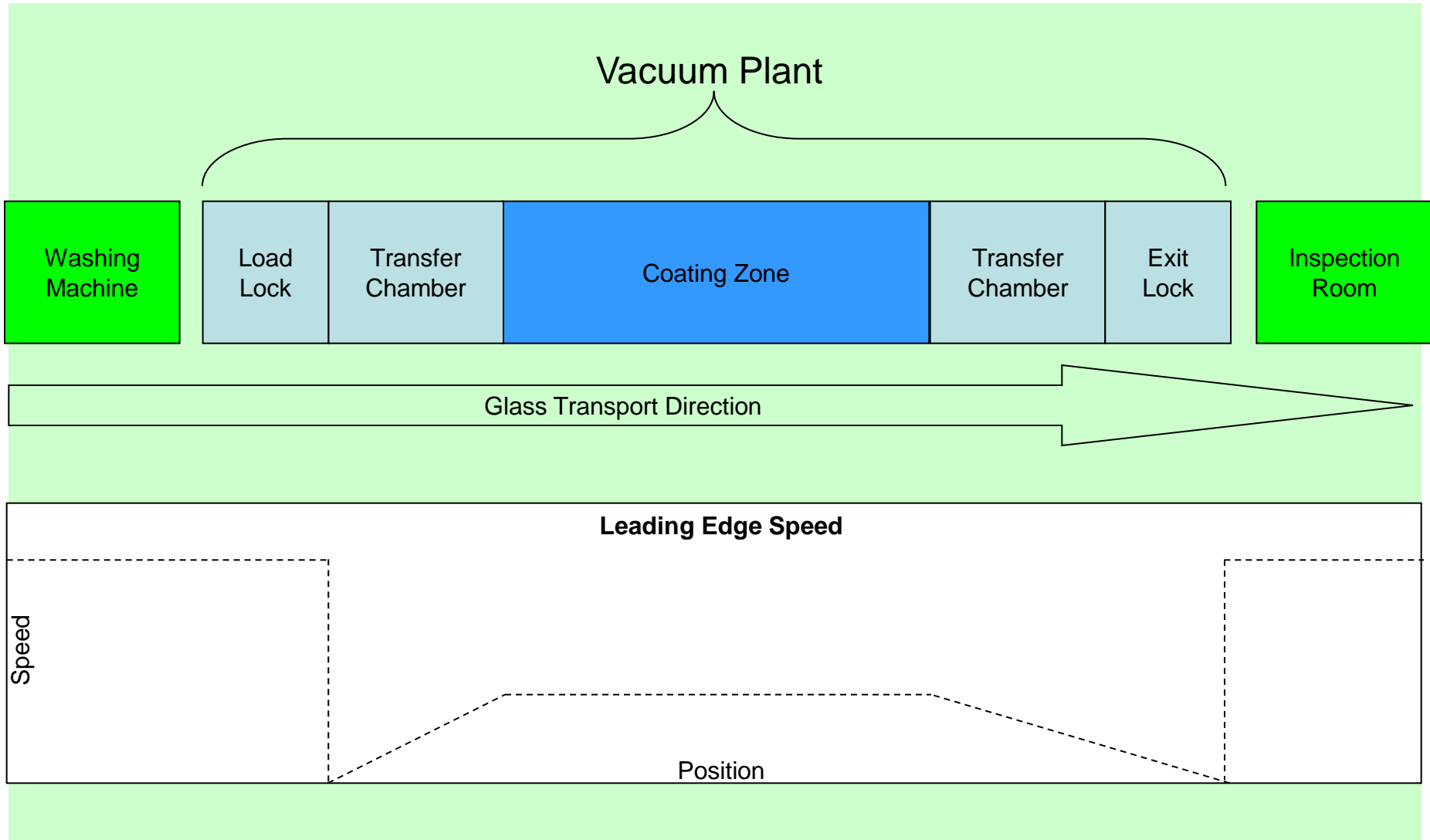
# Coating manufacturing – ESG3 Sweden



# Typical plant layout – for continuous coating



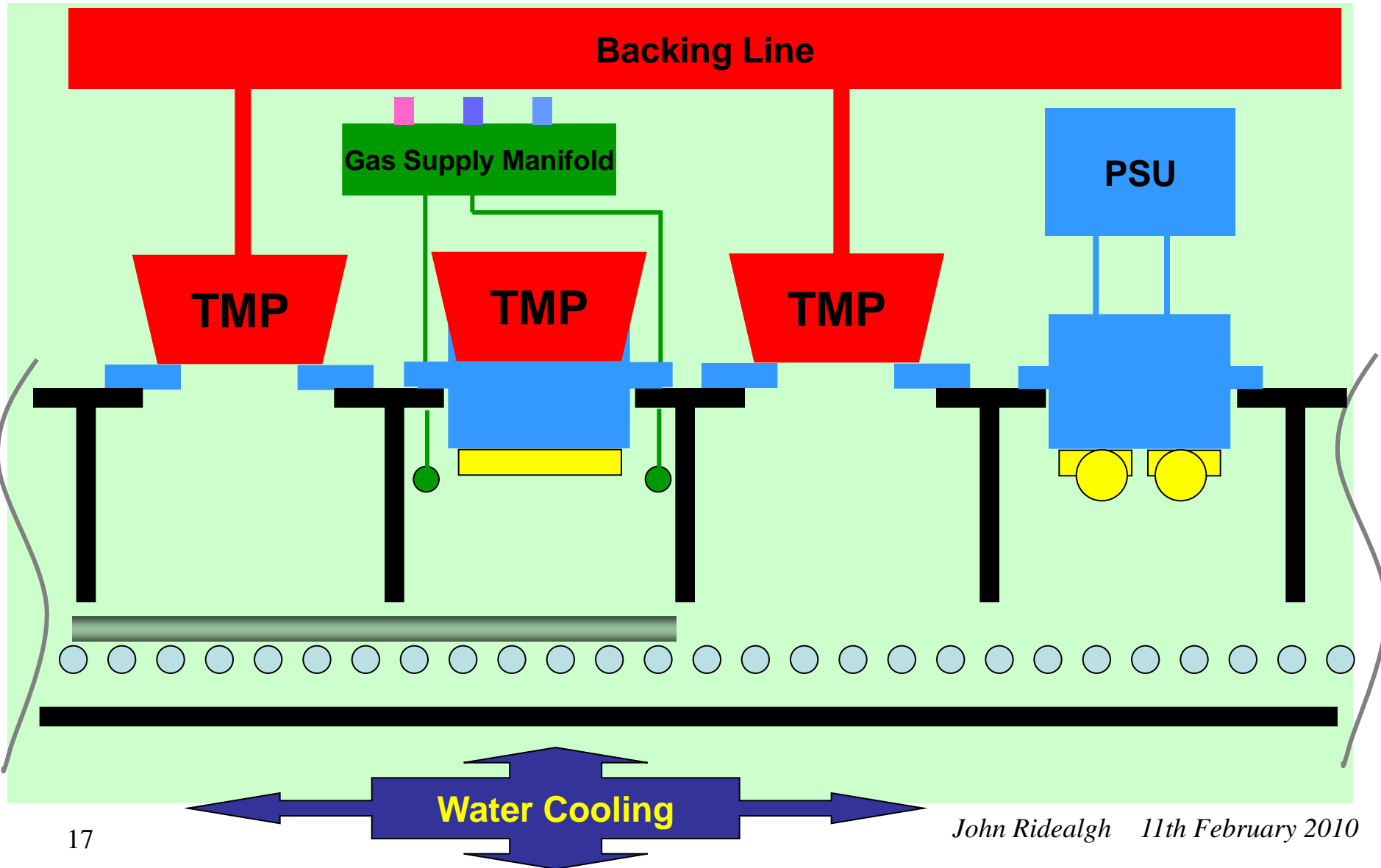
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# Flexible Plant Layout



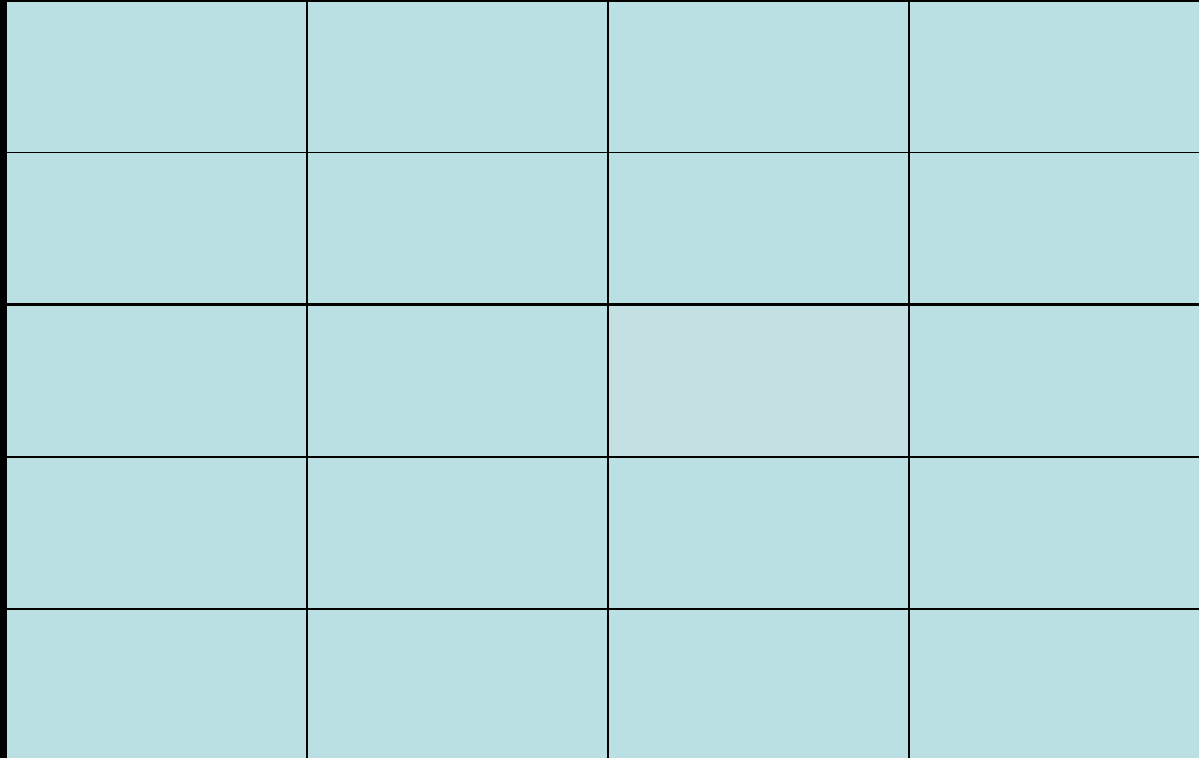


# Colour Problems

- Colour variation between and within plates
  - On-line measurement
    - optical spectra and sheet resistance
  - spectral data modelling and feedback



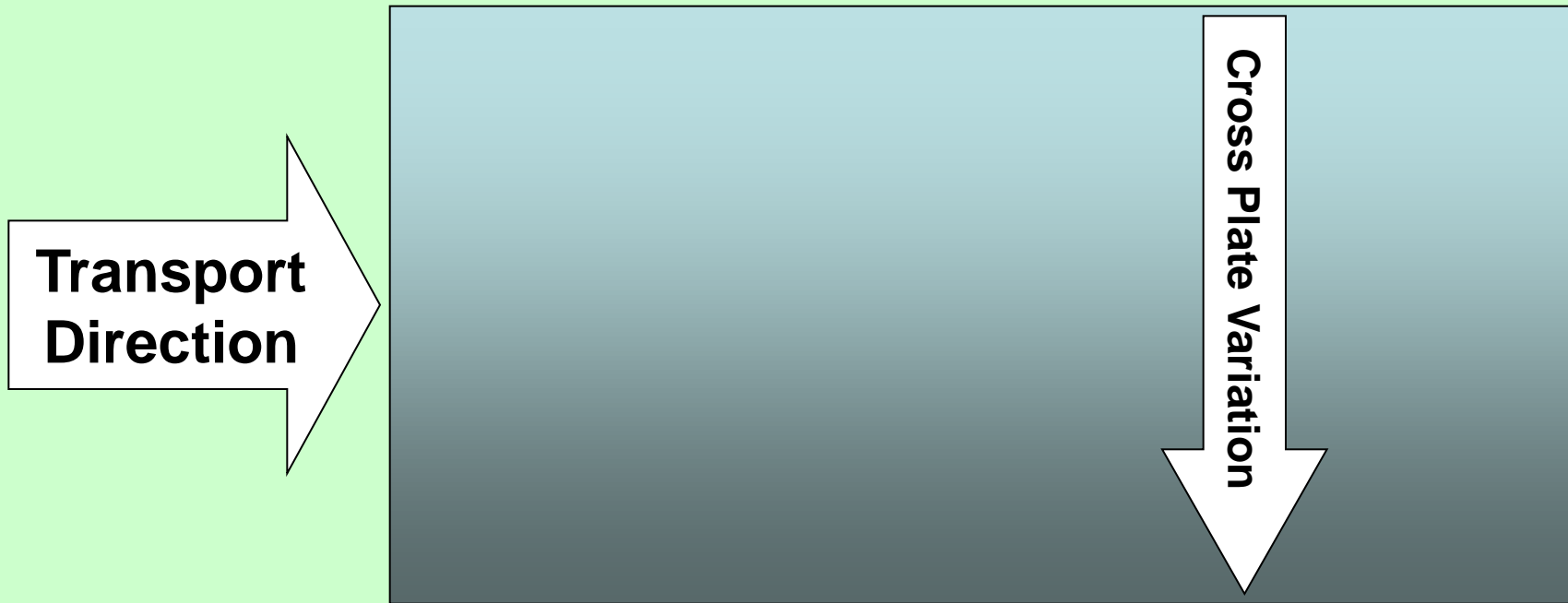
# Plate-to-plate colour variation



# Cross-Plate Colour Variation

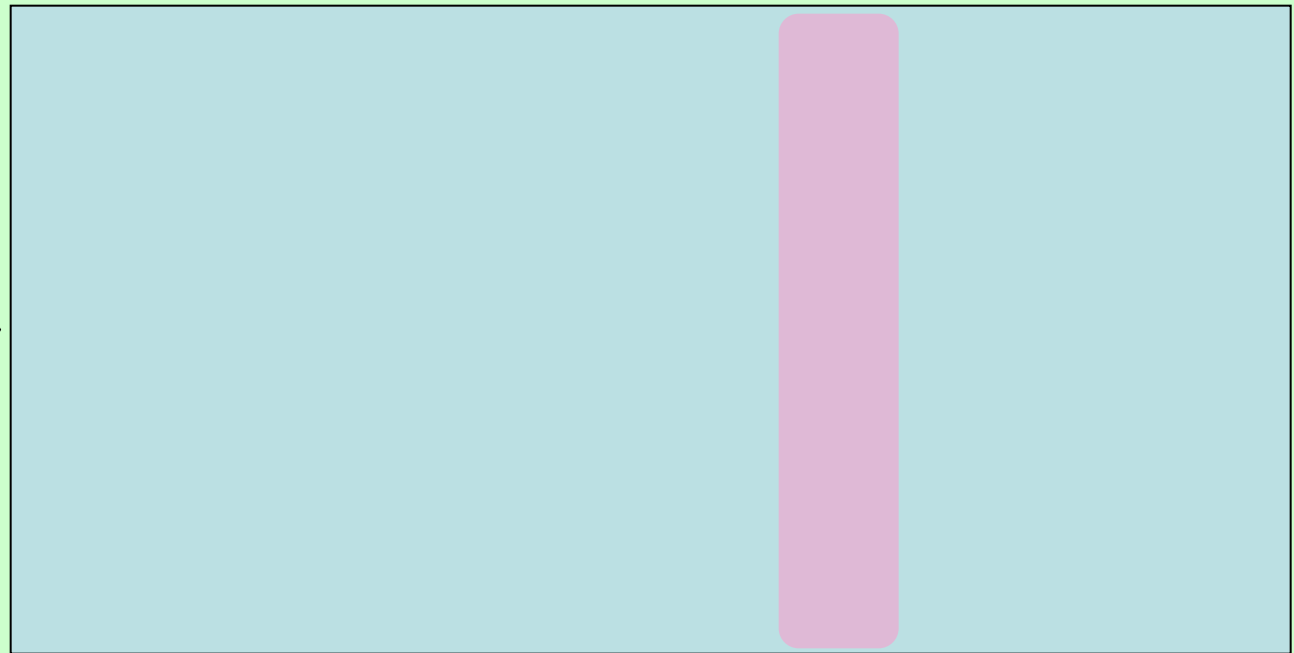
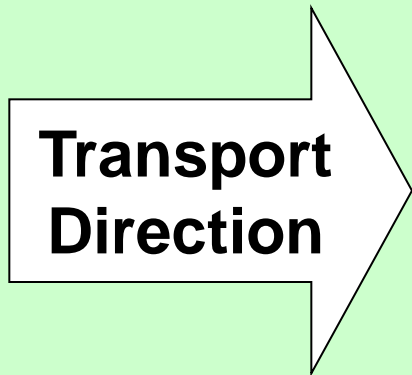


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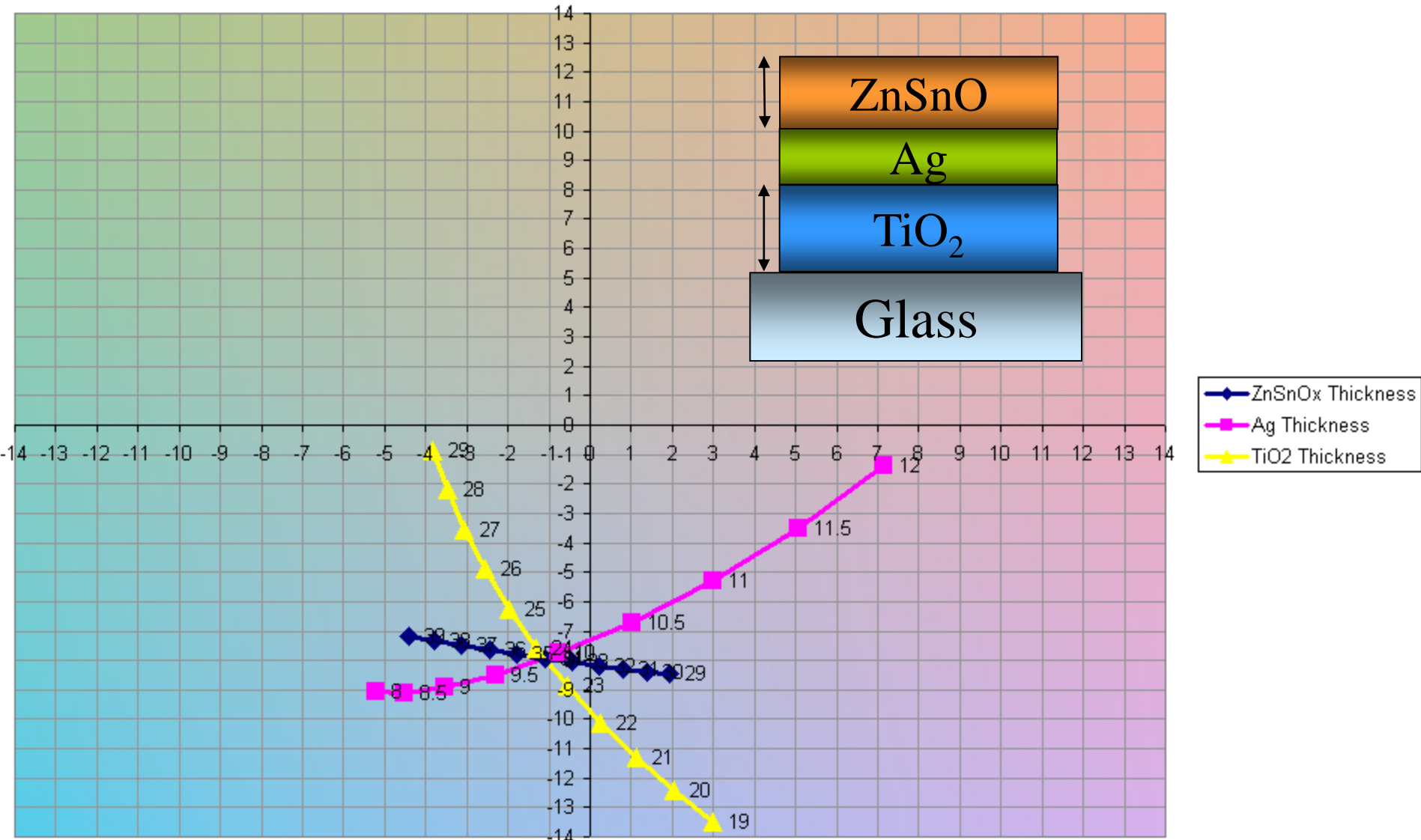


# Arc Colour Patches





# Colour Variation from Coating Thickness

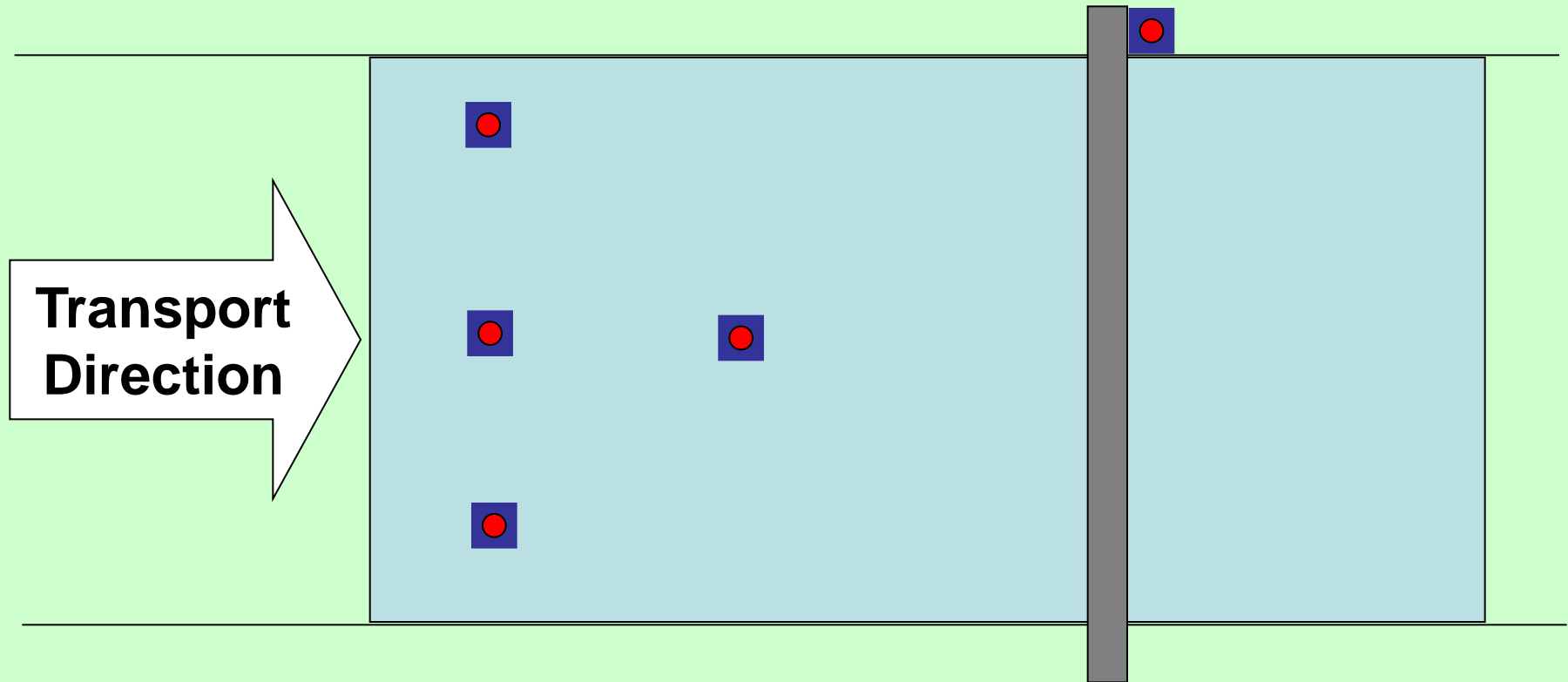


**We must control thickness accurately**

# Cross-width Optical Spectroscopy & $R_s$ Measurement



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- Traversing or static Spectrophotometer heads and non-contact sheet resistance

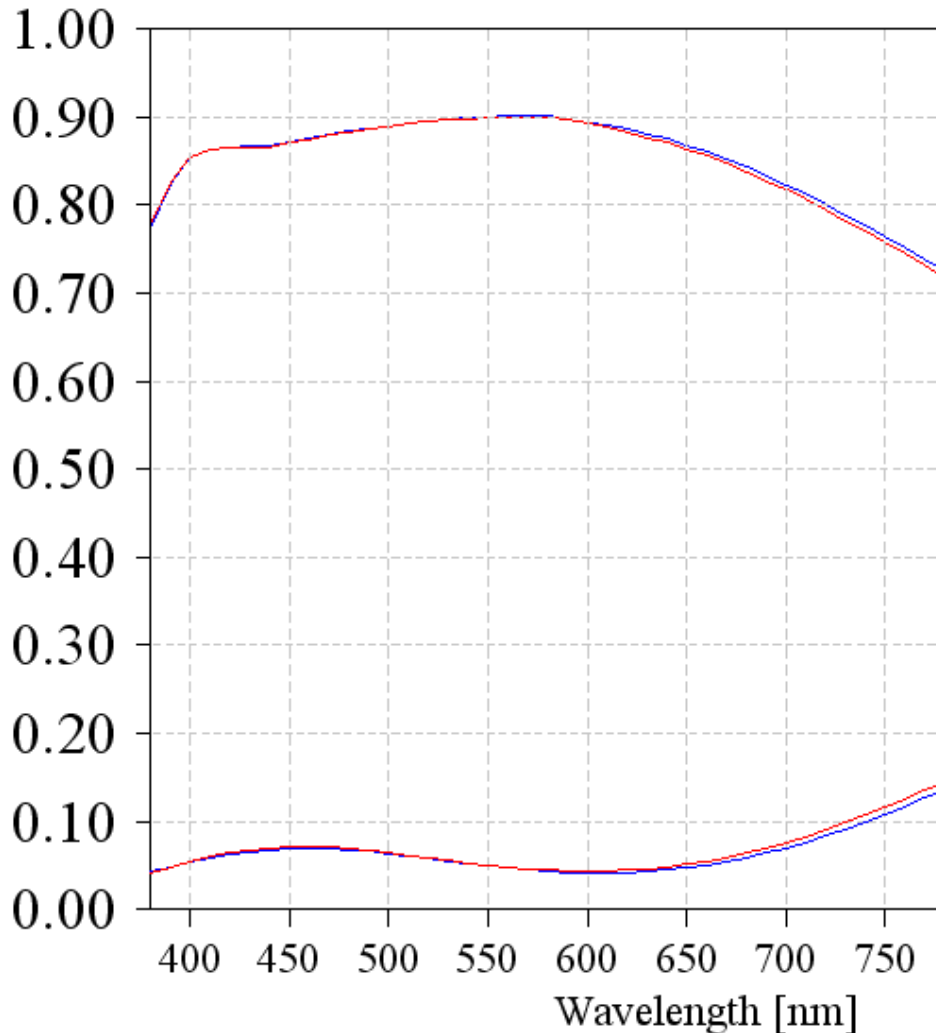


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# Optical Modelling for Control

$R_s$  4.5 ohms/sq

Visible Trans/Reflec



Yellow

Neutral

Transmittance Colour

L*:	95.79
a*:	-1.25
b*:	1.45

Reflectance Colour

L*:	26.80
a*:	-1.66
b*:	-7.51



ZnSnOx

0.0 37.9 80.0

Ag

0.00 10.22 20.00

TiO2

0.0 23.9 40.0

Angle of Incidence

0.00 0.00 40.00



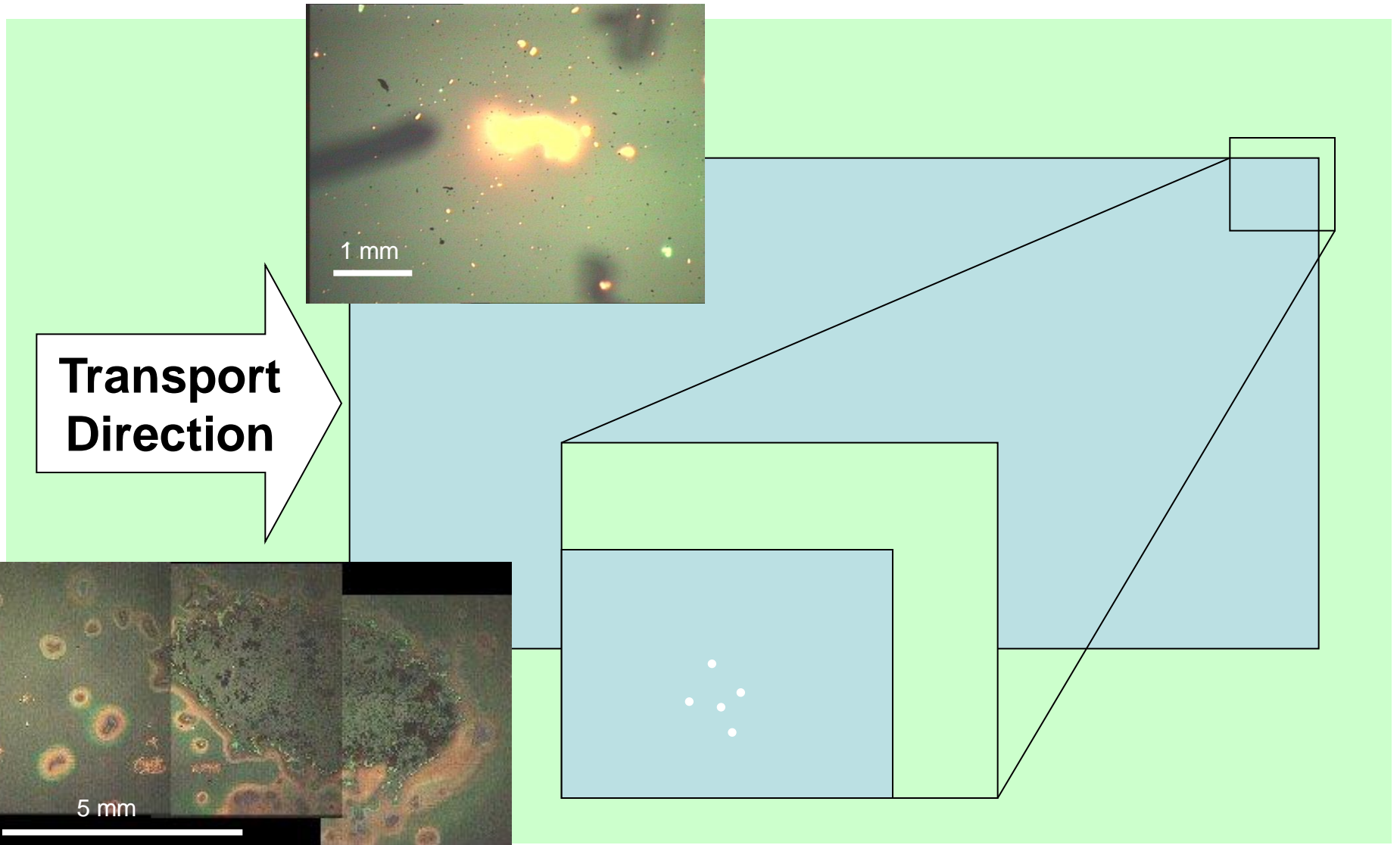


# Arcing and Debris

- Arcing and Debris cause pinholes and colour problems
  - Choice of best power supply
  - Cathode type
- Once debris is formed it is hard to get rid of and production run lengths are reduced
- Arc events can lead to cathodes turning off resulting in colour banding



# Pin-Holes/Debris



**Transport  
Direction**

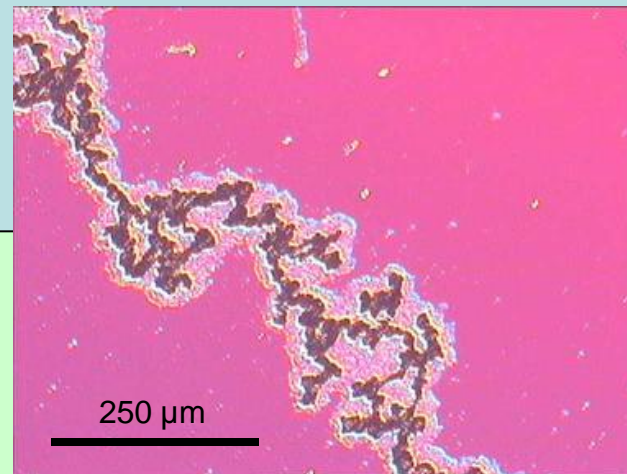
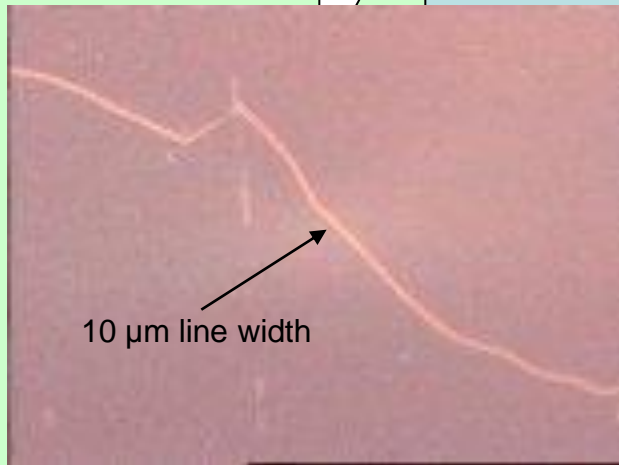
1 mm

5 mm



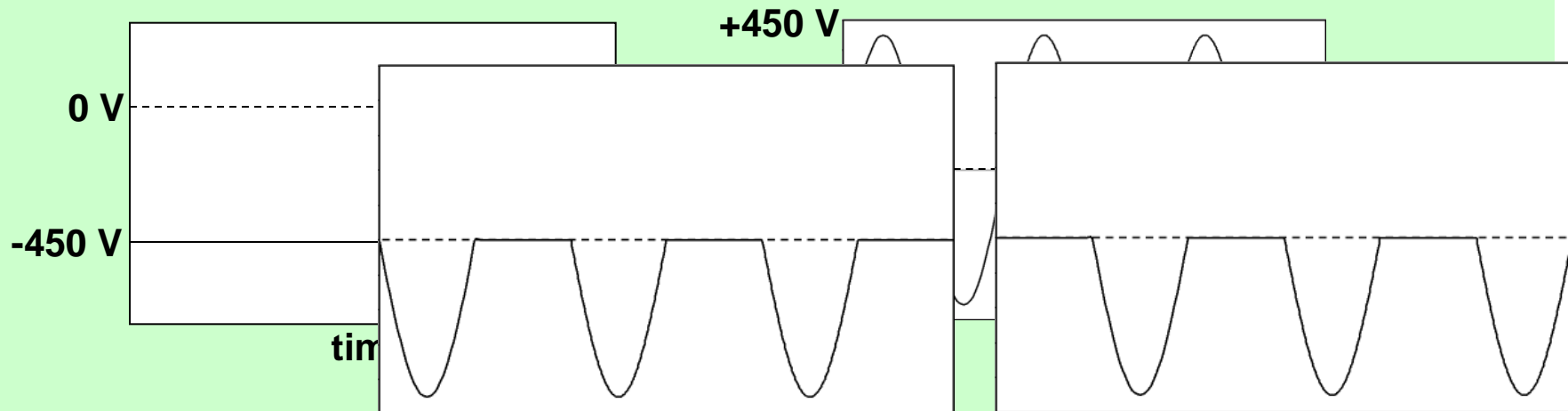
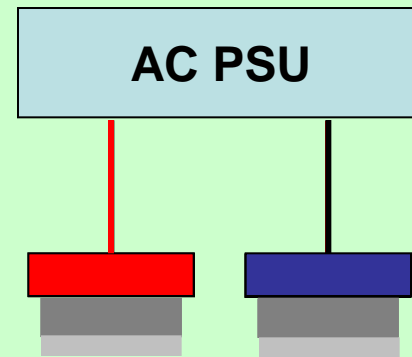
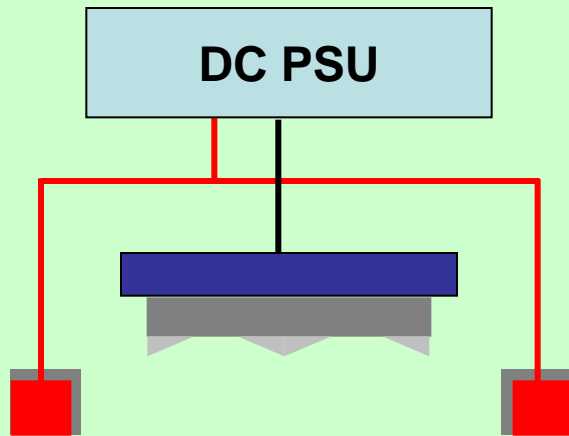
# Discharge Marks

**Transport  
Direction**



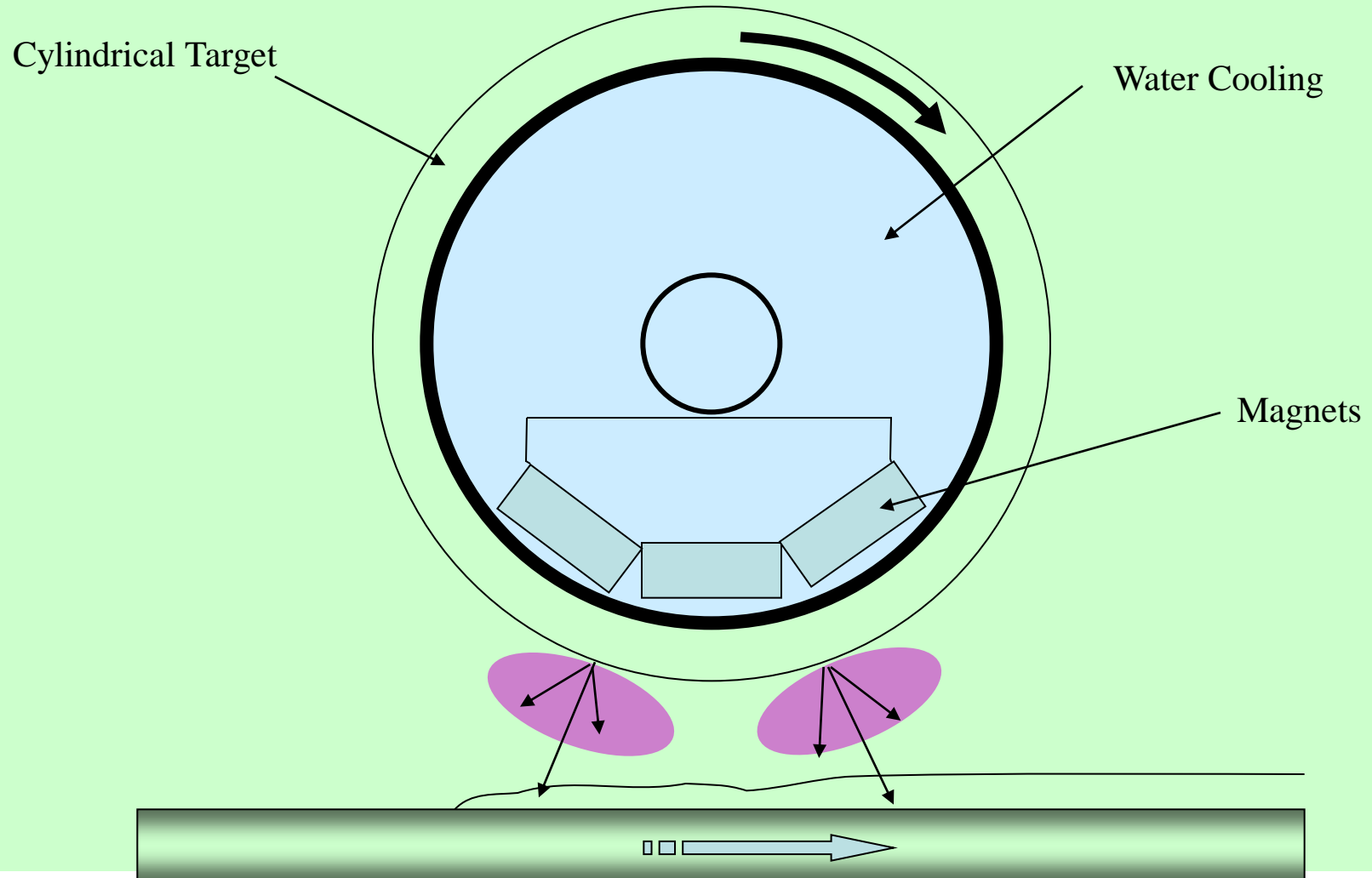


# Power Supplies





# Rotating cathodes





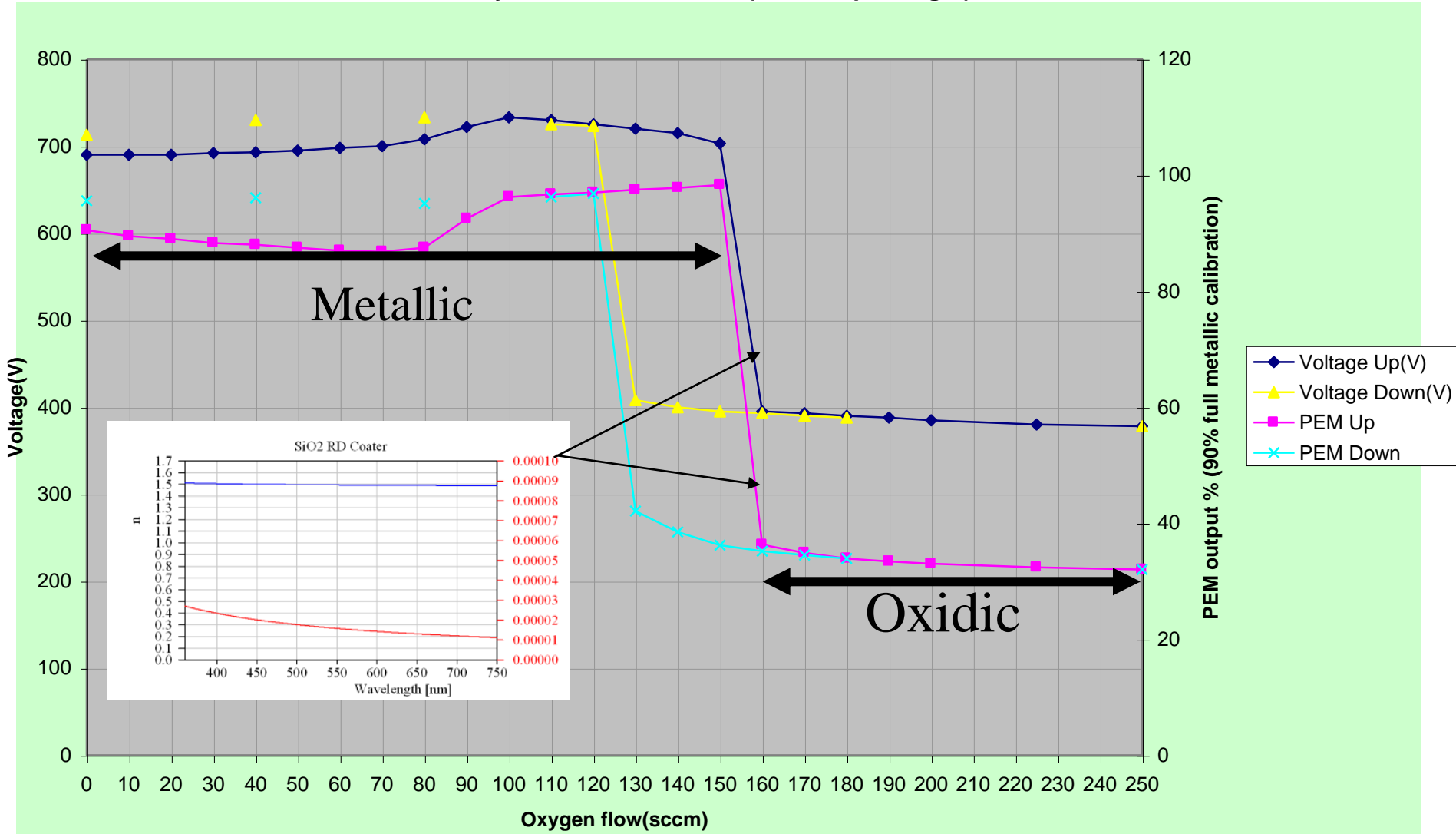
# Rate & Process Stability

- Need high rate for volume manufacture
  - High power output power supplies used with target materials that can take it!
  - Transition mode sputtering
    - OEM
    - Lambda Probe
    - Voltage Control



# Voltage and Optical Emission Hysteresis

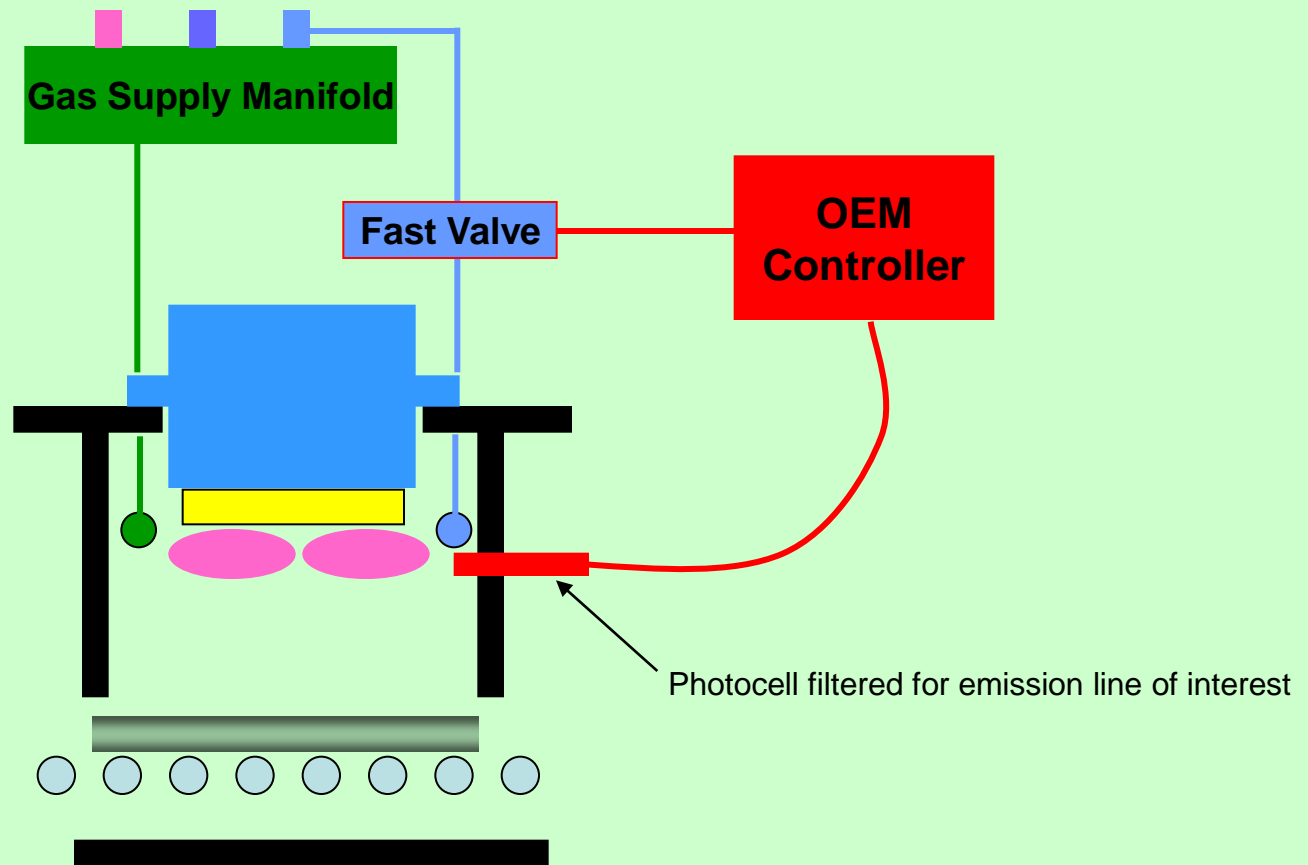
Hysteresis SiO<sub>2</sub> 15KW (from Sispa Target)



# High Rate Sputtering – OEM Control



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# Before and After Coating

- To get good coatings with very thin films the substrate condition is very important. It is considered good practice within the industry to only coat on glass less than 4 weeks old.
- Excellent glass washing is also very important – the thinnest layers in the stack are only a few nm, whereas even thin layers of dirt can be microns.
- Once the coating has been manufactured it must be stored, transported and processed without damaging the coating. This is a whole story in itself...



# Summary

- Modern glazing requires complex coating stacks
- These coatings have very low thicknesses but need to have uniformity and control over large areas.
- Sputter coating allows deposition of thin interference coatings from a variety of materials.
- Cathode and power supply design lead to stable coatings over coating campaigns.
- Feedback from optical and electrical measurements allow continuous control to stay in specification.
- Substrate condition and post-coating handling are very important non-trivial factors in delivering a quality product to customers.

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