



PILKINGTON

First in Glass

Outline

- Coating Technology in the Glass Industry
 - On-line coating
 - Off-line coating

- Coating applications
 - Low E
 - Solar control coating
 - Self cleaning coatings



Coating Technology

- A wide variety of coating technologies are utilised by the glass industry
 - Spray Pyrolysis
 - Powder Spray
 - Chemical Vapour Deposition
 - Sputter Coating
 - Thermal Evaporation Coatings
 - Sol Gel Coatings
- These are applied
 - On Line i.e. as the glass is produced on the float line (CVD)
 - Off Line i.e. as a batch process (PVD)



Online (CVD)

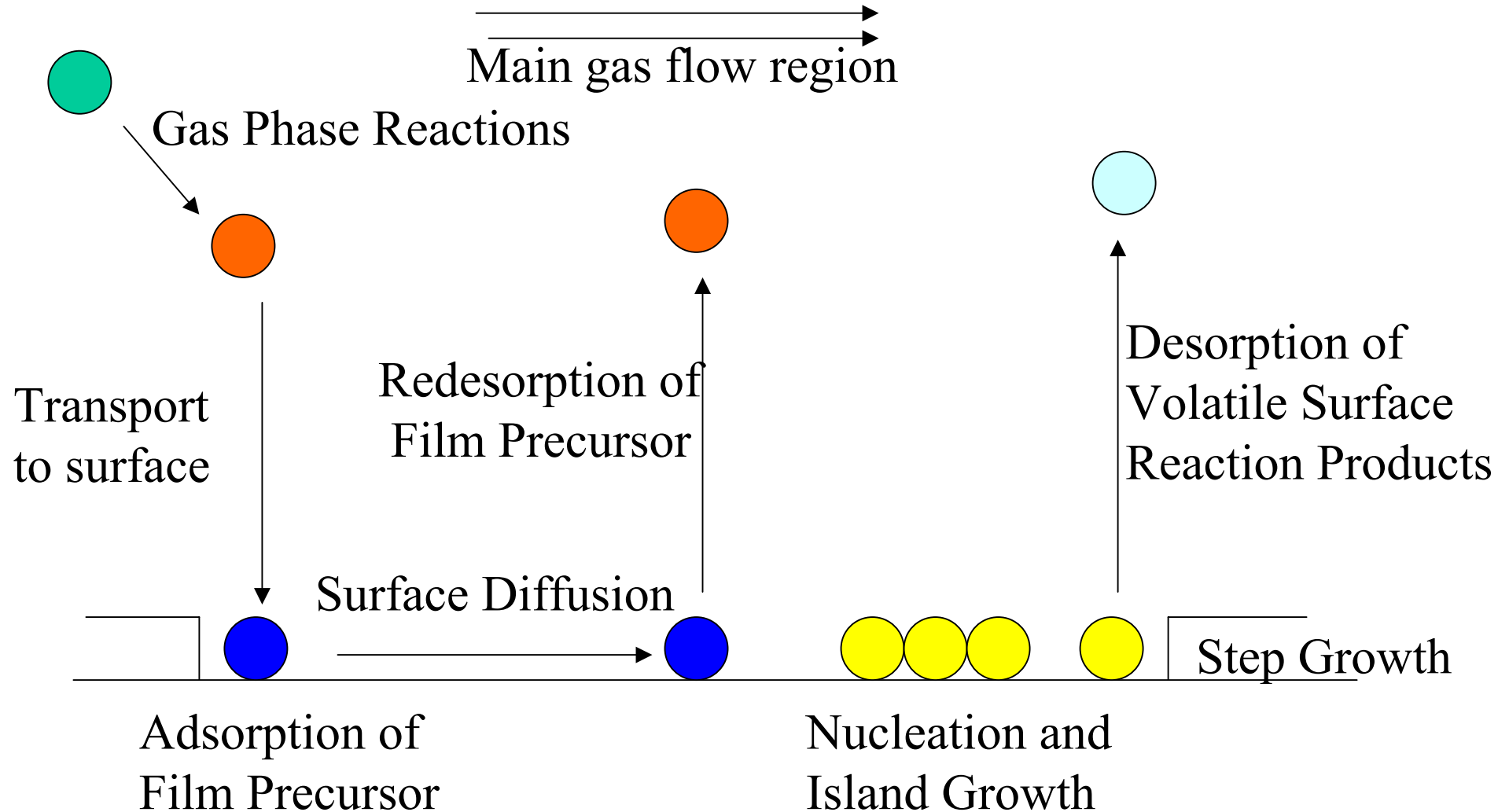


Chemical Vapour Deposition

- Pilkington Plc. has been involved with chemical vapour deposition for over 20 years
- Pilkington utilise atmospheric chemical vapour deposition to deposit coatings as the glass is produced
- On line coatings provides a variety of challenges
 - Glass is coated at $>600^{\circ}\text{C}$
 - Glass is moving at approximately 10-15 m/min and is 3.2m wide
 - Coating must be applied continuously for a long period (upto 2 days continuously to be economic)
- On Line Coatings are
 - Hard
 - Durable



What is CVD ?



From Chemical Vapour Deposition Principles and Applications M.L.Hitchman and K.F.Jensen

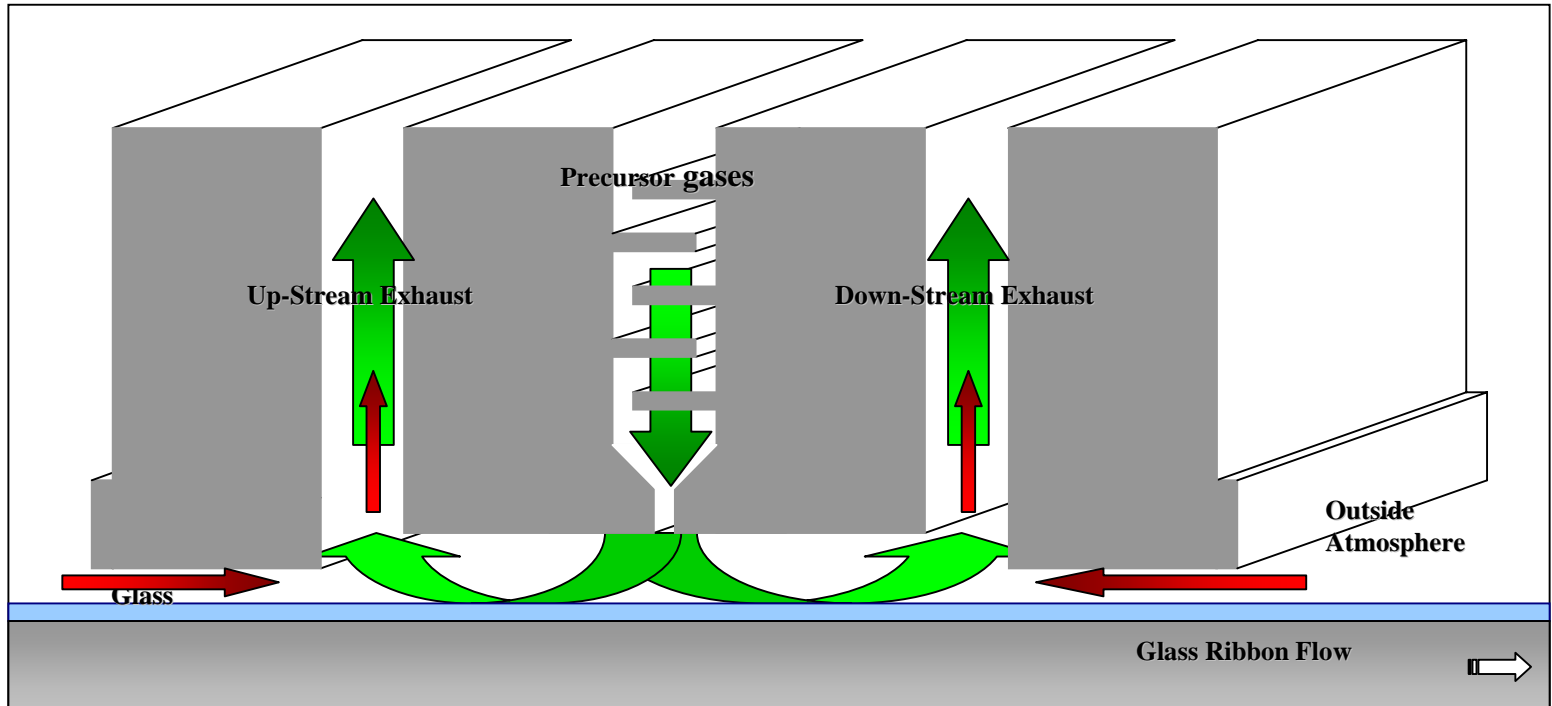
Pilkington and Coating Technology

Process Involves

- Vaporisation of chemicals
- Delivery of chemicals in inert gas
- Direction of chemicals over hot glass
- Extraction of by products
- Scrubbing of waste products



Coater Beam Design



Chemical Vapour Deposition (CVD) Coater Cross-section Diagram

Offline (PVD)



Physical Vapour Deposition

- Pilkington Plc. has been involved with physical vapour deposition for over 25 years
- Pilkington utilise magnetron sputter technology to deposit coatings as the glass is produced
- On line coatings provides a variety of challenges
 - Glass is coated in vacuum at 10^{-3} mbar
 - Glass is moving at approximately 2- 6 m/min and is 3.2m wide
 - Coating must be applied continuously for a long period (upto 10 days continuously)
- Off Line Coatings has
 - high performance
 - high flexibility



Physical Vapour Deposition

What is sputtering ?

a target is bombarded
and material is ejected



What is needed for sputtering ?

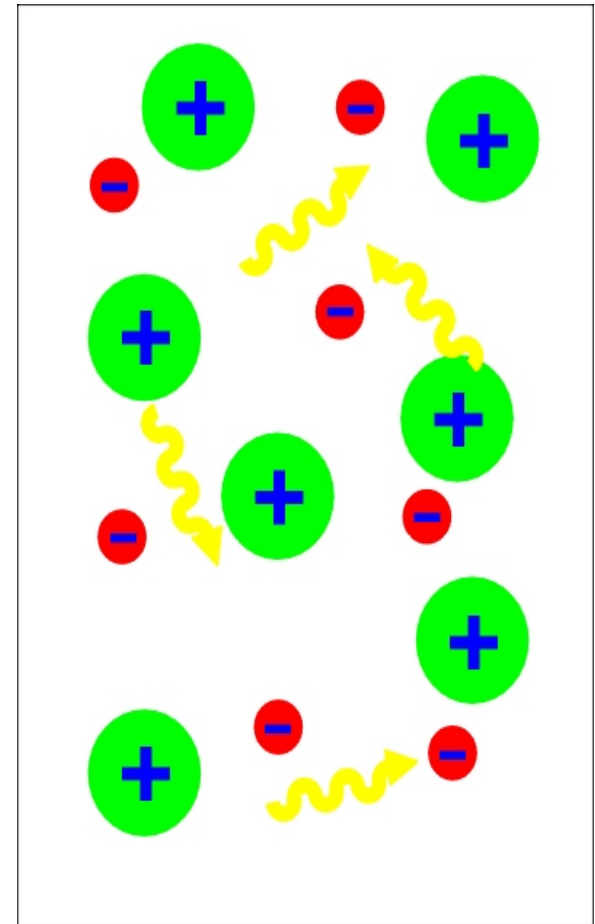
- target (electrical conductive)
- plasma which generated particle to bombard the target



Physical Vapour Deposition

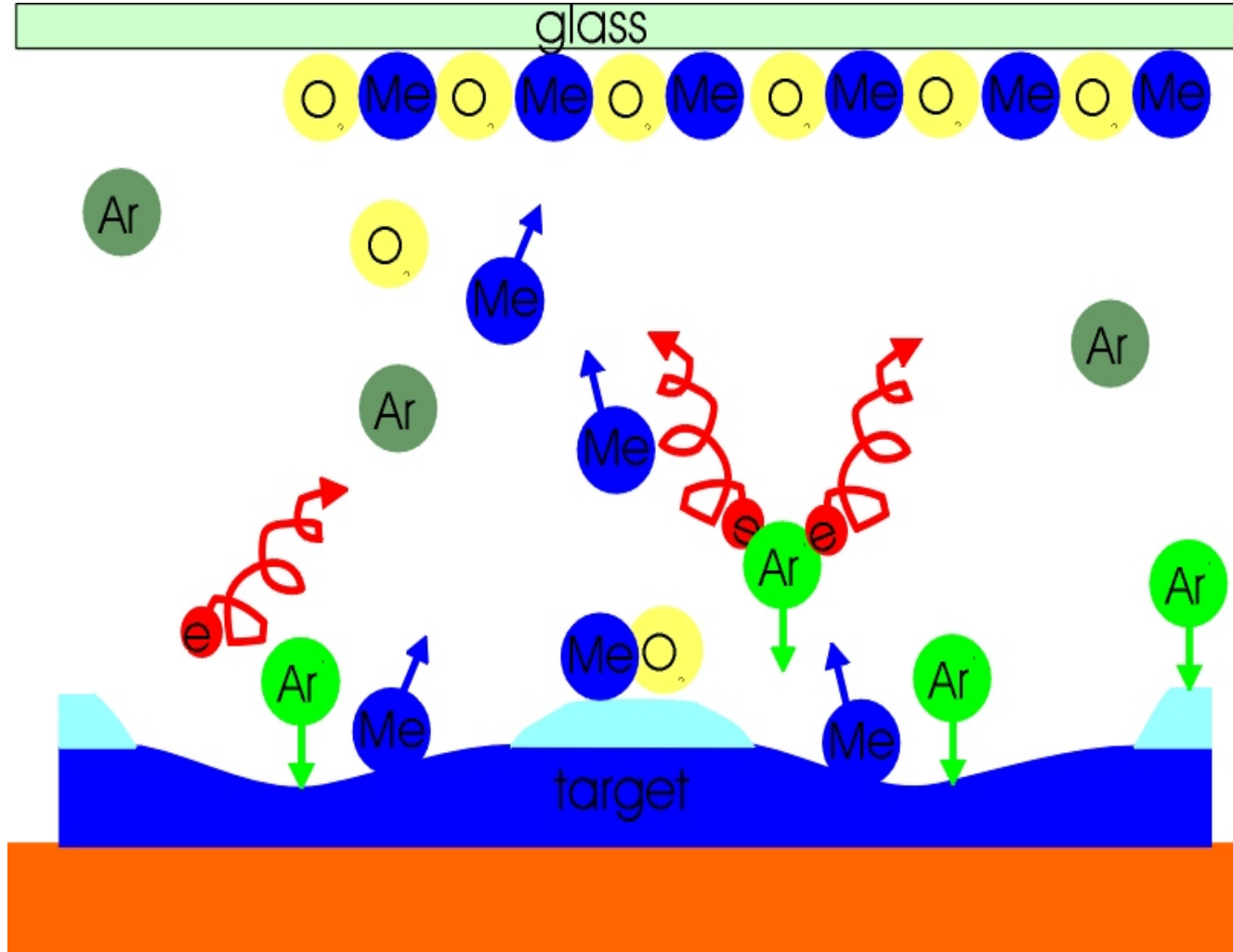
What is a plasma?

- a plasma consist of electrical **negative** and **positive** particles
- the number of the **negative** particles is equal to the number of **positive** particle the plasma is electrical **neutral**
- a plasma is electrical conductive
- electromagnetic wave e.g. light

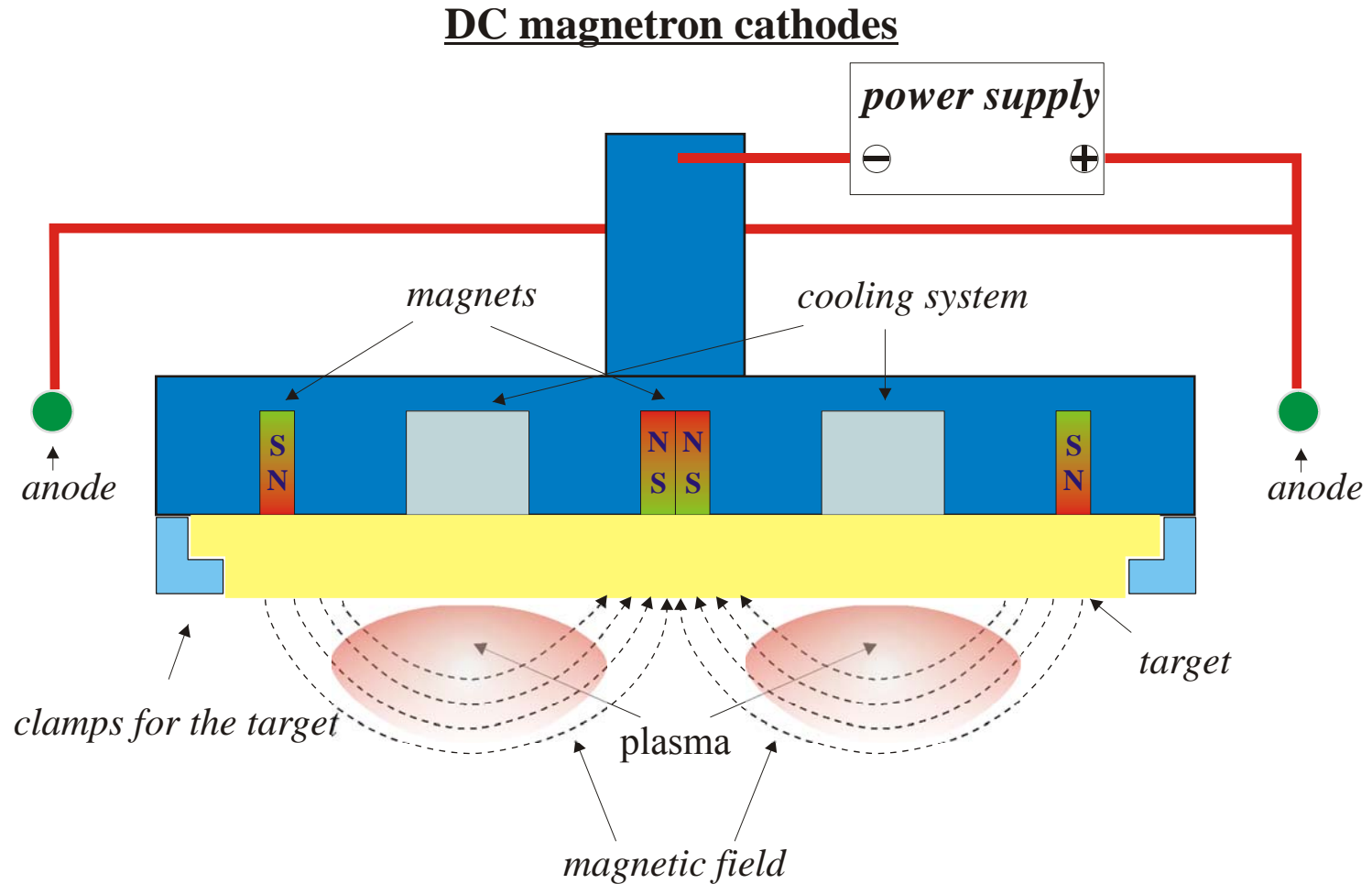


Physical Vapour Deposition

reactive sputtering



Physical Vapour Deposition

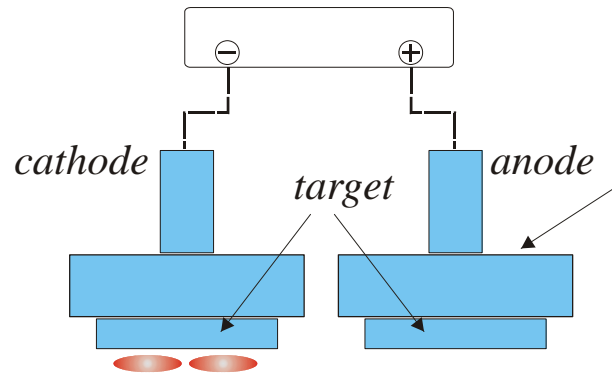


Physical Vapour Deposition

AC magnetron

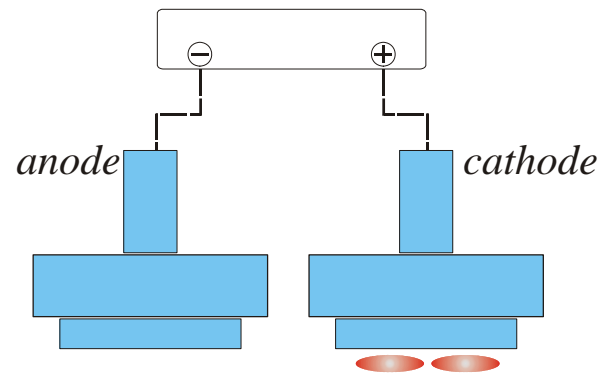
a) first half wave

AC power supply



b) second half wave

AC power supply

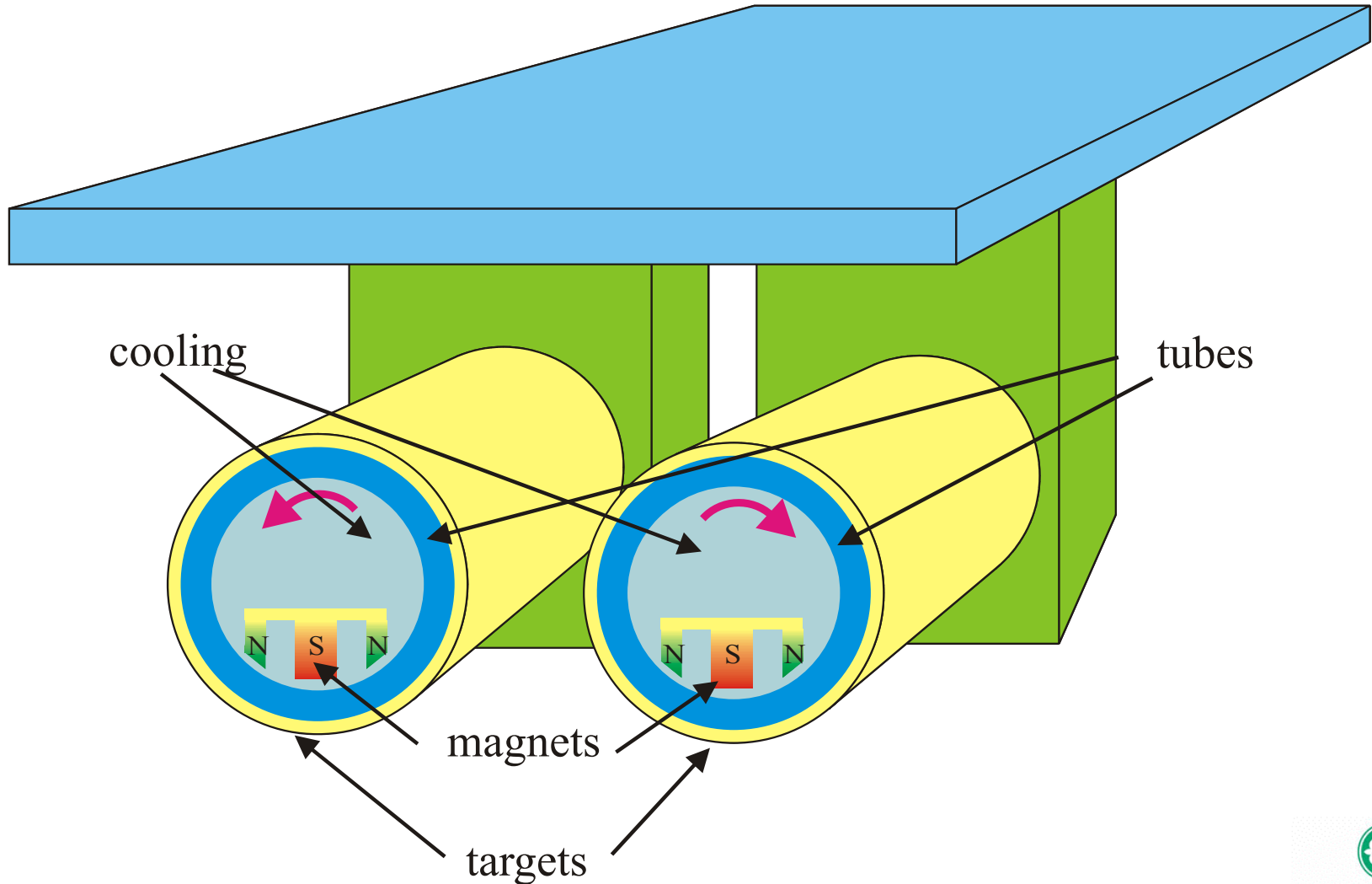


transport rolls

substrate

Physical Vapour Deposition

rotating cathodes



Pilkington Coater in Halmstad



Pilkington Coater in Gelsenkirchen



Purpose



Physical Vapour Deposition

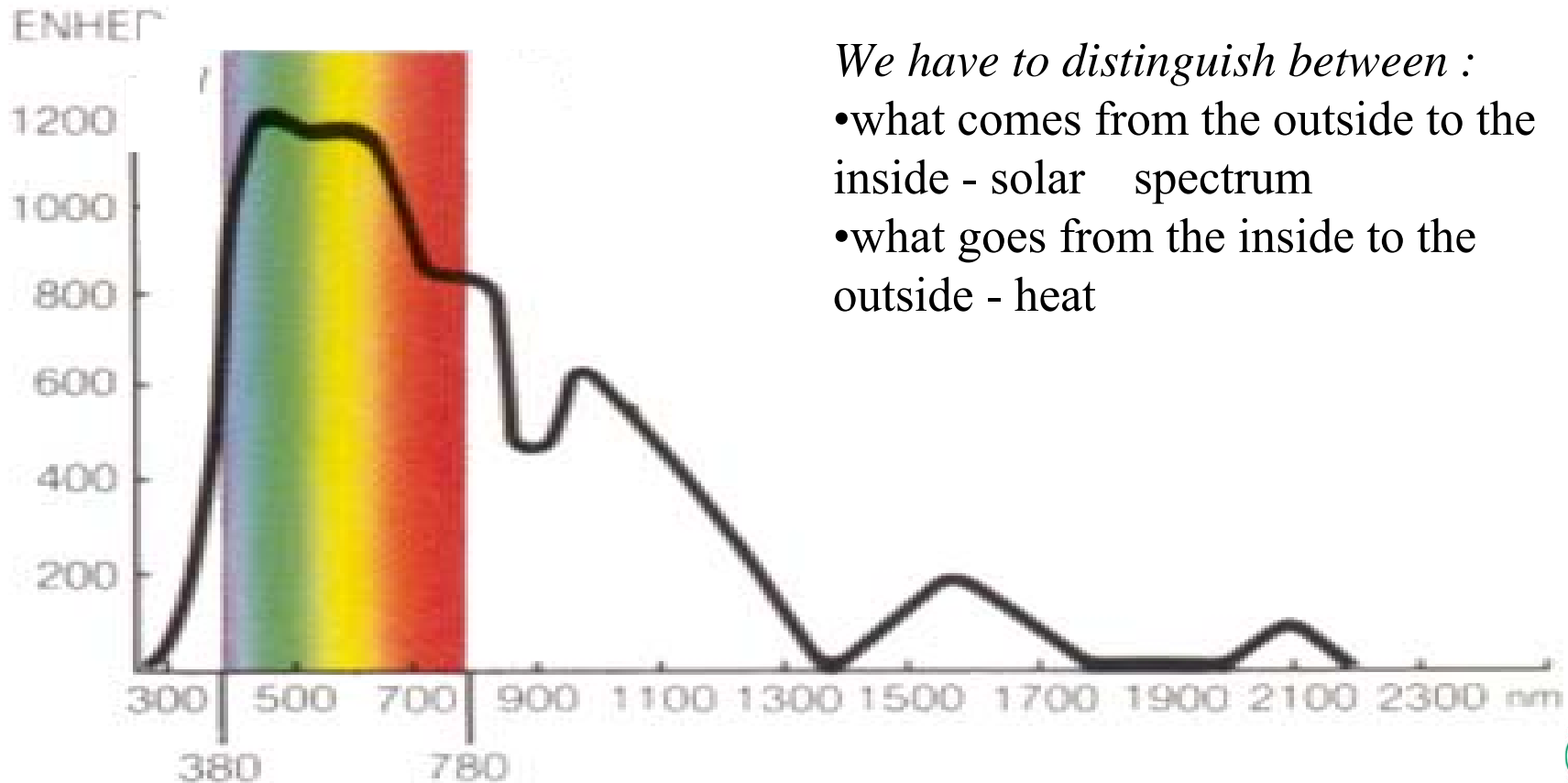
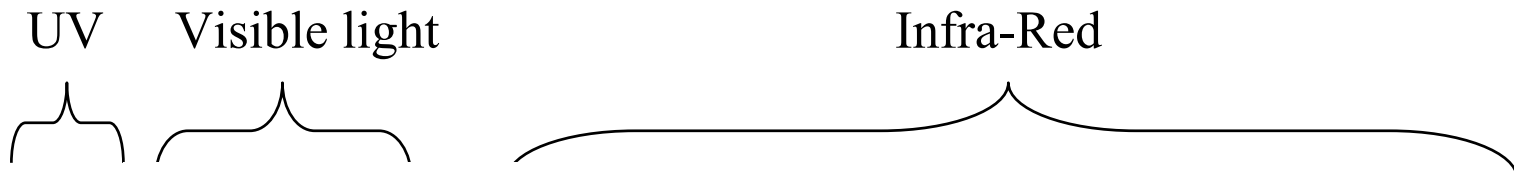


APCVD Applications on Glass

- Coating technology allows us to add functionality to glass
- Coating technology is today used for a variety of products
 - Low Emissivity coatings to reduce heating bills
 - Solar Control coatings to reduce solar heat gain and cooling bill
 - Technical products e.g. TCO's for displays etc.
 - Anti-Reflective Products
 - Hydrophobic Coatings
 - Self Cleaning Coatings



What coatings do - outside to inside



We have to distinguish between :

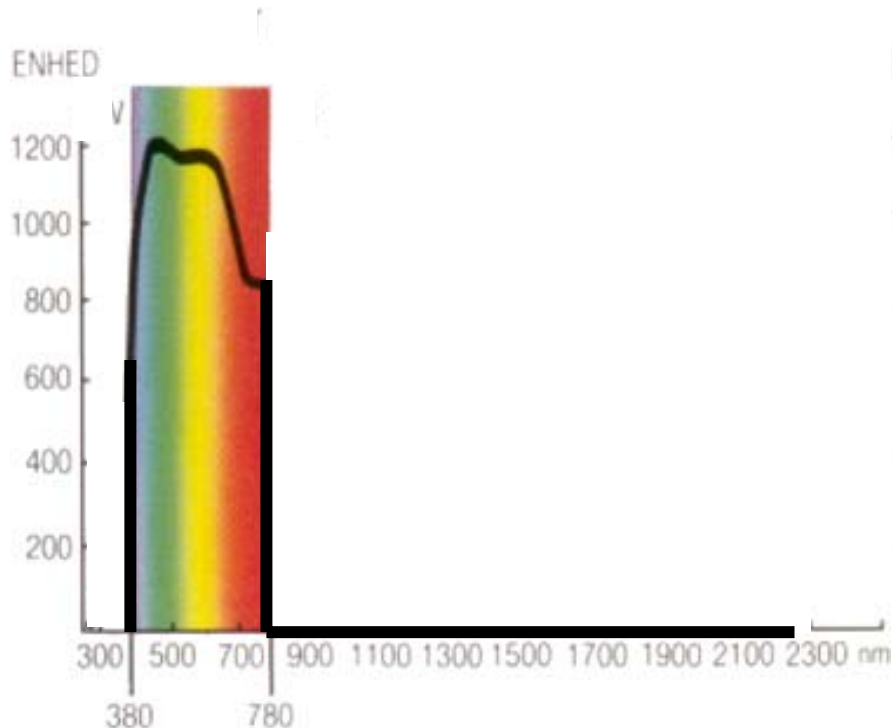
- what comes from the outside to the inside - solar spectrum
- what goes from the inside to the outside - heat



What coatings do - outside to inside

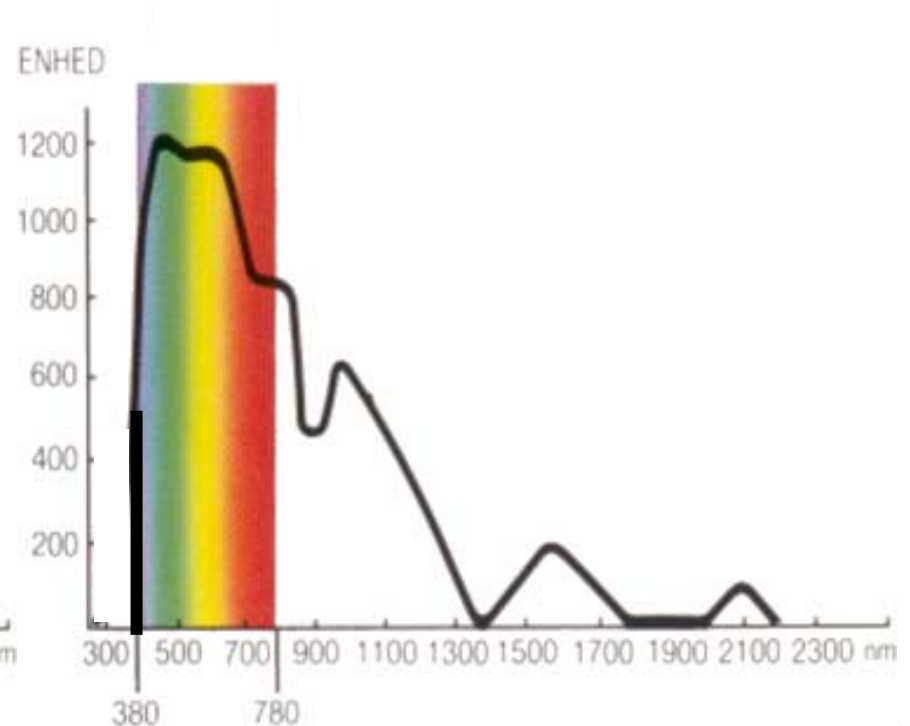
Optimal curve for solar control

- no UV
- all visible light pass
- no IR



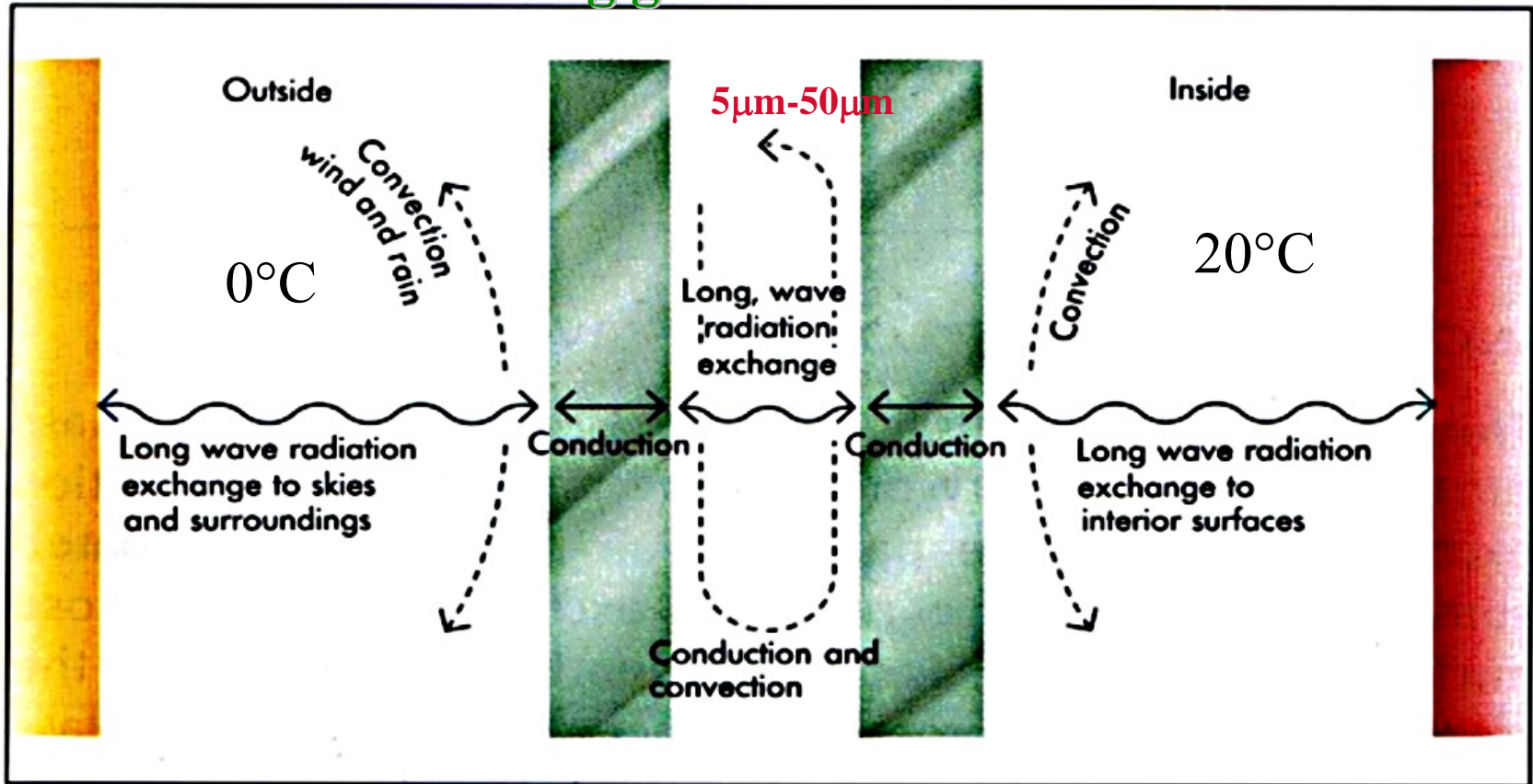
Optimal curve for low-e

- no UV
- all visible light pass
- all IR pass



Low E coatings

Insulating glass - heat transfer



Conduction + convection depends on the fill gas (air, Argon)
radiation exchange depends on the emissivity and temperature difference



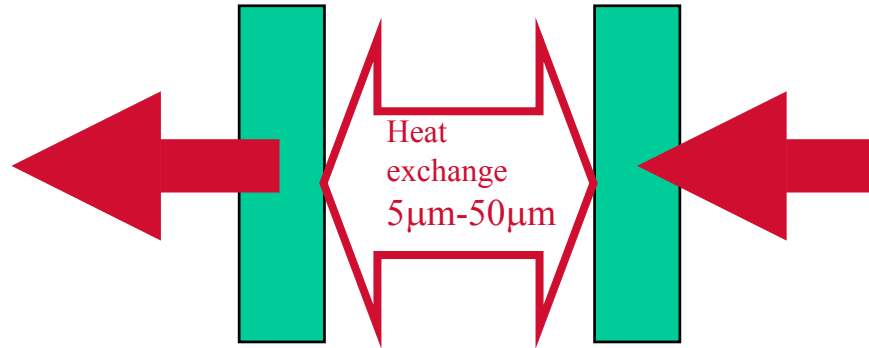
Low E coatings

Insulating glass - heat transfer

outside
inside

uncoated glass $\varepsilon = 0,89$

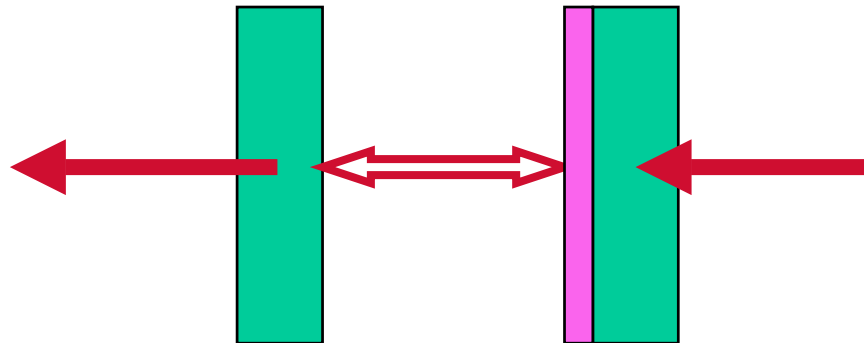
0°C



20°
C

Low e glass $\varepsilon = 0.04$

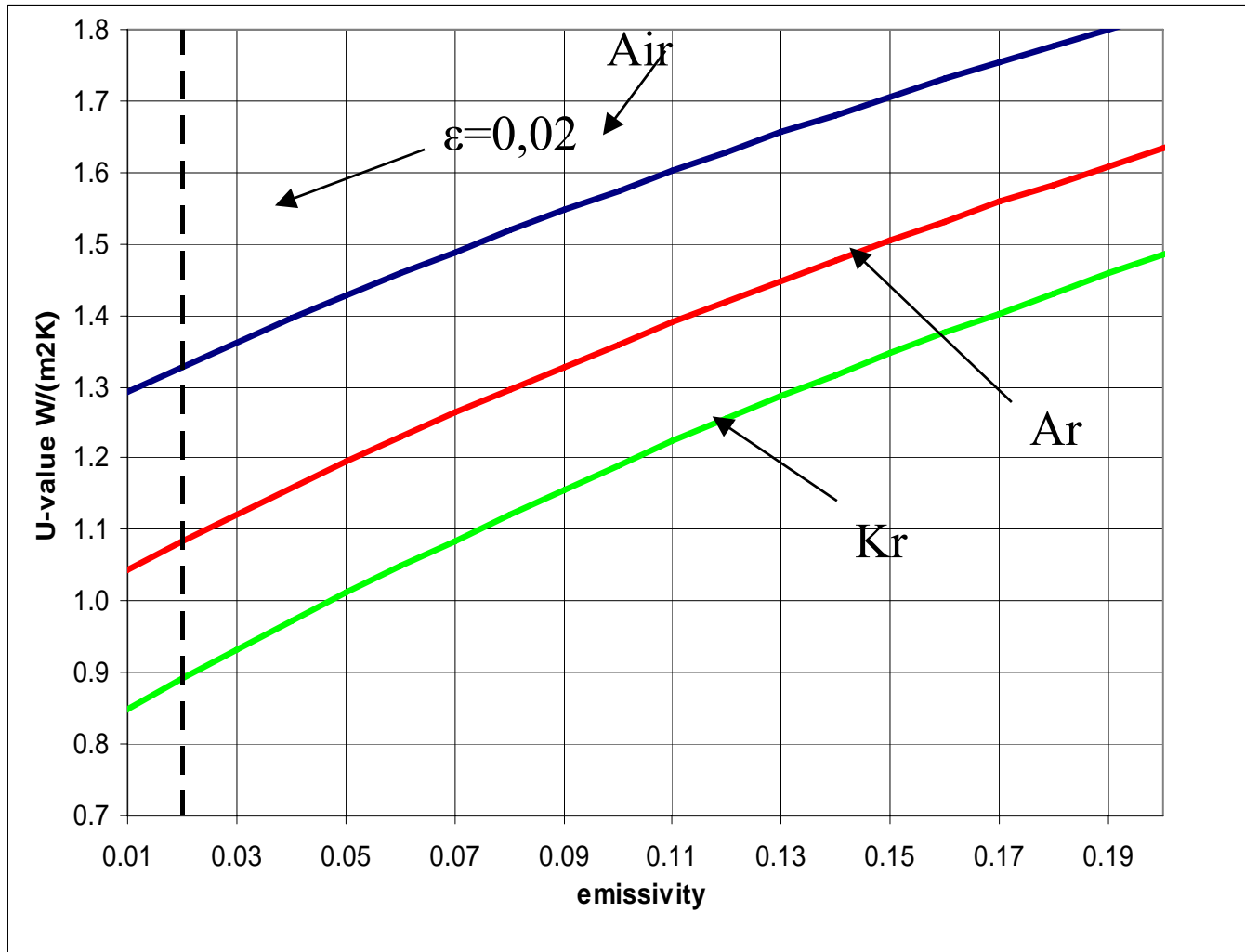
0°C



20°
C

Low E coatings

Double glazing – U-value



Low E coatings

Low emissivity = high reflectivity for IR-Radiation
(wavelength $5\mu\text{m} - 50\mu\text{m}$)

→ conductive layer

conductive oxide or high conductive metal

$\text{SnO}_2:\text{F}$

Ag

K glass

Optitherm SN

On-line coating

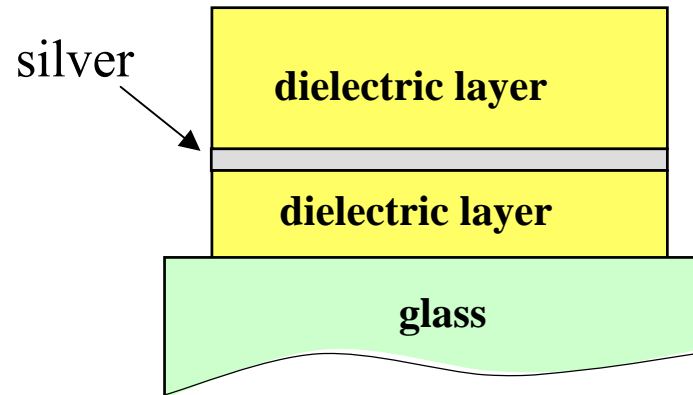
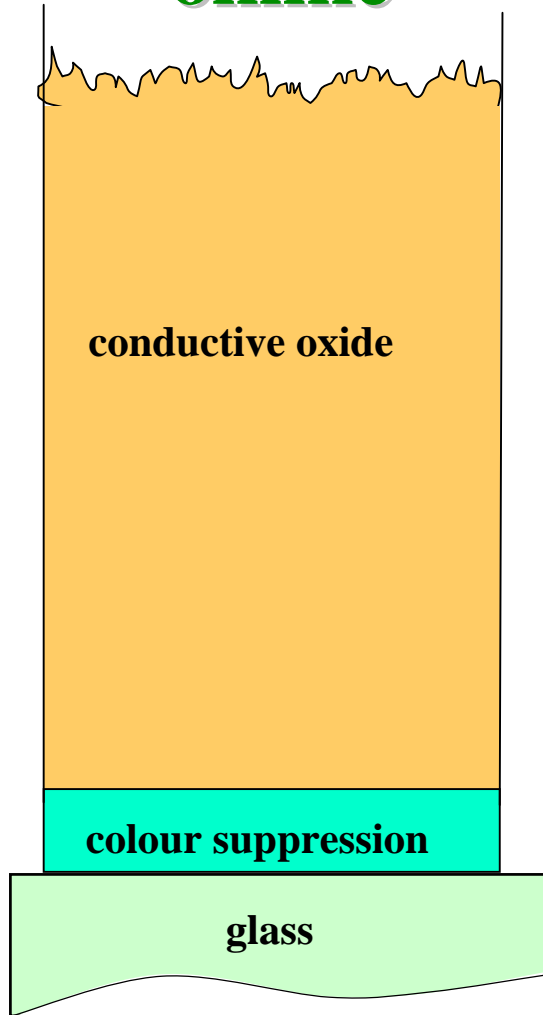
offline coating

Low E coatings

online

-

offline



Low E coatings

advantages - disadvantages

K glass

Advantages

Online
scratch resistant
humidity resistant
possible for single glazings

Disadvantages

Limited performance $\epsilon > 0,12$

Optitherm

Advantages

High performance $\epsilon < 0,03$
No Haze
High transmittion

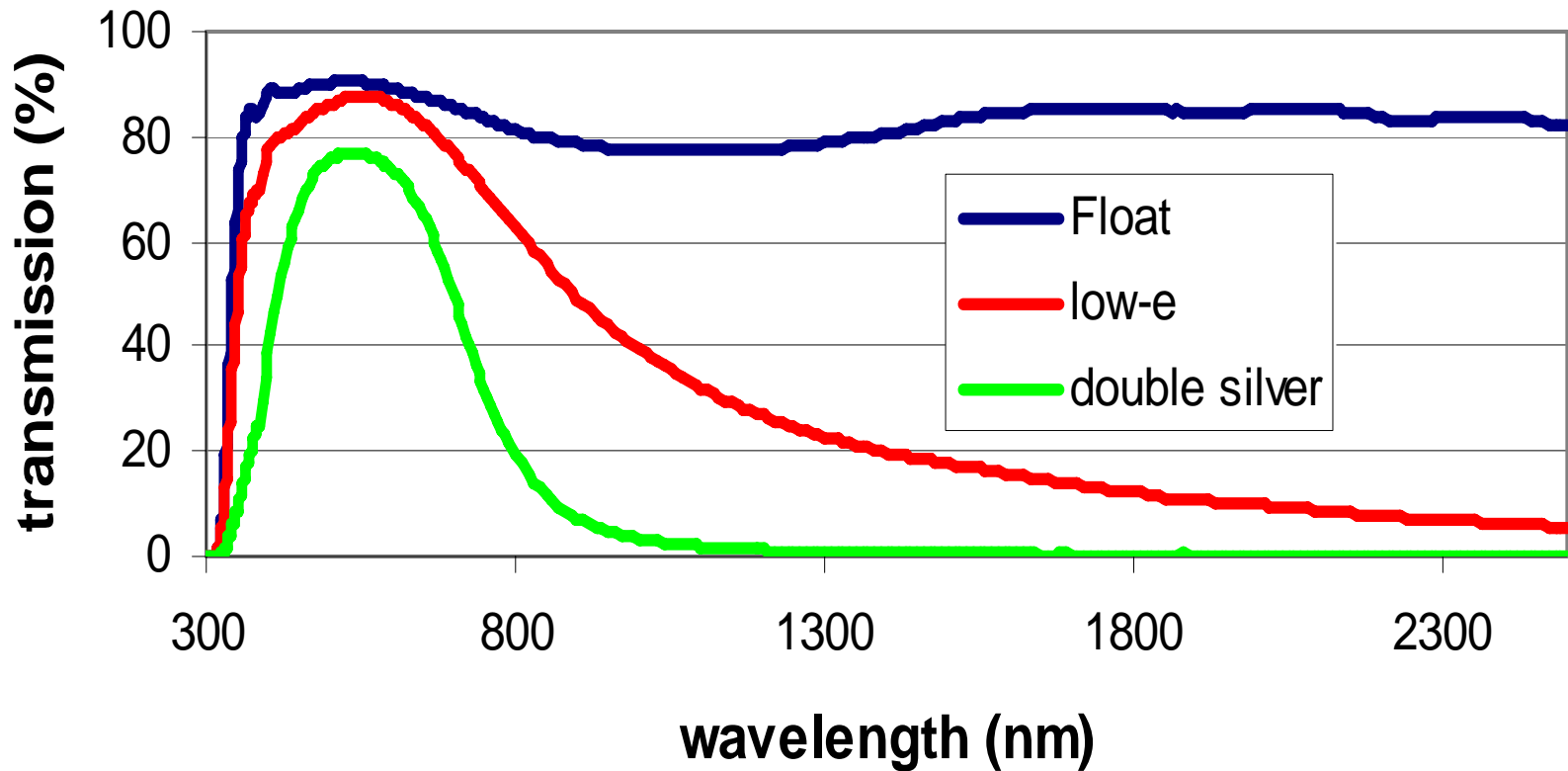
Disadvantages

vaccum process
limit storage time
needs special processing
stable only in insulating glass



Low-e and solar control

Comparison uncoated glass - low E glass

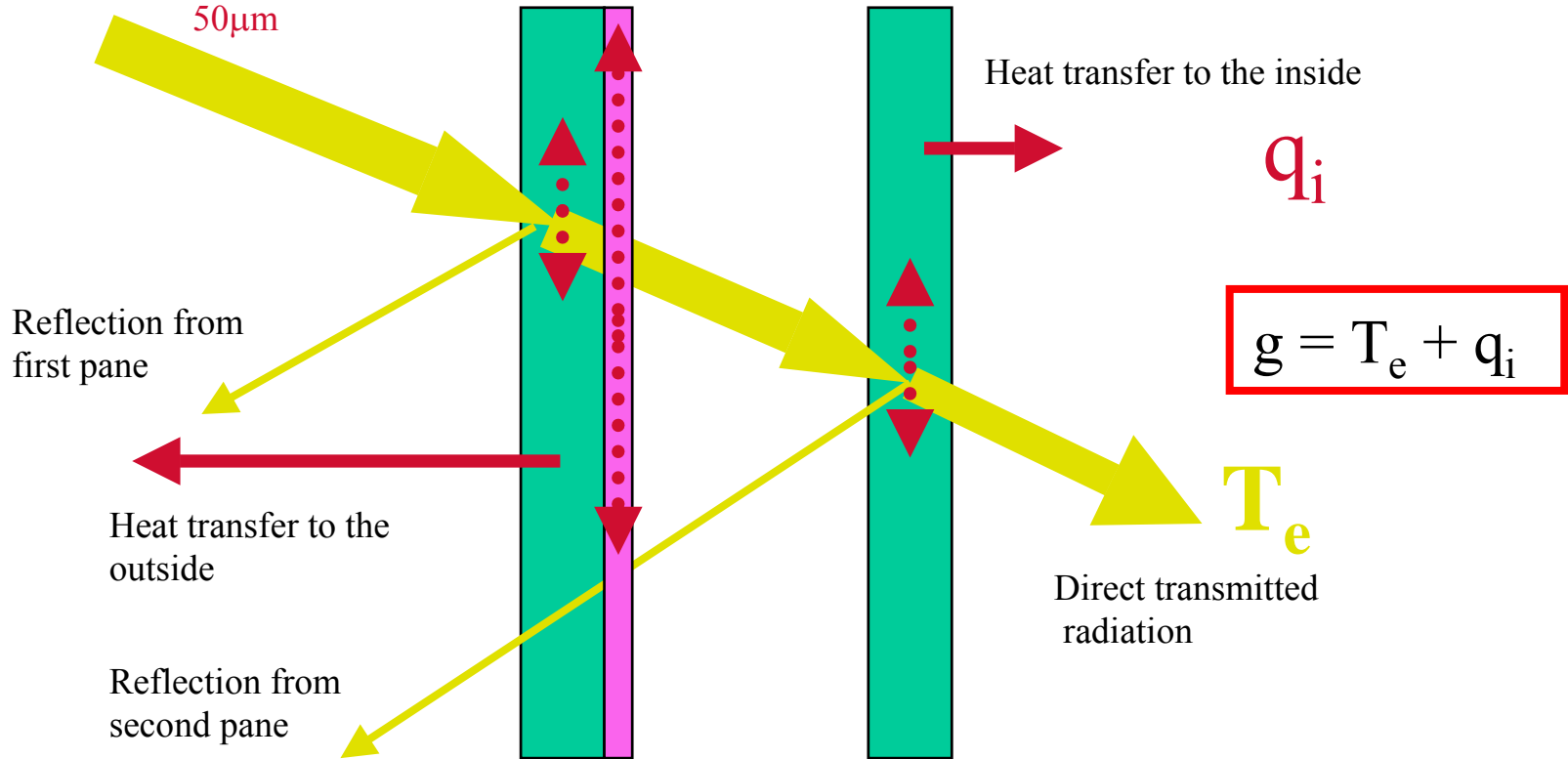


Solar control coatings

Position of the solar control coating

solar radiation
300nm - 2500nm

Absorbed radiation = heat
300nm-2500nm -> 5μm-
50μm

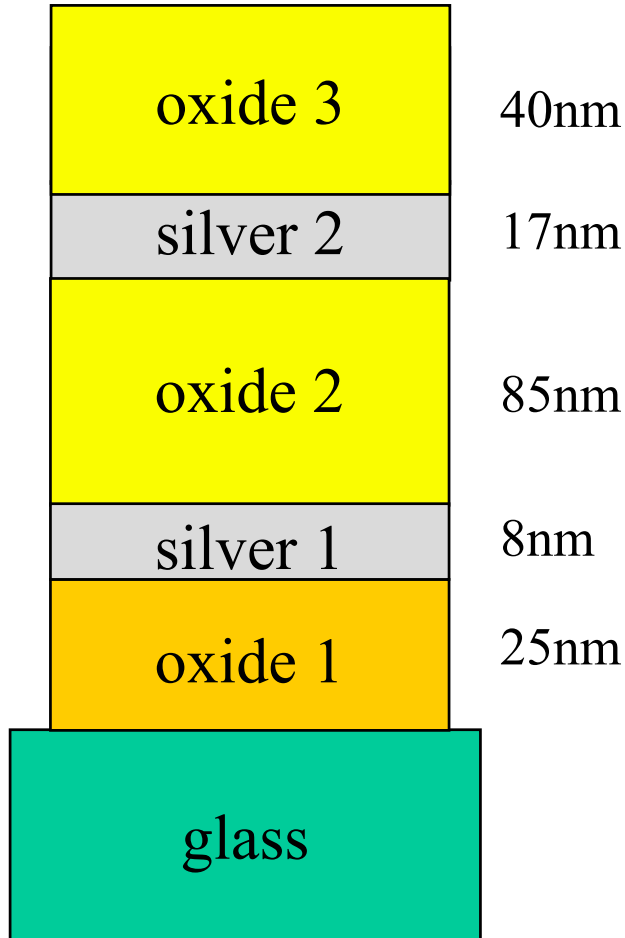


g should be low - coating should be on pos. 2



Solar control coatings

Example: double silver coatings



thickness variations for $\Delta E^* \leq 3$
have to be less than 2%.

2% of 8nm silver is 0.16nm,
which is about one atomic layer

Solar control coatings

DGU (6 mm clear / 16 mm Ar / 4 mm clear)					
product	g-value	T_L	$R_{L\ out}$	$R_{L\ inside}$	ε_n
PILKINGTON Suncool™ Brilliant 66/33	0,36	0,66	0,15	0,16	0,02
PILKINGTON Suncool™ Brilliant 50/25	0,27	0,50	0,18	0,16	0,02
PILKINGTON Suncool™ Clear 65/41	0,43	0,65	0,22	0,19	0,03
PILKINGTON Suncool™ Neutral 53/40	0,42	0,53	0,08	0,19	0,08
PILKINGTON Suncool™ Neutral 51/37	0,39	0,51	0,17	0,10	0,09
PILKINGTON Suncool™ Silver 50/30	0,32	0,50	0,39	0,33	0,02
PILKINGTON Suncool™ Neutral 70/40	0,43	0,71	0,10	0,11	0,03
PILKINGTON Suncool™ Brilliant Blue 50/27	0,29	0,50	0,19	0,15	0,02
PILKINGTON Suncool™ Brilliant 30/17	0,19	0,30	0,26	0,17	0,02



Self cleaning coatings

Pilkington Activ™

- **Self Cleaning performance uses two properties**
 - **Hydrophilic water sheet action and**
 - **Photo decomposition of organic material**

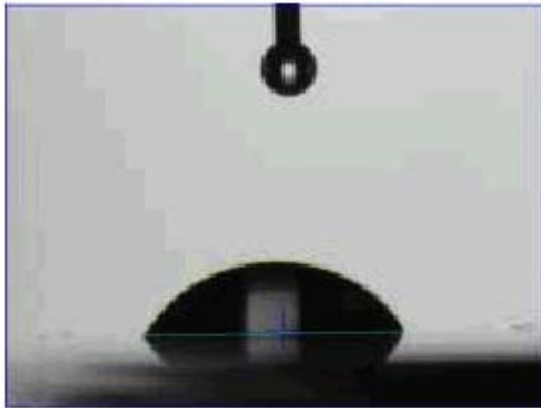
Properties reduce dirt build up and reduce the maintenance required



Pilkington Activ™

Changes in wetting properties with UV Exposure

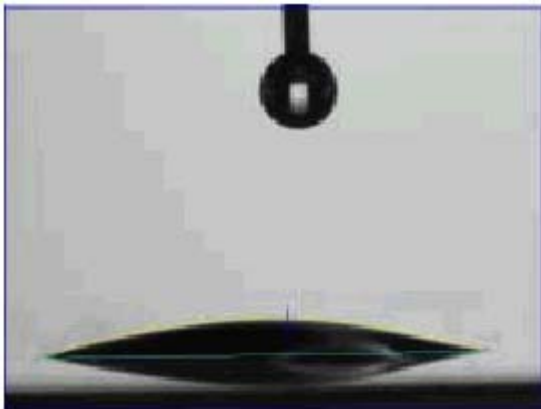
Before UV Exposure



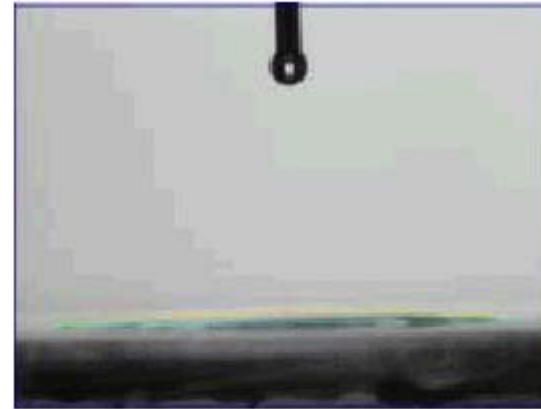
15 mins UV Exposure



30 mins UV Exposure



45 mins UV Exposure



PILKINGTON

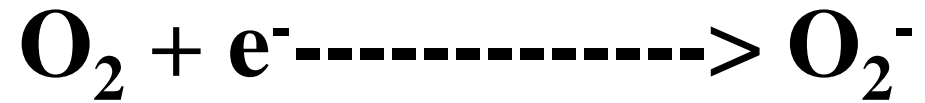
Pilkington Activ™

Comparisons of Titania Coated and Float Glass

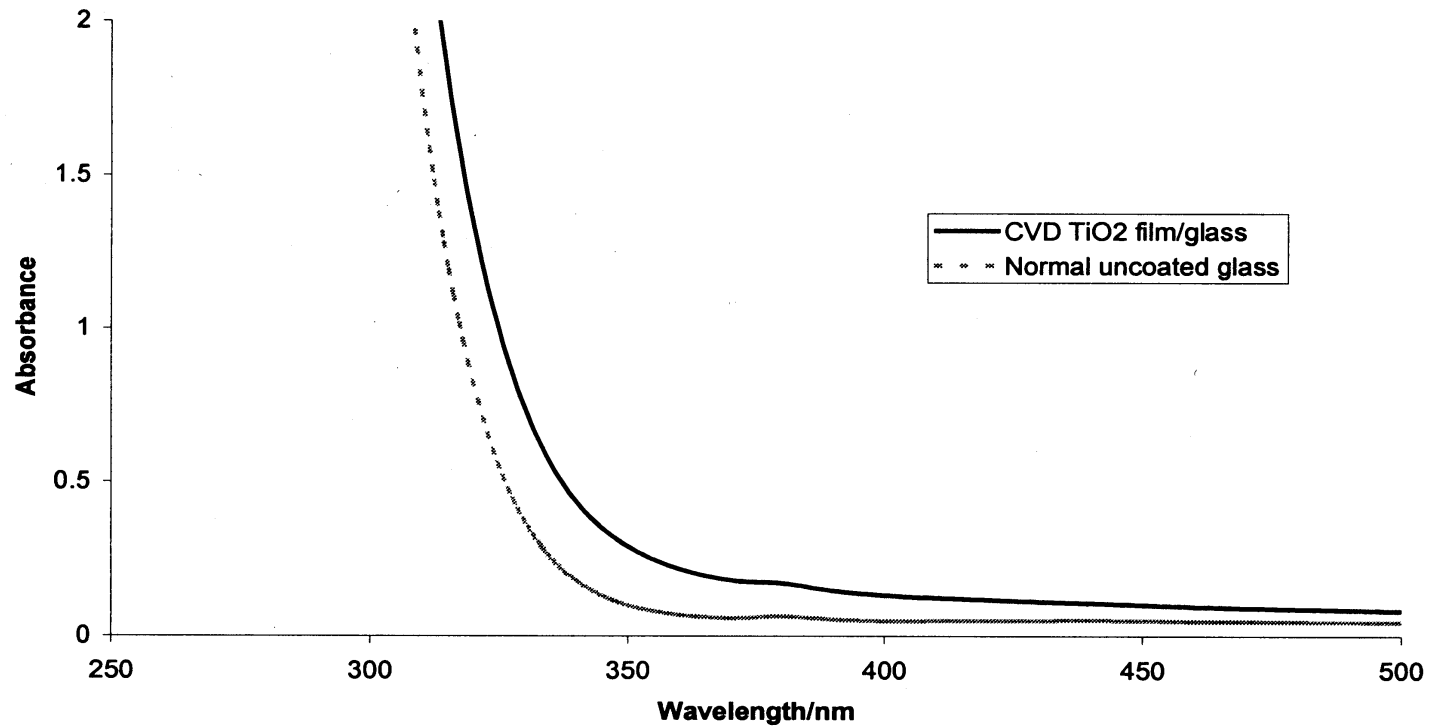


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Resulting Reactions



Pilkington Activ™

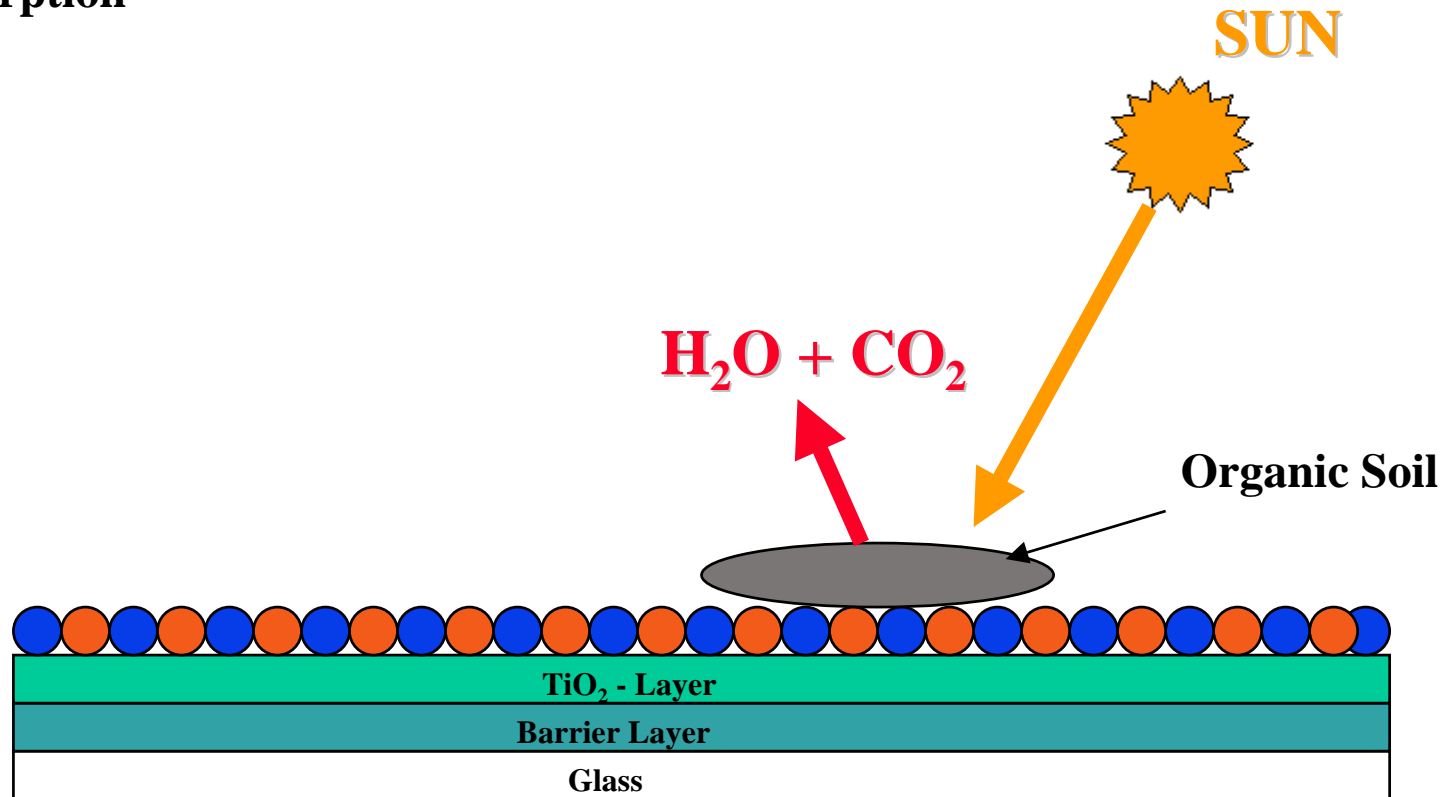


Pilkington Activ™

Photocatalytic Effect

UV-Absorption

- O_2^-
- OH^*



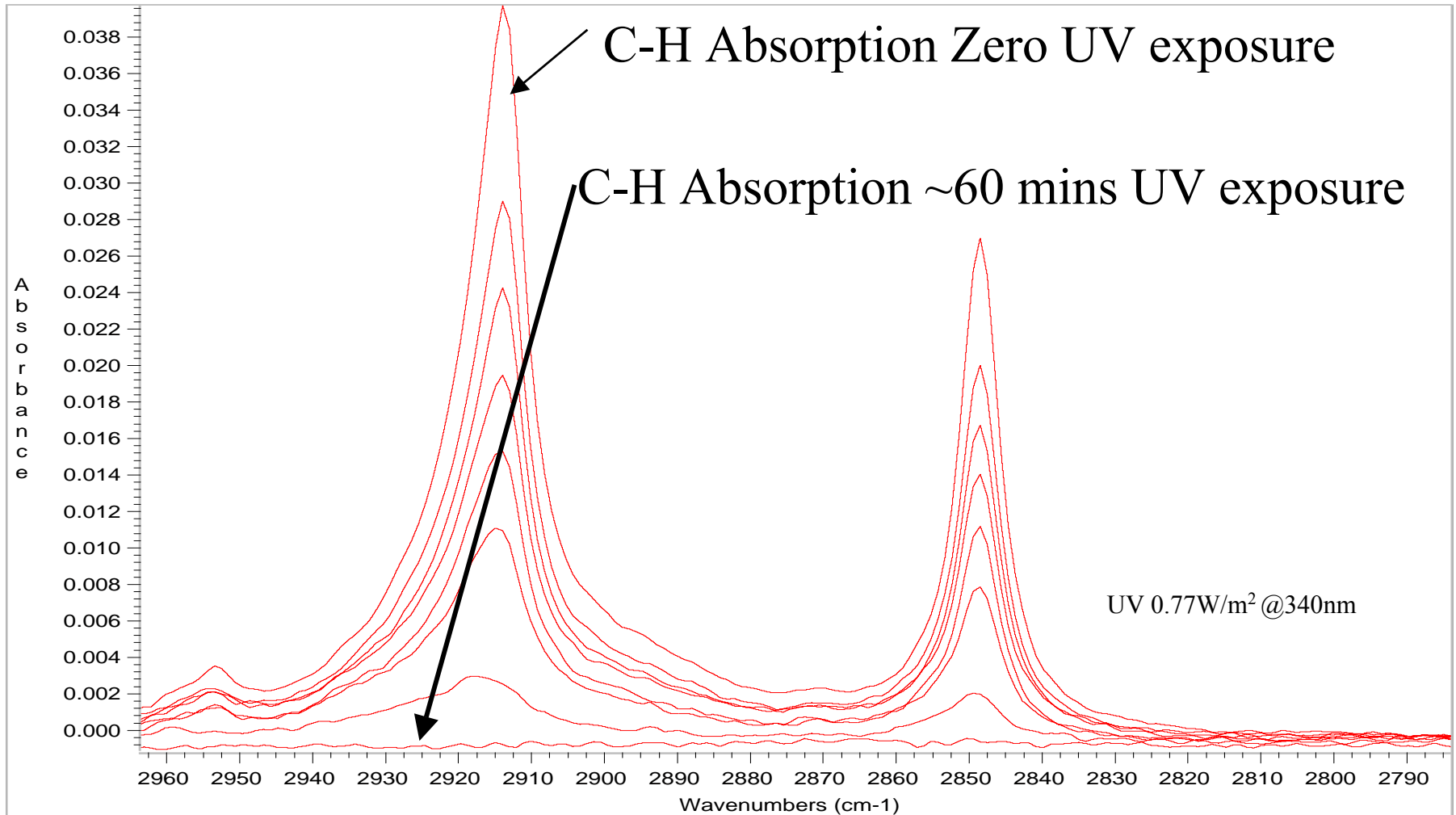
Pilkington Activ™

The photoactivity of the coating can be measured by monitoring the decomposition of a standard contaminant

- A thin film of stearic acid ($\sim 200\text{\AA}$) is applied from a methanol solution onto the coating
 - Stearic acid used as a typical organic contaminant
 - FTIR (Fourier transform infra-red spectroscopy) used to detect C-H stretch of stearic acid
 - C-H absorption intensity measured after varying UV exposure



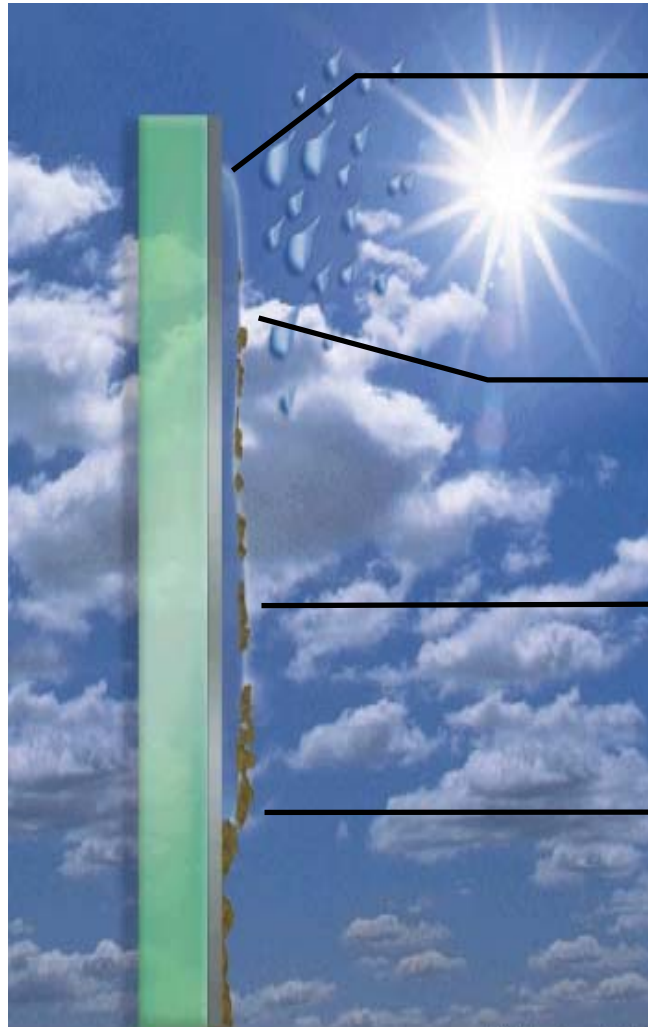
Stearic Acid Decomposition



Pilkington Activ™

The coating's **photoactivity** breaks down **organic** material reducing adherence of dirt to surface.

The coating's **hydrophilic** action then helps to wash off the dirt



**Water Droplets
Coalesce To Form
“Sheet”**

**Water Droplets Spread
Out On Surface Due To
Hydrophilicity**

**Dirt Particles On Surface
Picked Up in Water**

**Dirt Washed Down In
“Sheet” of Water and Off
Glass**

Pilkington Activ™



PILKINGTON

Clear Float / Pilkington Activ™ Comparison



PILKINGTON