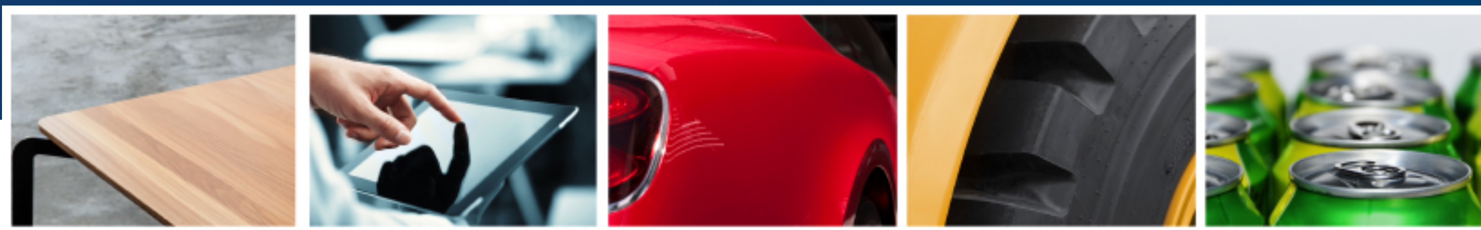
19 March 2020

Achieving Ultra-low Gloss Coatings Through the Use of Excimer Technology

Jonathan Shaw, Ph.D.



RADTECH UV+EB 2020

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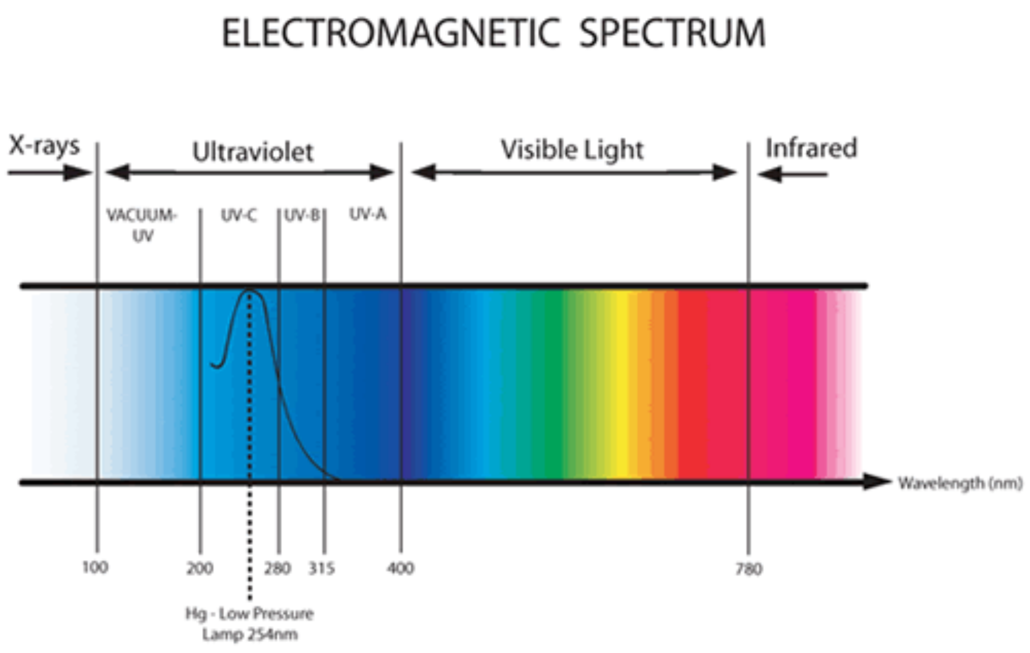
What is Ultra-Violet (UV) curing?

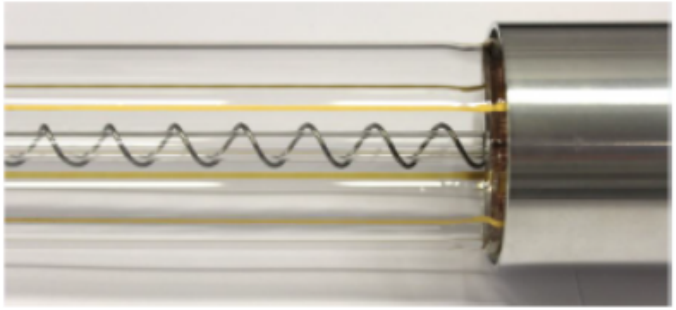
- Using UV energy or visible light, as opposed to heat, solvent evaporation, or oxidation (air-drying), to convert a liquid formulation into a solid material
- Types of energy used:
  - Ultra Violet (UV): 200 – 400 nm
  - Visible light: typically 380 - 450 nm

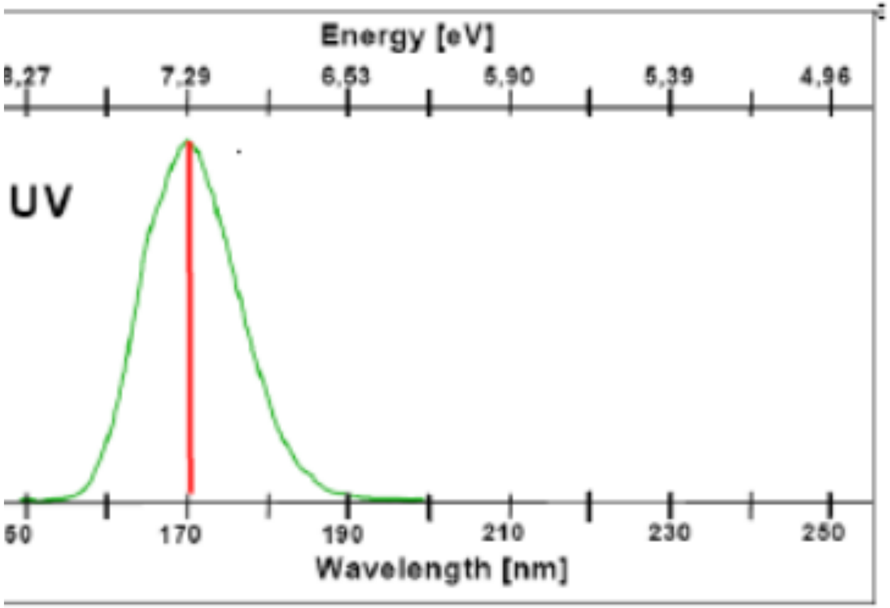


Advantages of 100% Solids UV Curable Systems

- Productivity, Productivity, Productivity
  - Seconds to cure vs. minutes or hours
- Lower Overall Cost (per cured part)
  - 100% solids, cure speed, recycling of coating, etc.
- Single component formulas
  - Eliminates mixing errors found in 2 component systems
- Regulatory Concerns (VOC emission)
  - Avoid solvent use in most cases
- Smaller equipment footprint
  - Less floor space needed
- Energy costs

Excimer Lamp Technology





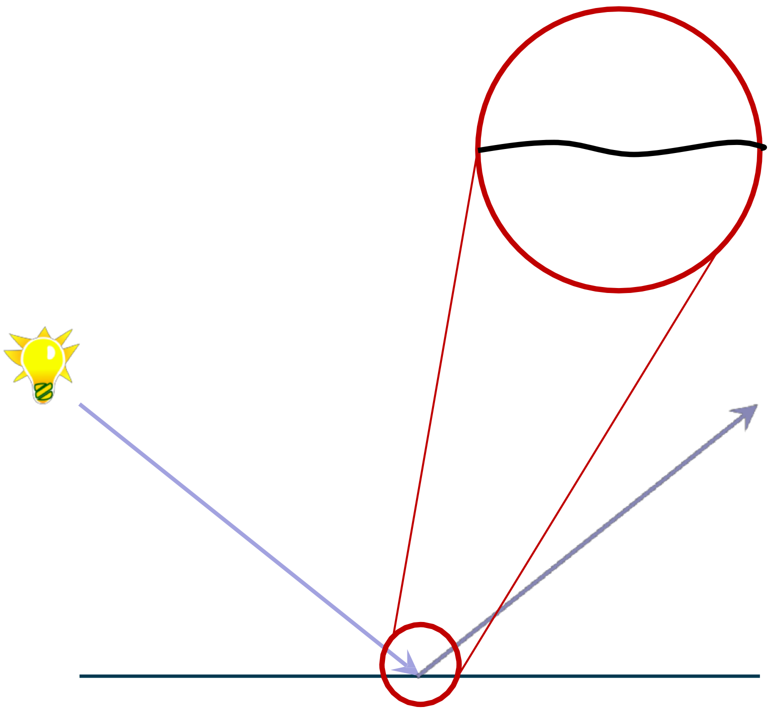
- Monochromatic irradiance centered at 172 nm (VUV)
  - Other wavelengths possible using different gas, e.g. KrCl (222nm) or XeCl (308nm)
- Inert atmosphere required
  - 5-50ppm O_2

Source: IST, "Excimer Technology and Applications

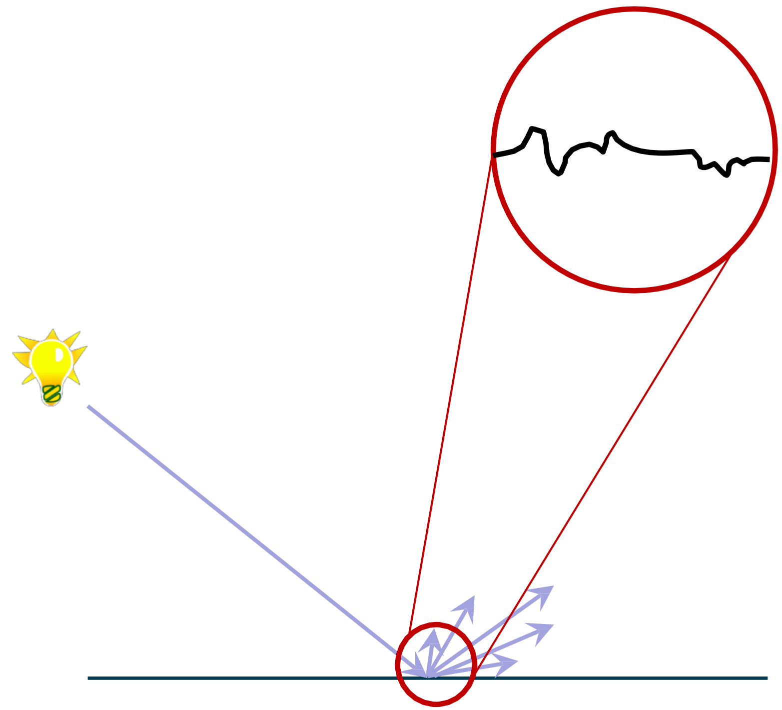
Excimer Lamp Technology

- Excimer line in Pilot Hall

Matting: Gloss vs. Matte Coatings

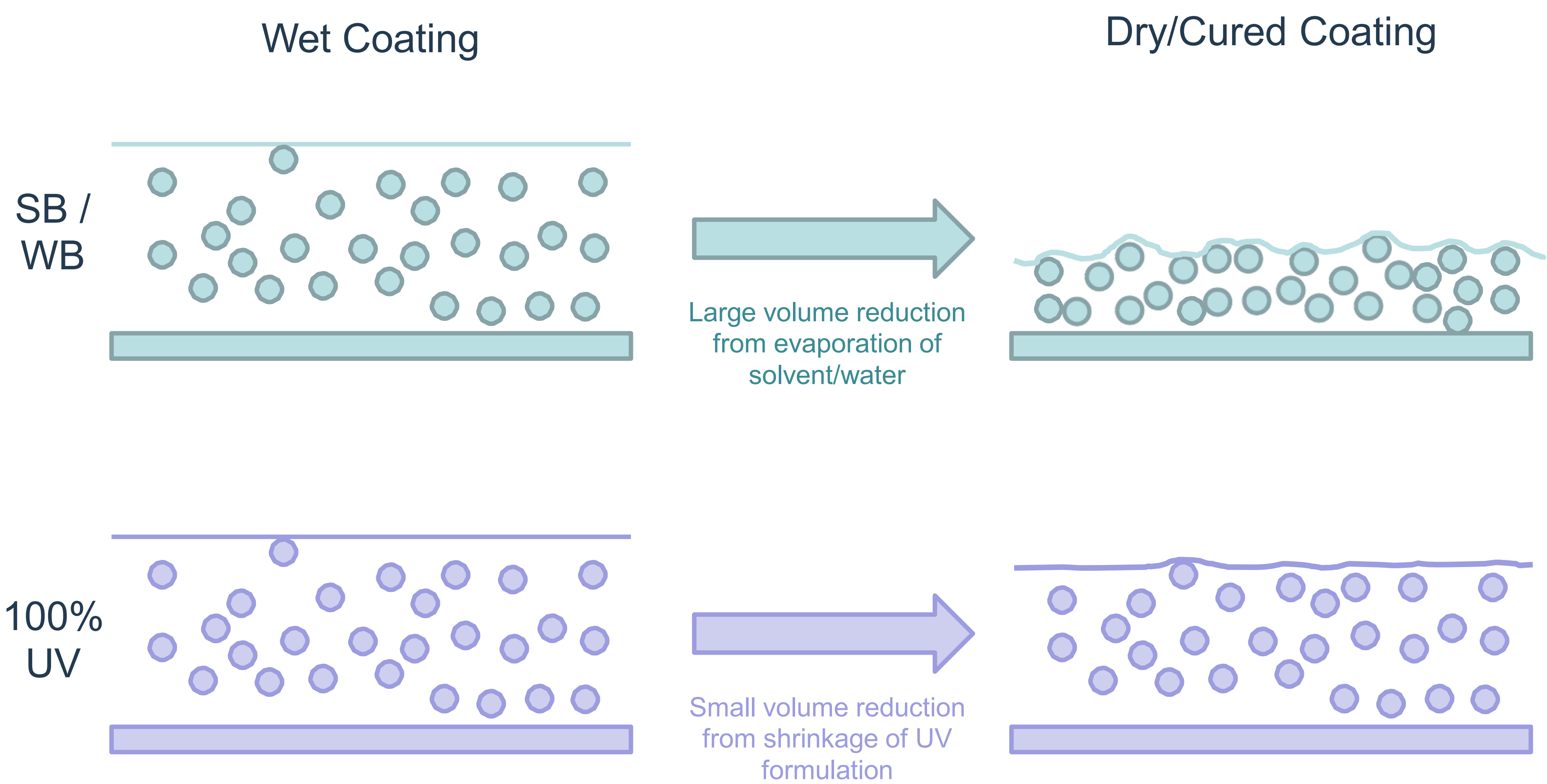


High Gloss Coating

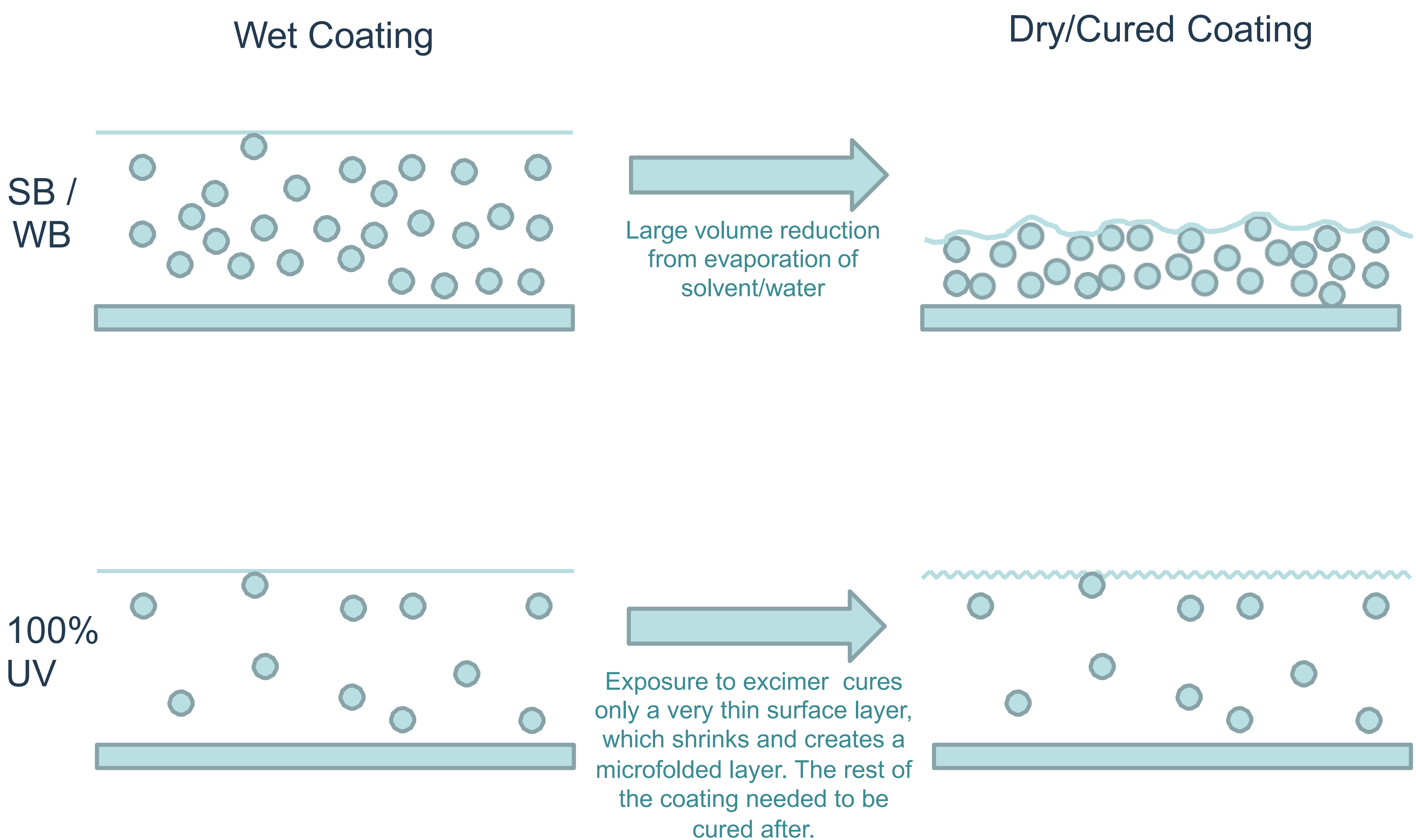


Matte Coating

Matting: SB/WB vs. 100% Solids Formulation



Matting: SB/WB vs. Excimer Cured 100% Solids



Formulations for Excimer vs. Hg Cure on LVT

Raw Material	Function	Original LVT	Modified LVT	Stnd Wood Ctg
ALUA 1	Film properties – hardness	14.0		
ALUA 2	Film properties – toughness	11.9	16.4	
ALUA 3	Film properties – hardness		16.4	
ALUA 4	Film properties – toughness		5.5	
ALUA 5	Film properties – toughness			29.3
PEA 1	Film properties – hardness			9.8
TPDGA	Viscosity control			41.1
HDDA	Viscosity control	28.0	18.6	
TMPTA	Viscosity control, XLD	25.4		
Diluent 1	Viscosity control, flexibility		10.9	
Diluent 2	Viscosity control, hardness		5.5	
Photoinitiator 1	Cure	3.4	4.4	2.9
Photoinitiator 2	Cure			2.0
Silicas	Gloss control	8.5	10.9	9.8
Waxes	Gloss control	6.3	8.2	2.0
Additives	Flow and leveling, wetting, dispersion	2.5	3.2	3.3

Note: Silica, waxes and additives are not the same for each formula

Formulations for Excimer vs. Hg Cure on LVT

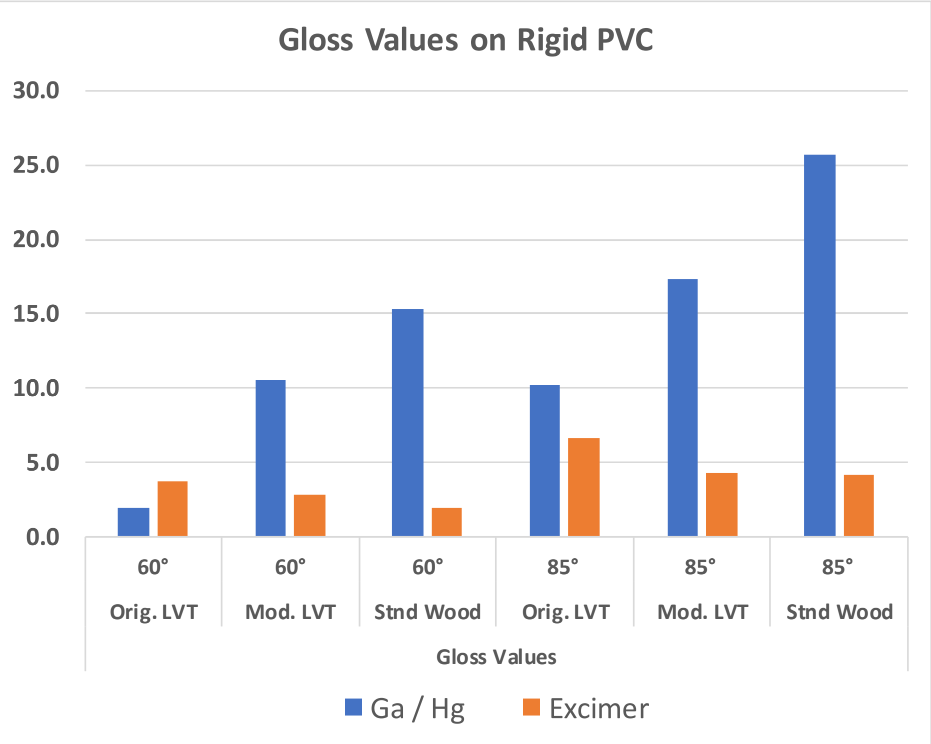
	Original LVT		Modified LVT		Stnd Wood Ctg.	
Flexible PVC	**Gloss Values**					
	60°	85°	60°	85°	60°	85°
Ga / Hg	2.7	6.3	16.4	24.8	18.3	28.0
Excimer	4.3	7.8	3.2	4.0	2.8	6.3
Rigid PVC	**Gloss Values**					
	60°	85°	60°	85°	60°	85°
Ga / Hg	1.9	10.2	10.5	17.3	15.3	25.7
Excimer	3.7	6.6	2.8	4.3	1.9	4.2

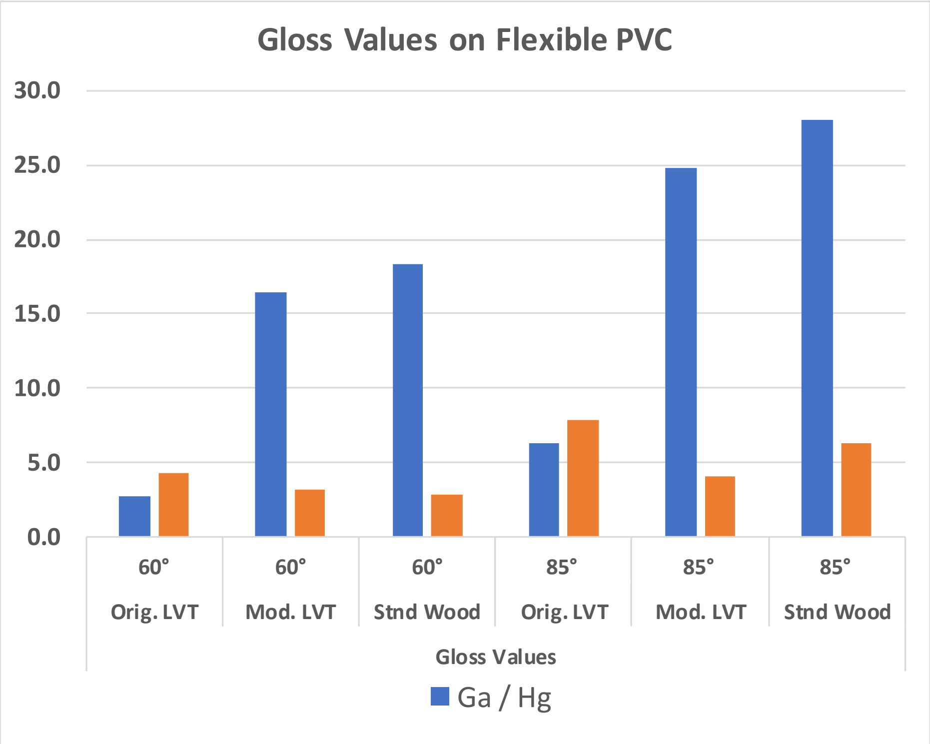
Ga / Hg – Cure using 100 WPI Ga followed by a 200 WPI Hg lamp at 25

Excimer - Cure using excimer lamp at 65 fpm followed by 200 WPI Hg lamp at 25 fpm

Coat Weight - Application by roller coater: 6-10g/m² estimated coating weight

Formulations for Excimer vs. Hg Cure on LVT





Ga / Hg – Cure using 100 WPI Ga followed by a 200 WPI Hg lamp at 25

Excimer - Cure using excimer lamp at 65 fpm followed by 200 WPI Hg lamp at 25 fpm

Coat Weight - Application by roller coater: 6-10g/m² estimated coating weight

Formulations for Excimer vs. Hg Cure at Different DFT

	Original LVT		Modified LVT	
	Gloss Values			
Leneta - 20um wet	**60°**	**85°**	**60°**	**85°**
Ga / Hg	12.5	52.6	31.15	66.65
Excimer / Hg	Ice flowers		Ice flowers	
Ga / Excimer / Hg	4.75	49.4	4.25	59.2
Leneta - 12um wet	**60°**	**85°**	**60°**	**85°**
Ga / Hg	8.25	42.7	31.8	74.9
Excimer (slow) / Hg	3.75	6	Ice flowers	
Leneta - 6um wet	**60°**	**85°**	**60°**	**85°**
Ga / Hg	8	45.15	2.6	71.45
Excimer (slow) / Hg	3.9	7.2	2.6	5.6
LED / Excimer / Hg	4.1	7.6	2.75	4.35

Ga / Hg – Cure using 100 WPI Ga followed by a 200 WPI Hg lamp at 25

Excimer / Hg - Cure using excimer lamp at 65 fpm followed by 200 WPI Hg lamp at 25 fpm

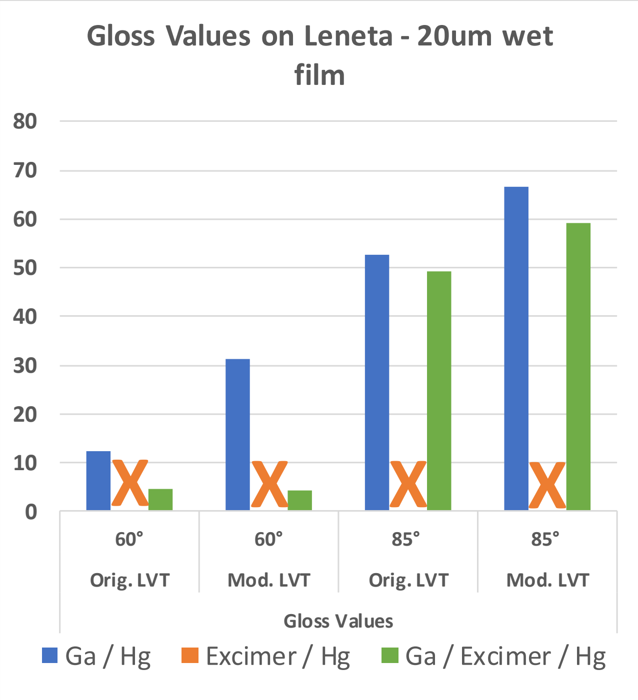
Ga / Excimer / Hg – Cure using 100 WPI Ga lamp at 65 fpm then excimer then 200 WPI Hg at 25 fpm

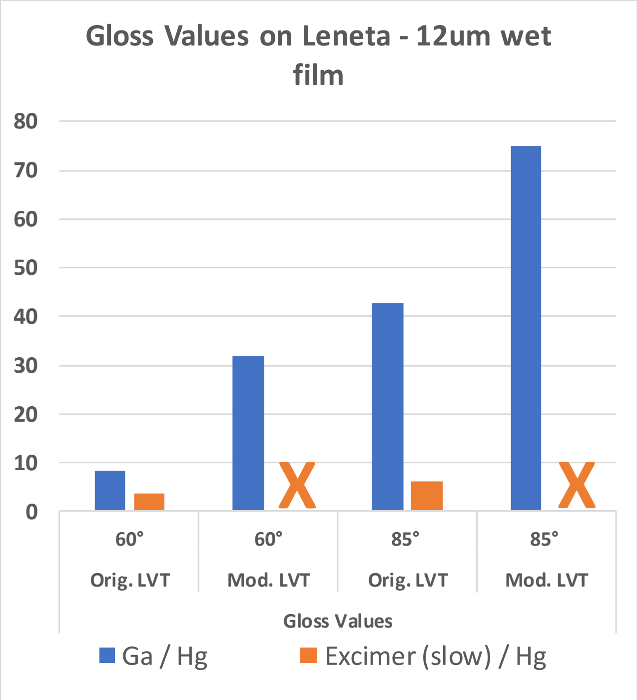
Excimer (slow) / Hg – Cure using excimer lamp at 32 fpm followed by 200 WPI Hg lamp at 25 fpm

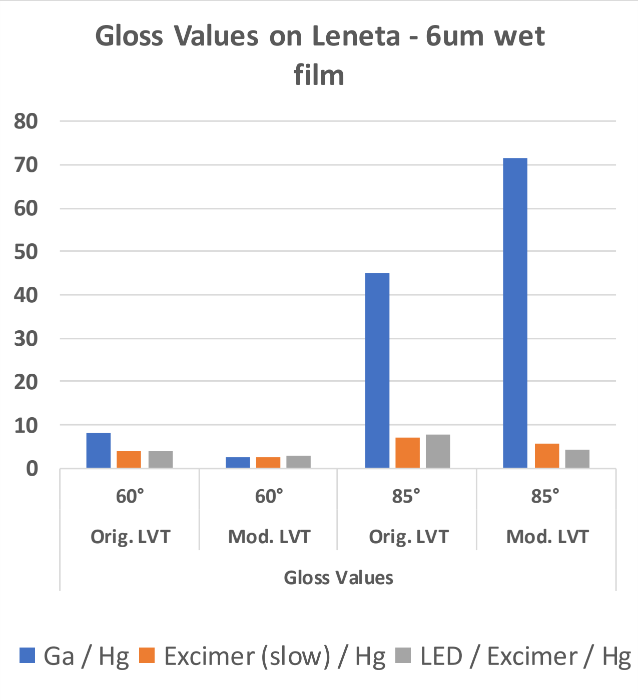
LED / Excimer / Hg – Cure using 395nm LED at 65 fpm then excimer at 65 fpm then 200 WPI Hg at 25 fpm

Formulations for Excimer vs. Hg Cure – "Ice Flowers"

Formulations for Excimer vs. Hg Cure at Different DFT







Ga / Hg – Cure using 100 WPI Ga followed by a 200 WPI Hg lamp at 25

Excimer / Hg - Cure using excimer lamp at 65 fpm followed by 200 WPI Hg lamp at 25 fpm

Ga / Excimer / Hg – Cure using 100 WPI Ga lamp at 65 fpm then excimer then 200 WPI Hg at 25 fpm

Excimer (slow) / Hg – Cure using excimer lamp at 32 fpm followed by 200 WPI Hg lamp at 25 fpm

LED / Excimer / Hg – Cure using 395nm LED at 65 fpm then excimer at 65 fpm then 200 WPI Hg at 25 fpm

Formulations for Excimer vs. Hg Cure

- Resilient flooring coated with formulation based on ALUA 2, ALUA 3, ALUA 4
- Left side of each picture shows a piece of coated PVC cured using Hg lamp
  - 60° gloss = 28.5 / 85° gloss = 54.4
- Right side of each picture shows a piece of coated PVC cured using Excimer + Hg
  - 60° gloss = 3.0 / 85° gloss = 4.2

Formulations for Excimer vs. Hg Cure – Film Properties

	Control	A	B	C
ALUA 5	41	41	41	41
DPGDA	55	55	55	55
Photoinitiator 1	4	4	4	5.2
Nano-composite UA		10		
Silicone acrylate			1	
6f ALUA				40

Cure :

1. Pre-gelling with 40W Ga (10m/min)
2. Excimer (20m/min) 40% output
3. Either UV or EB for final cure (next slide)

Formulations for Excimer vs. Hg Cure – Film Properties

	A	B	C	D
Final cure 1: 10m/min 120W Hg				
Gloss (60° / 85°)	3.1 / 17.4	2.9 / 19.3	1.5 / 11.4	2.5 / 16.5
Marring	na	Slightly poorer	Slightly poorer	Slightly poorer
Coffee	5	5	5	5
Mustard	5	5	5	5
Final cure 2: EB 250kV – 5Mrad				
Gloss (60° / 85°)	2.8 / 14.0	1.9 / 13.1	1.3 / 8.0	2.2 / 14.3
Marring	na	Same or better	Same or better	Same or better
Coffee	5	5	5	5
Mustard	5	5	5	5

- All coatings showed excellent stain resistance to mustard and coffee
- Mar resistance was slightly poorer with UV cure as final step
- Mar resistance could be improved by using EB cure as final step

Conclusions and Observations

- Inert Excimer cure as positive effect on stain resistance
- Including Excimer lamps in cure process decreases gloss of final coating
  - Standard UV cure: 15-18 gloss at 60°
  - Matted directly with the Excimer followed by Hg lamp: gloss 1-3.
- Inert atmosphere required (5-50ppm O_2)
- Stain resistance *may* be increased (inert atmosphere). Unfortunately, not iodine stain
- Pre-gelling is needed in most cases.
- Post cure is a must by UV or EB cure: often short open time.
- Every 100% UV recipe has is preferred settings:
- Coatings below gloss 5 have week marring resistance.

Acknowledgements

Guido Vanmeulder (Drogenbos, Belgium)

Thank you

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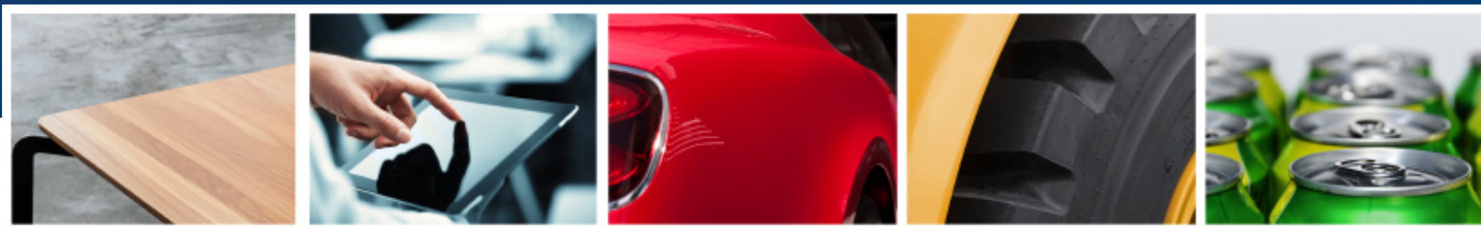

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