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Report:

Optical Data measurement and performance indices calculation of a glass samples with Sapphire 60 applied film

Report prepared for: ***A & B Films Pte Ltd***
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A & B Films Pte Ltd contracted Carli Inc for the optical data measurement and data preparation of a glass samples with Sapphire 60 applied film. The films were mounted on a 5 mm clear reference glass sample.

Test Methods and Procedures

Optical data Measurements

UV-Vis-NIR Measurements:
Total transmittance and total reflectance factor measurements were performed with ODA's Varian™ Cary 500E ™ UV-Vis-NIR Double Beam Spectrophometer equipped with a 150 mm diameter Labsphere™ Spectralon™ reference standard. Baselines are measured before and after the sample measurements, a zeroline is measured after the sample measurements and a didymia transmittance standard is measured during each set of measurements to verify the wavelength scale. For transmittance and reflectance factor, the angle of incidence is 0^o and 7^o, respectively. The typical wavelength interval is 5nm.

IR Measurements:

Specular transmittance and specular reflectance factor measurements are performed with ODA's Perking-Elmer™ 9836 G IR Double-Beam IR Spectrophotometer equipped with Perking-Elmer™ Specular Reflectance Accessory. The wavelength range is 2 to 56 μm. In reflectance, measurements are made with respect to a protected aluminum specular reflectance reference standard from National Physical Laboratory ™ [NPL}in the United Kingdom. Baselines are measured before and after the sample measurements, a zeroline is measured after the sample measurements, and a polystyrene transmittance standard is measured during each set of measurements to verify the wavelength scale. For transmittance and reflectance factor, the angle of incidence is 0^o and 7^o, respectively. The wavelength interval is $10cm^{-1}$. This is the method adopted by the Lawrence Berkeley National Laboratory [LBNL}.

The optical properties of glasses with films are summarized in Table 1 and the graphical details are shown in Appendix 1.

Table 1: Optical properties of the glass with Sapphire 60 applied film

Product Name	Thick-ness	Solar			Visible			Emissivity	
	mm	Tsol	$R_f$sol	$R_b$sol	Tvis	$R_f$vis	$R_b$vis	Front	Back
Sapphire 60	4.91	0.437	0.335	0.236	0.621	0.200	0.172	0.74	0.84

Note: Subscript f and b represent front and back respectively. Films are applied at the front side. T and R denote transmittance and reflectance respectively.

Optical Data Calculations

The centre of glass U factor, SHGC (Solar Heat Gain Coefficient), Shading Coefficient, Visible Transmittance and Relative heat gains of the glass with applied film, assuming it as a single glazed unit, was calculated using WINDOW5 and the values are given in Table 2 below: **The film side of the glass faces the indoor environment.**

Table 2: Thermal and optical properties of single glazing unit

Product Name	# of glass layer	Winter U-Factor	Summer U- Factor	SHGC	SC	Tvis	Relative Heat Gain	UV Indices		
		W/m^2K	W/m^2K				W/m^2	Tuv	Tdw-K	Tdw-ISO
Sapphire 60	1	5.54	4.97	0.53	0.61	0.62	424	0.008	0.218	0.446

The NFRC standard boundary conditions given below were used for the calculations in Table 2:

	ID	Name	U-factor Tin	U-factor Tout	SHGC Tin	SHGC Tout	SHGC Solar
			C	C	C	C	W/m2
	1	NFRC 100-2002	21.0	-18.0	24.0	32.0	783

Appendix 1.: Spectral properties of the glass sample with film.

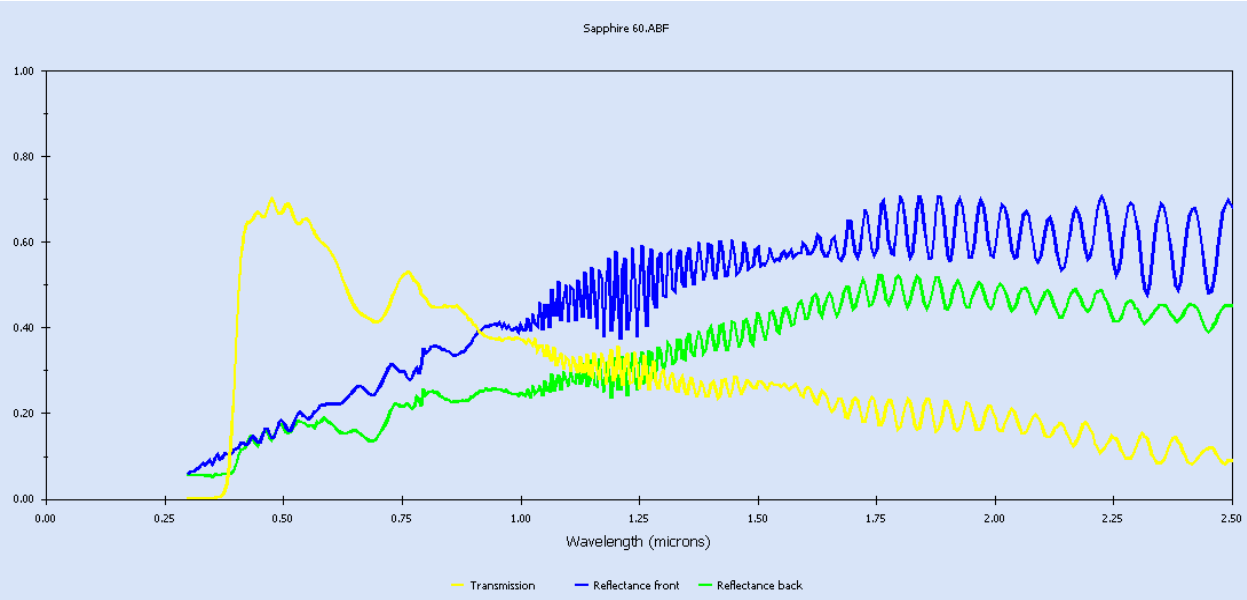

Figure 1: Spectral properties: Sapphire 60

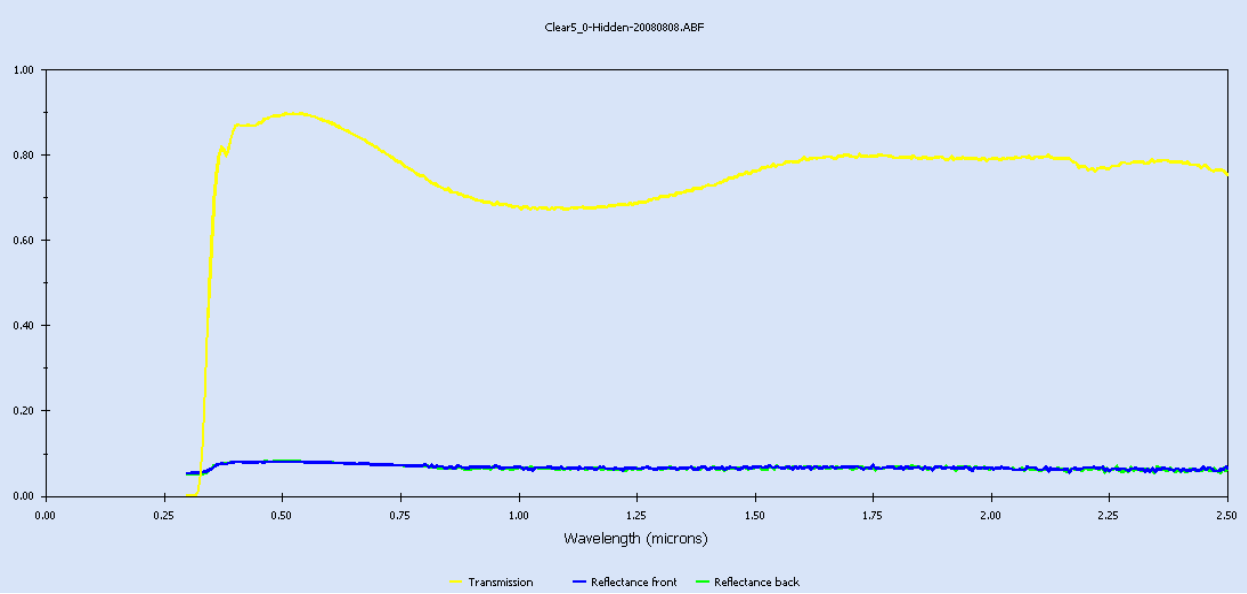

Figure 2: Spectral properties: Reference Glass sample (Substrate)

Appendix 2.: Detailed glazing data of a single glazed unit with film

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Window 5.2a  v5.2.17a Glazing System Thermal and Optical Properties 08/12/08
12:16:58

ID      : 14
Name    : Sapphire 60
Tilt    : 90.0
Glazings: 1
KEFF    : 0.1000
Width   : 4.913
Uvalue  : 5.54
SHGCc   : 0.53
SCc     : 0.61
Vtc     : 0.62
RHG     : 423.58

Glass and Gas Data for Glazing System '14 Saphire 60'

ID     Name            D(mm) Tsol  1 Rsol 2 Tvis  1 Rvis 2  Tir  1 Emis 2 Keff
------ --------------- ----- ---- ---- ---- ---- ---- ---- ---- ---- ---- ----
Outside
 30001FSapphire 60.ABF#  4.9 .437 .236 .335 .621 .172 .200 .000 .840 .740 .966
Inside


Environmental Conditions: 1 NFRC 100-2002

          Tout   Tin  WndSpd   Wnd Dir   Solar  Tsky  Esky
          (C)    (C)   (m/s)            (W/m2)  (C)
         -----  ----  ------  --------  ------  ----  ----
Uvalue   -18.0  21.0    5.50  Windward     0.0 -18.0  1.00
Solar     32.0  24.0    2.80  Windward   783.0  32.0  1.00

Optical Properties for Glazing System '14 Saphire 60'

Angle      0    10    20    30    40    50    60    70    80    90 Hemis

Vtc  : 0.621 0.626 0.618 0.608 0.596 0.575 0.528 0.430 0.259 0.000 0.543
Rf   : 0.172 0.165 0.164 0.167 0.176 0.192 0.222 0.302 0.515 0.999 0.215
Rb   : 0.200 0.193 0.192 0.195 0.204 0.219 0.248 0.326 0.532 0.999 0.241

Tsol : 0.437 0.440 0.434 0.427 0.419 0.405 0.371 0.302 0.182 0.000 0.382
Rf   : 0.236 0.230 0.228 0.231 0.240 0.254 0.282 0.356 0.553 0.999 0.275
Rb   : 0.335 0.330 0.328 0.331 0.338 0.351 0.375 0.440 0.611 0.999 0.367

Abs1 : 0.327 0.330 0.337 0.342 0.341 0.341 0.347 0.341 0.265 0.001 0.333

SHGCc: 0.526 0.530 0.527 0.521 0.513 0.498 0.466 0.396 0.254 0.000 0.473

Tdw-K  :  0.218
Tdw-ISO:  0.446
Tuv    :  0.008


      Temperature Distribution (degrees C)
        Winter         Summer
       Out   In       Out   In
      ----  ----     ----  ----
Lay1 -10.6  -9.5     38.9  38.9
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