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### **Report:**

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### **Optical Data measurement and performance indices calculation of a glass samples with Black Chrome 10 applied film**

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***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 Black Chrome 10 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 Spectrophotometer 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° and 7°, 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° and 7°, respectively. The wavelength interval is 10cm<sup>-1</sup>. 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 Black Chrome 10 applied film**

Product Name	Thick-ness	Solar			Visible			Emissivity	
	mm	T <sub>sol</sub>	R <sub>f, sol</sub>	R <sub>b, sol</sub>	T <sub>vis</sub>	R <sub>f, vis</sub>	R <sub>b, vis</sub>	Front	Back
Black Chrome 10	4.89	0.111	0.244	0.158	0.134	0.233	0.176	0.86	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	T <sub>vis</sub>	Relative Heat Gain	UV Indices		
		W/m <sup>2</sup> K	W/m <sup>2</sup> K				W/m <sup>2</sup>	T <sub>uv</sub>	T <sub>dw-K</sub>	T <sub>dw-ISO</sub>
Black Chrome 10	1	5.90	5.35	0.33	0.39	0.13	290	0.009	0.057	0.103

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

ID	Name	U-factor T <sub>in</sub>	U-factor T <sub>out</sub>	SHGC T <sub>in</sub>	SHGC T <sub>out</sub>	SHGC Solar
		C	C	C	C	W/m <sup>2</sup>
1	NFRC 100-2002	21.0	-18.0	24.0	32.0	783

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

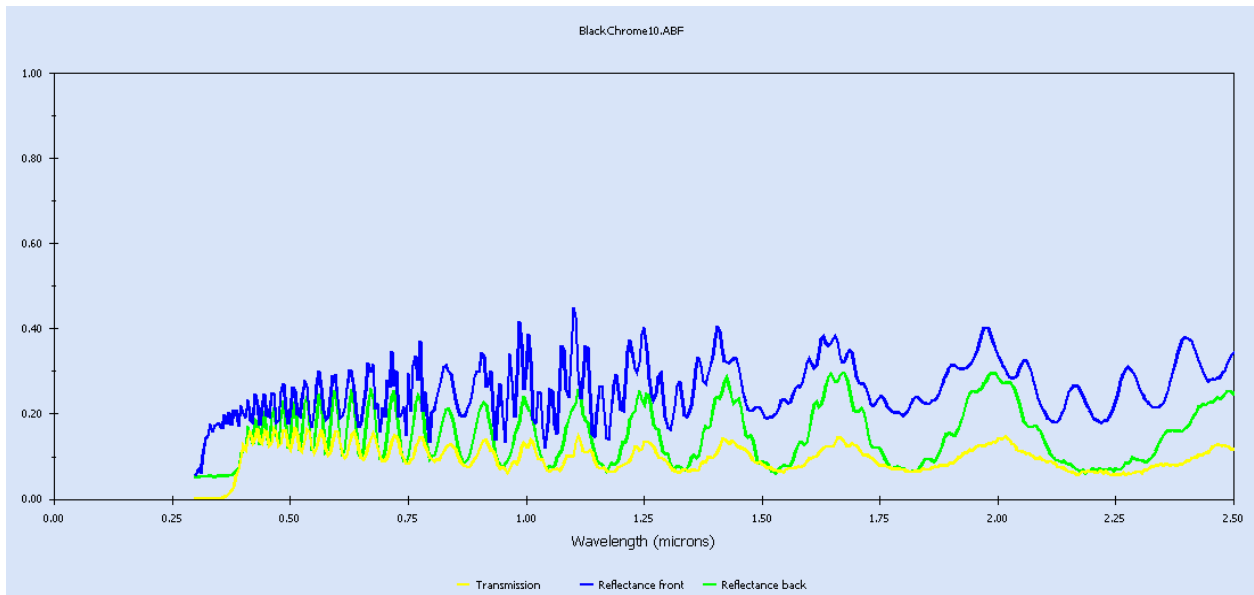


Figure 1: Spectral properties: Black Chrome 10

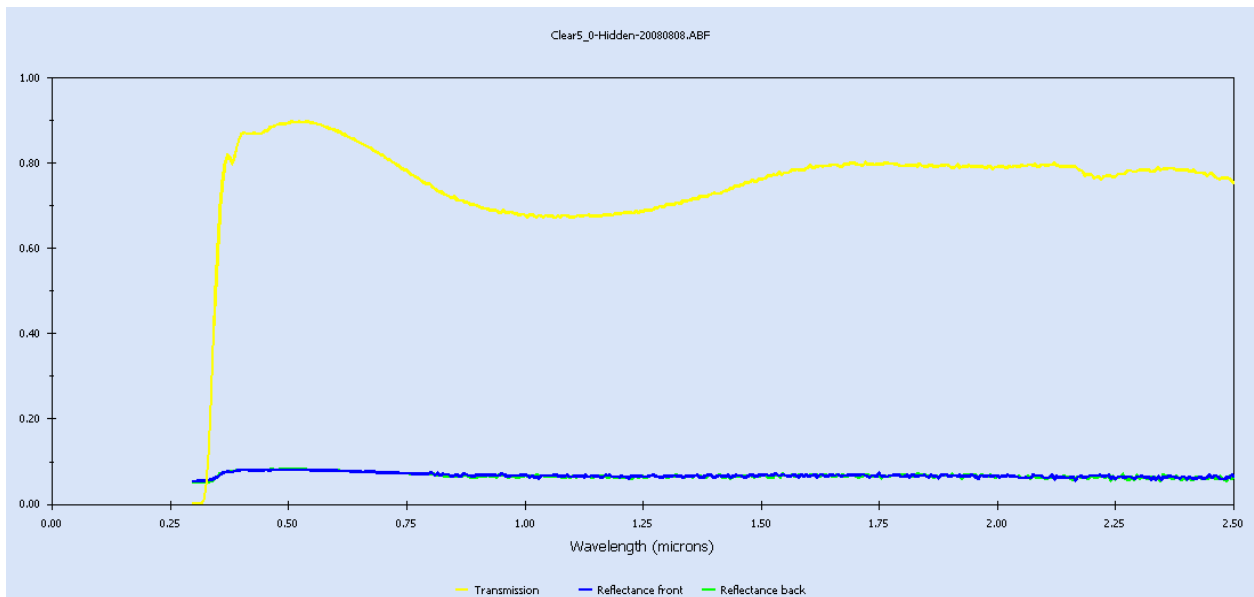


Figure 2: Spectral properties: Reference Glass sample (Substrate)

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

ID : 1  
 Name : Black Chrome 10  
 Tilt : 90.0  
 Glazings: 1  
 KEFF : 0.1000  
 Width : 4.891  
 Uvalue : 5.90  
 SHGCc : 0.33  
 SCc : 0.39  
 Vtc : 0.13  
 RHG : 289.69

### Glass and Gas Data for Glazing System '1 Black Chrome 10'

ID	Name	D(mm)	Tsol	1 Rsol	2 Tvis	1 Rvis	2 Tir	1 Emis	2 Keff			
Outside												
	30029FBlackChrome10.A#	4.9	.111	.158	.244	.134	.176	.233	.000	.840	.860	.975
Inside												

### Environmental Conditions: 1 NFRC 100-2002

	Tout (C)	Tin (C)	WndSpd (m/s)	Wnd Dir	Solar (W/m2)	Tsky (C)	Esky
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 '1 Black Chrome 10'

Angle	0	10	20	30	40	50	60	70	80	90	Hemis
Vtc	: 0.134	0.135	0.133	0.131	0.129	0.124	0.114	0.093	0.056	0.000	0.117
Rf	: 0.176	0.169	0.168	0.171	0.180	0.196	0.226	0.306	0.518	0.999	0.219
Rb	: 0.233	0.226	0.225	0.228	0.236	0.251	0.279	0.353	0.551	0.999	0.272
Tsol	: 0.111	0.112	0.110	0.109	0.107	0.103	0.094	0.077	0.046	0.000	0.097
Rf	: 0.158	0.151	0.150	0.153	0.162	0.179	0.209	0.291	0.507	0.999	0.202
Rb	: 0.244	0.237	0.236	0.239	0.247	0.262	0.289	0.363	0.557	0.999	0.282
Abs1	: 0.731	0.737	0.740	0.738	0.731	0.719	0.696	0.632	0.446	0.001	0.691
SHGCc	: 0.334	0.337	0.337	0.334	0.330	0.322	0.306	0.268	0.179	0.000	0.307
Tdw-K	: 0.057										
Tdw-ISO	: 0.103										
Tuv	: 0.009										

	Temperature Distribution (degrees C)			
	Winter		Summer	
	Out	In	Out	In
Lay1	-10.1	-9.0	48.5	48.8