

## View Achieves Best in Class Tint Color Quality

View offers two product options, *View Gen 4* and *View Gen 3*, for achieving best in class color quality and visual comfort performance.

### Introduction

View Smart Glass balances daylight harvesting, occupant comfort, and energy performance by dynamically tinting glazing in response to the exterior environment and user needs. In doing so, the appearance of the glazing itself, and the characteristics of the light transmitted through it, undergo subtle changes. This paper describes the color performance of a space glazed with View Smart Glass as perceived by occupants. *View Gen 3* and *View Gen 4* products both achieve excellent color quality in the clear tint state, and *View Gen 4* achieves the most neutral color quality in the industry in the tinted state.

### Daylight and Color in Architecture

There are two primary ways that occupants experience color within an interior daylight environment: 1) looking within the space as light reflects off interior finishes, objects, and people, and 2) looking outside through the glass from the inside. In both scenarios, it is important that colors appear as natural and authentic as possible.

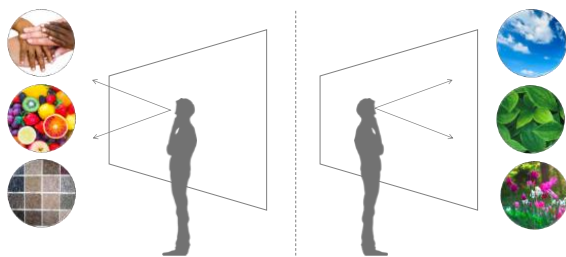


Figure 1: Occupants experience color from one of two vantage points: the space interior (L) or through the window to the outside (R).

The first scenario introduces the likely possibility that interior electric lighting will influence the perception of color. For example, when controlling for glare, View Smart Glass transmits

only 1% of the visible spectrum, which means the interior electric lighting will constitute the majority of lighting in the space and will, therefore, dictate the interior color quality. A separate whitepaper titled “[Synergies between Electrochromic Glazing and Tunable White LEDs](#)” addresses this topic. This paper mainly focuses on the color quality of daylight transmitted through View glass in isolation of any other light source.

### Color Quality Metrics

ANSI/IES TM-30-18 is the industry standard for evaluating the color quality of an arbitrary light source. In this case, the light source is daylight transmitted through View Smart Glass, but it can also refer to the color of electric lighting, such as LEDs or fluorescents, or a combination thereof. There are three primary metrics used to describe the color quality of light in IES TM-30-18, as summarized below.

#### Color Temperature

Color Temperature (CCT) quantifies the “warmth” or “coolness” of white light. Lower color temperatures are associated with “warm” light sources such as sunrise/sunset, candlelight, and incandescent lamps. Higher color temperatures are associated with “cool” light sources such as the blue sky. Most LED or fluorescent lights for commercial interiors are selected in the range of 3,000K to 4,000K. Daylight is typically between 5,500K and 12,000K depending on sky conditions, which is naturally “cooler” or “bluer” than most interior electric lighting.

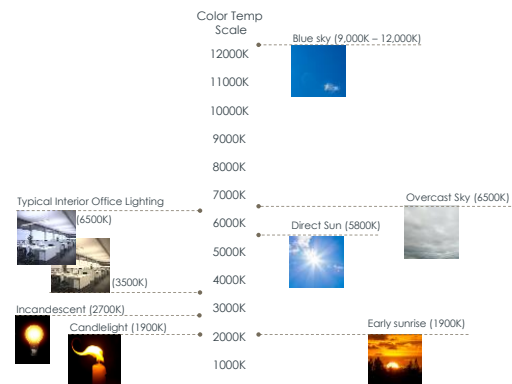


Figure 2: Color Temperature scale and examples

### Color Fidelity

Color Fidelity ( $R_f$ ) quantifies how accurately a light source renders a set of 99 color samples (see Figure 3) as compared to a standard daylight source of the same color temperature. An  $R_f$  of 100 indicates that there is no color shift compared to daylight. Most electric lighting for commercial interiors is selected with an  $R_f$  of 80 or higher to minimize perceptible color shift.

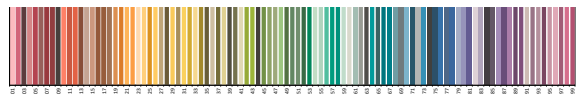


Figure 3: The 99 sample colors used in ANSI/IES TM-30-18 to calculate Color Fidelity

Note: Color Fidelity ( $R_f$ ) replaces Color Rendering Index (CRI) as the industry standard for measuring color rendering in ANSI/IES TM-30-18.

### Color Gamut

Color Gamut ( $R_g$ ) quantifies how saturated or unsaturated colors appear under a given light source as compared to a reference daylight source of the same color temperature. An  $R_g$  of 100 indicates natural saturation of colors, whereas an  $R_g > 100$  indicates oversaturation, and  $R_g < 100$  indicates desaturation.



Figure 3: Three examples of Color Gamut

## Color Quality Through View Smart Glass

All three of the color metrics listed above are calculated for View Smart Glass based on the transmitted interior daylight spectrum. The interior daylight light spectrum is the product of the exterior daylight spectrum and the spectral transmission of View glass at a given tint state. For this paper, we assume that exterior daylight is a constant 5500K color temperature, which is typical of direct sunlight.

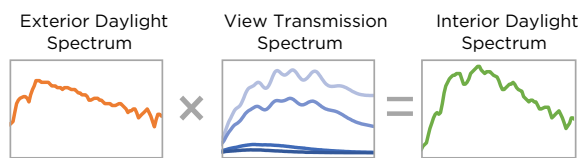


Figure 4 shows the transmission spectra of View Smart Glass in each of the four standard tint states. It is apparent from the graph that the two clearest tint states (tint 1 and 2) feature a relatively broad spectrum across the visible wavelengths (380 to 780 nm). As a result, the transmitted daylight spectrum is similar to that of exterior daylight, and the color quality is anticipated to be correspondingly high.

The transmission spectrum in the darkest tint states (3 and 4) are noticeable lower in magnitude and feature a peak in the blue wavelengths (at approximately 460 nm). While this spectrum does shift the transmitted color toward blue, its overall intensity is so low that any mixing from electric lighting will balance out the color in the space.

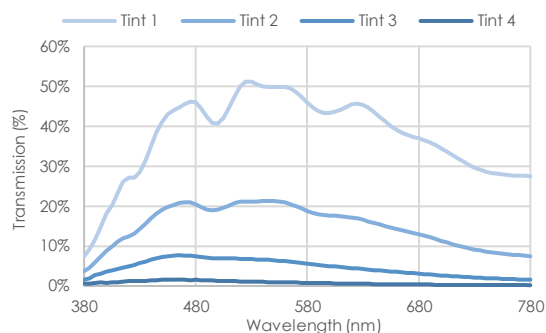


Figure 4: Transmission spectra of View G4 Smart Glass.

## Two Color Options

View offers two glazing options that achieve the same light transmission, SHGC, and U-value, but do so with different color characteristics in the tinted states: *View Gen 3* and *View Gen 4*. Table 1 and Table 2 summarize the color quality metrics of the two glazing options, with and without electric lighting, respectively, and the following page illustrates the difference between the two with photos.

## Color Quality of Daylight Alone

Both glazing options achieve excellent color quality in the clear tint states, when electric lighting is not required, closely matching other high quality, non-tinted glazing systems.

*View Gen 4* achieves industry-leading Color Fidelity and Color Gamut in the tinted states, with values that are comparable to high quality LED lighting. Interior finishes, skin tones, and exterior scenery (through the glass) appear more natural and vibrant.

However, regardless of the glazing option, interior lighting will always dictate interior color quality in the tinted states, as explained below.

## Color Quality of Electric Lighting

While View's clear tint states are intended to maximize daylight and allow electric lighting to be turned off, the darkest tint states are designed to limit light transmission and control glare. As a result, electric lighting will always be used to supplement daylight levels when in Tint 3 and 4.

Table 2 shows the resulting average space color quality when electric lighting is added. The data assumes that an LED source (CCT=3500K, Rf = 89, Rg=99) will be used to supplement available daylight to achieve a 400 lux interior light level. No electric lighting is added to the clearest tint states.

High color quality is maintained in the darkest tint states regardless of the glazing option due to the presence of electric lighting.

Color Fidelity and Gamut are actually higher than either electric lighting or daylight transmitted through Tint 3 or 4 alone. This is because when the two sources are additively mixed, some of the gaps in the spectrum are filled. Refer to Figure 6 for spectral power curves used in this analysis.

No electric lighting is needed in Tint 1 and 2, so the results are the same as Table 1 (without electric lighting).

Table 1: Glazing option comparison without electric lighting contributions, assuming 5500K daylight outside.

	Tint	View Gen 3	View Gen 4
Color Temp.	1	5,000K	5,300K
	2	5,100K	5,900K
	3	8,700K	7,300K
	4	17,500K	11,100K
Color Fidelity	1	95	93
	2	95	92
	3	86	90
	4	81	87
Color Gamut	1	97	95
	2	96	94
	3	89	92
	4	85	90

Table 2: Glazing option comparison with electric lighting contributions in Tint 3 and 4

	Tint	View Gen 3	View Gen 4
Color Temp.	1 <sub>1</sub>	5,000K	5,300K
	2 <sub>1</sub>	5,100K	5,900K
	3 <sub>2</sub>	5,300K	5,000K
	4 <sub>3</sub>	4,400K	4,300K
Color Fidelity	1 <sub>1</sub>	95	93
	2 <sub>1</sub>	95	92
	3 <sub>2</sub>	93	93
	4 <sub>3</sub>	92	92
Color Gamut	1 <sub>1</sub>	97	95
	2 <sub>1</sub>	96	94
	3 <sub>2</sub>	97	98
	4 <sub>3</sub>	99	99

1 Daylight alone satisfies the lighting criteria, no electric lighting is added.

2 A 50/50 split of daylight and electric lighting is assumed in Tint 3

3 A 25/75 split of daylight and electric lighting is assumed in Tint 4.

Figure 5: Interior photos comparing *View Gen 3* and *View Gen 4* options in the darkest tint state (Tint 4) with daylight alone.

### View Gen 3 Option

View through the window in Tint 4:



Interior photos behind Tint 4 showing Color Fidelity and Gamut (no electric lighting included):



### View Gen 4 Option

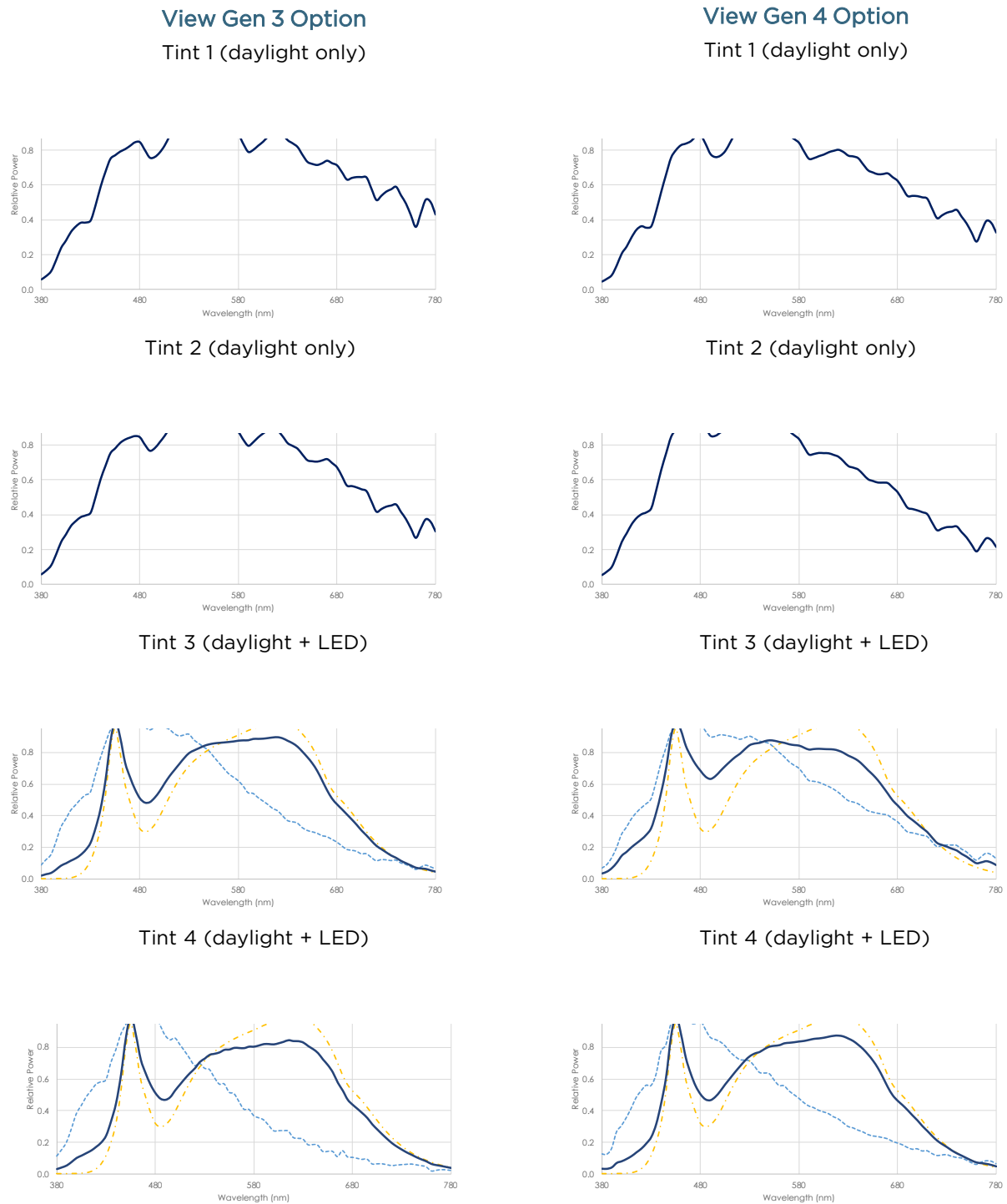
View through the window in Tint 4:



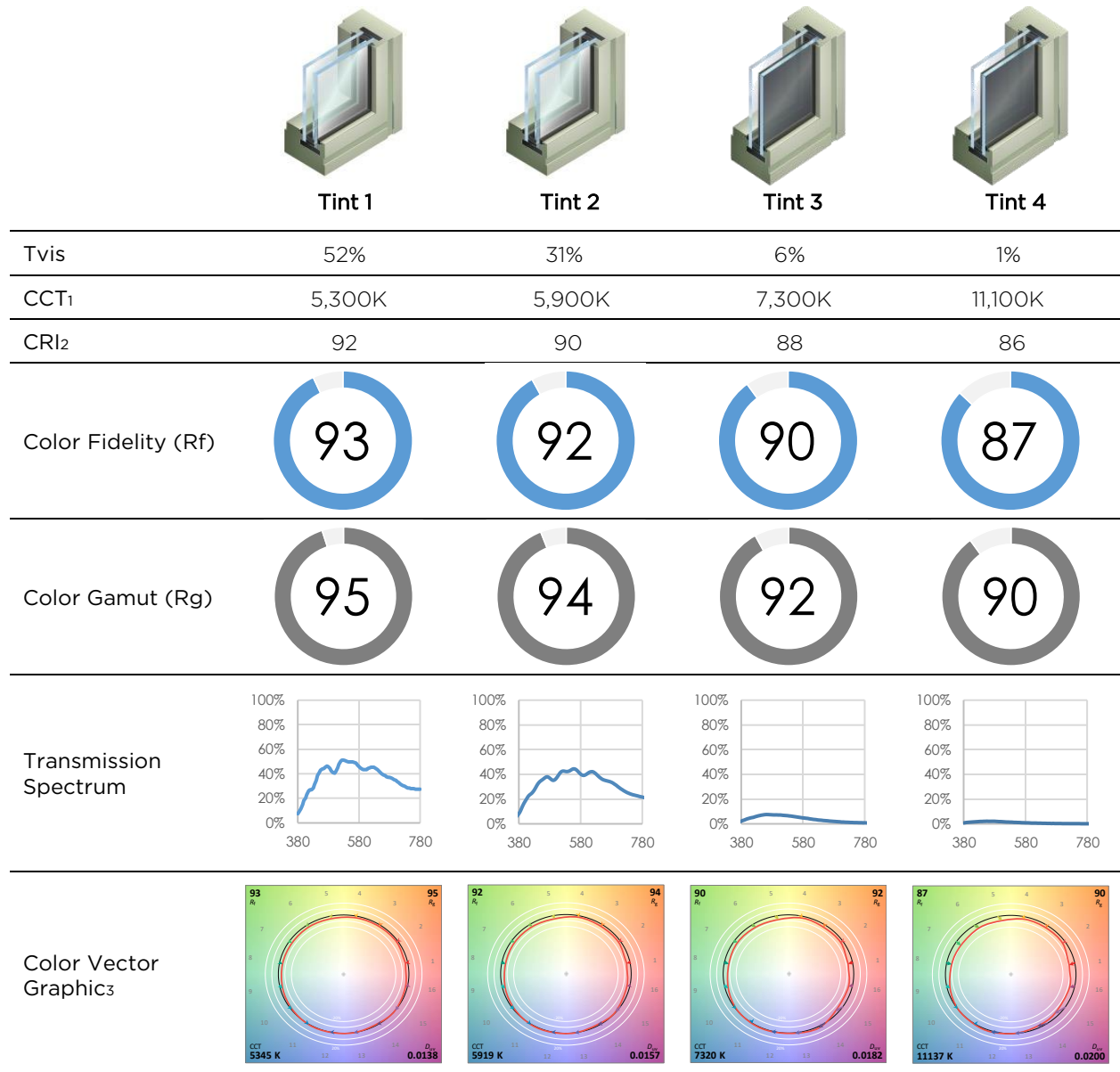
Interior photo behind Tint 4 showing Color Fidelity and Gamut (no electric lighting included):



Figure 6: Relative spectral power curves for four tint states assumed in this paper.



## Color Data Sheet – View Gen 4

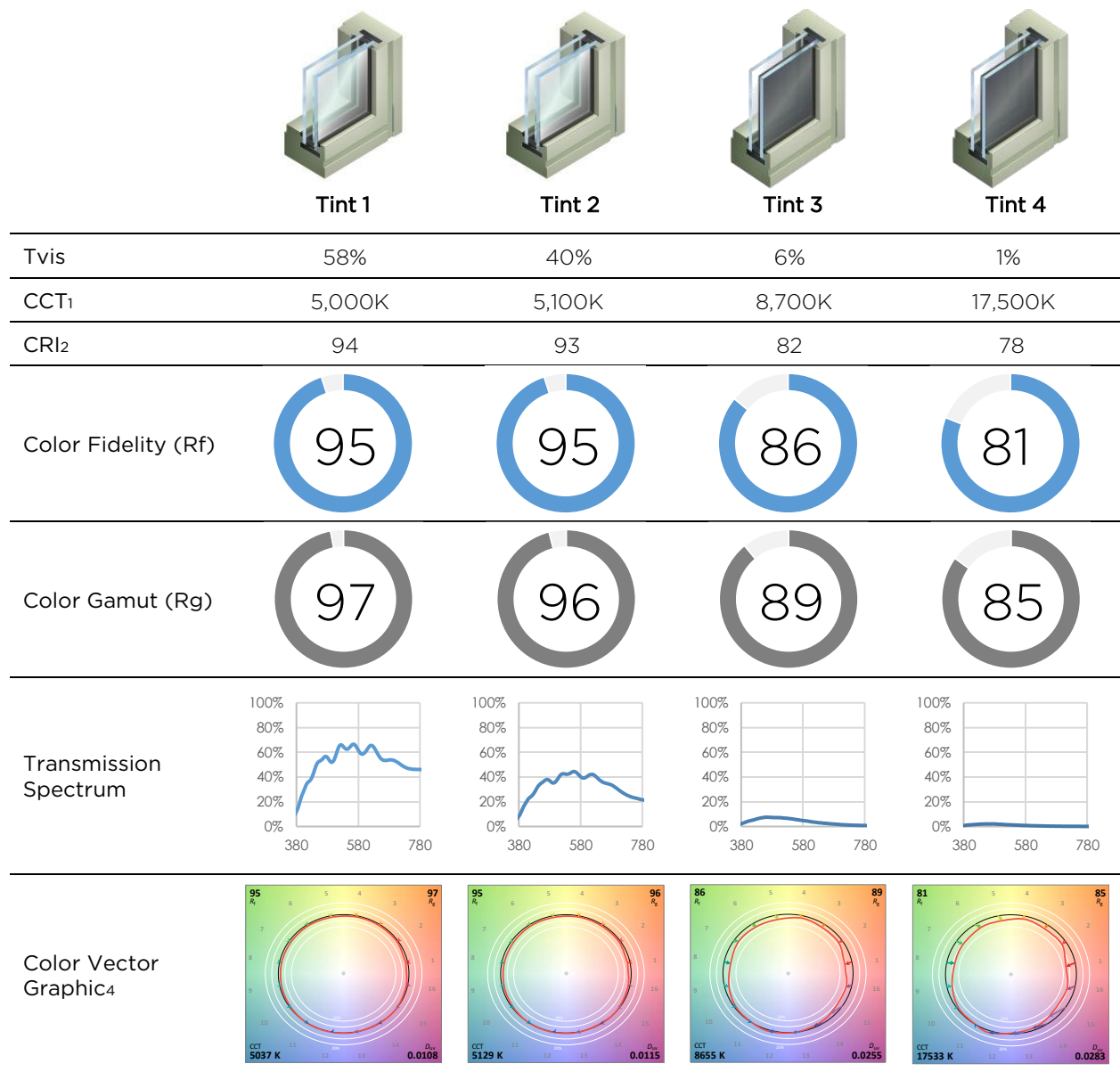


<sup>1</sup> All values assume a 5500K daylight illuminant transmitted through View Smart Glass

<sup>2</sup> CRI values provided for reference only. Color Fidelity replaces CRI as the industry standard for color rendering performance in ANSI/IES TM-30-18.

<sup>3</sup> Color Vector Graphics and all color metrics are calculating using the ANSI/IES TM-30-18 Advanced Calculation Tool v2.0

## Color Data Sheet - View Gen 3



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