OLEDWorks LumiCurve Wave

Neutral white – 4000K
Warm white – 3000K

Now it's time to bend!

After the huge success of the brightest OLED Lighting panel in the market Brite FL300, with the now already third generation and further improvements in efficacy and lifetime, OLEDWorks introduces the new flexible OLED lighting family LumiCurve. For the first time ever, the panel is flexible to a minimum radius of 10 cm while still providing the high brightness and high reliability of the Brite panels.

The only flexible panel on the market processed on 0.1mm thin Corning Willow® glass allowing the total thinness of the panel to be just about 0.6mm. That thinness offers completely new opportunities and application areas. The integration of light becomes as easy as handling a piece of paper. And at the same time being still very bright and reliable that it can easily fulfil the requirements of a functional light source.

The LumiCurve Wave family products are available at two integration levels making it the ideal building block for every OLED lighting application to be used in the area of functional lighting. These new LumiCurve OLED panels are available in rectangular and still two different color temperatures which will make it easy to bring functional OLED lighting to places or products that require beautiful and functional lighting at the same time.

The advantages:

Flexible: In total about half a millimeter thin – minimum bending radius 10 cm
Bright: Unique high brightness of more than 8,000 cd/m² and light output of up to 300 lumen
Beautiful: Available like the whole Brite portfolio in 3,000K and 4,000K with the high CRI of 90

OLEDWorks

Thin Film Encapsulation for ultimate reliability.
Ideal for applications in functional general lighting systems.
All the known advantages of OLED technology: – thin – homogenous – instant glare free

Description

The LumiCurve Wave is a flat light source. Focusing on general lighting applications, OLEDWorks OLED Lighting is developing products with a high lumen output at low costs. One significant step in this direction is the range extension of the OLEDWorks LumiCurve Wave which are available at two different integration levels and in two color temperatures.

Introduction

OLED is a large-area diffuse light source. Unlike incandescent bulbs, which generate light by passing electricity through a wire, or fluorescent lamps, which pass current through a gas, OLED lighting works by passing electricity through one or more extremely thin layers of organic semiconductor material. These layers are sandwiched between one positively and one negatively charged electrode. The 'sandwich' is placed on a sheet of glass or other transparent material known as the substrate. The OLED is protected by a thin-film encapsulation and a flat heat spreader on the rear side. When current is applied to the electrodes, they inject positively and negatively charged holes and electrons. These recombine in the organic layer of the sandwich and create a brief, high-energy state called 'exciton'. As this layer returns to its original stable, non-excited state, the energy flows evenly through the organic film causing it to emit light.

Standard Compliance and Sustainability

OLEDWorks products are environmentally friendly and provide efficient illumination without the use of hazardous materials.

This product is RoHS (EU Directive 2011/65/EU) and IEC 62868 (OLED safety) and IEC 62922 (OLED performance) compliant

CE

This product is compliant with UL8752 (OLED safety). This product is UL recognized in file E353273.

c UL US

Within the UL report certain 'Conditions of Acceptability' are mentioned as follows. When installed in the end product, the following shall be taken into consideration:

Conditions of Acceptability - When installed in the end-product, consideration shall be given to the following:

1. These products have been evaluated for connection to an isolated DC Class 2 constant current power source.

2. This product has been evaluated for use in dry or damp locations.

3. The OLED panel temperature shall not exceed 80°C.

4. Input leads to the OLEDs are intended for factory installation only. Strain relief to be considered in the end-use application when leads may be subjected to mechanical stress.

5. Input leads to the OLED panels shall be sufficiently separated from higher voltage conductors in the end-product in compliance with end-product requirements.

6. For products identified as flexible:
   i) The bendability of the panel has not been evaluated and shall be considered in the end use.
   ii) Temperature shall be measured in the locations of maximum bending to determine hot-spots.
   iii) The panel is not intended for continuous flexing/adjustment.

System

	Description	Remark
Indoor / outdoor	Indoor buildings	location with insignificant shock and vibration
Ingress protection		not applicable for OLED components
Classification	Applicable in applications with Class III (IEC) and Class II (UL) protection	Application standard IEC61140
OLED color	White	
Carrier material	Glass	
Cable	None (Level1), FFC (Level 1.5)	Wave 4000K Level 1 Wave 4000K Level 1.5 Wave 3000K Level 1 Wave 3000K Level 1.5
Connector	Solder Pads (Level 1) FFC Terminal (Level 1.5)	
RoHS conform	Yes	2011/65/EU

Operational Environmental Conditions*

Specification item	Value	Unit	Condition
Ambient temperature	+5 … +40	°C	
Relative humidity	20 … 80	%rH	no dew, no water spray, a maximum %rH of 60 is recommended.
Recommended internal operation temperature (OLED organic temperature)	≤45	°C	local temperature
Maximum internal operation temperature (OLED organic temperature)	≤ 80	°C	local temperature, for T > 45 °C lifetime will be reduced.

* please refer to Thermal Characteristics on page 19 for more information.

Wave is designed for indoor use only. Do not expose to water or excessive moisture.

Storage Conditions*[1]

Specification item	Value	Unit	Condition
Ambient temperature	-40 … +60	°C	
Relative humidity	5 … 85	%rH	no dew, no water spray

*[1] Recommended storage temperature is between 15 ... 25 °C with a humidity < 65 %rH.

Transport Conditions

Specification item	Value	Unit	Condition
Ambient temperature	-40 … +60	°C	
Relative humidity	5 … 85	%rH	no dew, no water spray

MECHANICAL DIMENSIONS

Specification item		Value	Unit	Condition
Wave 4000K Level 1 Wave 4000K Level 1.5 Wave 3000K Level 1 Wave 3000K Level 1.5	length	243.4 ±0.2	mm	
	width	64.7 ±0.2	mm	
	height	0.6 ±0.1	mm	
	weight	15 ±1	g	
Light emitting area	length	221.3 ±0.2	mm	Wave 4000K Level 1 Wave 4000K Level 1.5 Wave 3000K Level 1 Wave 3000K Level 1.5
	width	46 ±0.3	mm	
	area	101.8	cm^2	
Minimum bending radius		100	mm	Wave 4000K Level 1 Wave 4000K Level 1.5 Wave 3000K Level 1 Wave 3000K Level 1.5

Diagrams of Wave Level 1

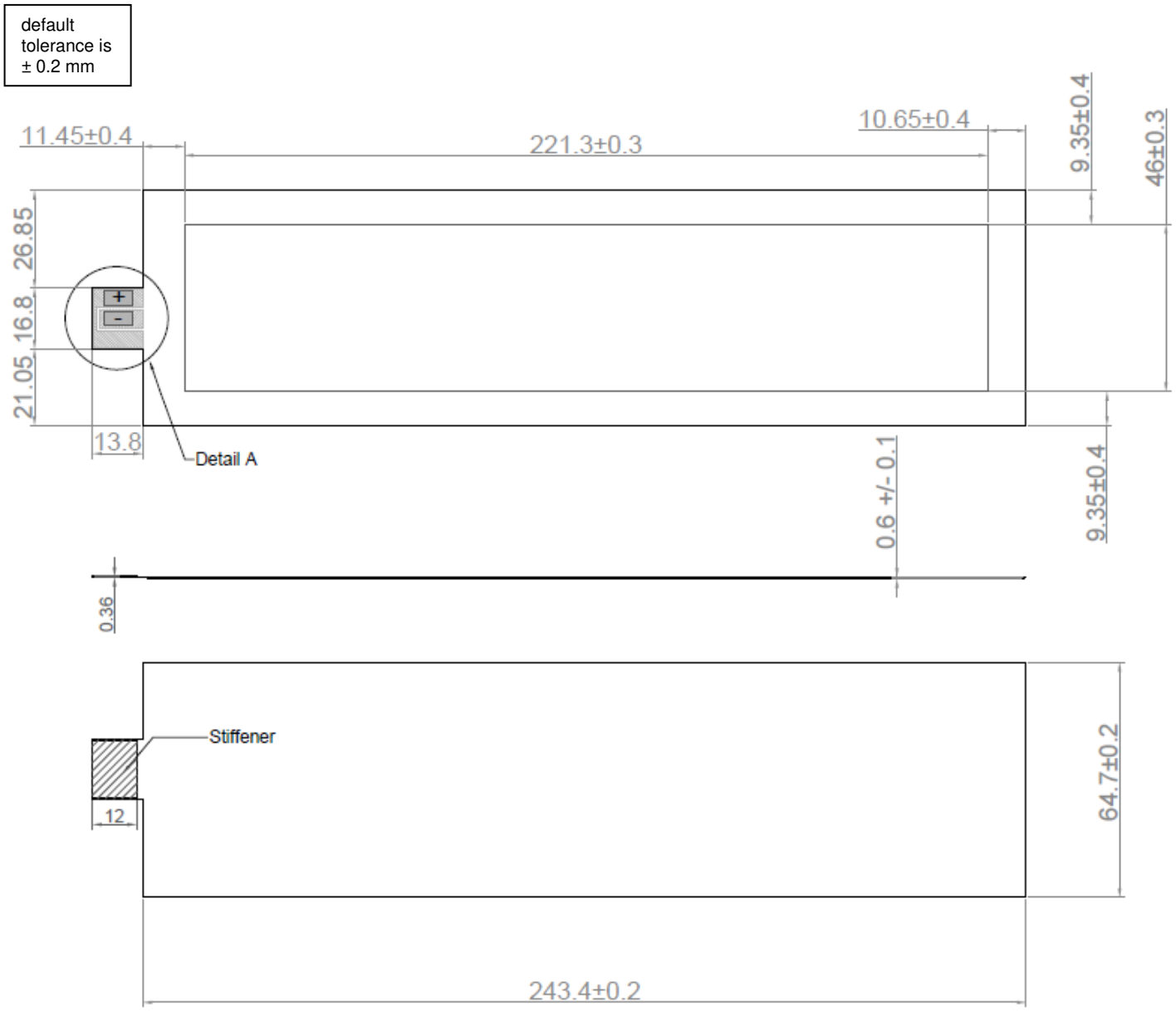

Figure 1: Wave Level 1 – front (top), side view (middle), rear view (bottom)

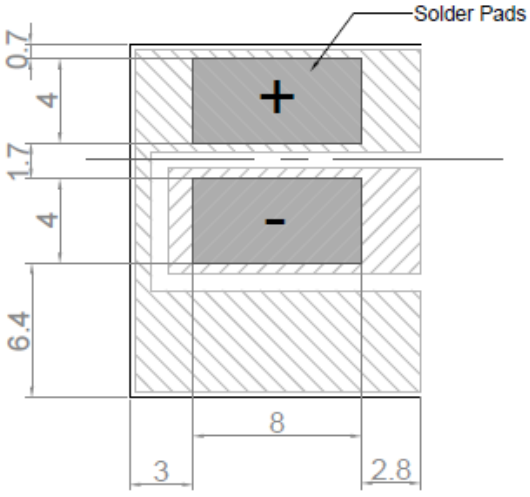

Figure 2: Detail A of Figure 1; Wave Level 1

Diagrams of Wave Level 1.5

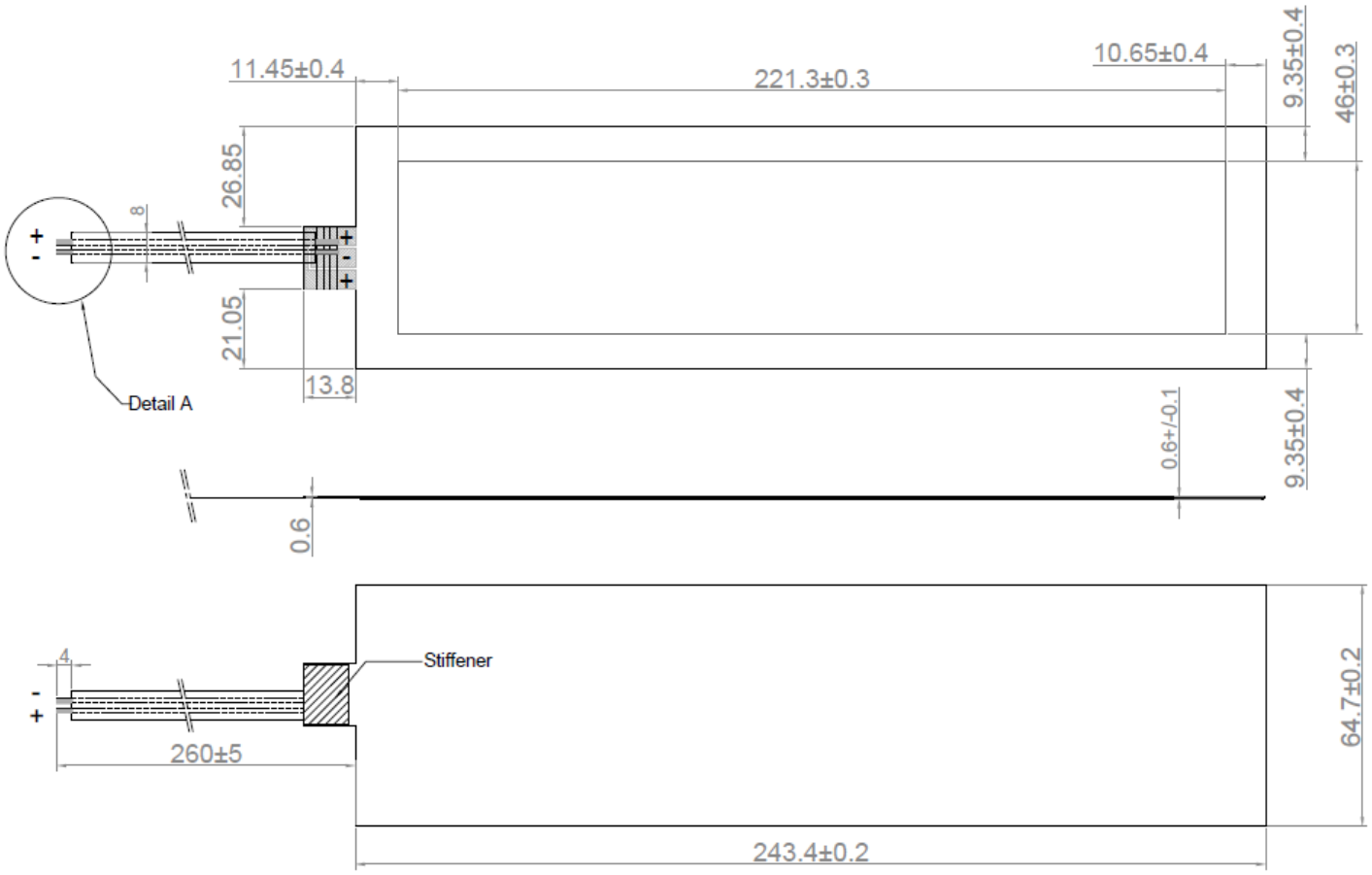

Figure 3: Wave Level 1.5 – front (top), side view (middle), rear view (bottom)

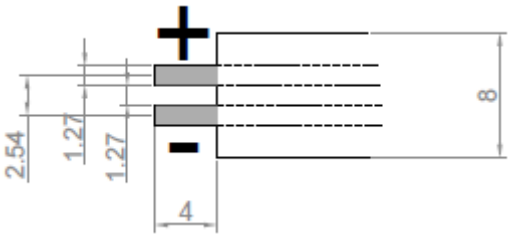

Figure 4: Wave Level 1.5 - Detail A of Figure 3

Mechanical handling

The Wave product range incorporates the newest lighting technology to combine bright, homogeneous lighting with a super-thin and sleek product appearance. This enables the design of unique, innovative and functional luminaires. Several mechanical and handling aspects arise due to the special characteristics of the Wave product family.

With an extreme thinness of 0.6 mm, the light panels demand careful handling. To achieve this the light panels are based on ultrathin glass encapsulated by thin-film encapsulation making them electronic components sensitive to mechanical impact and e.g. ESD. To guarantee optimal operation, the panel may not be altered by any means (torsion, pressure, point loads, bending with a radius smaller than specified, electrical connections, etc.). Potentially sharp glass edges are no issue in handling because they are covered by the optical foil and the FPC. To avoid fingerprints on the front side, preferably handle the OLED with gloves.

Avoid contact with water. Do not submerge OLEDs in any kind of solvent, acid, base, salt or other chemicals.

In case of damage to the product, disconnect the product from power supply without touching the damaged parts. Do not reconnect the product. Contact the manufacturer or a qualified service technician.

The product may become warm during normal use. Do not cover with materials that are flammable.

Do not bend below specified bending radius | Do not twist | Do not press

ELECTRICAL AND OPTICAL CHARACTERISTICS

Electrical Characteristics

Specification item	Value	Unit	Condition
OLED rated current, $I_{in\ rated}$	0.295	A	
OLED voltage at t=0, $U_{in;}$ Wave 4000K	19.8 ±1.0	V DC	$I_{in\ rated}$
OLED voltage at t=0, $U_{in;}$ Wave 3000K	19 ±1.0	V DC	$I_{in\ rated}$
OLED voltage at end of life, $U_{EOL} = U_{in\ max}$	22	V DC	$I_{in\ rated}$
Power consumption at t=0, $P_{in,}$ Wave 4000K	5.8	W	$I_{in\ rated}$
Power consumption at t=0, $P_{in,}$ Wave 3000K	5.6	W	$I_{in\ rated}$
Power consumption at end of life, $P_{EOL} = P_{in\ max}$	6.5	W	$I_{in\ rated}$

All data nominal at stabilized conditions after 5 min warm-up, $T_{organic}$ = 45 °C.

OLED Drivers

Use of power supplies with dedicated controls for turning off output power if an OLED fails is recommended when operating Wave. Different types of dedicated drivers are available featuring different supply voltages as well as single and multiple output channels. Various interfaces (DMX, DALI, analog, TouchDim) allow a high level of flexibility in the design of all kinds of luminaires and lighting applications. Examples of recommended drivers are shown in the table below.

Product	Supply voltage	Output channels	Philips Product Code
Driver D230V 80W/0.1-0.5/1A/28V TD/A 8CH	120, 220-240, 277 V AC	8	9254.000.10200
Driver D024V 10W/0.1A-0.4A/28V D/A	24 V DC	1	9254.000.10100
Driver D024V 10W/0.1A-0.4A/28V DMX	24 V DC	1	9254.000.12000

Please consider that drivers with 24V supply voltage in the table above require a Molex PicoBlade connector. More details can be found in the driver product sheets.

Dimming

Both pulse width modulation (PWM) and amplitude modulation (AM) techniques can be used to dim the OLED.

OLED Connection

Wave is available at two different integration levels. At integration level 1, no cable is attached to the device. Solder pads on the connection tab can be used for connecting customized wires (see Figures 1 and 2). Integration level 1.5 is based on level 1 with an additional flat flexible cable (FFC) connected to the connection tab (see Figures 3 and 4).

OLED Voltage

The voltage of the OLED depends on the point of operation, temperature of the organics and the age of the OLED. As a result, the OLED voltage is affected by the ambient temperature. During operation the

temperature of the organics may increase, especially shortly after powering the OLED. At constant current control, this may result in a change in voltage.

Example of voltage evolution after a cold start at different ambient temperature levels is shown in Figure 5. The initial voltage drop is due to the device heating up until steady state (approx. 5 min after turning on). Besides this the voltage/organic temperature depends on the ambient temperature.

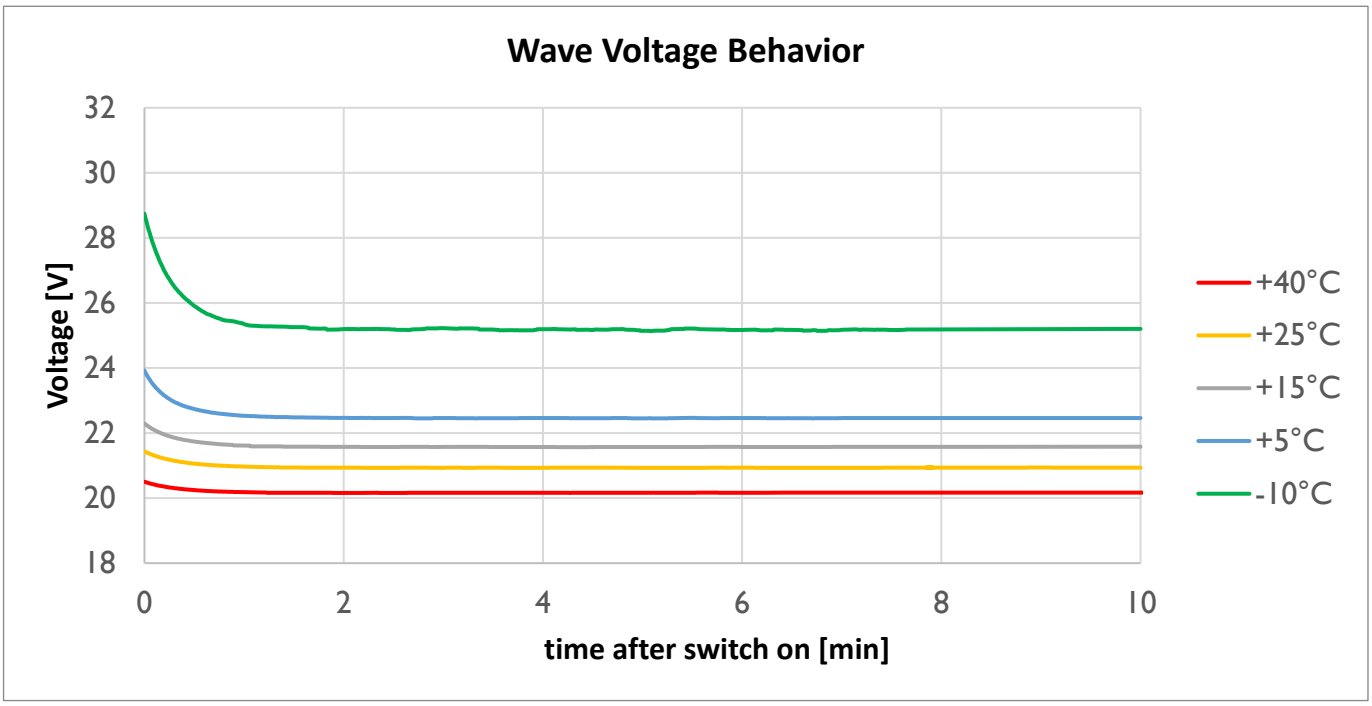

Figure 5: typical voltage evolution after start-up at different ambient temperatures, level 1, vertical orientation, air, $I_{in\ rated}$ = 0.295 A

Short Circuit Behavior

If an OLED fails it can fall into a short circuit. Such a condition may mean that

- no light is generated
- the OLED is heated locally, i.e. one small spot of the OLED surface gets hot
- the current still flows through the OLED but the voltage drops to a lower value.

In case such a fault occurs turning off the OLED is recommended.

Optical Characteristics Wave 4000K*[2]

Specification item	Value	Unit	Condition
Luminance, nominal	7000	cd/m²	@ $I_{in\ rated}$ = 0.295 A, perpendicular, center
	3000		@ 0.12 A, perpendicular, center
Luminous flux	250 ± 10 %	lm	@ $I_{in\ rated}$ = 0.295 A with L70B50 = 10khrs
	100 ± 10 %		@ 0.12 A with L70B50 = 50khrs
Luminous efficacy, nominal	43	lm/W	@ $I_{in\ rated}$ = 0.295 A
	47		@ 0.12 A
Color	White		
Chromaticity x, nominal	0.3738		integral measurement, CIE 1931
Chromaticity y, nominal	0.3684		
Chromaticity u', nominal	0.2240		integral measurement, CIE 1976
Chromaticity v', nominal	0.4968		
Duv	-0.0020		center of color box with respect to BBL
Color spec limits CIE xy	0.3650 0.3669 0.3850 0.3799 0.3825 0.3699 0.3625 0.3569		corner coordinates of area in colorspace
Color spec limits CIE u'v'	0.2288 0.4949 0.2268 0.5036 0.2293 0.4988 0.2211 0.4898		corner coordinates of area in colorspace
CCT	4000	K	@ $I_{in\ rated}$ = 0.295 A
Color Rendering Index: CRI / R9	90 / 75		@ $I_{in\ rated}$ = 0.295 A
TM-30 metrics: R_f / R_g	85 / 97		@ $I_{in\ rated}$ = 0.295 A
Surface chromaticity uniformity	0.0020		Referring to IEC 62922
Angular chromaticity uniformity	0.0050		Referring to IEC 62922
Luminance Uniformity	90%		Referring to IEC 62922, $I_{in\ rated}$ = 0.295 A

*[2] all data for stabilized electrical conditions of the device after 5 min warm-up period, integration level 1.5.

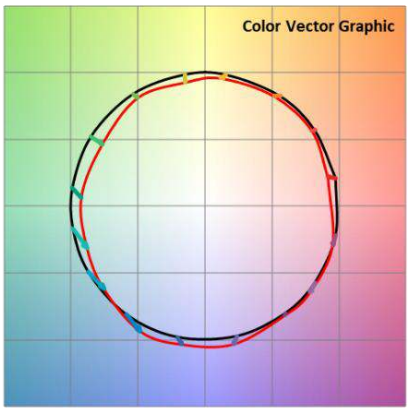

Figure 6: Color vector graphic based on TM-30 metrics for Wave 4000K

Optical Characteristics Wave 3000K*[2]

Specification item	Value	Unit	Condition
Luminance, nominal	8500	cd/m²	@ $I_{in\ rated}$ = 0.295 A, perpendicular, center
	3000		@ 0.1 A, perpendicular, center
Luminous flux	300 ± 10 %	lm	@ $I_{in\ rated}$ = 0.295 A with L70B50 = 10khrs
	100 ± 10 %		@ 0.1 A with L70B50 = 50khrs
Luminous efficacy, nominal	55	lm/W	@ $I_{in\ rated}$ = 0.295 A
	62		@ 0.1 A
Color	White		
Chromaticity x, nominal	0.4345		integral measurement, CIE 1931
Chromaticity y, nominal	0.3992		
Chromaticity u', nominal	0.2511		integral measurement, CIE 1976
Chromaticity v', nominal	0.5190		
Duv	-0.0016		center of color box with respect to BBL
Color spec limits CIE xy	0.4270 0.4010 0.4470 0.4073 0.4420 0.3973 0.4220 0.3910		corner coordinates of area in color space
Color spec limits CIE u'v'	0.2455 0.5187 0.2557 0.5242 0.2568 0.5195 0.2465 0.5139		corner coordinates of area in color space
CCT	3000	K	@ $I_{in\ rated}$ = 0.295 A
Color Rendering Index: CRI / R9	90/ 50		@ $I_{in\ rated}$ = 0.295 A
TM-30 metrics: R_f / R_g	85 / 98		@ $I_{in\ rated}$ = 0.295 A
Surface uniformity chromaticity	0.0020		Referring to IEC 62922
Angular chromaticity uniformity	0.0100		Referring to IEC 62922
unif. Luminance IEC	90%		Referring to IEC 62922, $I_{in\ rated}$ = 0.295 A

*[2] all data for stabilized electrical conditions of the device after 5 min warm-up period, integration level 1.5.

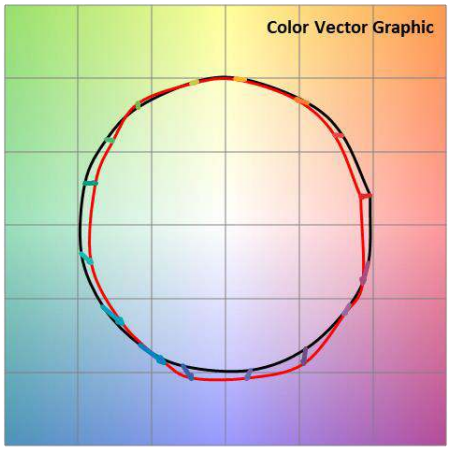

Figure 7: Color vector graphic based on TM-30 metrics for Wave 3000K

OLED Spectral Power Distribution (SPD)

Typical spectra of the OLED at different driving currents are given in Figure 8 and 9.

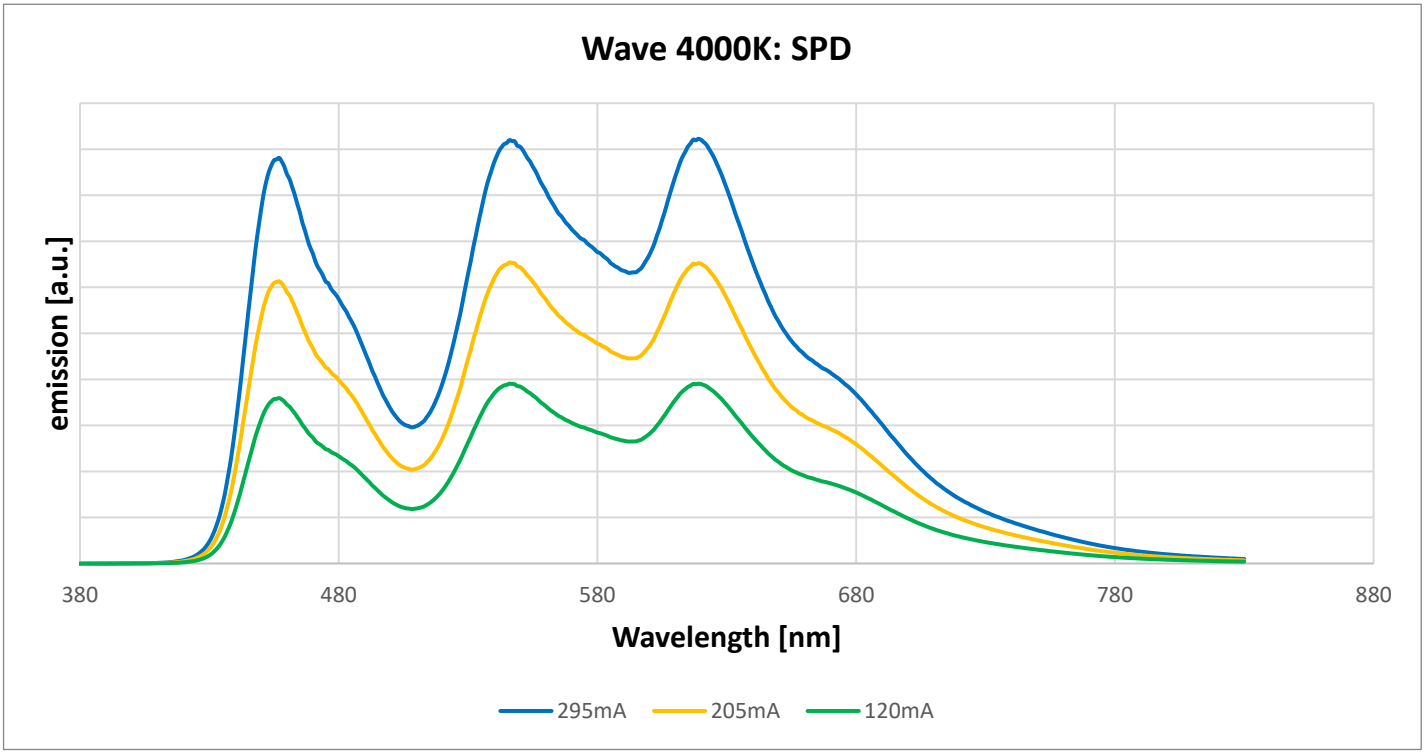

Figure 8: typical emission spectra of the Wave 4000K at different driving currents (I = 0.120 A, 0.205 A, 0.295 A)

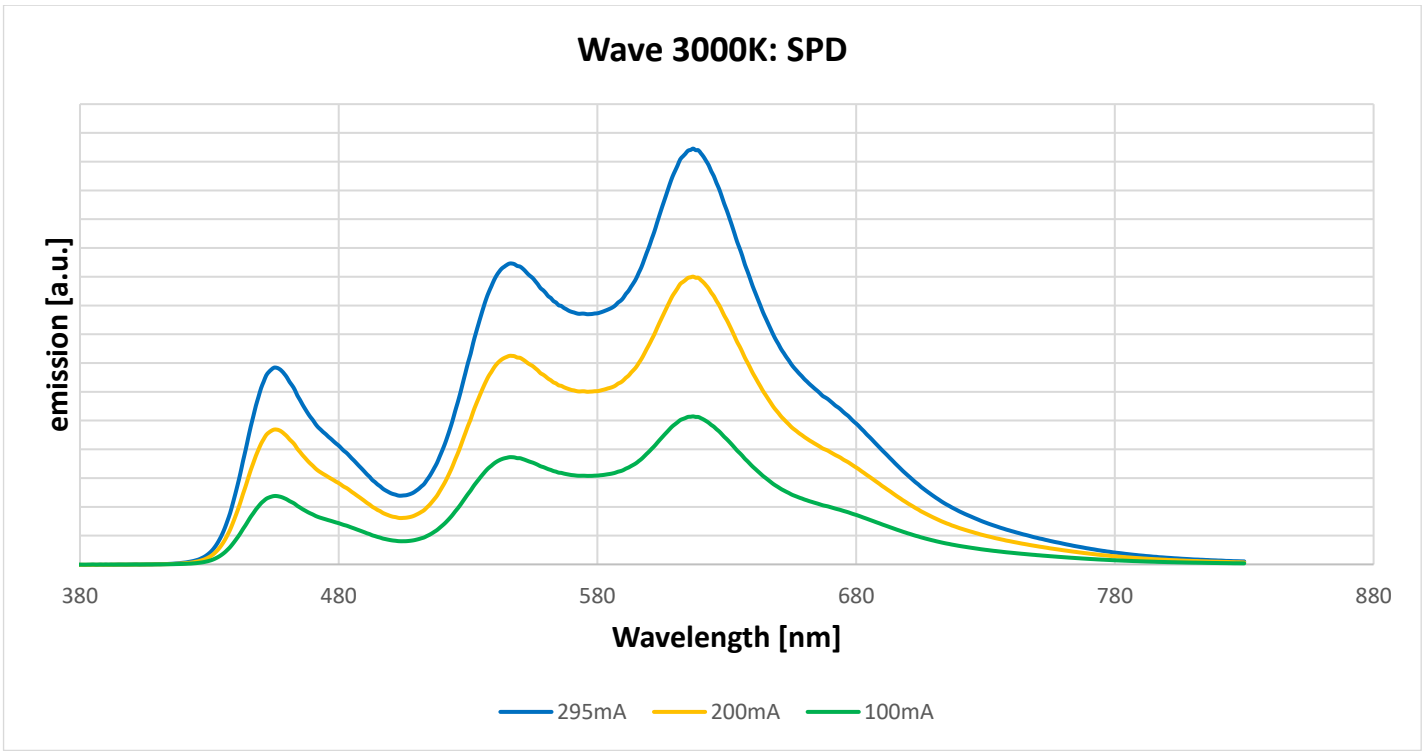

Figure 9: typical emission spectra of the Wave 3000K at different driving currents (I = 0.100 A, 0.200 A, 0.295 A)

Current – Voltage – Luminance Characteristics

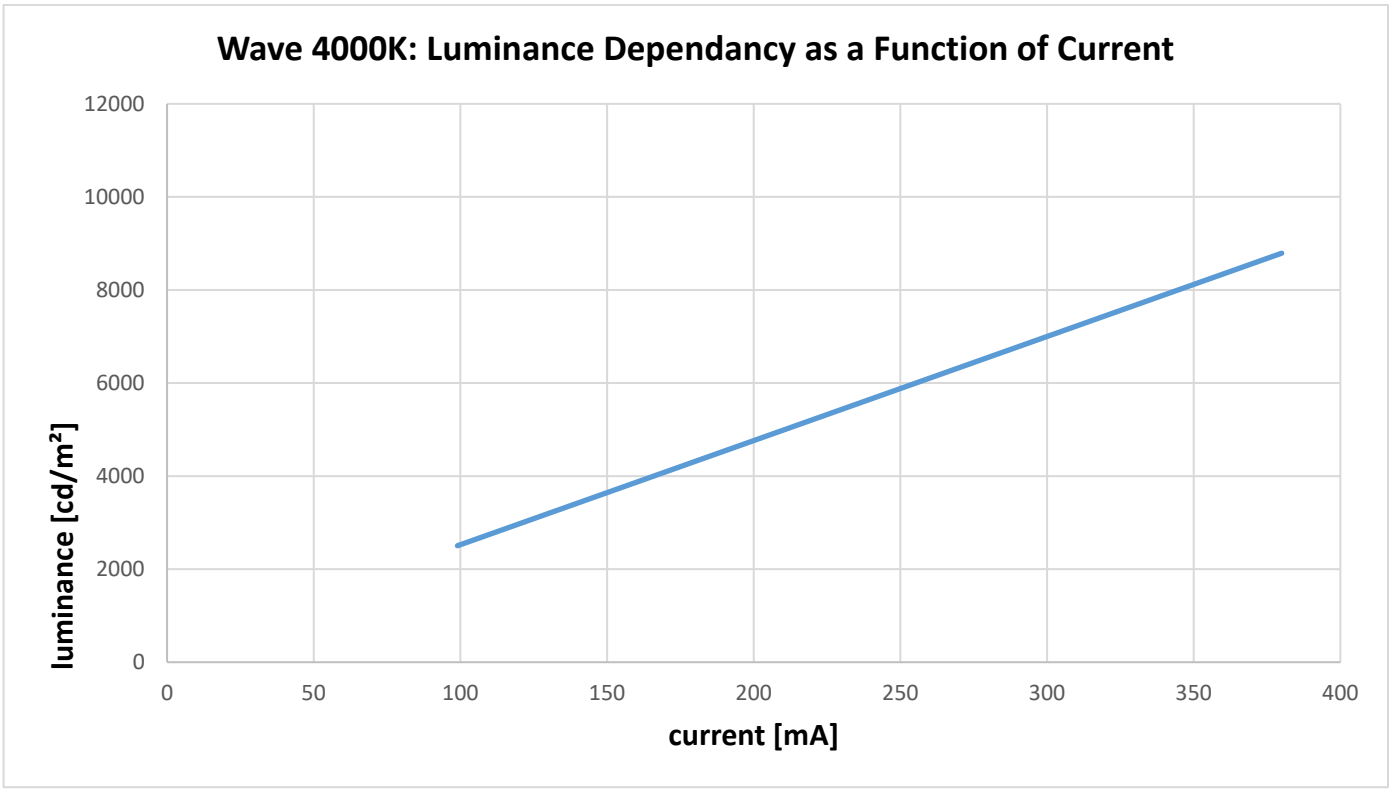

Figure 10: Luminance versus forward current at room temperature, 4000K, level 1

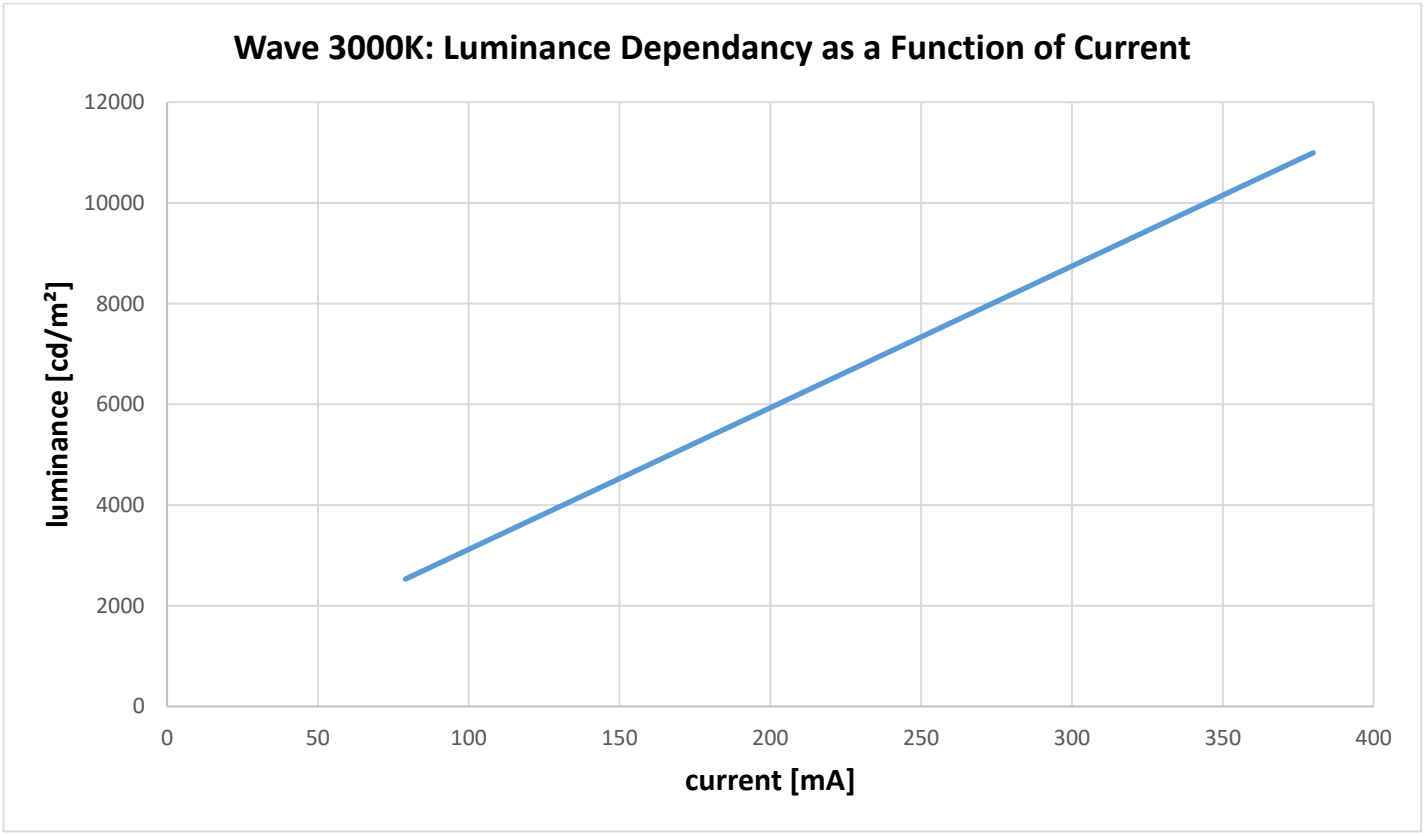

Figure 11: Luminance versus forward current at room temperature, 3000K, level 1

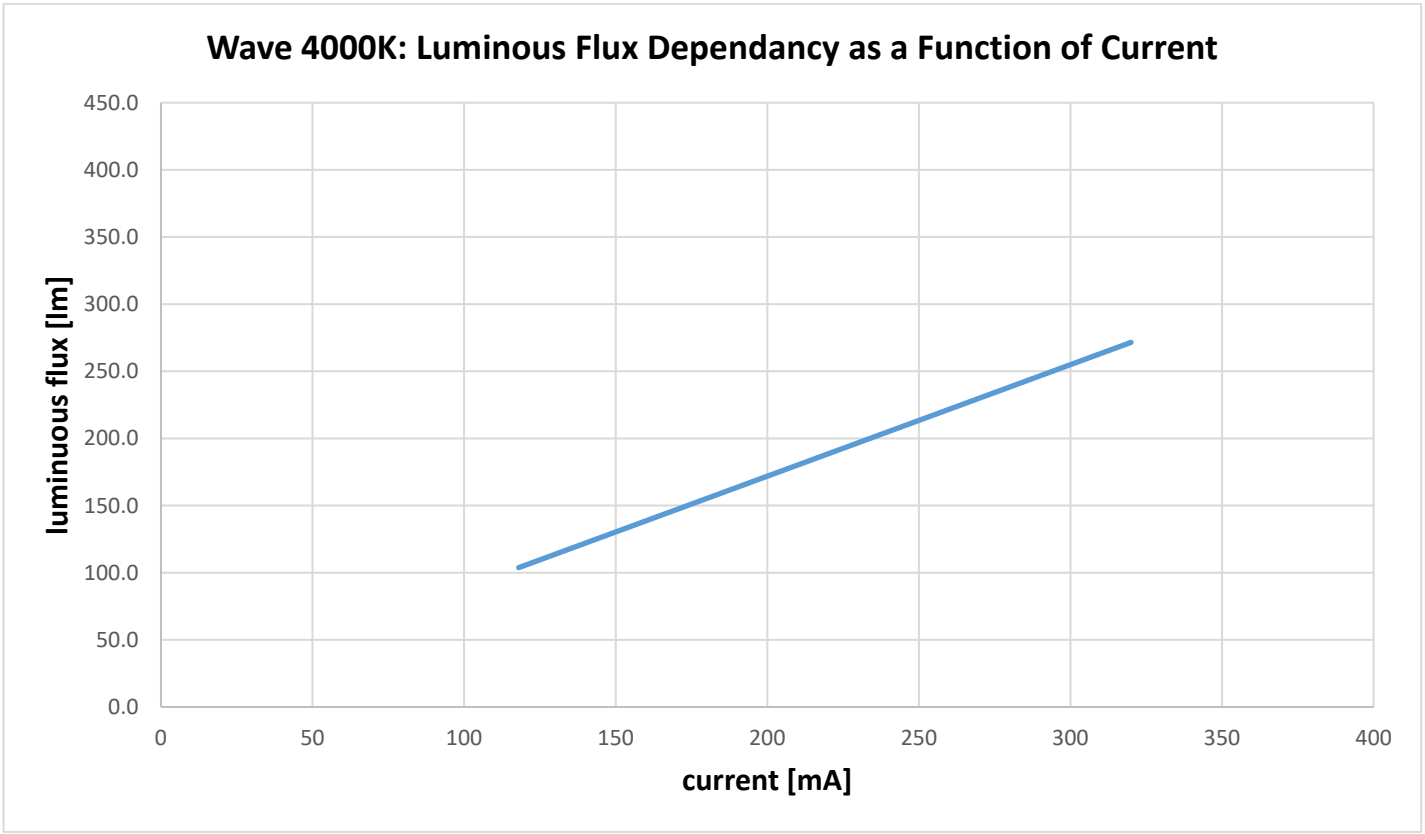

Figure 12: Luminous flux vs current, 4000K, level 1

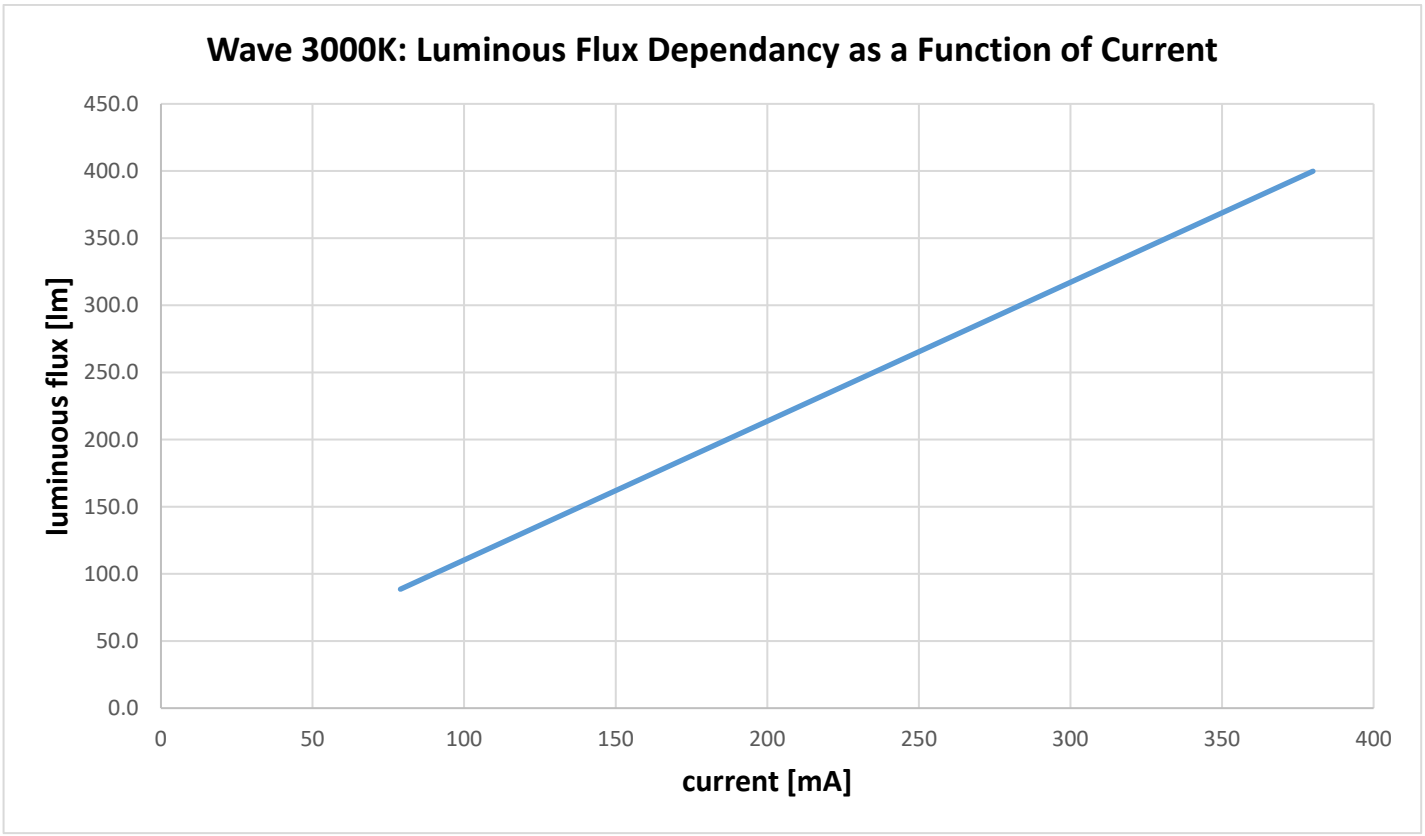

Figure 13: Luminous flux vs current, 3000K, level 1

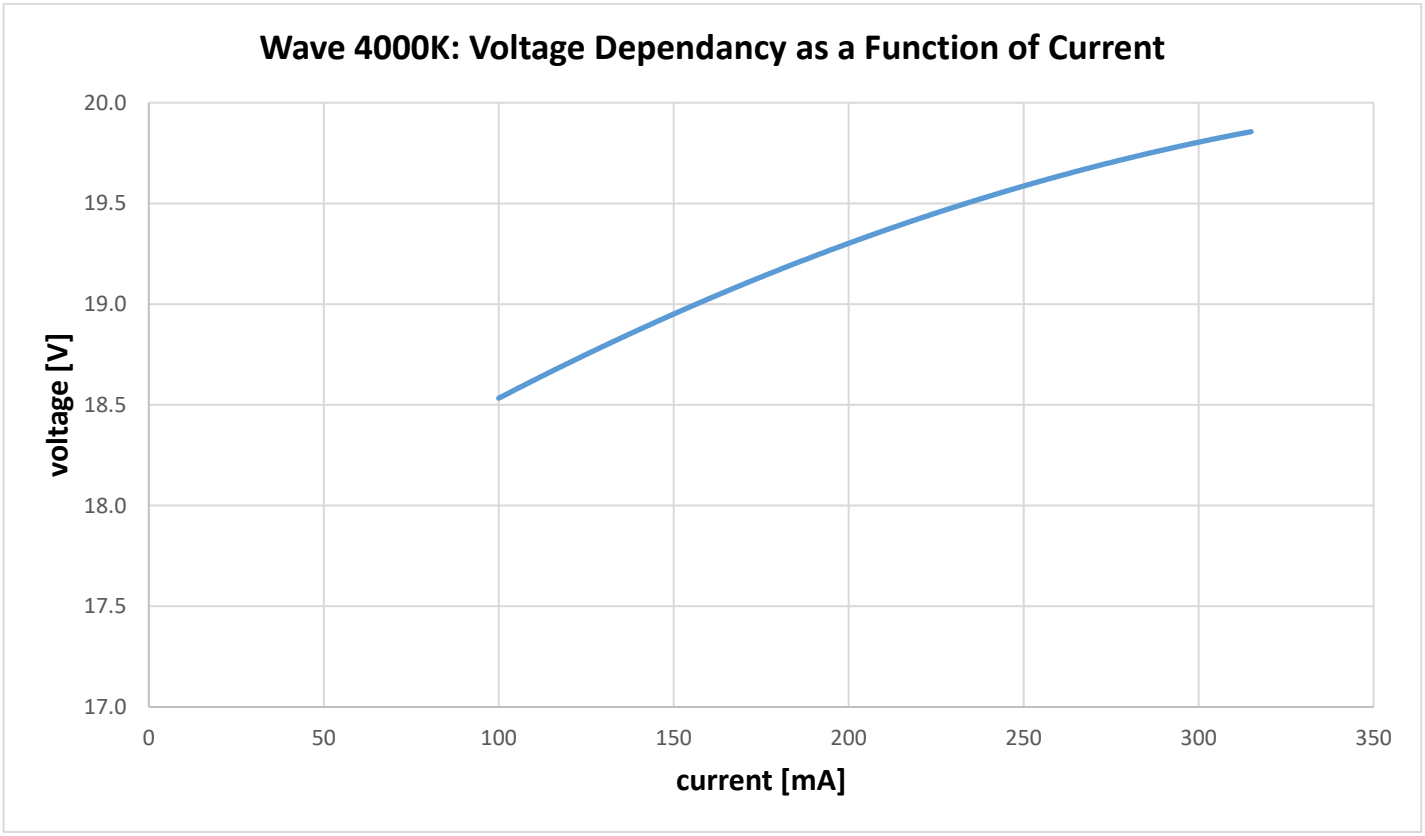

Figure 14: Voltage versus forward current at room temperature, 4000K, level 1

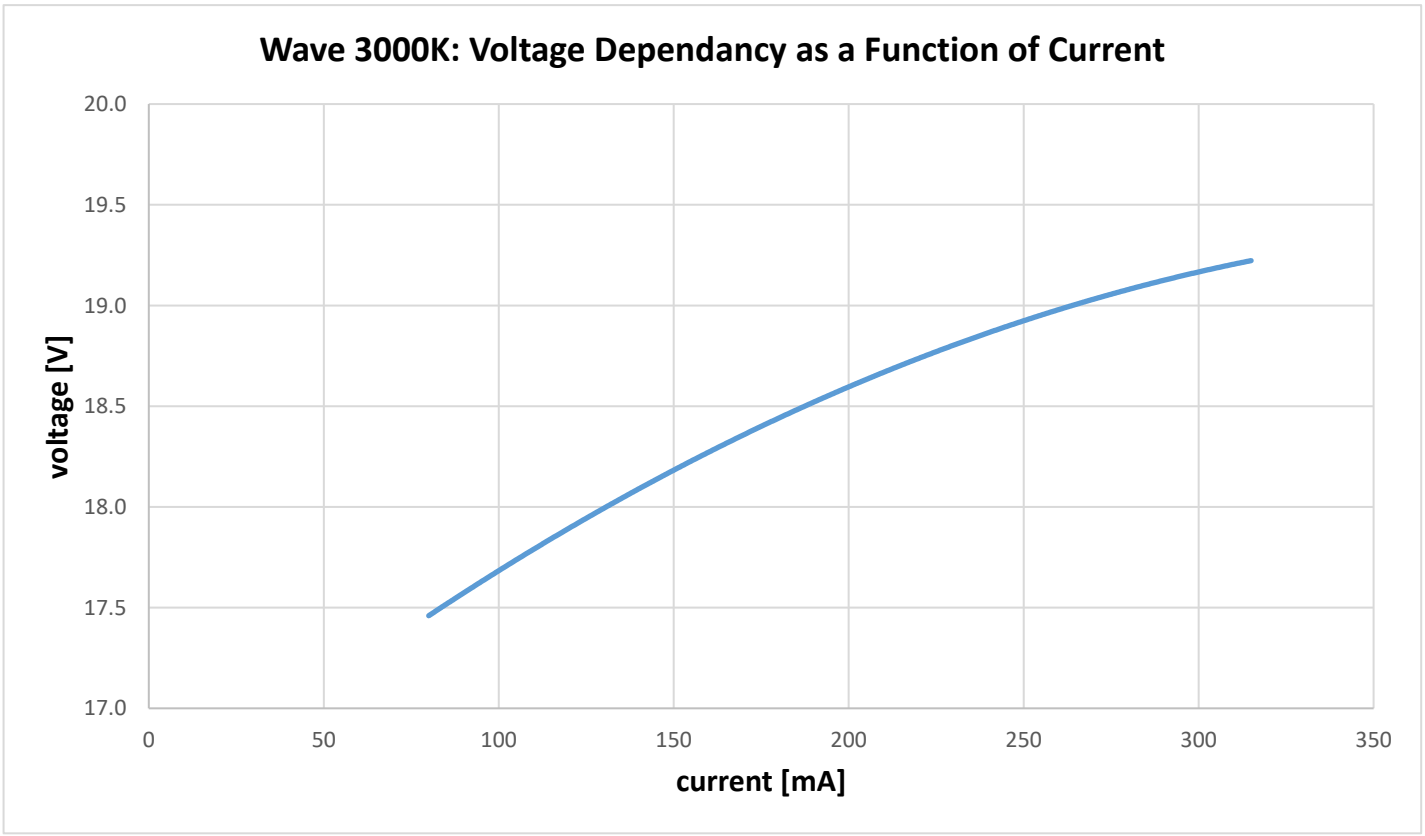

Figure 15: Voltage versus forward current at room temperature, 3000K, level 1

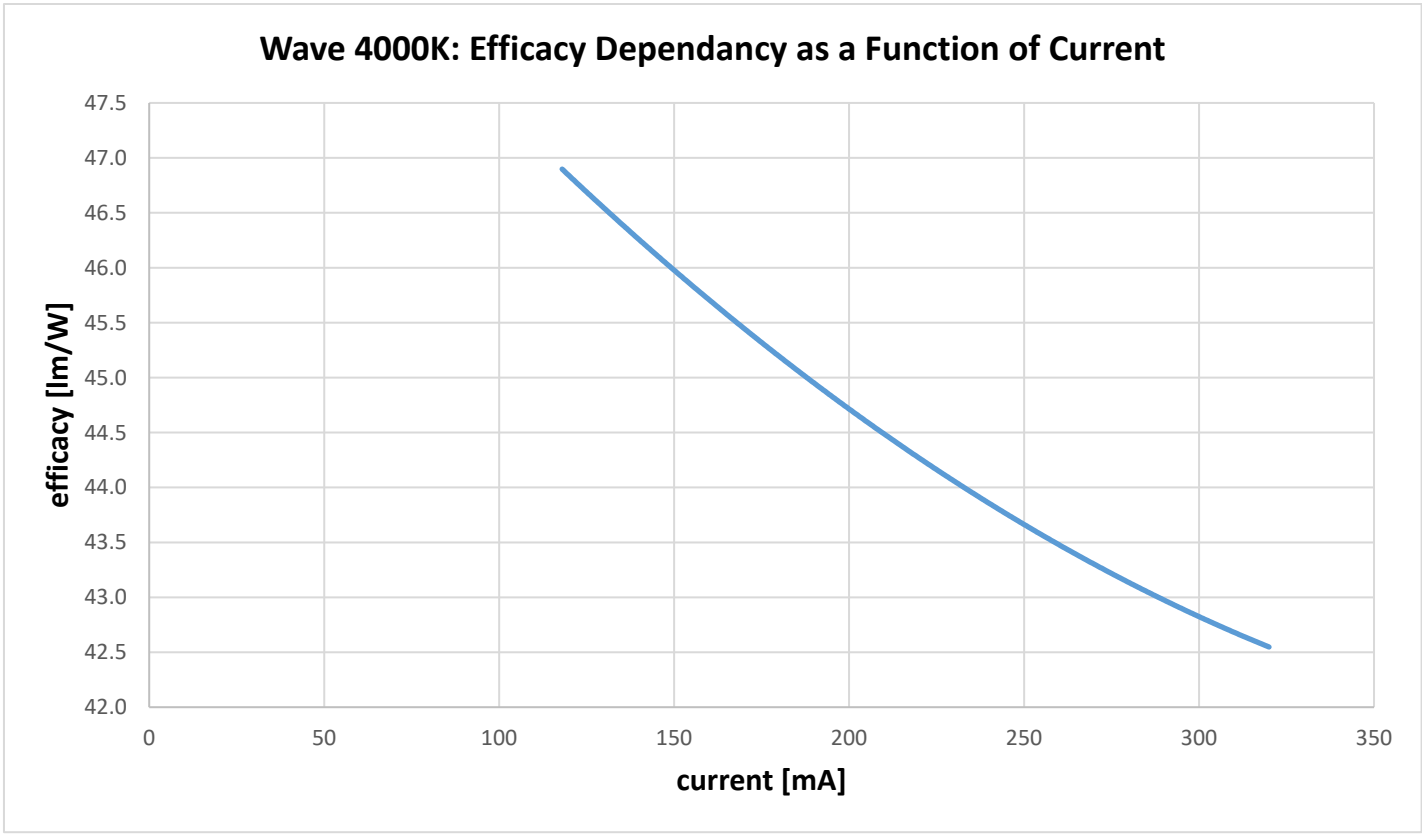

Figure 16: Efficacy versus current at room temperature, 4000K, level 1

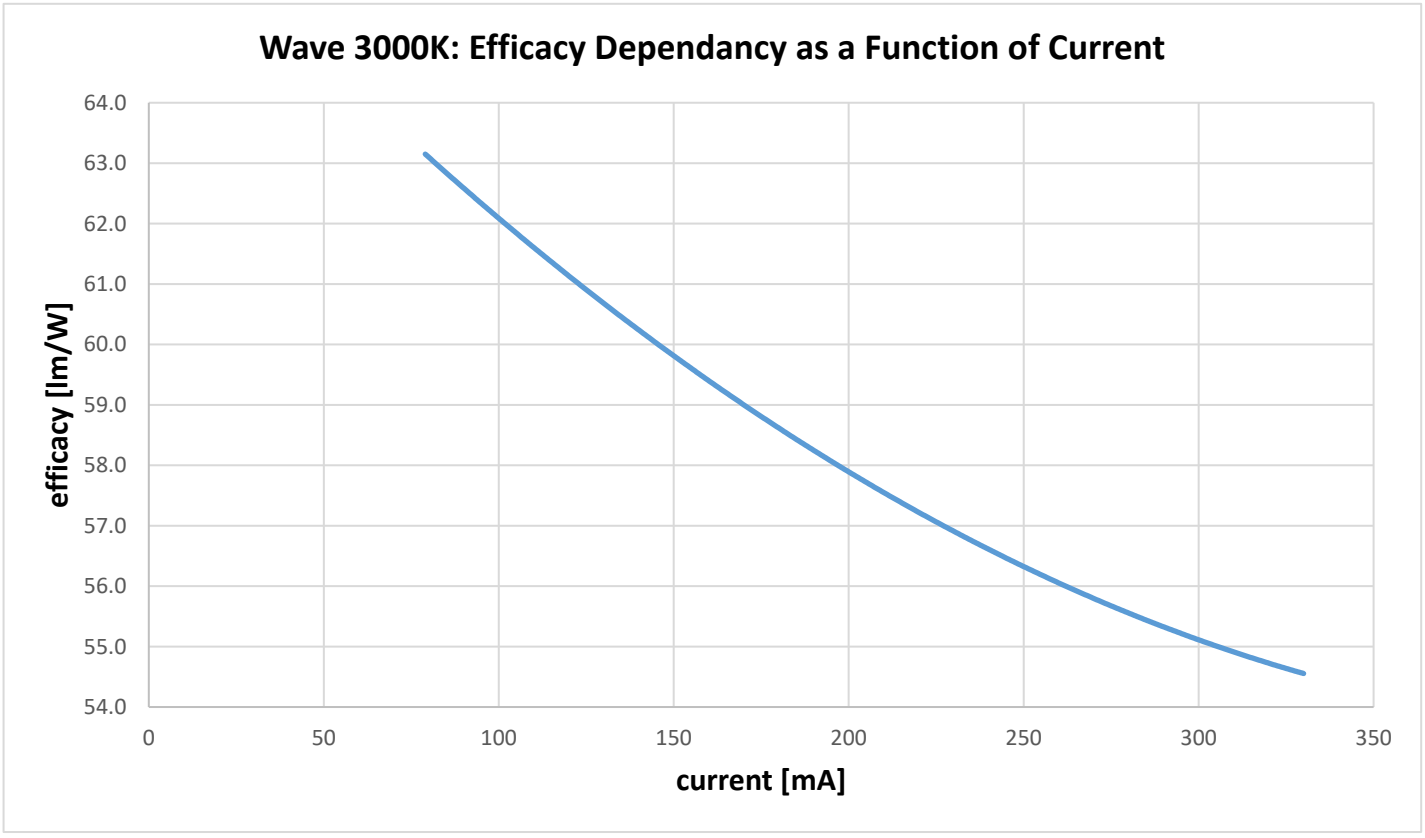

Figure 17: Efficacy versus current at room temperature, 3000K, level 1

Homogeneity of Optical Parameters

The Wave is a large area device and the luminance value may depend on the location within the active area. A very small color point distribution may also be observed.

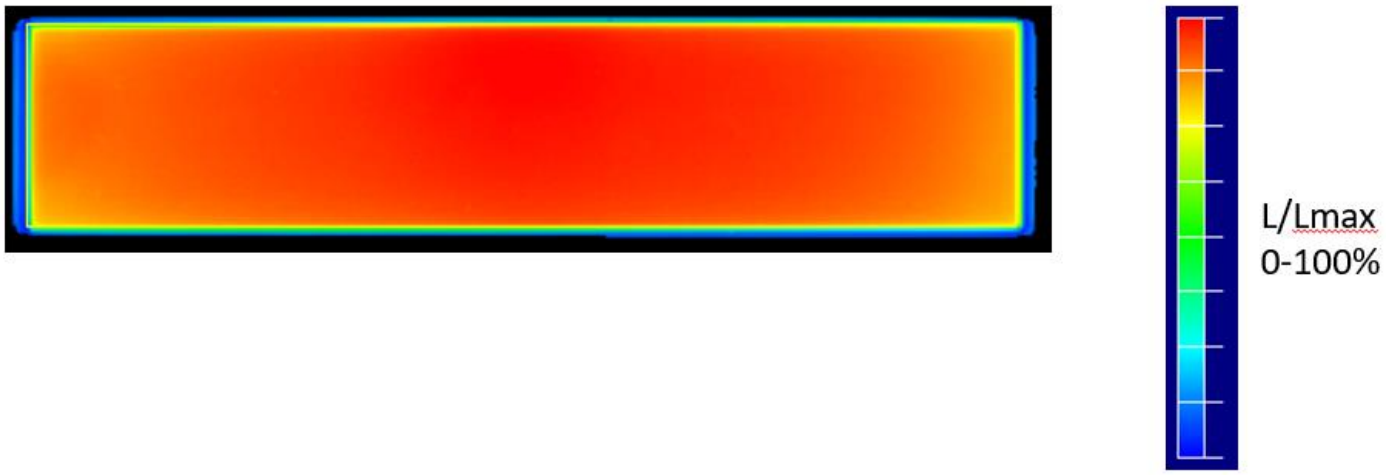

Figure 18: Typical luminance distribution for a Wave Level 1. Operation conditions: vertical in air, RT (= 25 °C), I = $I_{in\ rated}$

Angular Dependency

The luminance (measured in cd/m^2) of the OLED light depends on angle of observation. Figure 19 and 20 show typical values for the Wave Level 1.5 4000K and 3000K operated at different driving currents.

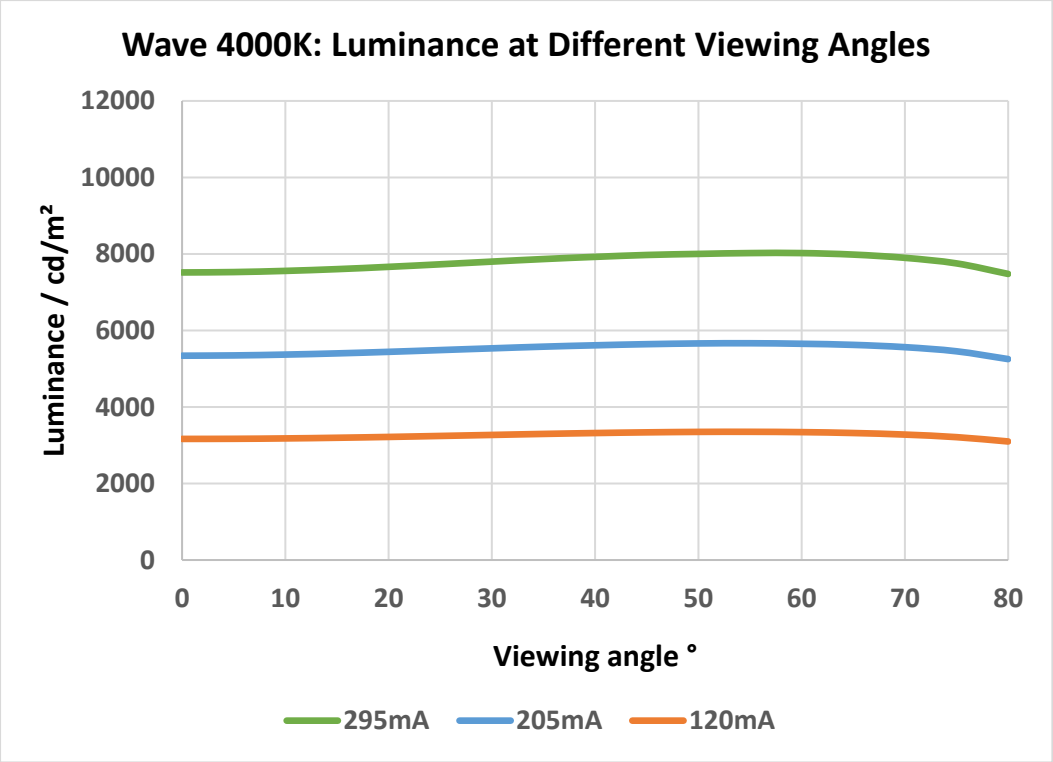

Figure 19: Luminance as function of the viewing angle. Driving currents I= 0.120 A, 0.205 A, 0.295 A, Wave 4000K

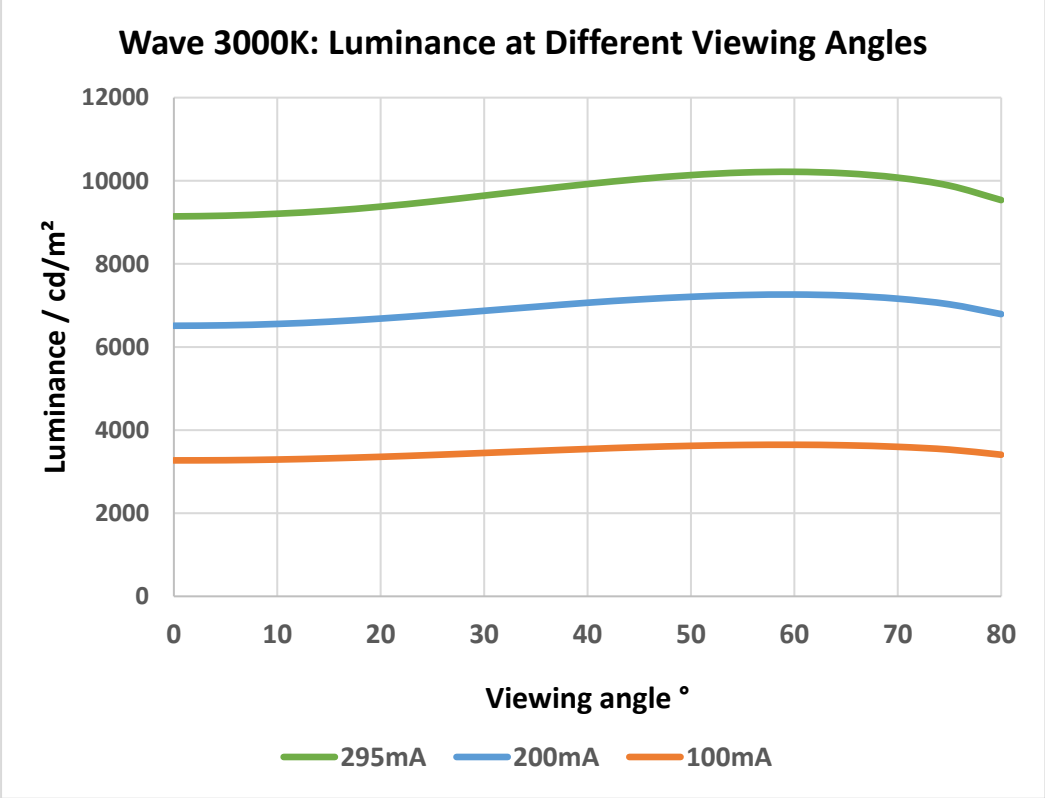

Figure 20: Luminance as function of the viewing angle. Driving currents I= 0.100 A, 0.200 A, 0.295 A, Wave 3000K

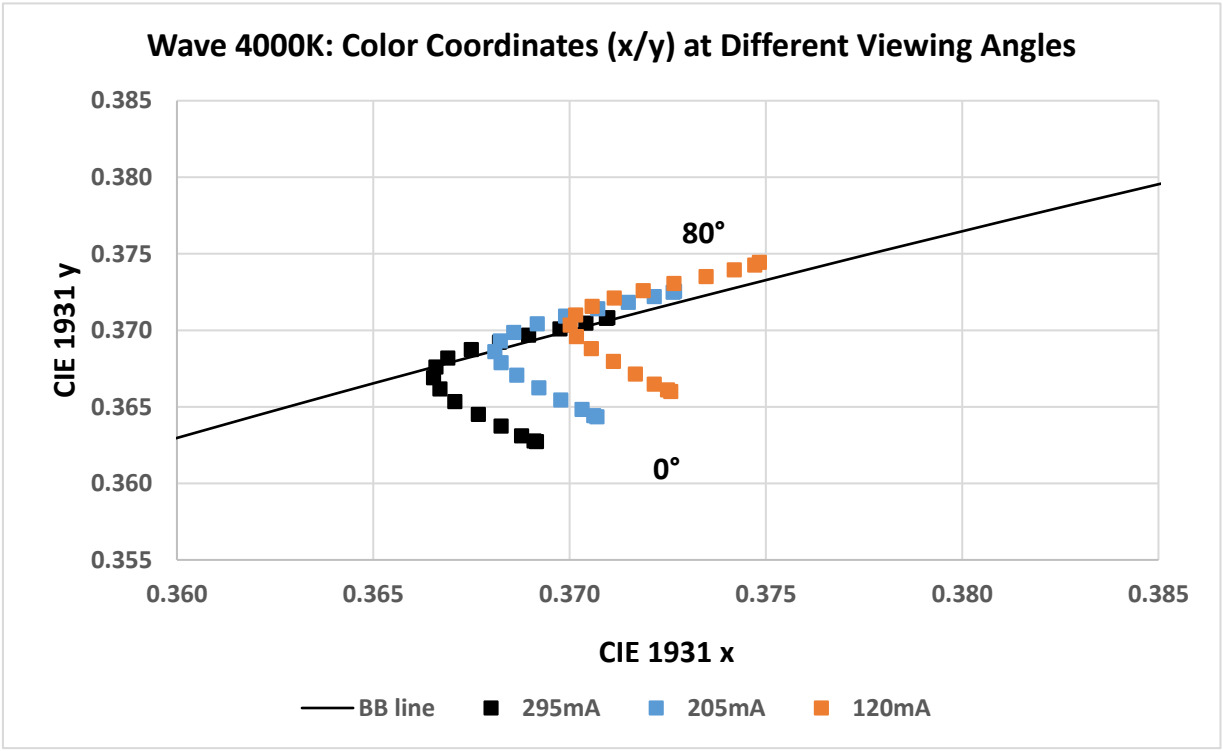

Figure 21: CIE x/y as function of the viewing angle. Driving currents I= 0.120 A, 0.205 A, 0.295 A; 4000K, level 1

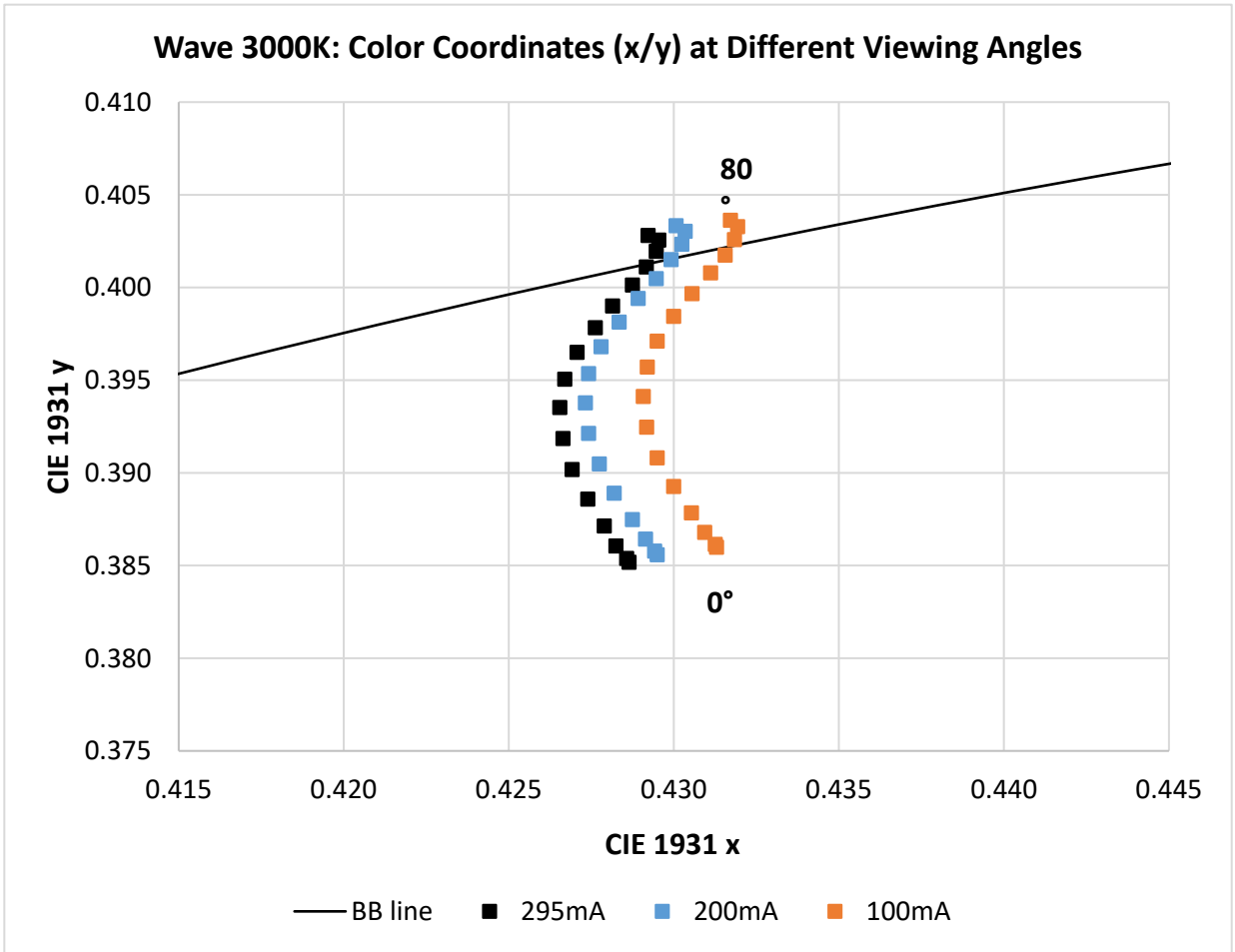

Figure 22: CIE x/y as function of the viewing angle. Driving currents I= 0.100A, 0.200 A, 0.295 A, 3000K, level 1

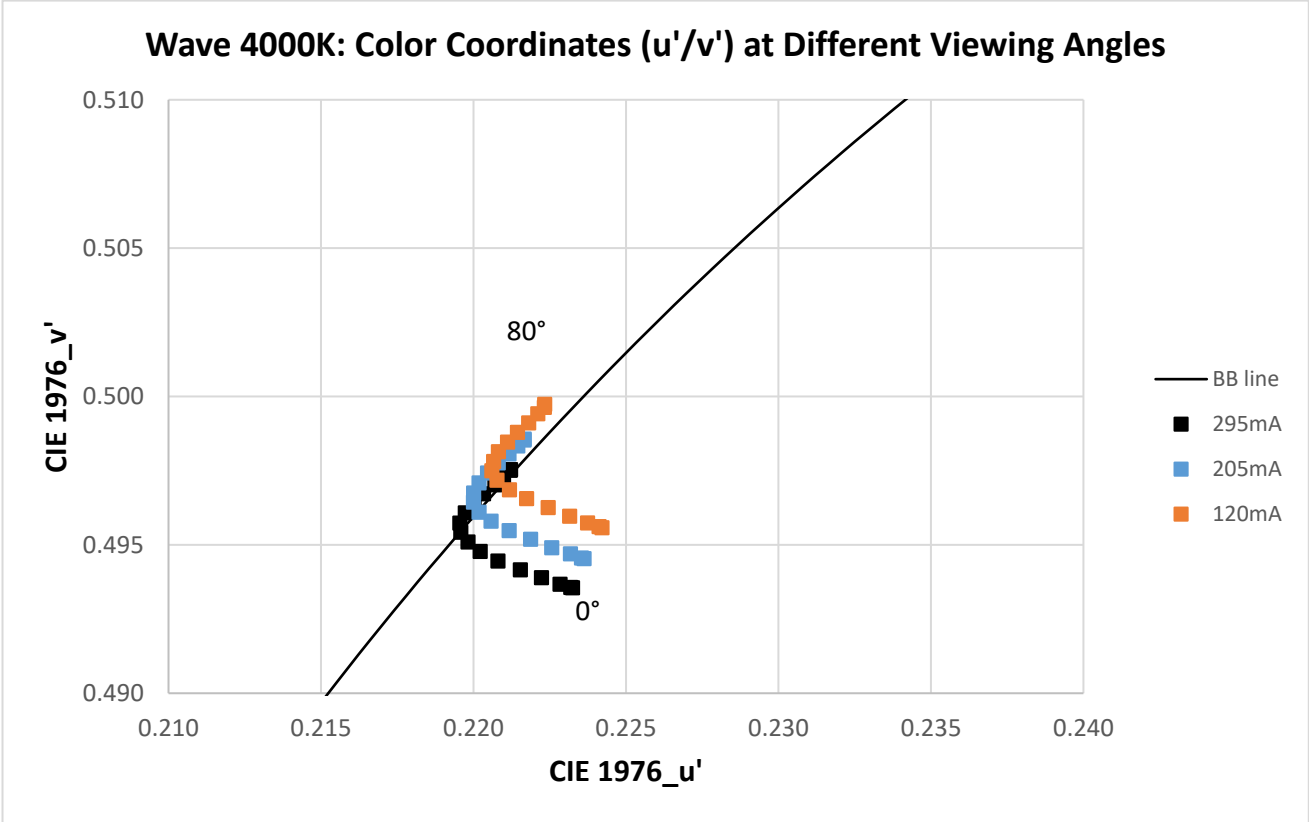

Figure 23: CIE u'/v' as function of the viewing angle. Driving currents I= 0.120 A, 0.205 A, 0.295 A, 4000K, level 1

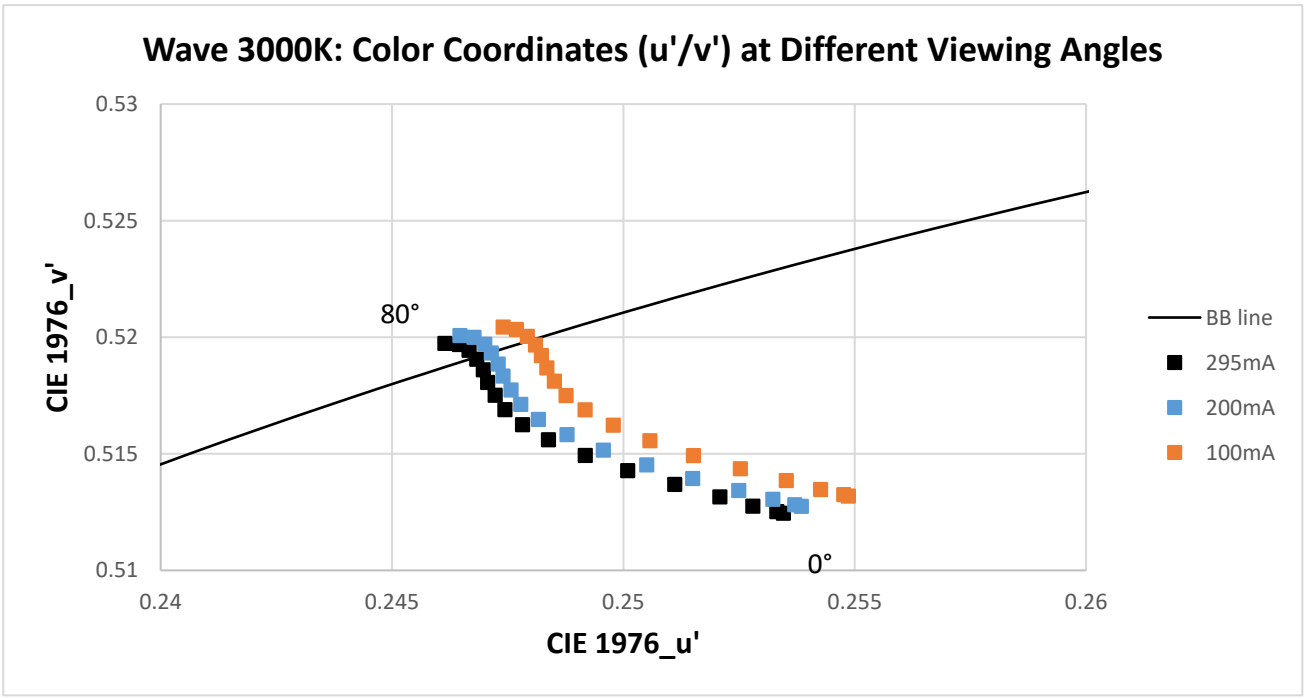

Figure 24: CIE u'/v' as function of the viewing angle. Driving currents I= 0.100 A, 0.200 A, 0.295 A, 3000K, level 1

THERMAL CHARACTERISTICS

OLEDs are solid-state lighting components. Like other electronic components the behavior of an OLED depends on its thermal state. The ambient temperature conditions as well as the driving conditions of the OLED itself influence the operating temperature.

Operating temperature has an impact on a several parameters including:

- driving voltage at a given current
- achievable lifetime (lumen maintenance)
- achievable reliability [1] (abrupt, catastrophic failures)

Local organic temperature differences in the OLED Panel may result in inhomogeneity. As the OLED itself also generates thermal energy depending on the driving current, the current directly impacts the parameters given above. Even though no active cooling is required, the panels should not be covered to avoid heat accumulation.

Thermal requirements must be considered thoroughly in the design of the luminaire to achieve proper optical results and the targeted lifetime. More details can be found in the design-in guide.

The OLED temperature during operation depends on ambient conditions and driving current. Indicative values for internal (organics) temperature of the device can be measured at the glass surface at the center of the device with a thermocouple attached.

Typical temperature for the Wave Level 1 is 45 °C with the following set-up:

- $I = I_{in\ rated} = 0.295$ A
- $T_{ambient}$ = RT = 25 °C
- vertical orientation
- climate chamber, no active convection

Lifetime

Luminous flux reduces with lifetime of the OLED. The luminous flux of the Wave decreases to approximately 70% after 10,000 hours at rated current.

Wave 4000K

Specification item	Value	Luminous flux	Condition
OLED Panel Lifetime L70B50	10,000 hours	250lm	@ Iin rated = 0.295 A, Torganic = 45 °C
OLED Panel Lifetime L70B50	50,000 hours	100lm	@ 0.12 A, $T_{organic}$ = 35 °C

Wave 3000K

Specification item	Value	Luminous flux	Condition
OLED Panel Lifetime L70B50	10,000 hours	300lm	@ Iin rated = 0.295 A, Torganic = 45 °C
OLED Panel Lifetime L70B50	50,000 hours	100lm	@ 0.1 A, $T_{organic}$ = 35°C

Voltage increases over lifetime of the OLED; color and homogeneity of the panel may also change.

Storage lifetime

Under the recommended storage conditions the shelf life of the OLED is 2 years.

[1] Reliability - the ability of the OLED panel to perform its required functions under stated conditions for a specified period.

General Handling Recommendations and Care

Do's

Please handle the Wave products very carefully to avoid breakage of the built-in ultrathin glass. Please use gloves always when handling the products to avoid fingerprints.

Don'ts

When mounting Wave products into the luminaire avoid bending below the specified bending radius, torsion or pulling forces which may cause damage to the OLED. Please also avoid any kind of point loads caused, for example, by writing on the product with a pen. Do not scratch the light source with any hard or sharp objects. Do not drop the light source and do not let anything fall on top of it. Discontinue use of the product if this happens, even if there is no visible alteration. Defective OLED panels or panels with visible damage must not be used.

Cleaning Instructions

For everyday cleaning, the use of a compressed air de-duster is recommended. Should fingerprints or more persistent contamination have occurred, isopropyl alcohol should be applied to a lint-free cloth. Apply a little of the liquid to the cloth and gently wipe the surface of each OLED with a circular movement, beginning at the center and moving towards the edge. Never use water on the OLEDs as this may shorten the lifetime or reliability of the product.

Storage and Operating

Please note that the recommended storage temperature is 15 °C to 25 °C. The recommended relative storage humidity is 65% or lower. Avoid exposing OLEDs to UV light.

Safety

In the unlikely event that an OLED fails, the temperature may rise locally to high levels. To avoid this the OLED should be turned off immediately.

Disposal

OLEDs should be disposed of according to local legislation.

Logistical data

Specification item	Value
Product name	Wave 4000K Level 1
Order code	LPC1300R1NWL101
Pieces per box	2

Specification item	Value
Product name	Wave 4000K Level 1.5 (FFC)
Order code	LPC1300R1NWL105
Pieces per box	2

Specification item	Value
Product name	Wave 3000K Level 1
Order code	LPC1300R1WWL101
Pieces per box	2

Specification item	Value
Product name	Wave 3000K Level 1.5 (FFC)
Order code	LPC1300R1WWL105
Pieces per box	2

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