superfici

customized finishing solutions

LED UV CURING

New applications in the wood and graphic arts industry

Date July 20, 2017

CHAPTER 1 – **THE LED UV REVOLUTION – A NEW CHALLENGE**

TO START WITH…JUST A QUICK REMINDER

BENEFITS AND DRAWBACKS OF UV LED CURING VS. TRADITIONAL UV LAMPS

Traditional UV lamps

- High installed power
- IR irradiation
  - ▸ **HEAT**
- Lifetime approx. 1500 h
- Ozone emission
  - ▸ **EXHAUST SYSTEM NEEDED**
- Mercury
  - ▸ **ISSUES ABOUT LAMP DISPOSAL**
- Start up time required

- Low investment costs
- Low replacement costs
- Suitable reflectors achieve good irradiation performances even at distances
- Wide spectrum
  - Wide range of lacquer formulations

UV LED

- Low installed power
  - ▸ **ENERGY SAVING**
- No IR emissions
  - ▸ **PURE COLD UV**
- Long lifetime more than 20,000 hours
- No ozone
  - ▸ **NO NEED FOR EXHAUST DUCTS**
- No mercury
  - ▸ **NO ISSUES ABOUT DISPOSAL**
- Instantaneous ON-OFF
- Narrow spectrum
  - Ideal for deep curing

- High investment costs
- High replacement costs
- Focus area at limited distance
- Monochromatic spectrum
  - Narrow range of lacquer formulations

What is necessary to efficiently cure inks or coatings by an LED system ?

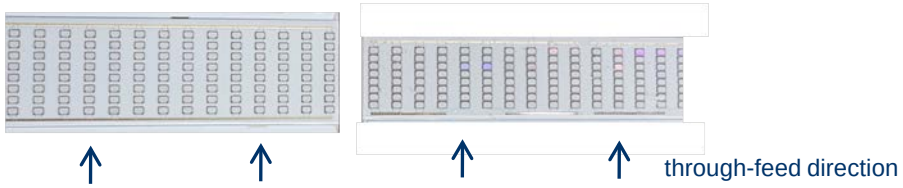
What are the construction variables which can influence the final performance of an LED UV system vs/investment costs ?

What is necessary to efficiently cure inks or coatings?

How to evaluate the real curing capacity:

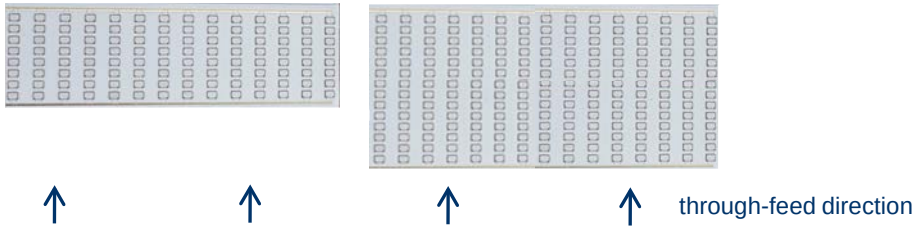
- the **required min. peak value** to activate the curing reaction

  mainly influenced by installed power and led assembly density, as well as by the optics.



- the **right energy dose** to complete polymerisation,

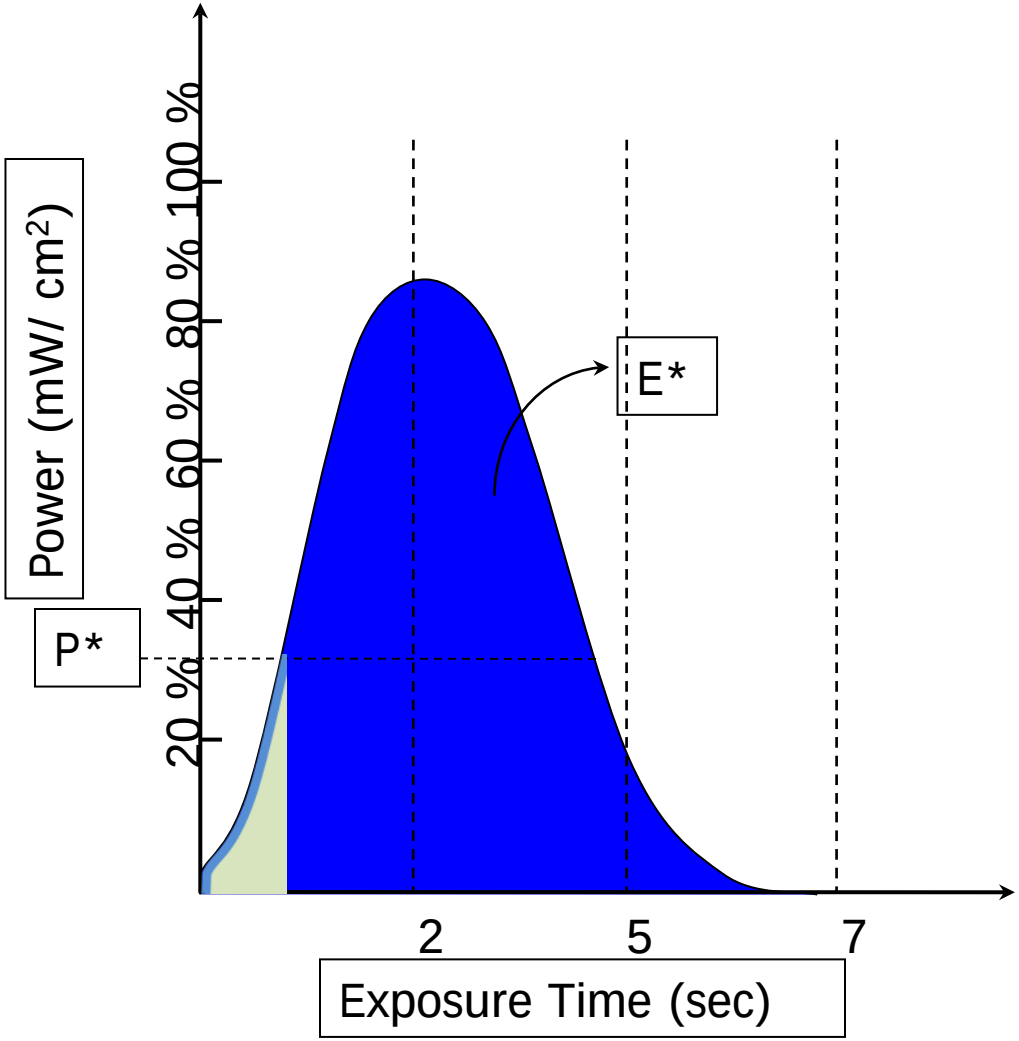
  mainly influenced (considering comparable specific powers) by the window depth in throughfeed direction



- **the irradiation wave-length** that should be the most suitable to be properly absorbed by the photo-initiators in use.

  to be selected by the LED type. LEDs generate a mono-chromatic emission.

The required min. peak value and the right energy dose



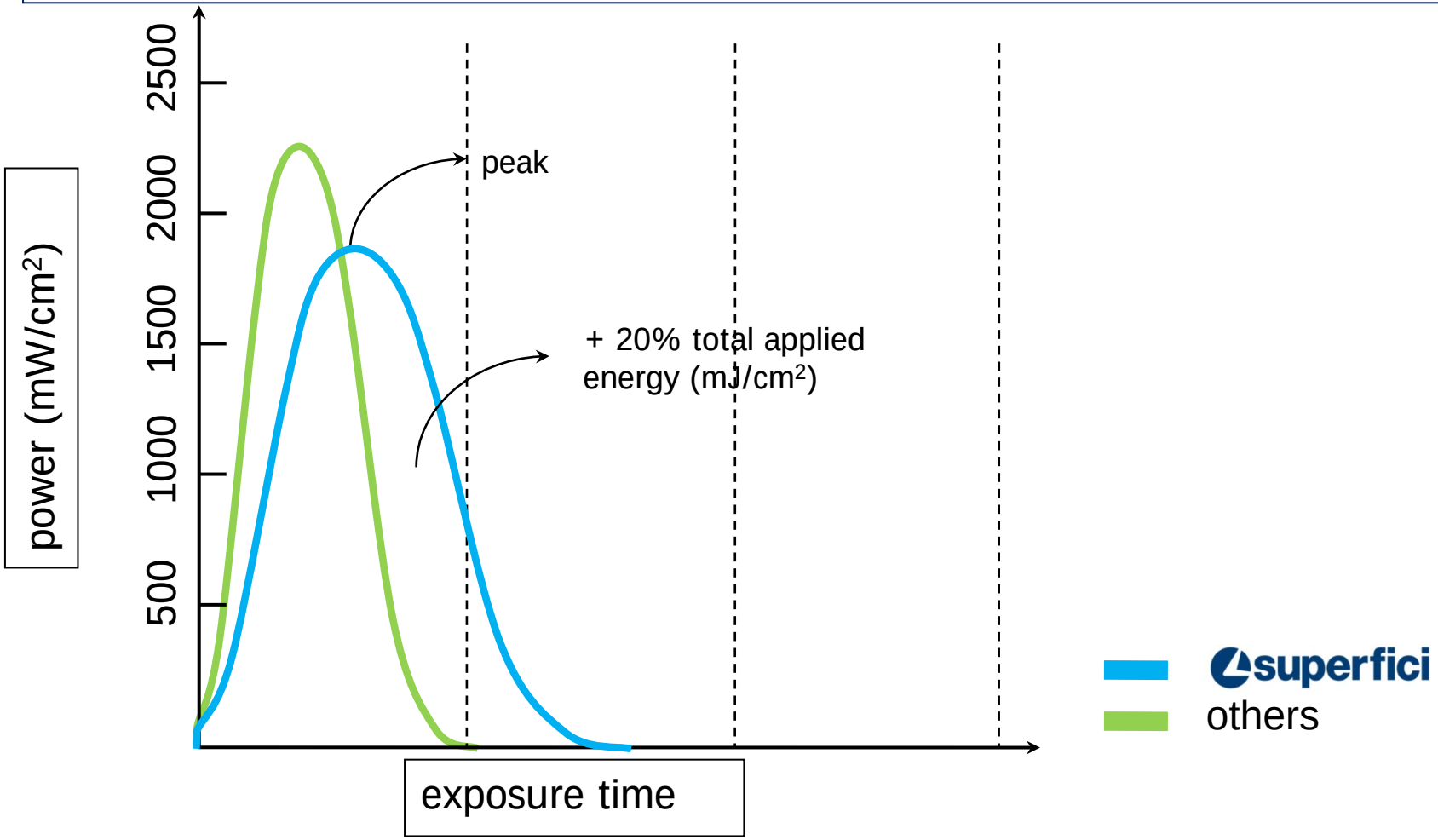
As long as the minimum peak value is reached, proper lacquer curing is achieved by the total energy amount, delivered to the lacquer layer.

CHAPTER 2 – **LED UNIT CLASSIFICATION AND CURING CAPACITY**

The required min. peak value and the right energy dose

The same global energy is achieved with a more efficient and less powerful LED system

- lower working temperature
- lower installed power
- reliability and stability in time
- lower equipment cost



CHAPTER 2 – **LED UNIT CLASSIFICATION AND CURING CAPACITY**

The required min. peak value and the right energy dose

- So, unless mandatory because of the specific application or lacquer, Superfici using lower specific power LED sources, but
  - working extremely efficiently (low and controlled working temperature + optics)
  - with an increased exposure time, by installing more LEDs to achieve high energy levels.

  As long as the minimum peak value is reached, proper lacquer curing is achieved by the total energy amount, even at higher speeds.

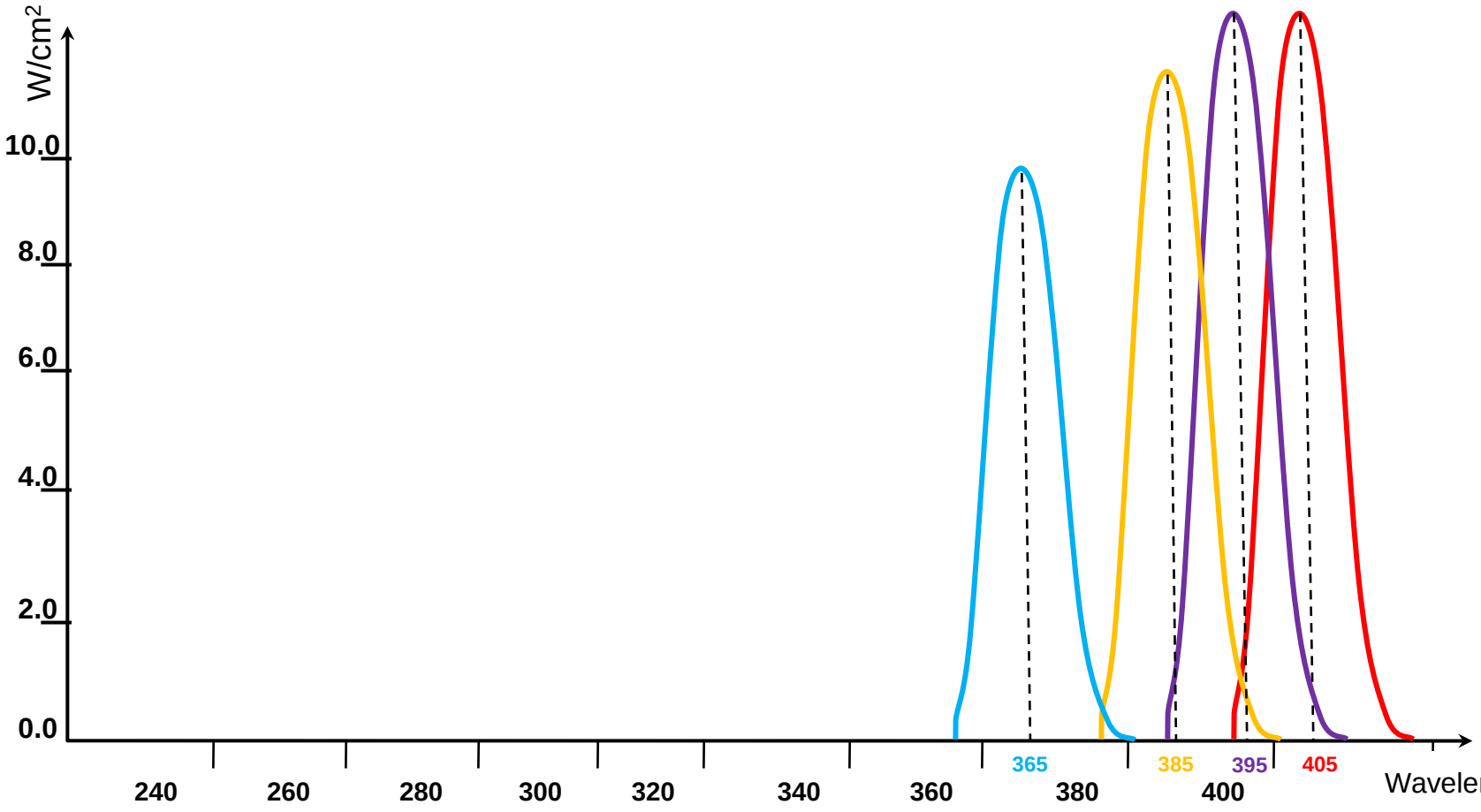
- Using extremely powerful LED sources implies important issues that might make the whole system technically and economically less efficient
  - cooling becomes more critical at higher powers
  - the system might easily become unstable in time
  - higher equipment costs

- The classification based on the specific power measured at the window only is not so relevant.
  Comparisons should be made considering the real curing capacity (based on the energy in mj applied on the lacquer film) of the systems related to the investment costs.

CHAPTER 2 – **LED UNIT CLASSIFICATION AND CURING CAPACITY**

the irradiation wave-length

The UV LED **emission is on a single selected wave-length.**
UV LED wavelengths typically in use are at present 365nm 385 nm 395 nm and 405 nm. Some LEDs on wave-length 340 or even 280 nm are available, but still with high costs and reduced power and lifetime. Available nominal powers of the LED are linked to the selected wave-length.

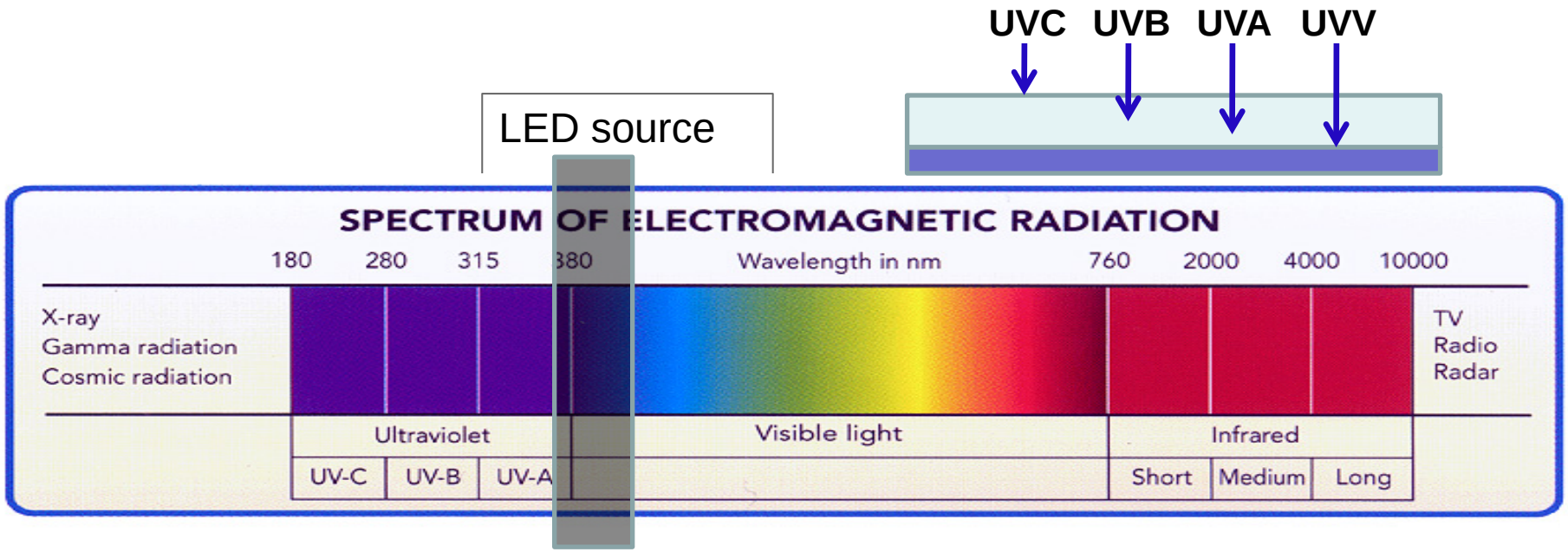


CHAPTER 2 – **LED UNIT CLASSIFICATION AND CURING CAPACITY**

the irradiation wave-length

The highest performance UV LED sources are available within the UVV emission range.

- Some more expensive and less efficient diodes are also available on 365 nm.
- No short wave UV irradiation is at the moment achievable by LED.
- Lacquer and inks formulations must be adapted, so that the energy supplied on a specific selected wave-length is properly absorbed by the lacquer layer.
- Deep curing is highly efficient, even on highly pigmented paints.
- Final surface curing is more critical, as it requires the use of expensive raw materials.

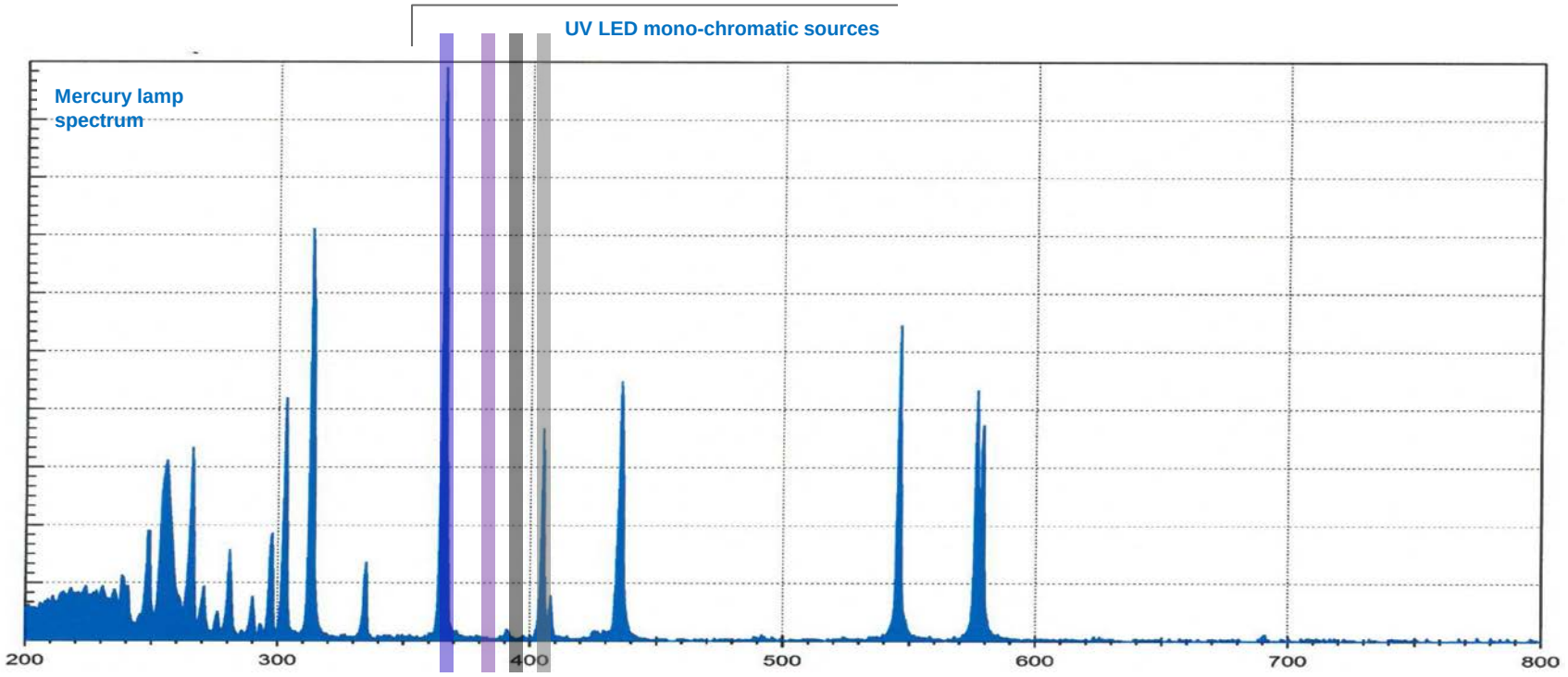


CHAPTER 2 – **LED UNIT CLASSIFICATION AND CURING CAPACITY**

the irradiation wave-length

The use of a wave-length blend is also possible so to widen the formulation possibilities for the chemical components to be used in the preparation of paints and lacquers.

If required by chemistry for example a mixture of 385 nm , combined with 395 nm or 405 nm can be used



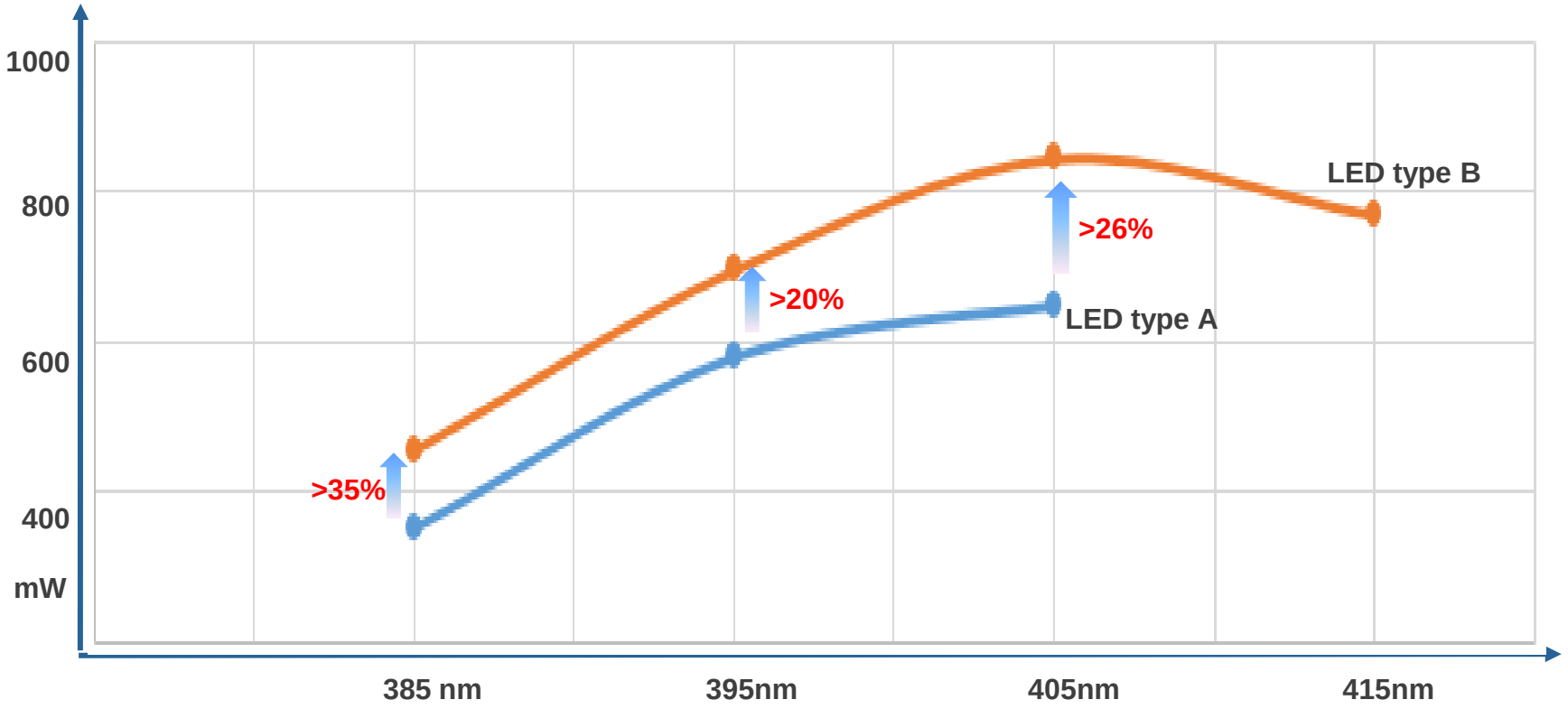
CHAPTER 3 – **UV LED UNIT ELEMENTS**

What are the construction variables which can influence the final performance of an LED UV system vs/investment costs ?

- UV diodes and c.o.b.
- Optics
- Cooling
- Electronic control and logic
- Power supply

UV diodes and c.o.b.

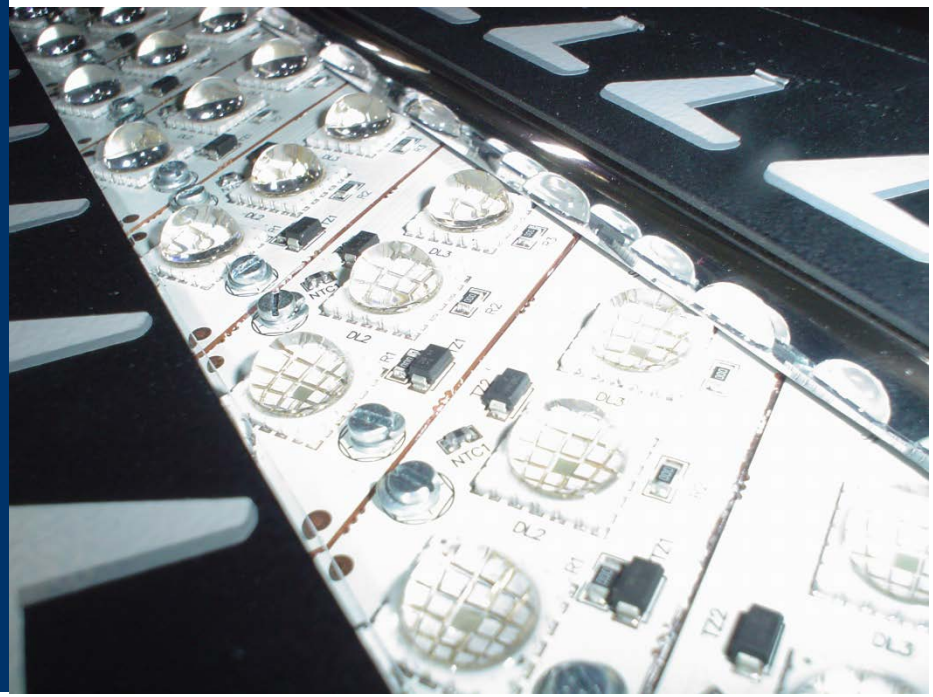
- High performance LED chips mean superior flux with less LED count and less installed power.
- Diodes are selected in terms of quality also according to the accepted power and wavelength shift tolerance.



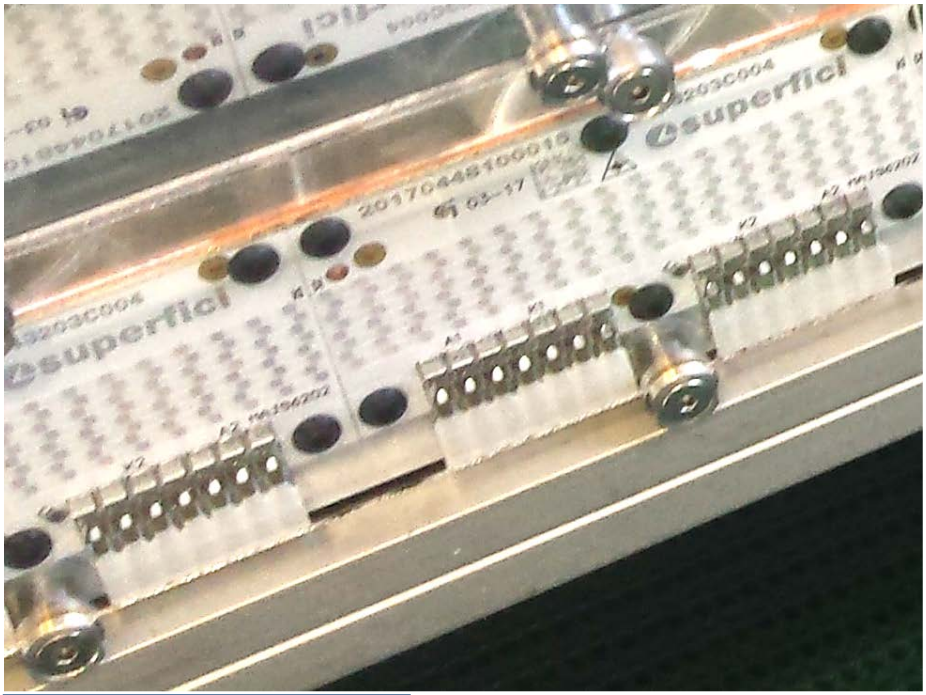
***** comparison at the same current supply value

UV diodes and c.o.b.

- LED's can be arranged in different configurations according to purpose.
- Using LEDs instead of a bulb, gives more choices in the final geometry.



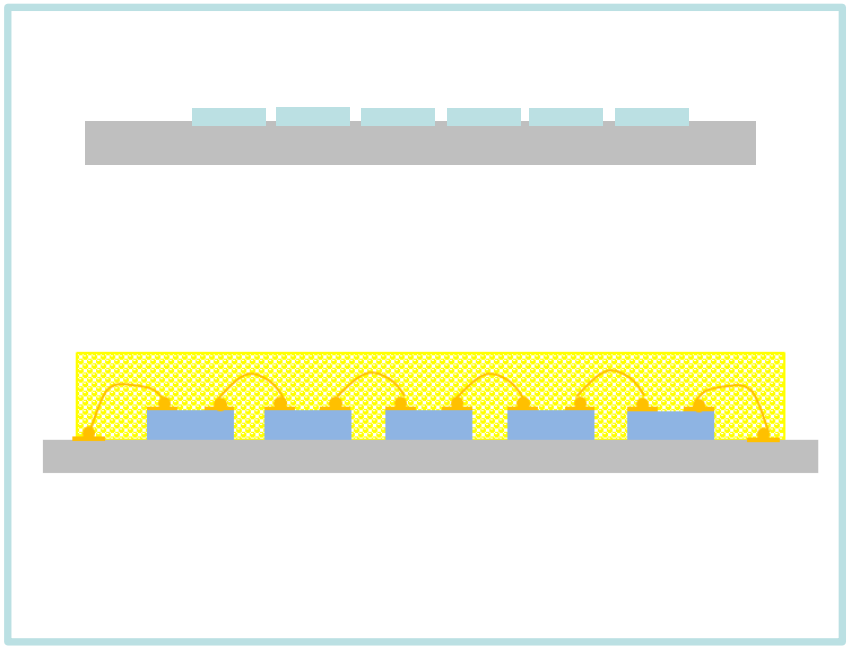
multichips



single chips in array

UV diodes and c.o.b.

- C.o.b.. costruction engineering also influences the final performance of the system in terms of heat dissipation and irradiation uniformity.
  - Substrate material , bonding, etc
- No silicone over mold in chips and c.o.b. means excellent reliability and stability in the irradiation performance
  - no silicone decay.

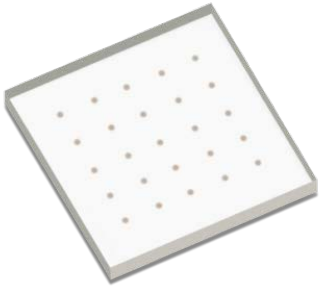


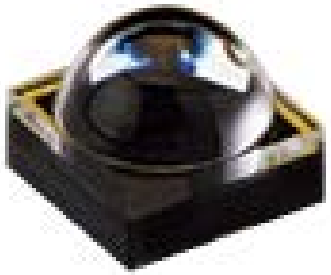
- **No wire bond**
  - Less spacing
  - No broken wire failure
  - No silicone decay cracking
- **Substrate material & package**
  - More efficient heat dissipation
  - Higher irradiation uniformity

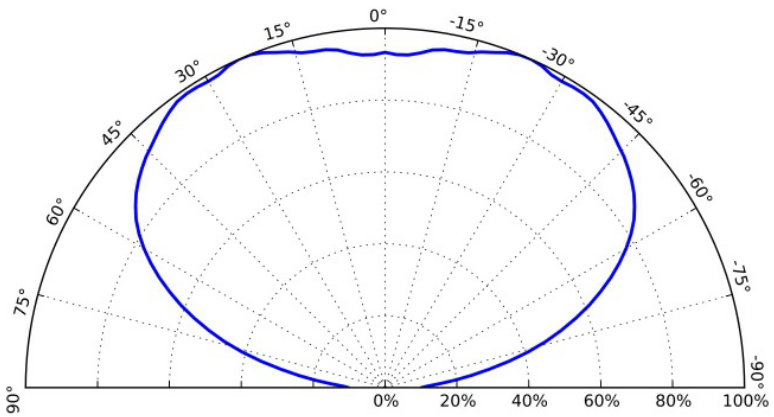
optics

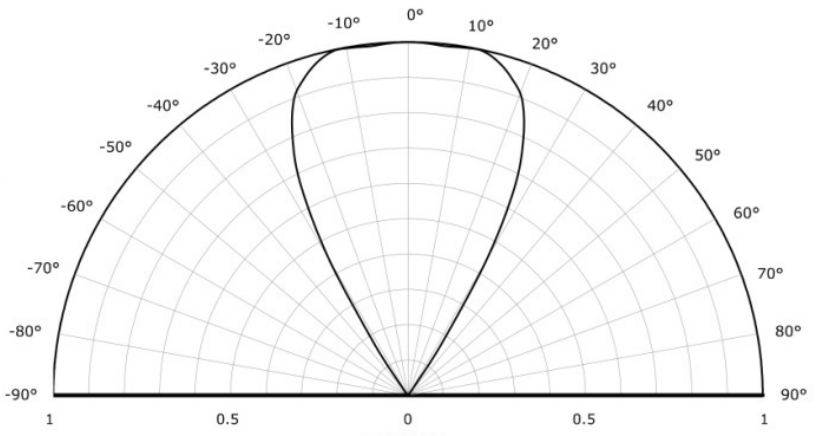
Energy and peak values applied by a system for lacquer curing is influenced in addition to the quality of the LED sources also by the optics used.

- LED's themselves have a their own typical irradiation pattern.
- They can also eventually be provided with their own collimation lens



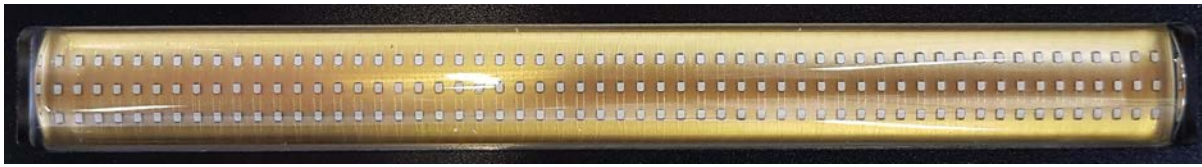






optics

Secondary optics can be added to more efficiently deliver the emitted energy to the lacquer layer and to influence irradiation conditions at the planned working distance.

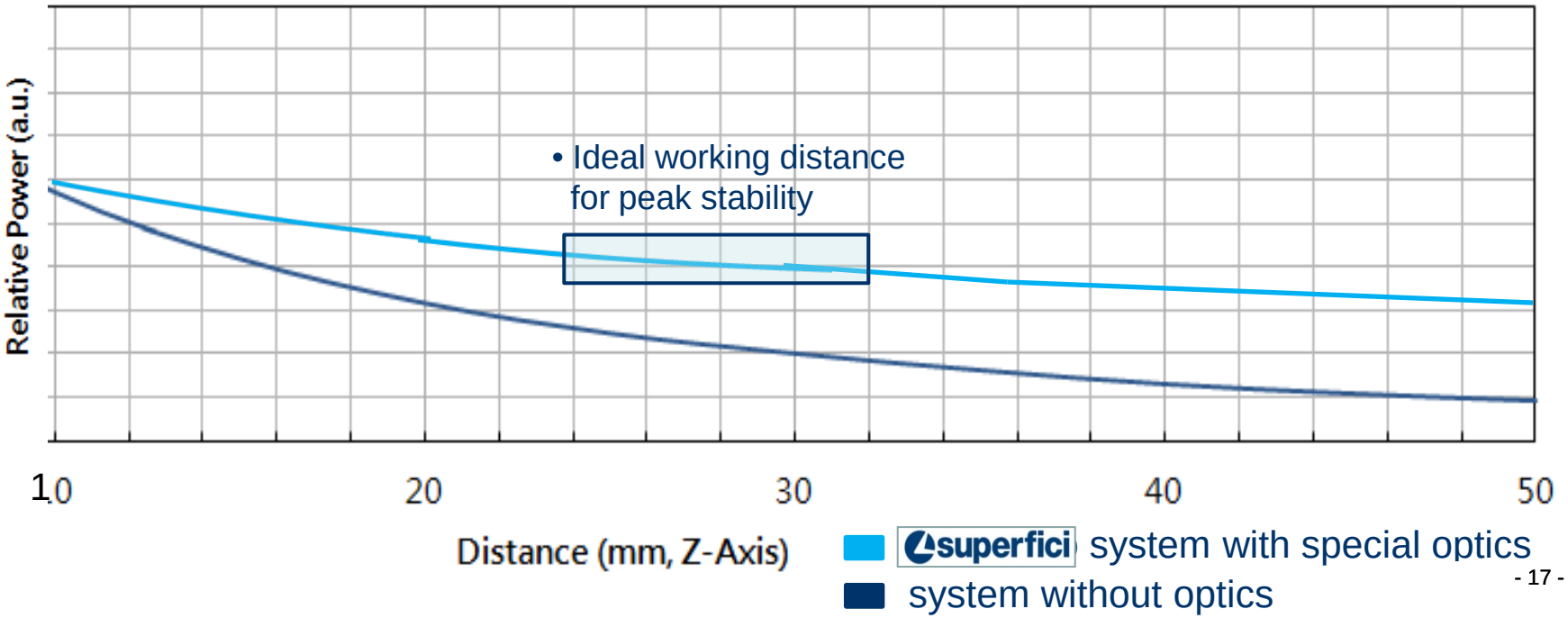


optics

In all LED systems, the power output drops down significantly at little increase in the distance from the LED source.

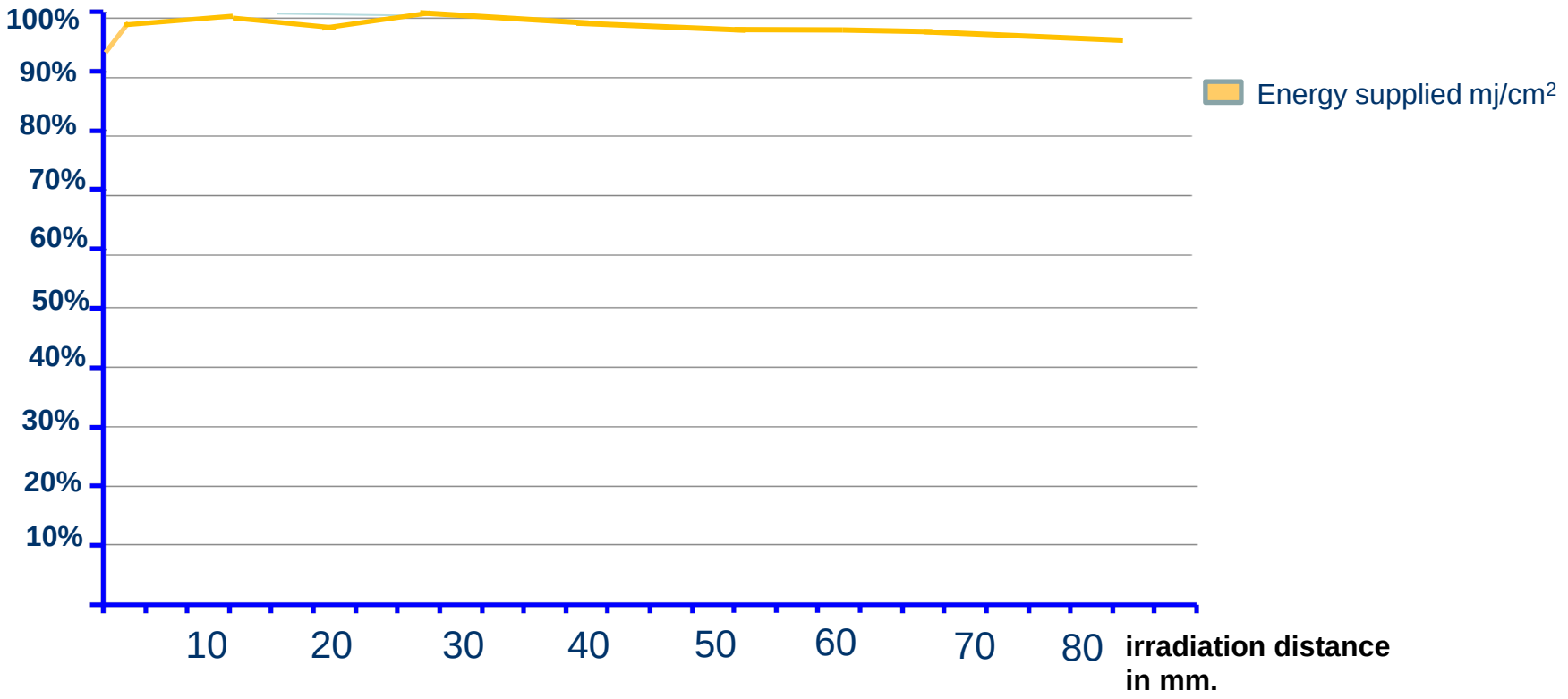
Having a properly studied optics significantly increases the efficiency of the UV LED system, achieving:

- Uniformity of irradiation.
- Flux concentration to achieve higher peak value.
- Suitable curing parameters at the desired working distances



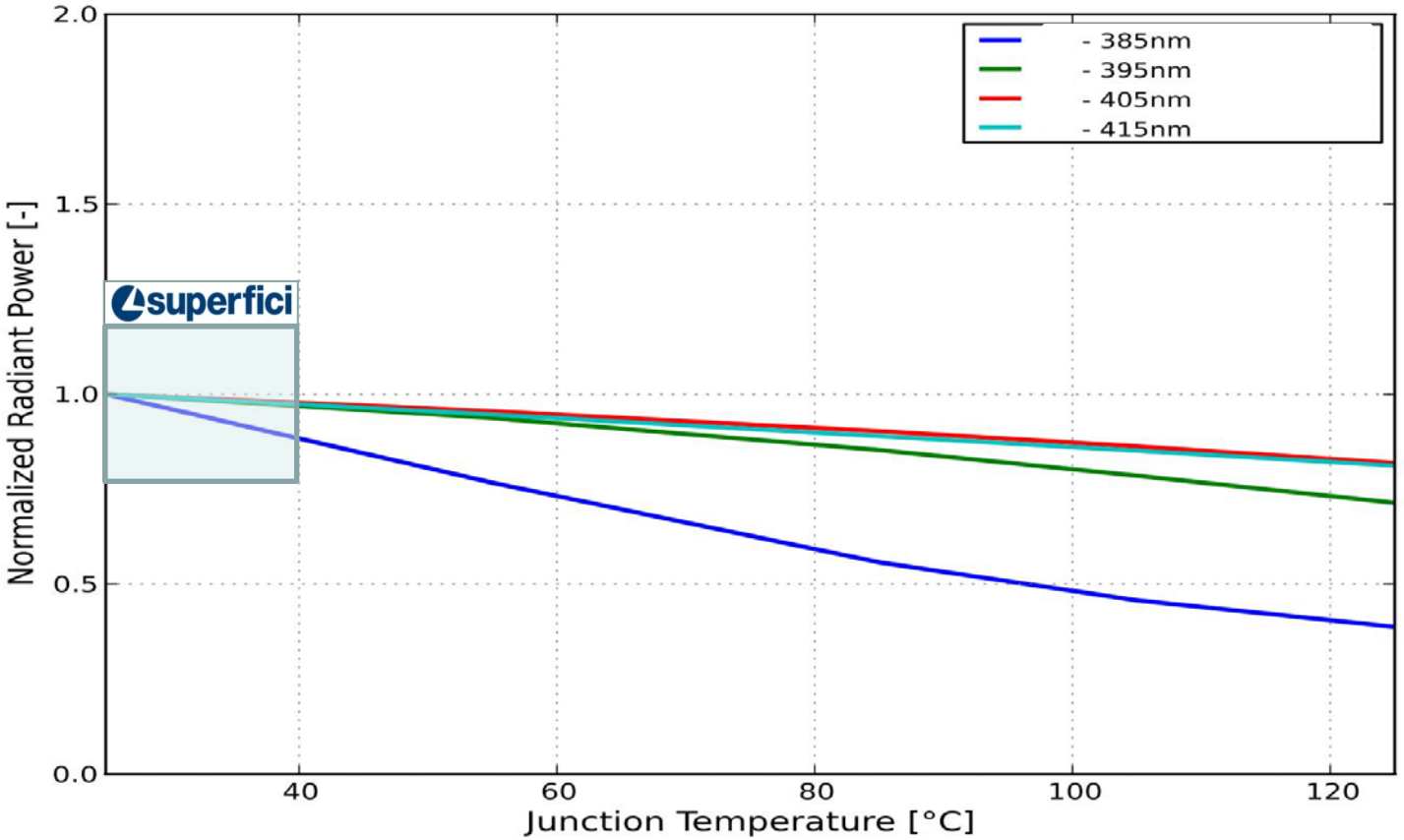
optics

Energy irradiation remains almost unvaried, even at relevant working distances.



cooling

- Working temperature dramatically influences the emission efficiency of UV LED sources.
- Air cooling systems can be used for low power UV LED systems
- Water cooling systems are recommended for more powerful UV LED application



cooling

Air Cooling

- Applicable for low power units, in Superfici range for units 8 W/cm ^{2} max.
- Variable working conditions according to external environment temperature
- Air movement is critical in some applications, dust contamination.
- Air filter maintenance necessary
- Less temperature uniformity along the unit width especially for wider units.
- Lower LED lifetime, due to higher and more unstable working temperature conditions.

- Lower initial investment costs

Water Cooling

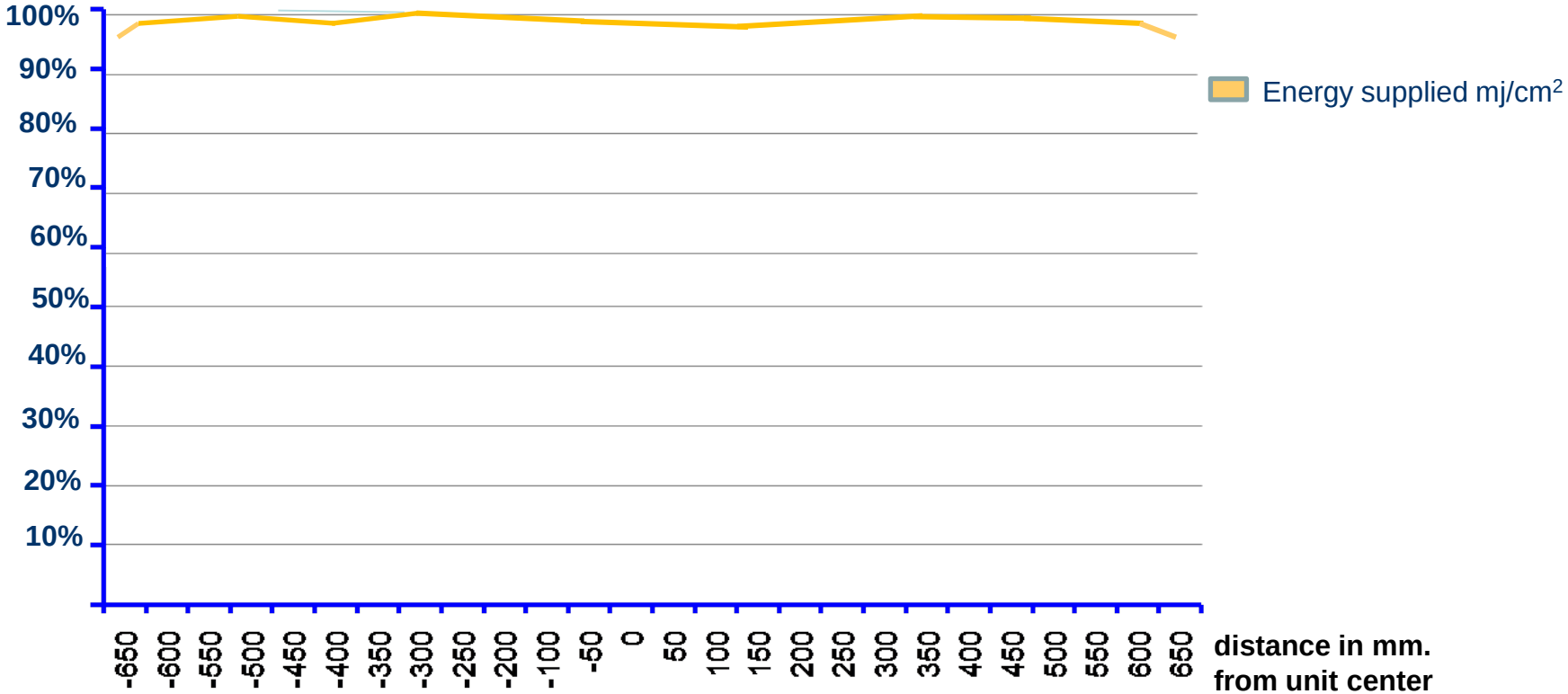
- Lower and more control over LED working temperature
  - More efficiency
  - Longer LED lifetime
- Constant working temperature conditions along the year
  - Irradiation parameters constancy
- Uniform temperature along the whole working width, particularly relevant in wider units
  - More irradiation uniformity in the working width
- No air movement
  - Cleaner working environment.
- No fan noise
- Lower line down times and maintenance costs

- Higher initial investment costs

cooling

Irradiation uniformity depends, among other factors, such as LED quality, LED distribution, c.o.b. construction, on the LED working temperature uniformity along the LED unit width.

A correctly studied cooling system, considering heat sink engineering, water circuit etc. is particularly important to assure proper performances, especially on wide UV units.



** data refer to our double matrix unit w/width 1344 mm.

electronic control and logic

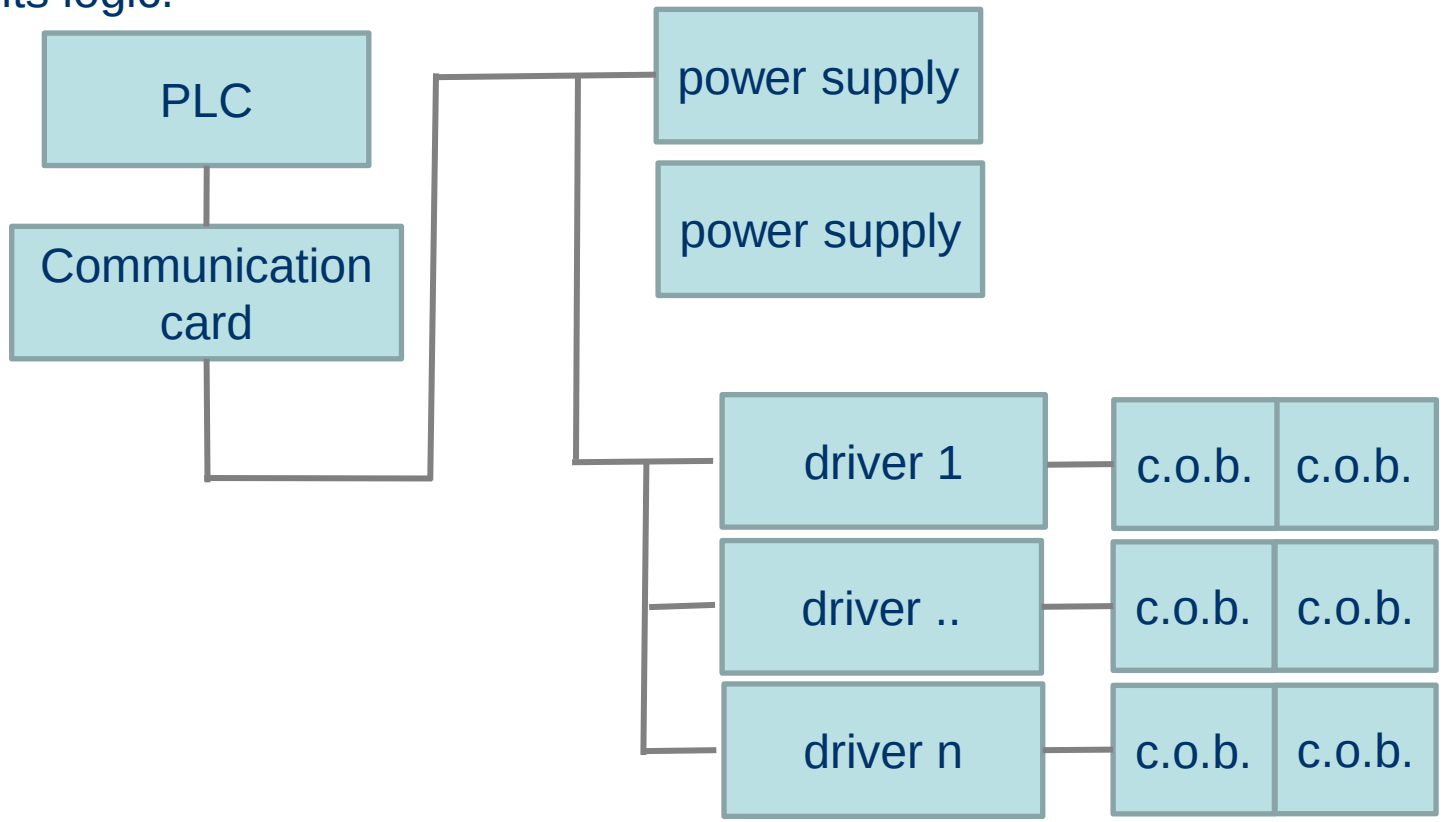
- LEDs permit **instantaneous switching on and off -** through the control this can be easily used in automatic lines to optimize the “on time” according to the presence of pieces - This increases the global energy savings.

- LED units also easily allow to **partially switch on and off sections** of the emitting window, to adjust the irradiation width according to need.

- **Power can be adjusted** instantaneously and in a very **wide range of 10% to 100%** to adapt the emission to what specificaly needed for the lacquer in use.

electronic control and logic

All of this , together with the monitoring of the unit working paramaters, such as temperature, current…, is achieved by the electronic control and its logic.

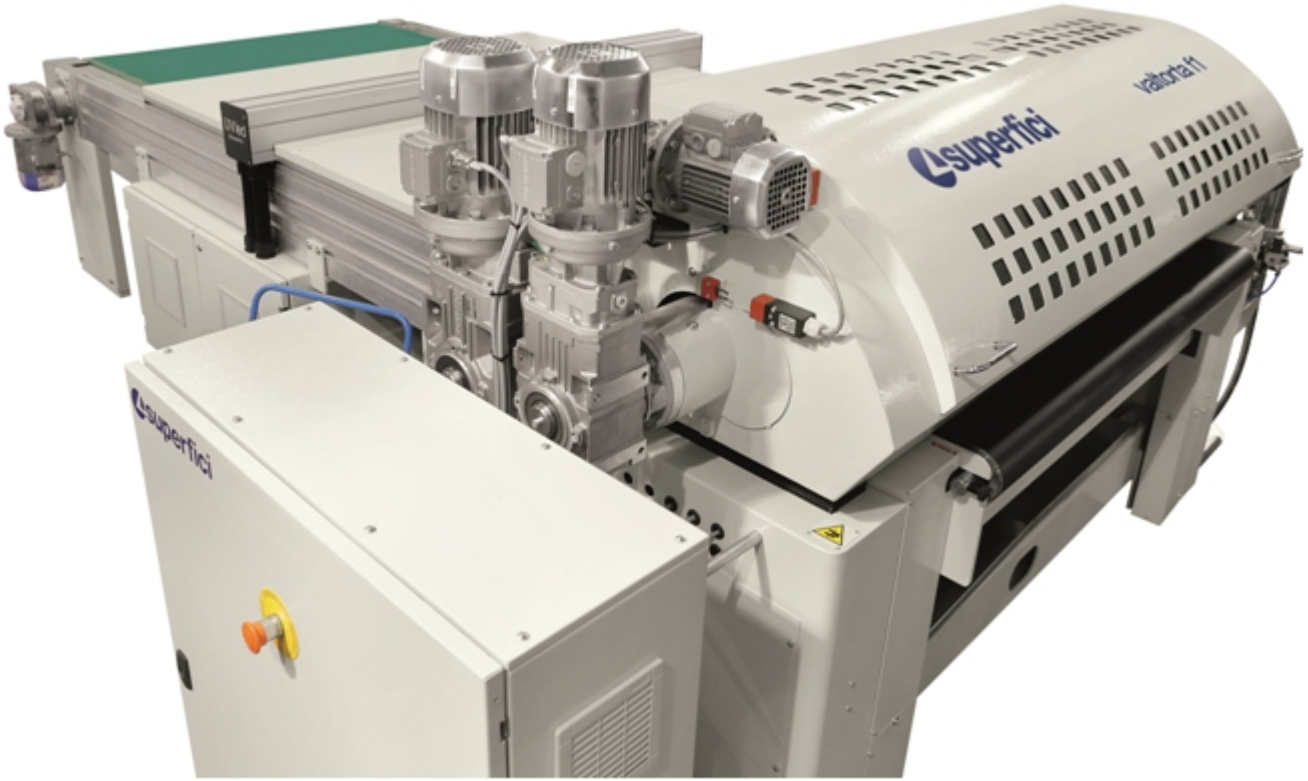


electronic control and logic

- the whole electronic control is translated into an easy , user friendly software interface to control the unit.
- the machine is easy to integrate in full automatic lines and it is industry 4.0 ready

power supply

The power supply is our own project, so to control and guarantee the efficiency and the reliability of the complete system.
Stable and controlled LED power supply conditions influence performance and LED lifetime.



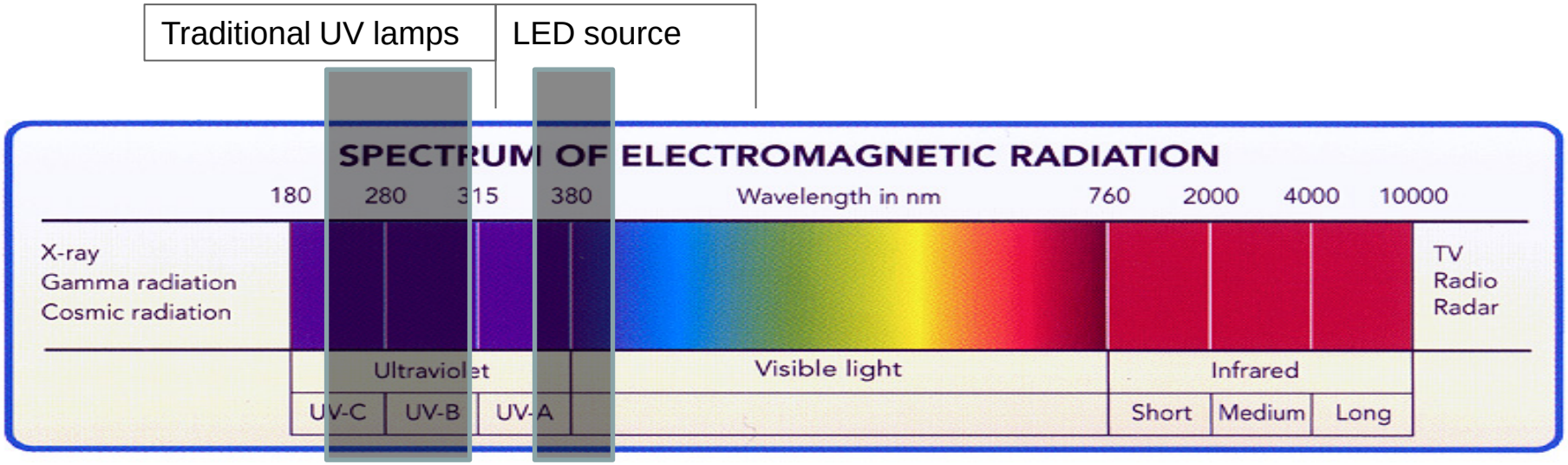
LED UV complete system

CHAPTER 4 – **UV LED APPLICATIONS**

- **graphic arts**
- **wood**
- **plastic**
- **glass**

CHAPTER 4 – **UV LED APPLICATIONS**

- **LED UV curing of printing inks** is state of the art.
  - UV LED emission wave-length perfectly suits UV printing inks curing requirement.
- **Pure LED UV curing coatings are also available.**
  - Their formulation range is still limited and their cost is slightly high.
- **LED systems for lacquer curing are therefore often combined with traditional UV lamps as a final lamp,** to achieve surface curing more easily and without yellowing.
  - Final traditional lamps can be normally put at a very low power setting.
- **a combination LED plus low power amalgam lamps is also possible.**
  - The typical benefits of the pure UV LED curing are in this case maintained (no ozone, cold irradiation).



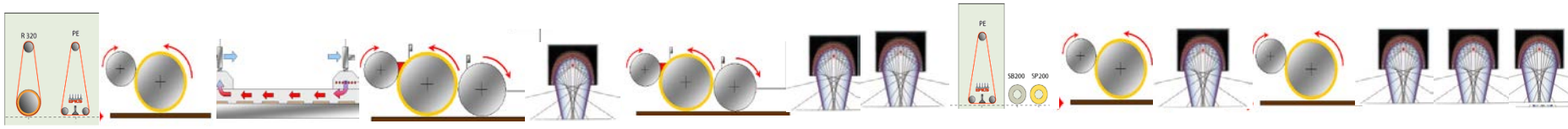
CHAPTER 4 – **UV LED APPLICATIONS**

Example of roller coating line for clear finishing of wood-based panels

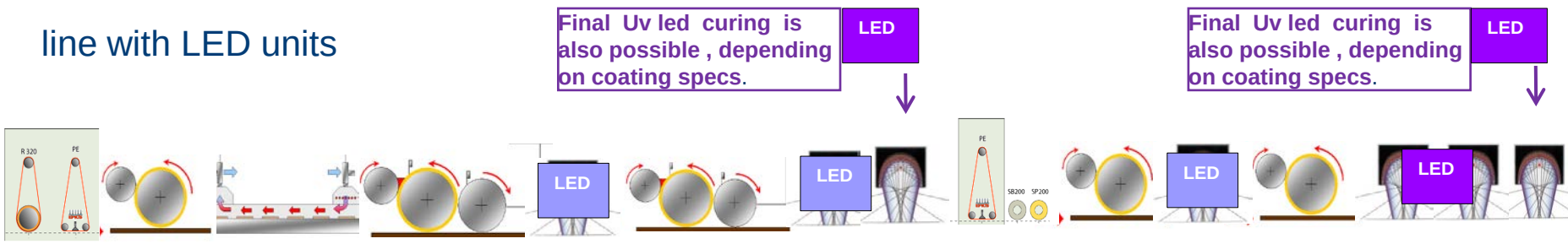
Main benefits

- **much cooler process** ▸ higher quality control ▸ less rejects
- **less installed power** ▸ reduced power consumption 40 - 50% according to line set up
- **no work-piece cooling system necessary** ▸ lower consumption in related energy
- **no exhaust necessary for the LED** ▸ lower energy consumption

line before LED installation



line with LED units

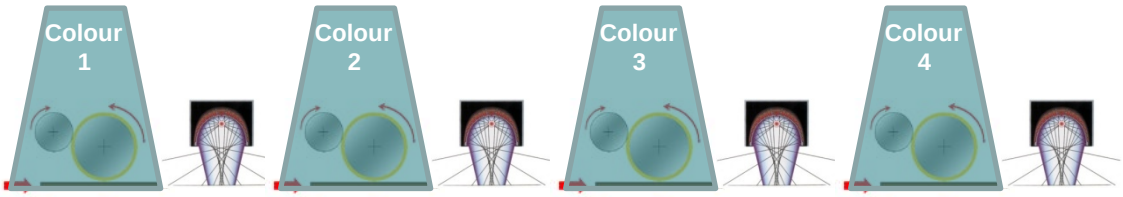


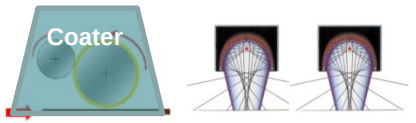
Typical printing line in the graphic art industry

Main benefits

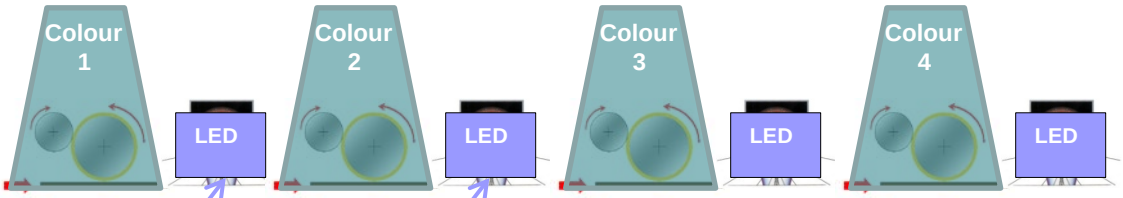
- **much cooler process** ▸ huge benefits on narrow web, flexography and offset ▸ higher quality control ▸ precise pattern matching on thermo-sensitive substrates.
- **less installed power** ▸ reduced power consumption 40 - 50% according to line set up
- **no material cooling system necessary** ▸ lower consumption in related energy
- **no exhaust necessary for the LED** ▸ lower energy consumption

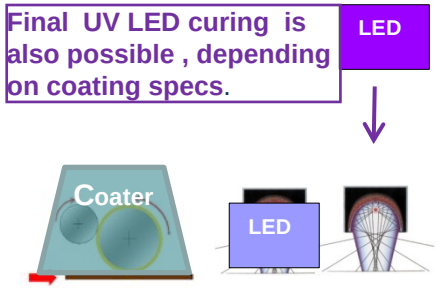
line before LED installation





line with LED units for pinning





CHAPTER 5 – **ENERGY SAVINGS**

ENERGY CONSUMPTION COMPARISON _ UV TRADITIONAL LAMPS vs/LED

	UV bulbs-3 lamps w/w 1300 mm	LED UV double matrix 1344 mm
Energy consumption		
hourly energy consumption for the UV system considering a benefit for the LED istantaneous switching on/off of approx. 5%	57 kWh	17 kWh
hourly energy consumption for cooling exhaust fans vs. chiller	2,25 kWh	4,4 kWh
hourly consumption for air conditioning necessary for conditioning of the exhausted air	7,6 kWh	0
Total hourly average energy consumption	66,8 kWh	21,4 kWh

Energy savings are approx. 65% - 70%.
We should actually also consider in addition the energy eventually needed for cooling before stacking.

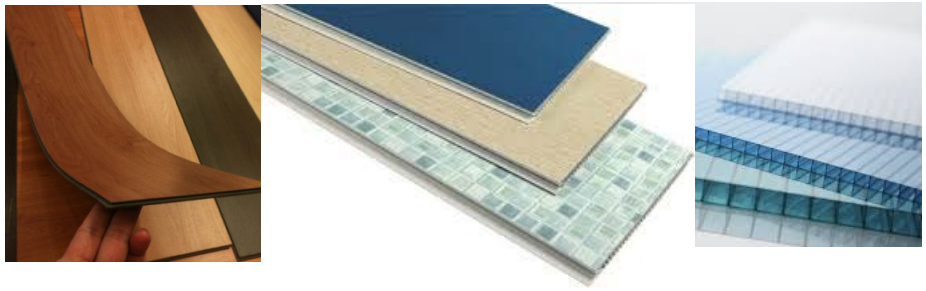
Energy consumption regarding cooling and air conditioning is calculated considering average max. daily temperatures recorderd in Milan.

CHAPTER 5 – **ENERGY SAVINGS**

- **Energy saving estimations vary a lot according to the process and the line set up**. Specific calculations are made for each custom line and proposal

- **Additional benefit is achieved in case of thermo-sensitive materials** to be processed:
  - No cooling energy required
  - No space required for material cooling equipment
  - No investment costs for material cooling system
  - Higher quality and less rejected pieces

Pinewood or other resinous woods , paper coated boards, high gloss finishing



Pvc flooring boards, hollow pvc wall panelling, polycarbonate boards

CONCLUSION

- **LED curing units have to be appreciated with reference to their real curing capacity,** i.e. according to the total energy delivered (mj/cm^2) to the work-piece surface in through-feed, together with the supplied peak (mw/cm^2) at working distance.
- **Inks, lacquer or paints must be adapted** to efficiently absorb the irradiation wave-length provided.
- **All the LED unit elements** , such as LEDs, c.o.b., optics, cooling, electronic control, power supply as well as line integration software , **influence the final performance** and reliability of the system.
- **Thermo-sensitive** materials with UV LED lines = savings are huge and quality is improved!

Many thanks for your kind attention

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