UV-SHiPLA

Development of the Flexible Surface Light Source using Luminous Array Film Technology

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Outline

1. Basic structure for Deep UV flexible surface light source with “Luminous Array Film (LAFi)” technologies
2. Fabrication process and device configuration for flexible characteristics
3. Improvement of the UV emission power and the life time
4. Performance of the UVC surface light source for a sterilization application
5. Summary

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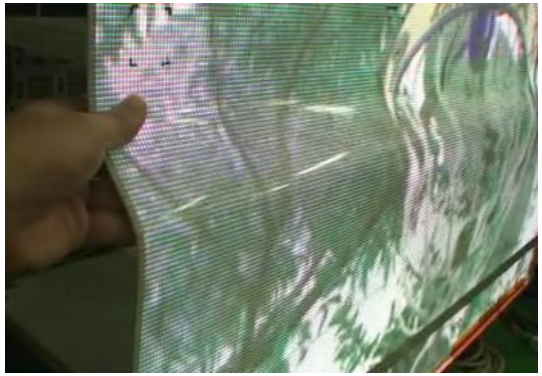
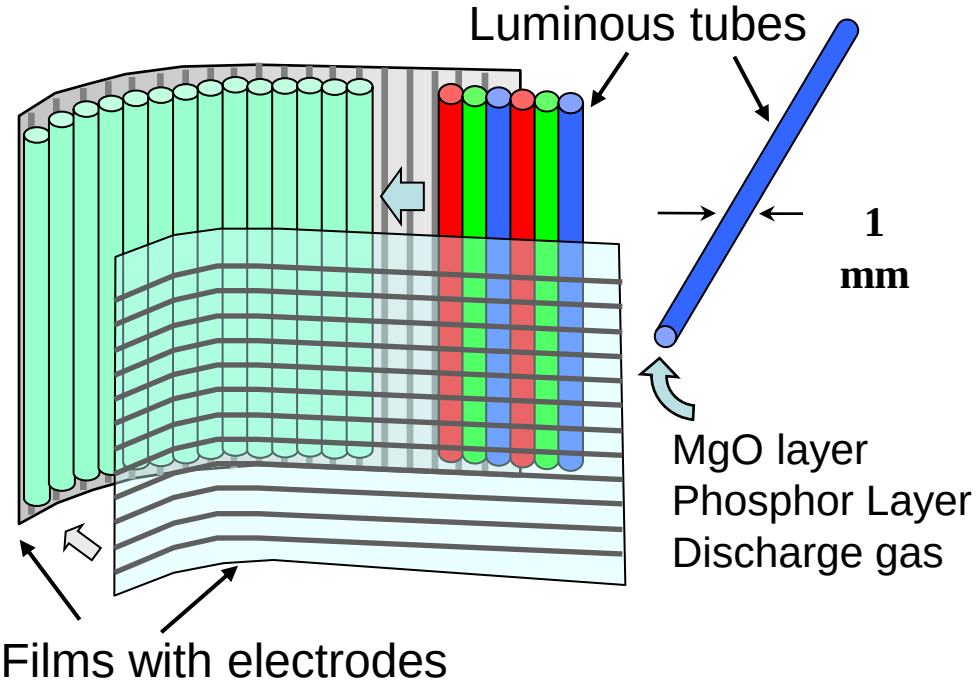
Prototype roll-up display by LAFi technology

Prototype 1 x 1-m display in I-Zone,
Display Week 2013 at Vancouver, Canada

Display Application of LAFi



Display film:
1024 x 1024 mm,
320 x 320 pixels
Thickness < 1 mm
weight =2 kg



Basic structure of Luminous Array Film (LAFi)

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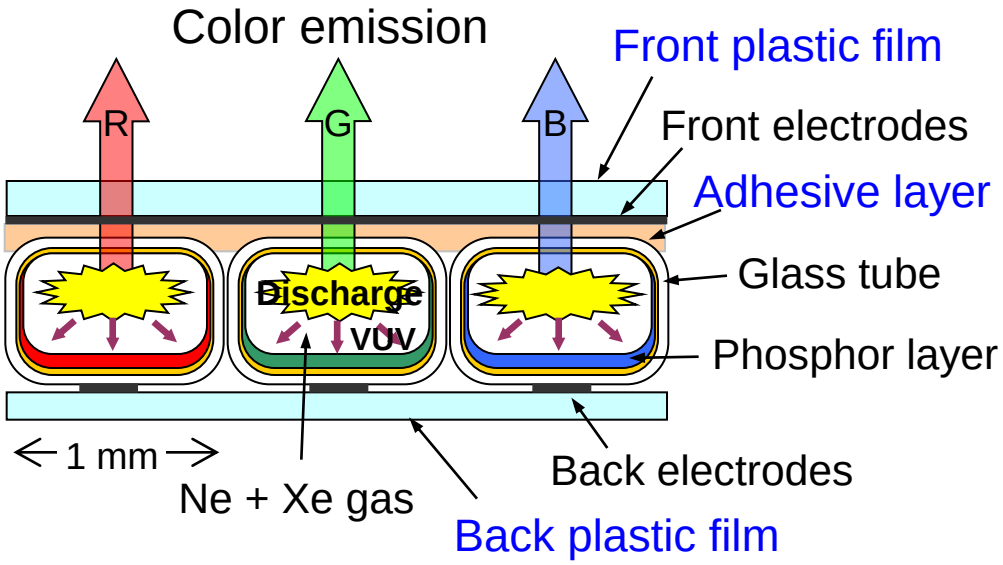
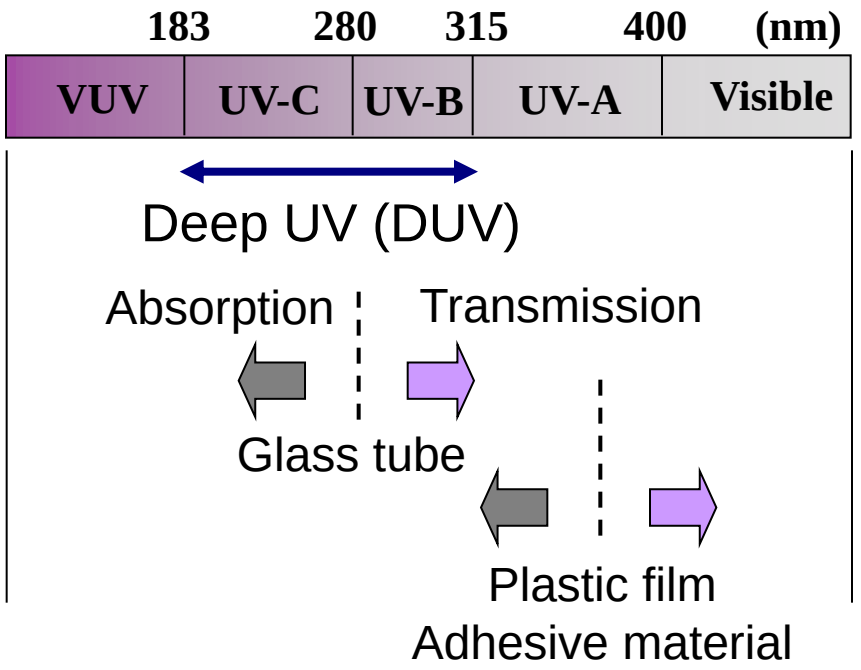
Issues of LAFi structure for DUV light

Cross section of the LAFi for display





- ✓Front and back plastic film with electrodes and adhesive layer absorb UVB and UVC light
- ✓Film material and adhesive material deteriorate by UV light
- ✓Glass tube material of the bolo-silicate absorb UVC light

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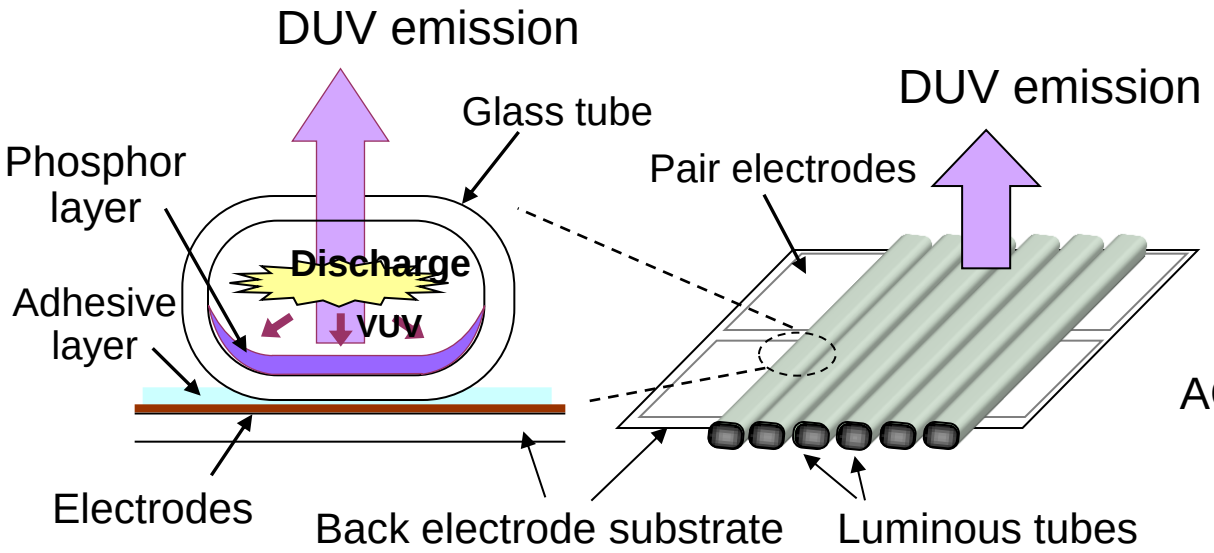
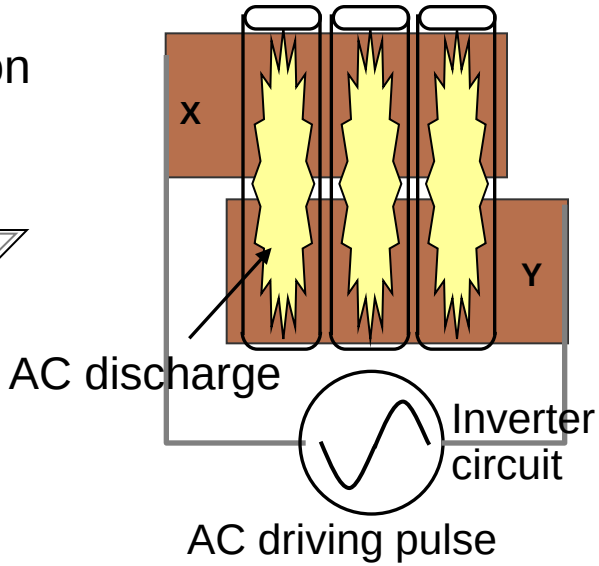
Basic structure for DUV emission



Cross section of the DUV luminous tube and the array structure



Driving structure

- ✓ Backside electrodes apply AC electrical field on the discharge gas in the glass tube, and DUV light emits only to front side
- ✓ Electrode film and adhesive material are protected by reflecting the UV light with widely formed phosphor layer in bottom of the tube
- ✓ AC driving pulse provide a stable and uniform discharge in the tube

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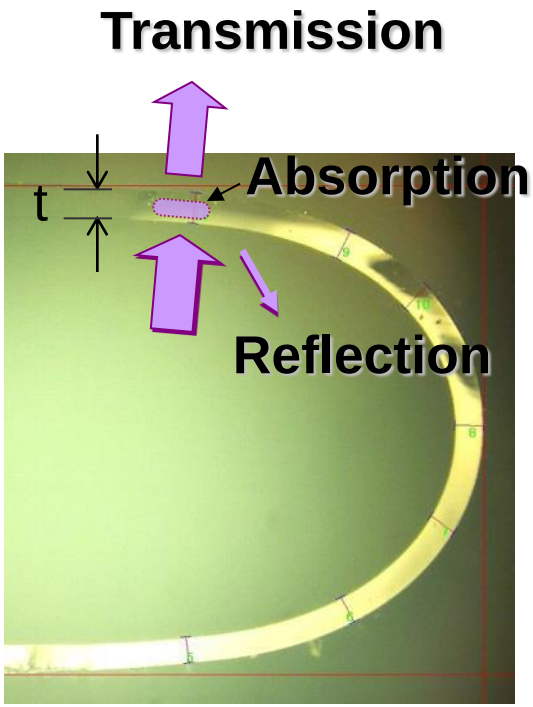
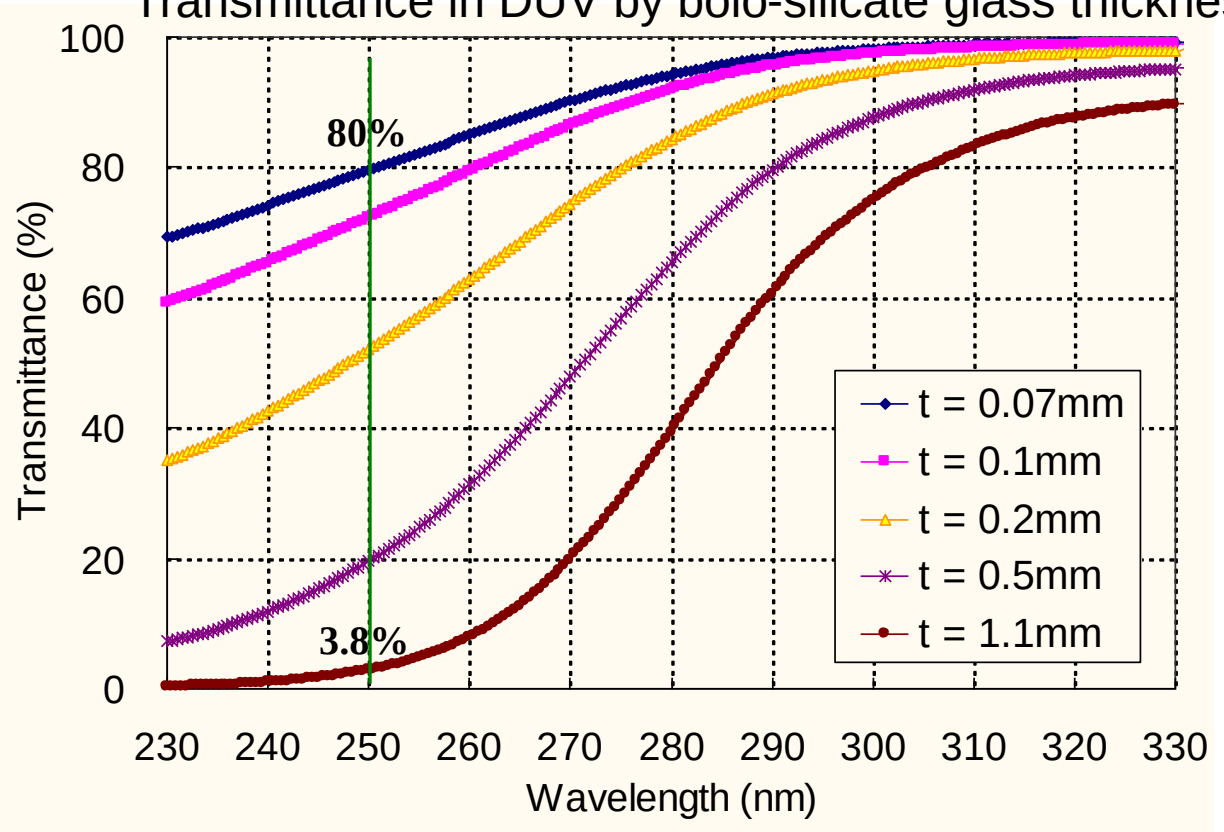
Transmittance of the glass wall





- ✓ **Absorption of UVC by the glass wall was reduced by ultra thin glass tube formation technique**
- ✓ **Reflection of UVC by the glass wall was very little because of low dispersion at the no phosphor area of the glass tube**
- ✓ **UVC output was achieved with low cost glass material**

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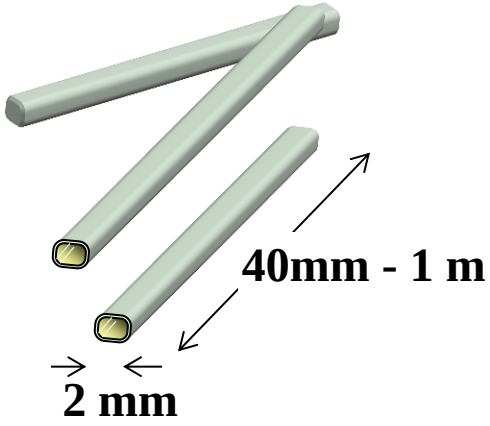
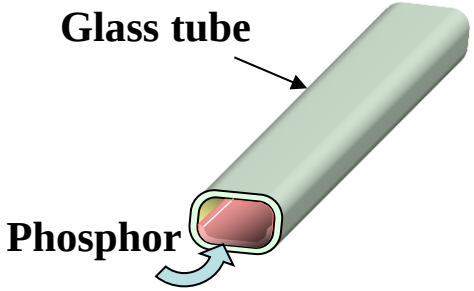
Fabrication Process of LAFi

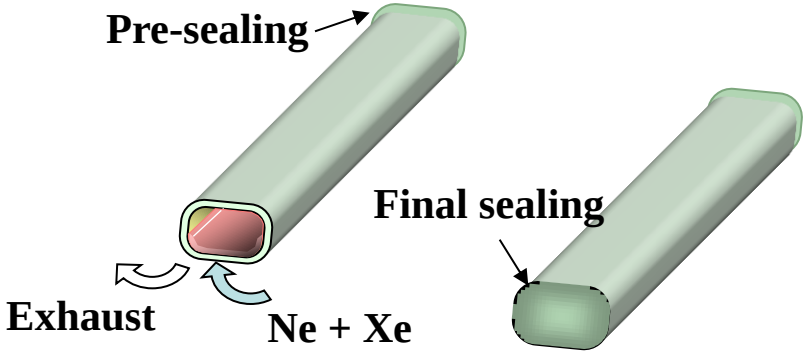
1st step
Glass formation



2nd step
phosphor layer formation

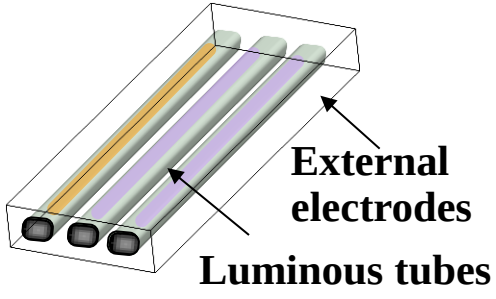


3rd step
Exhaust and gass filling

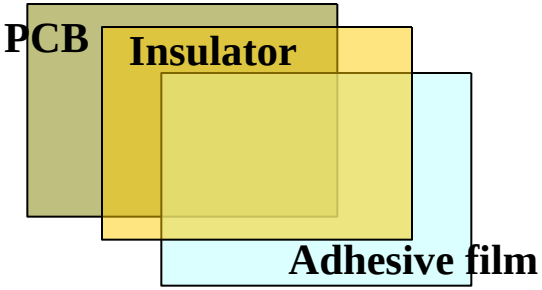


Bolo-silicate glass is formed as designed size

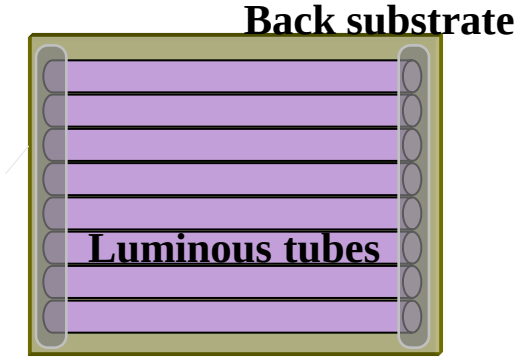
4th step
Aging and selection



5th step
Back substrate formation



Last step
Arraying and adhere



✓ Simple process of the luminous tube without electrode formation

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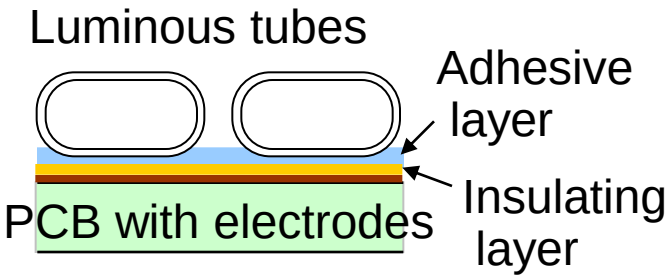
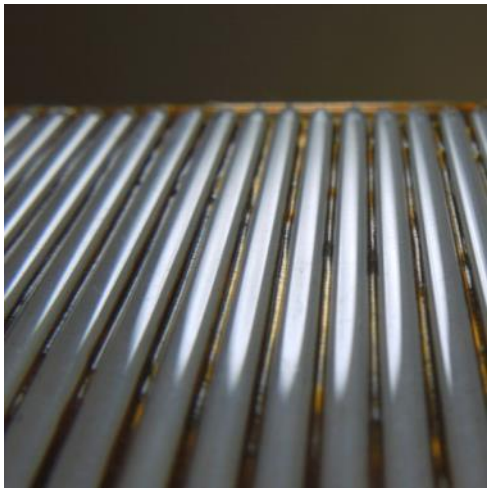
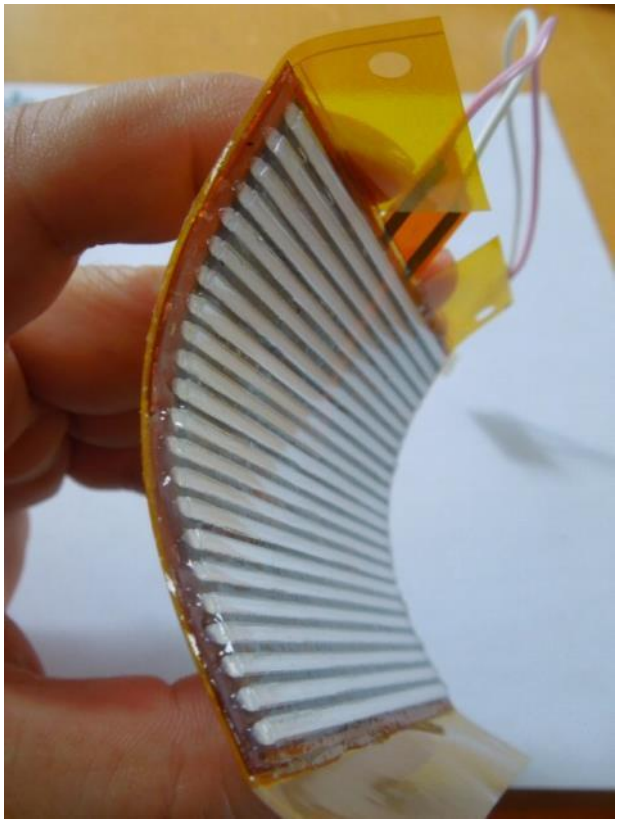
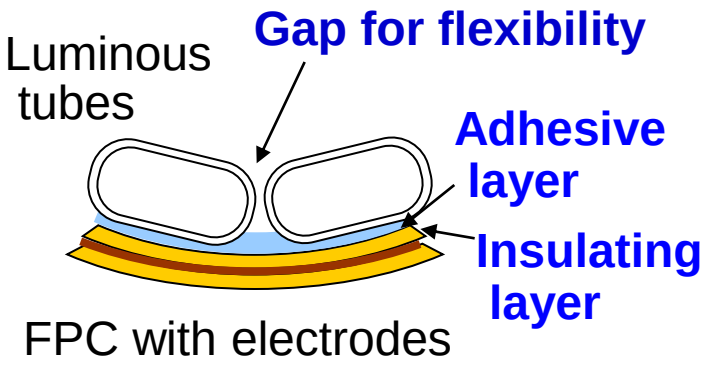
Configuration for the bendable array

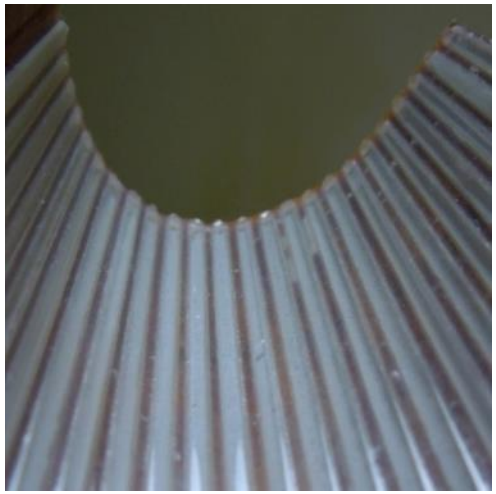






8 x 6-cm surface light source with FPC substrate





- ✓Selectable substrate; the solid plate or the flexible film
- ✓The tube gap, the adhesive and insulation layer is important

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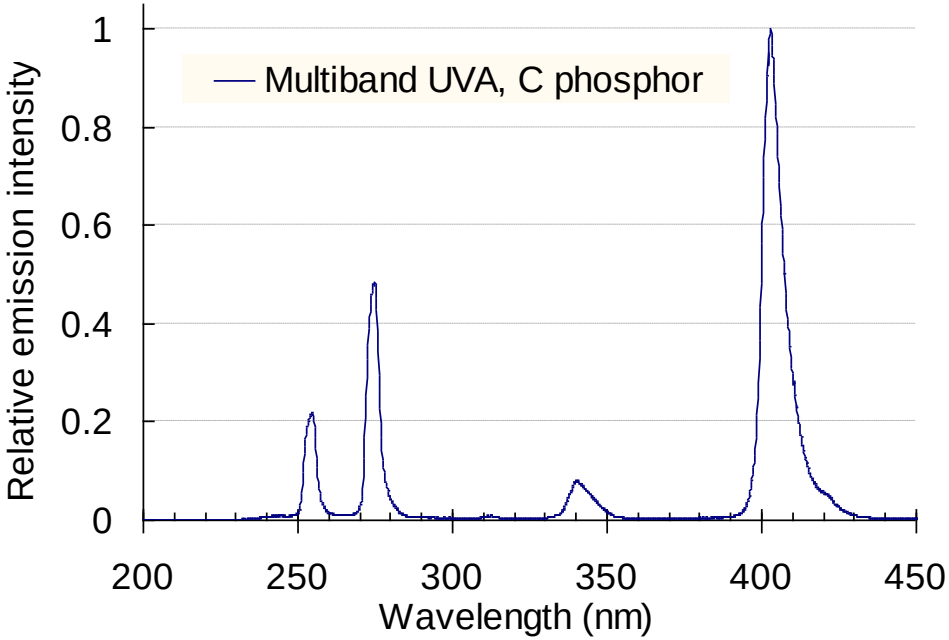
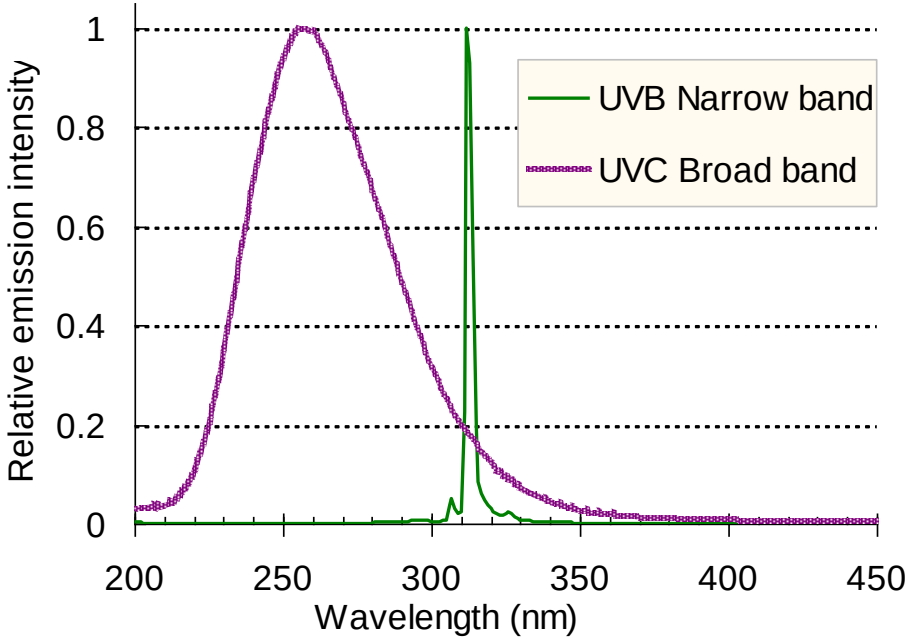
UV emissions spectrum
by typical three phosphors





- ✓ Several phosphor materials were tested by making a small size LAFi light source
- ✓ Single-band phosphor is expected to focus on a particular application
- ✓ UVC broadband light provides a several new applications

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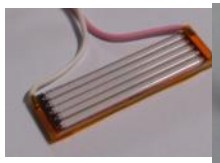
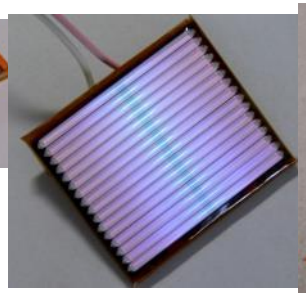
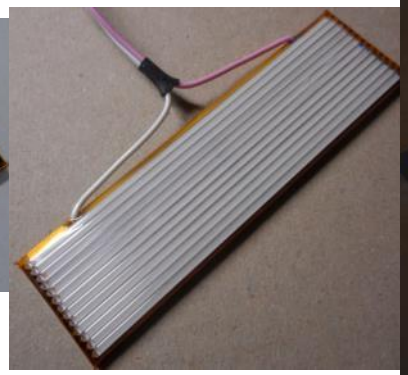
Variation of UV-LAFi



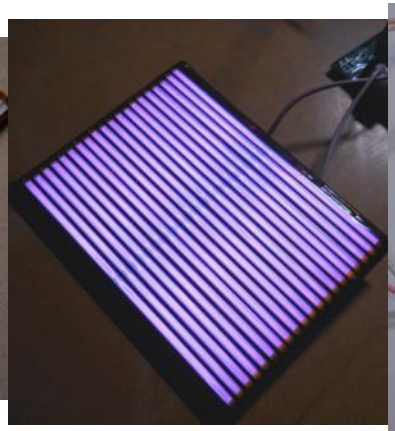
4 x 1-cm



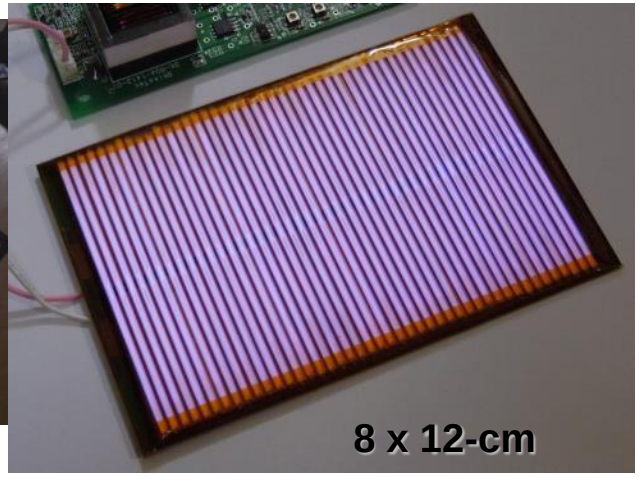
4 x 3.2-cm



8 x 2.2-cm

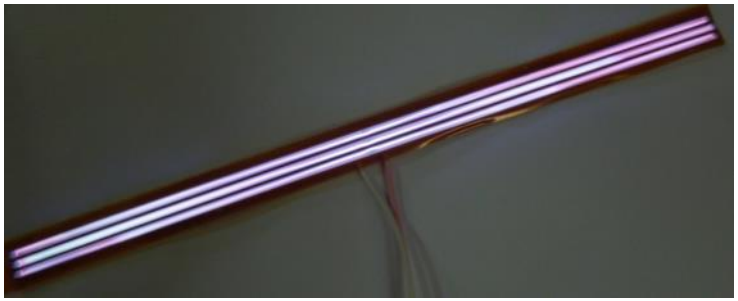


8 x 6-cm



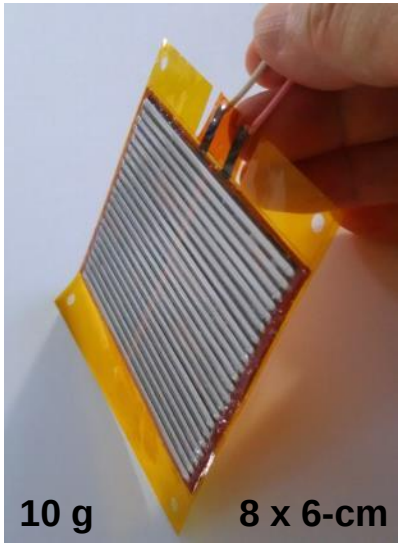
8 x 12-cm

- Surface size is designed by the tube length and the tube arrangement



- Long tube of over 20cm is available

✓ These design flexibilities provides many advantages for UV applications



10 g 8 x 6-cm

- Flexible film substrate is available

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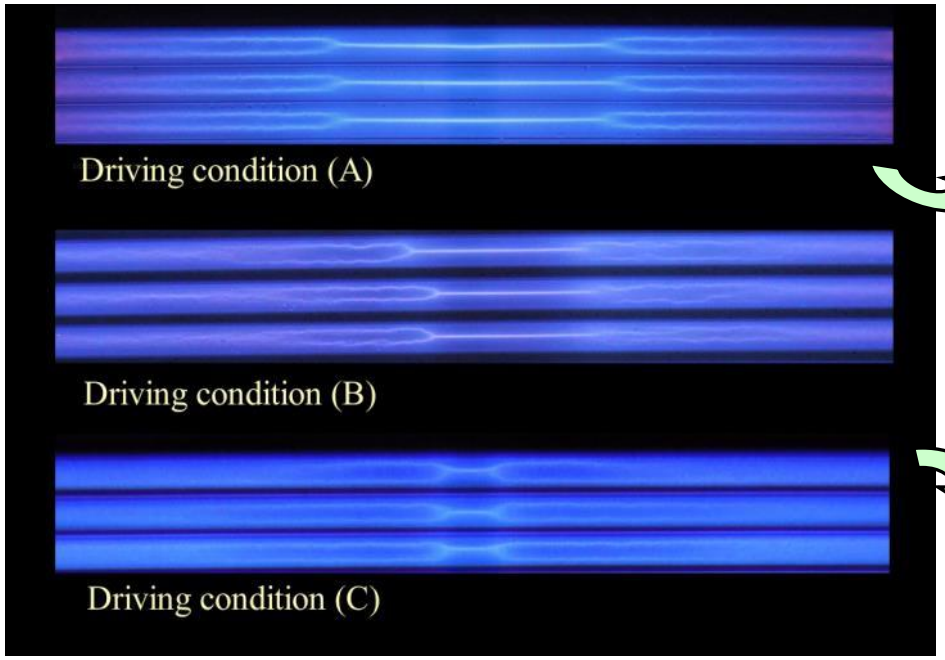
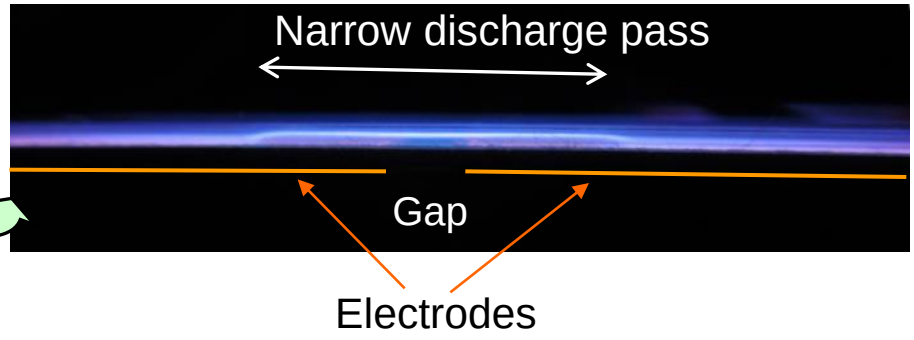
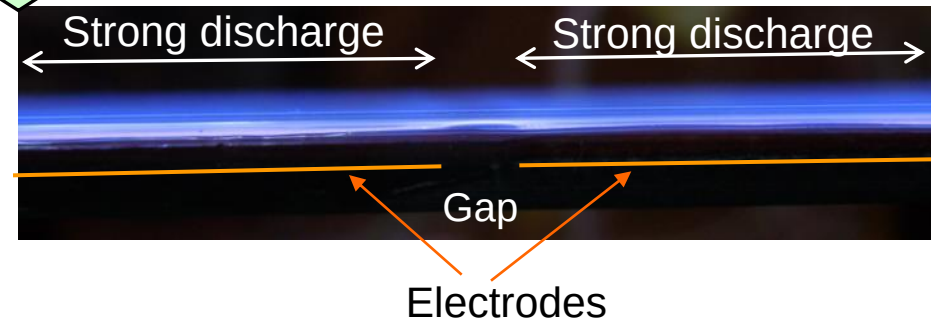
Improvement of UV emissions power



Top view of the luminous tubes



Side view of the discharge in the luminous tubes



- ✓ Miss-matching of the impedance between the drive circuit output and the gas space was reduced by optimizing the insulation layer and the inverter circuit
- ✓ By these optimization, the high UVC emission of 200 mW (4 mW/cm^2) was achieved with 8 x 6-cm surface light source

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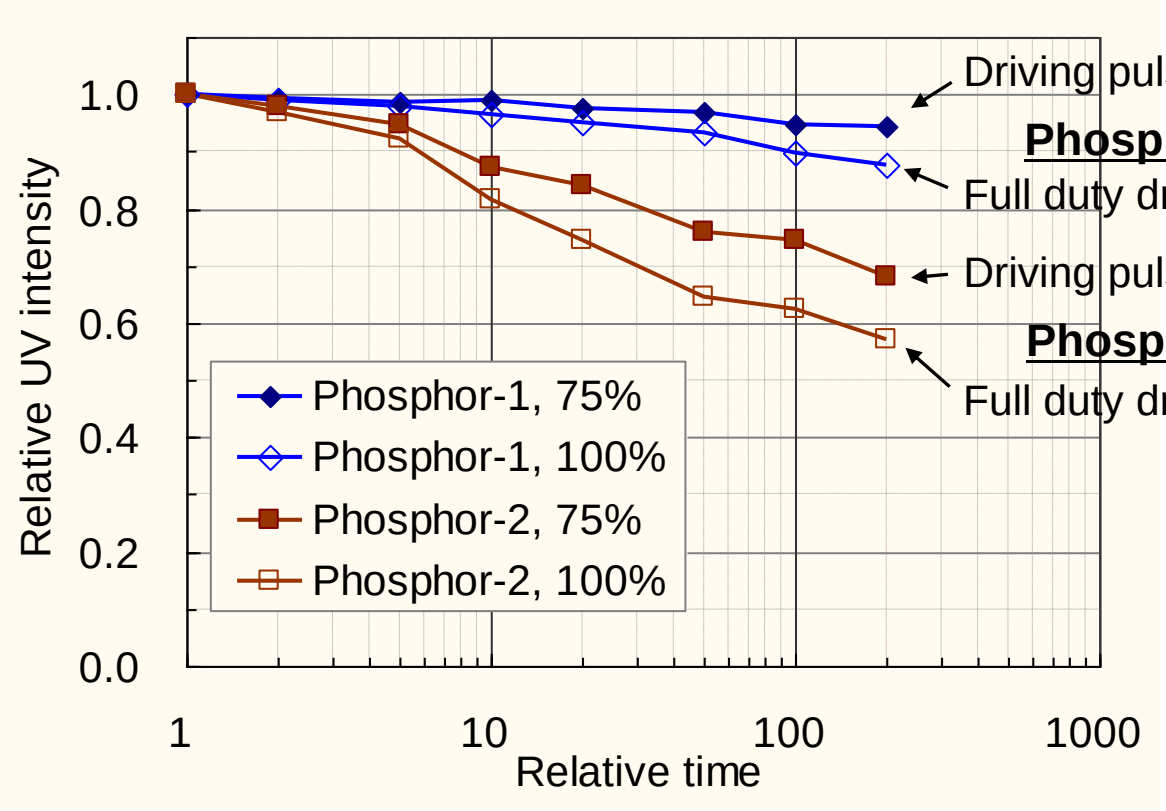
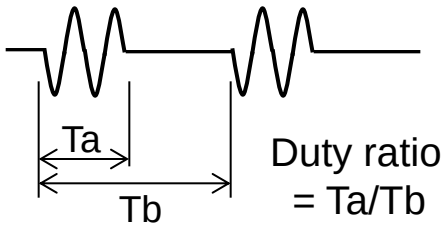
Life test results and life control

The 8 x 6-cm light sources with two types of UV phosphors were tested in two driving condition



Burst driving



- ✓ The life time varies according to the phosphor material
- ✓ The life time is controllable by controlling emission power with pulse duty ratio control technique

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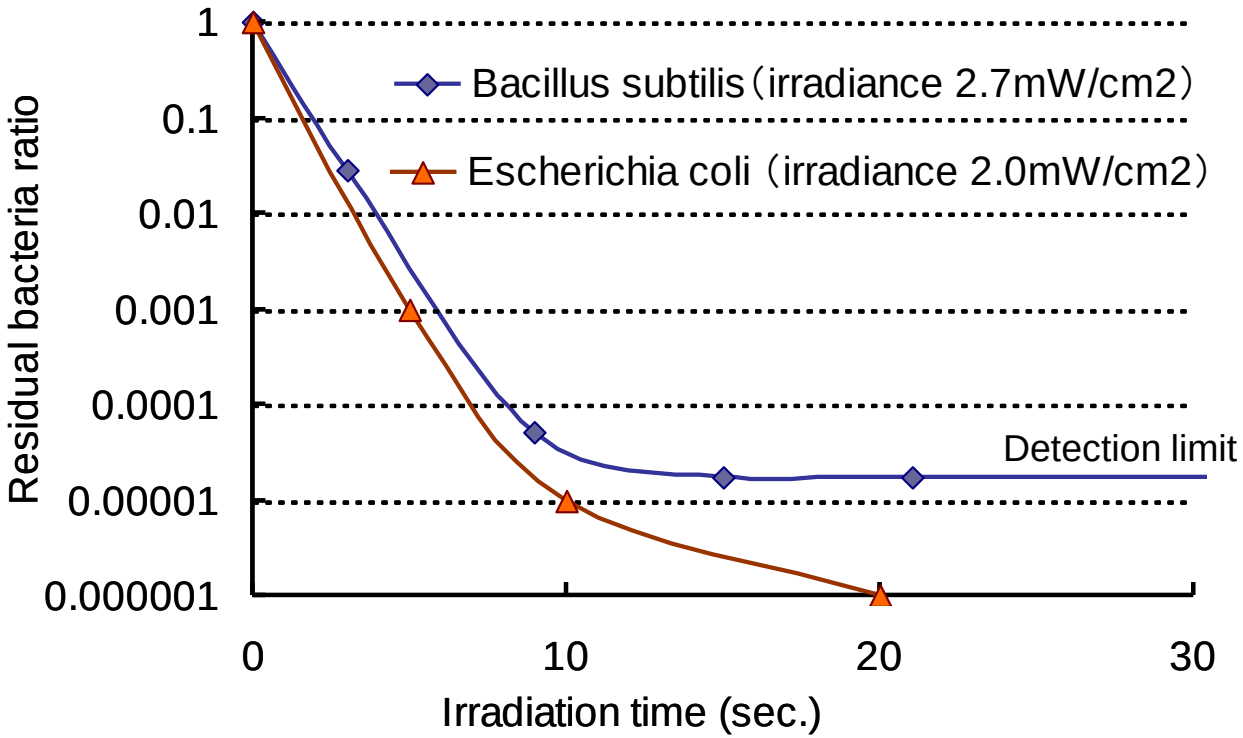
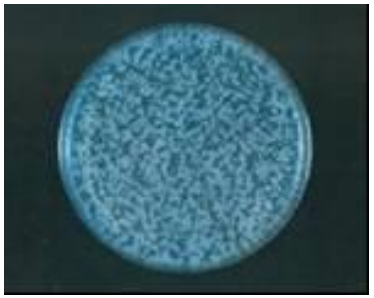
Sterilization by UV-LAFi
with broad band UVC phosphor





No irradiation

After 15 sec irradiation
(D = 35 mm Labo-dish)

- ✓ High speed sterilization
- ✓ 99.999% of sterilization rate within 10 sec
- ✓ High sterilization efficiency with UVC broad band phosphor

Irradiation energy for 99.9% inactivation with 254 nm emission by Low-pressure Hg lamp

Name of a bacteria	UVC irradiation for 99.9% inactivation
Bacillus subtilis *(spores, NBRC 3134)*	20.3 mJ/cm^2
Escherichia coli (NBRC 3972)	9.8 mJ/cm^2

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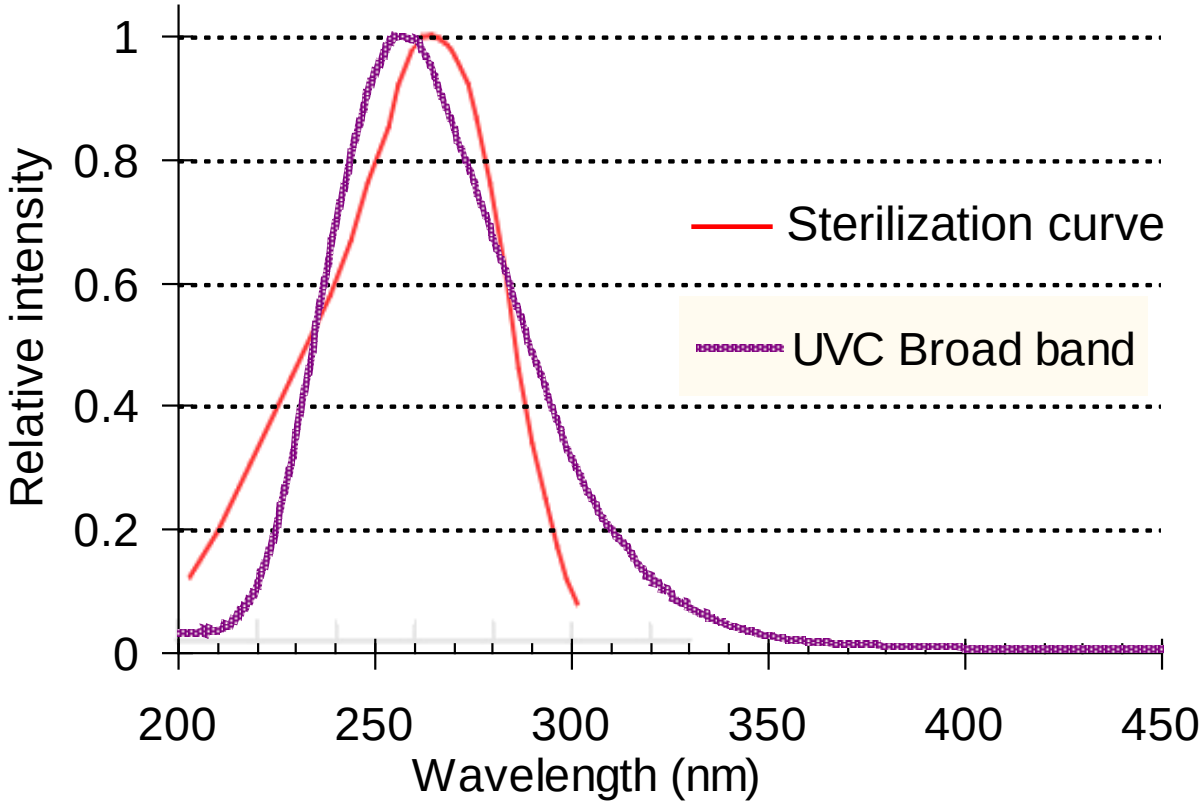
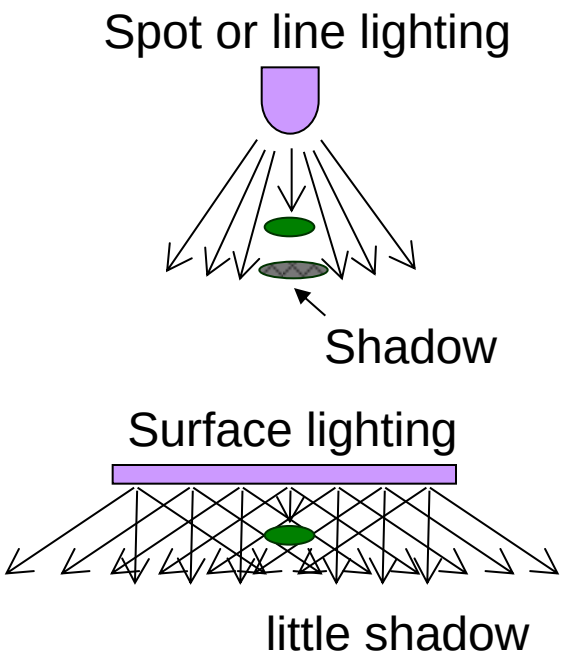
Advantage of UV-LAFi with broadband UVC phosphor





- ✓ The shape of the emission spectrum of broadband UVC phosphor is very similar to that of sterilization curve
- ✓ Diffusion light by surface light source provides a shadow free lighting

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Summary

- ✓ A flexible light source technologies using Luminous Array Film (LAFi) realized a new mercury free flexible surface deep-UV light source.
- ✓ We developed several wavelength and size of DUV-LAFi and improved emission power to spread there application field.
- ✓ UVC light source for sterilization provides very high performance against to strong bacteria.
- ✓ LAFi is the best device for large area surface light source in DUV light applications.