High refractive index glass for OLED lighting

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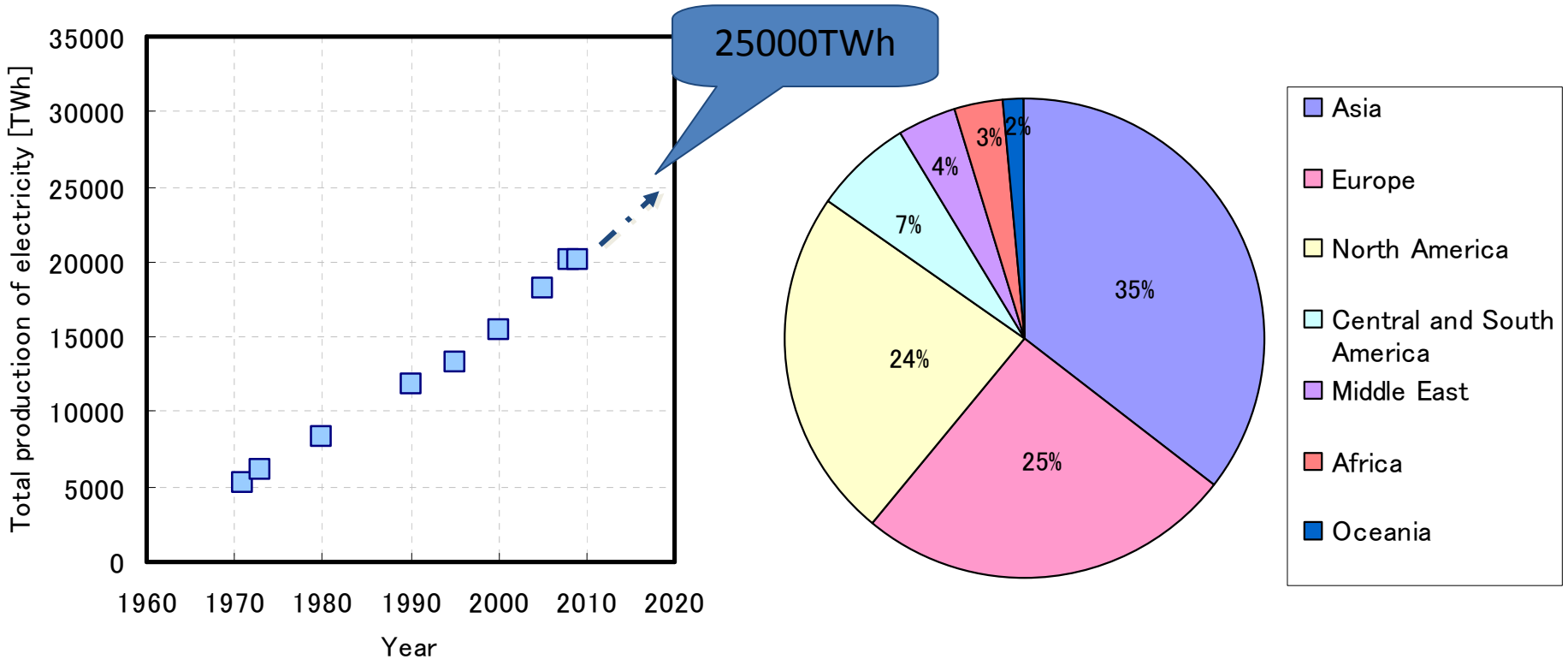
Nippon Electric Glass

Worldwide energy consumption

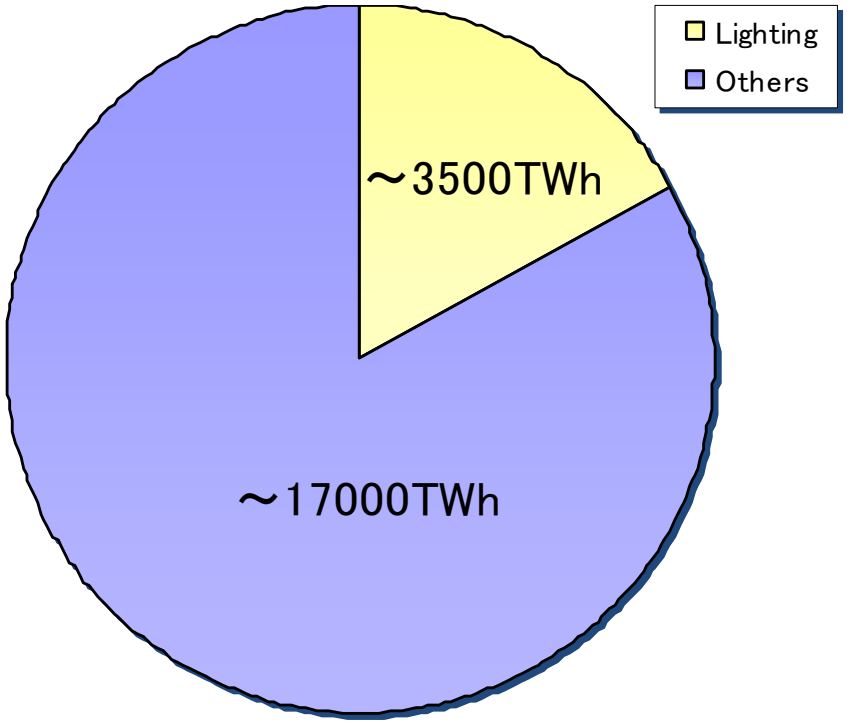
Worldwide energy consumption shows an upward tendency
Asia, Europe and North America consume over 85% of the total



エネルギー・経済統計要欄

Energy consumption of "lighting"

- "Lighting " consumes 20% of world wide energy consumption
- Improving the efficiency of lighting device will save world wide energy consumption

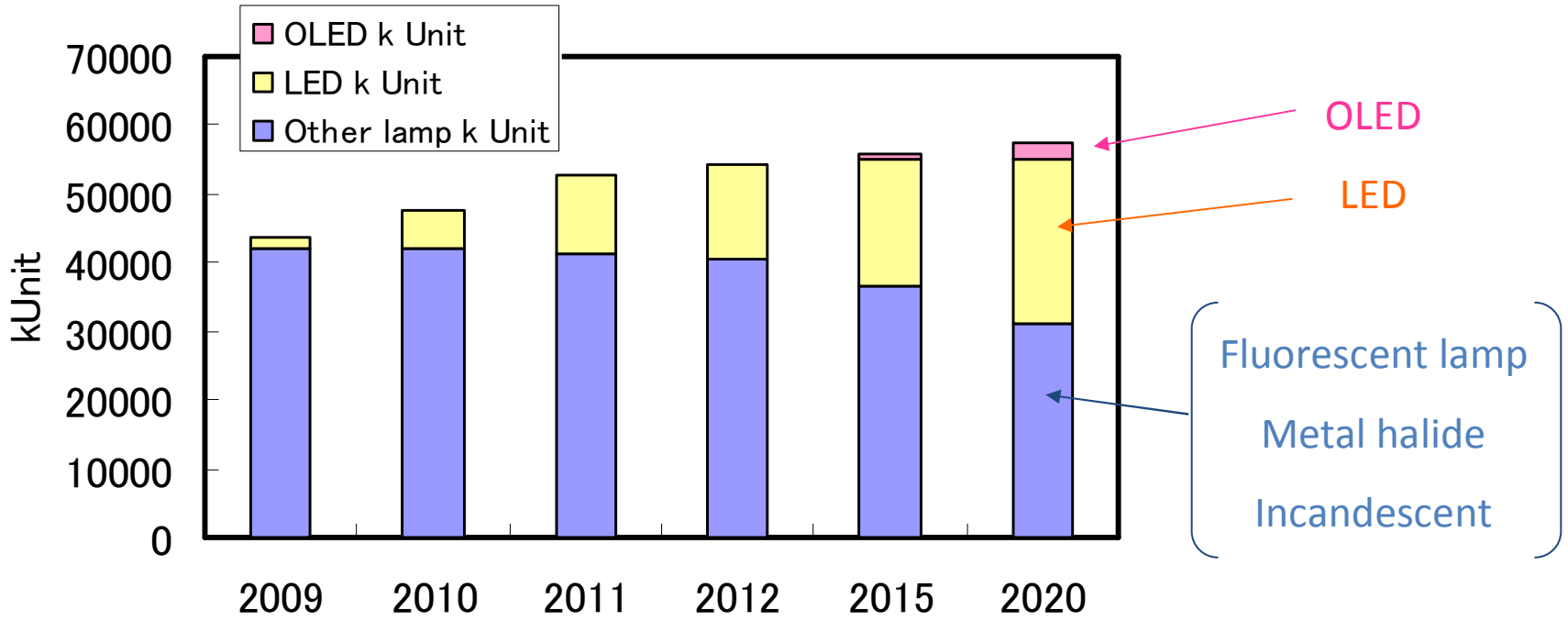


2009

LED及び有機EL照明の現状と中長期的な市場展望

Efficiency of lighting device

LED and OLED are candidates for the next generation lighting device.

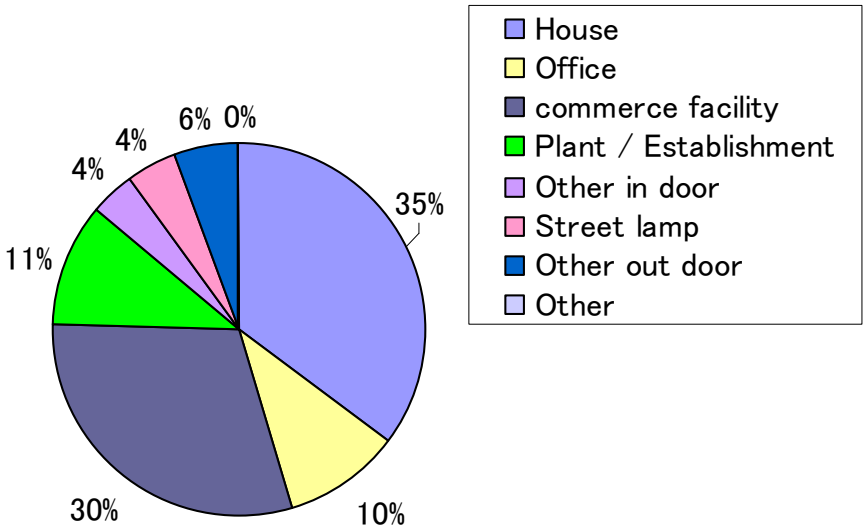


Special Appli 光源/証明市場 実態・技術・予測2011年番 （上巻 市場動向編）

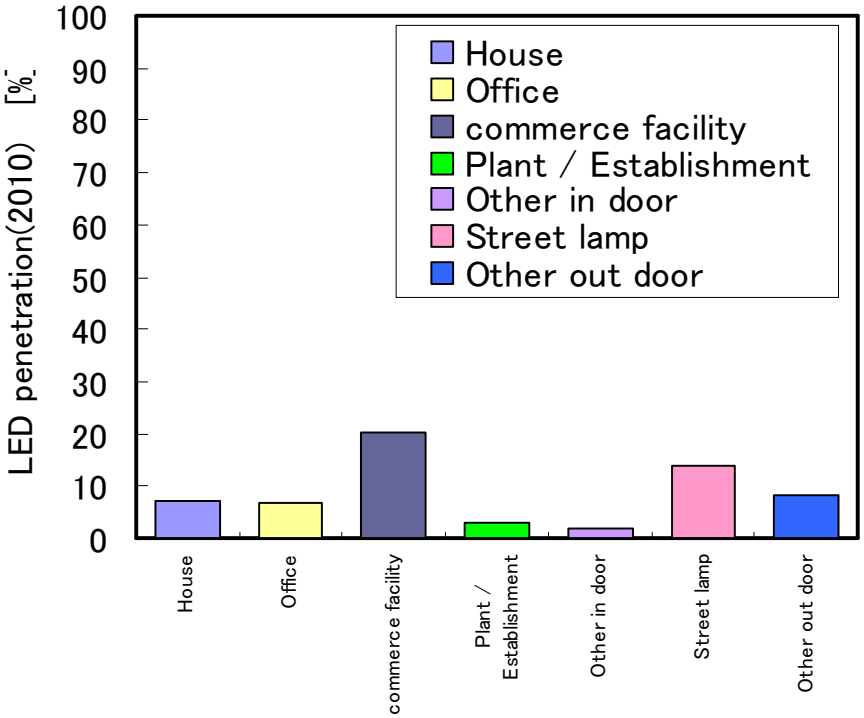
LED lighting market

LED has been successfully penetrate into commerce facility and street lamps, but the penetration ratio for home is still low.

Lighting market in Japan 2010
(application / million ¥)



LED penetration in Japan (2010)



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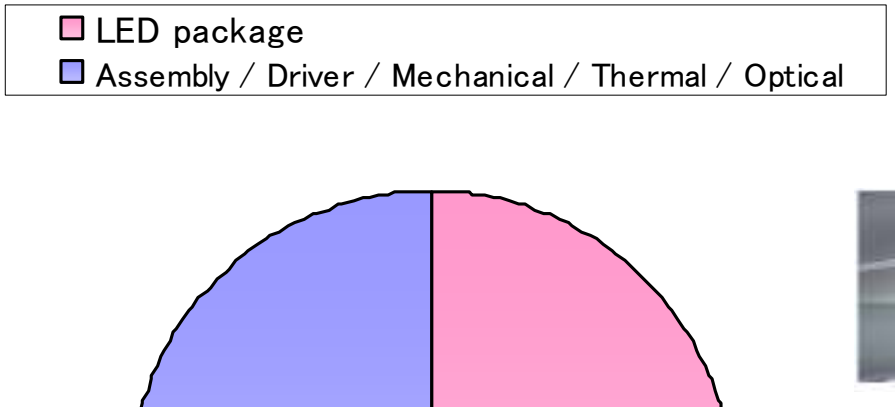
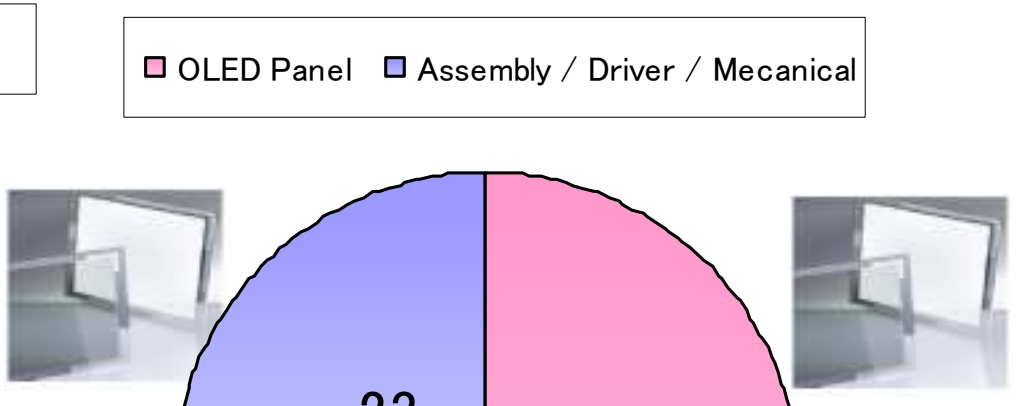
Challenges for LED

LED requires higher cost for making into luminaire

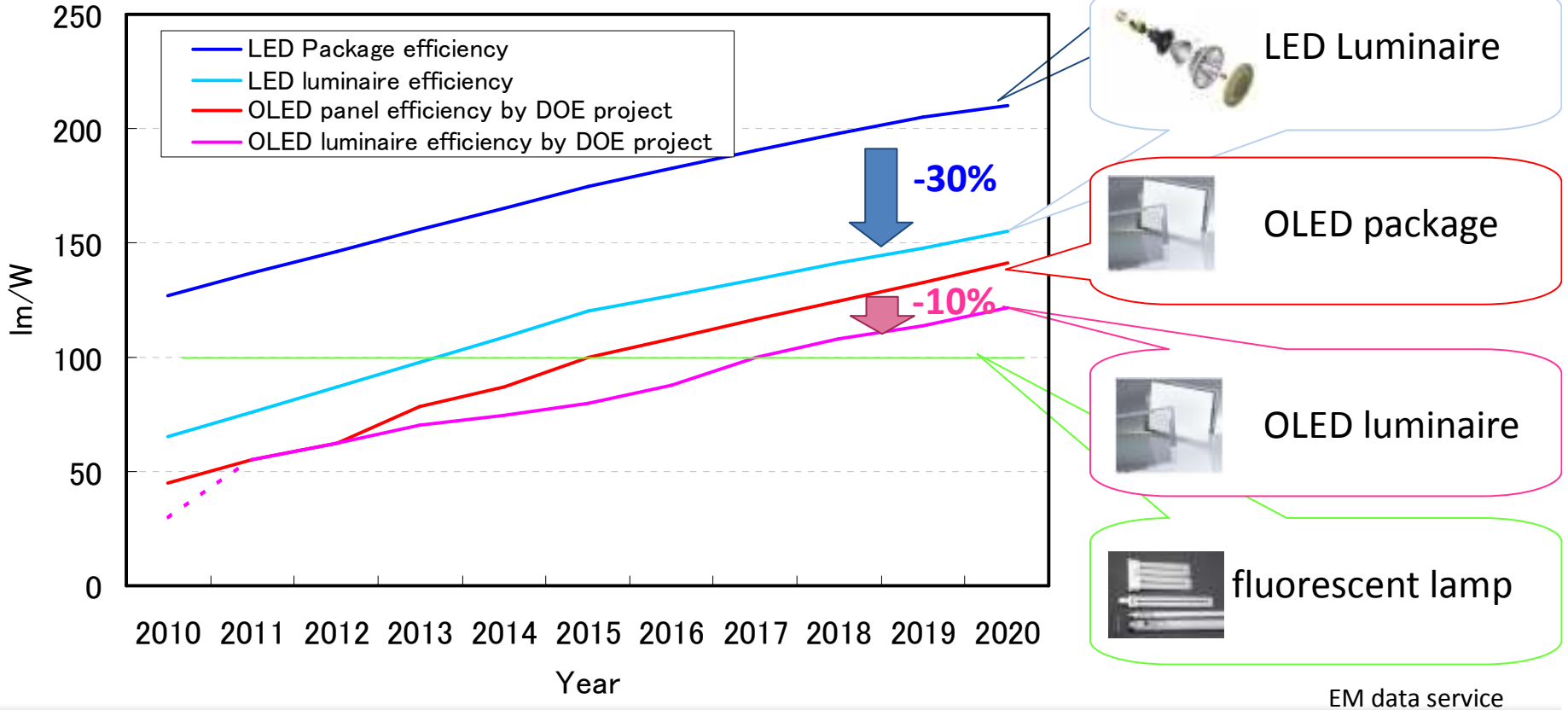




EM data service

Challenges for LED

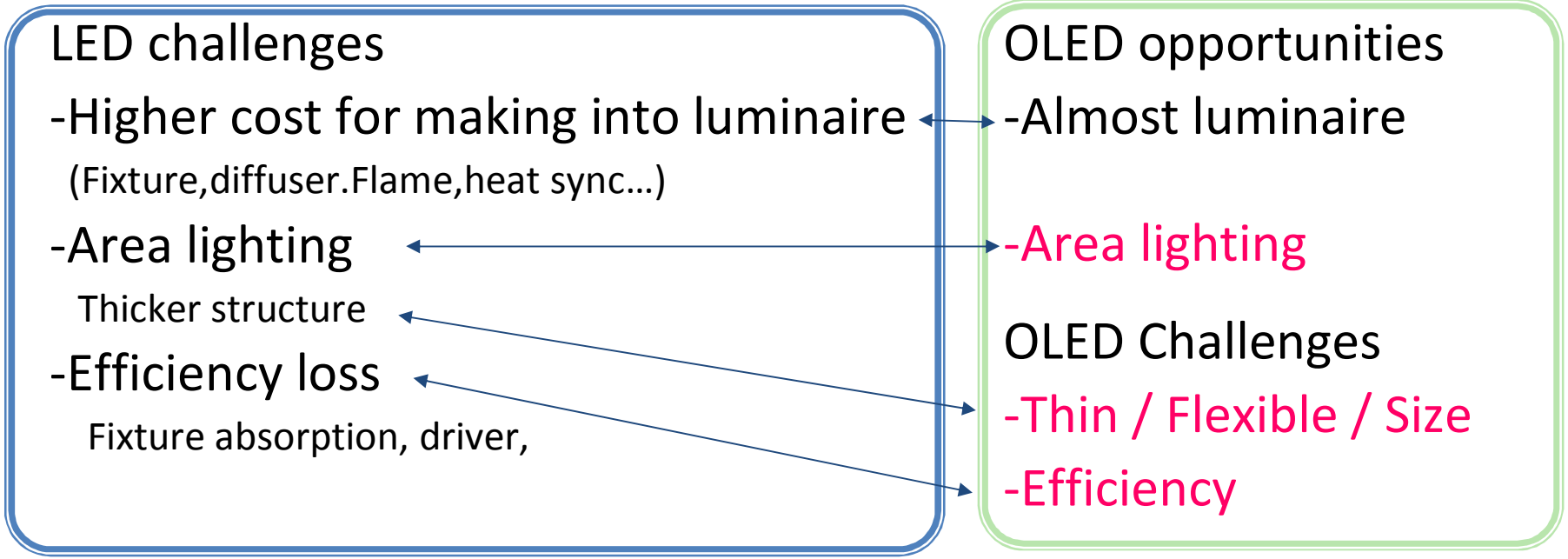
LED lose 30% of Efficiency for making into luminaire



EM data service

Challenges for LED and opportunity for OLED

LED's challenges would be an opportunity for OLED.
Key points for OLED are Efficiency, large size area lighting, thin and flexible.



Objective

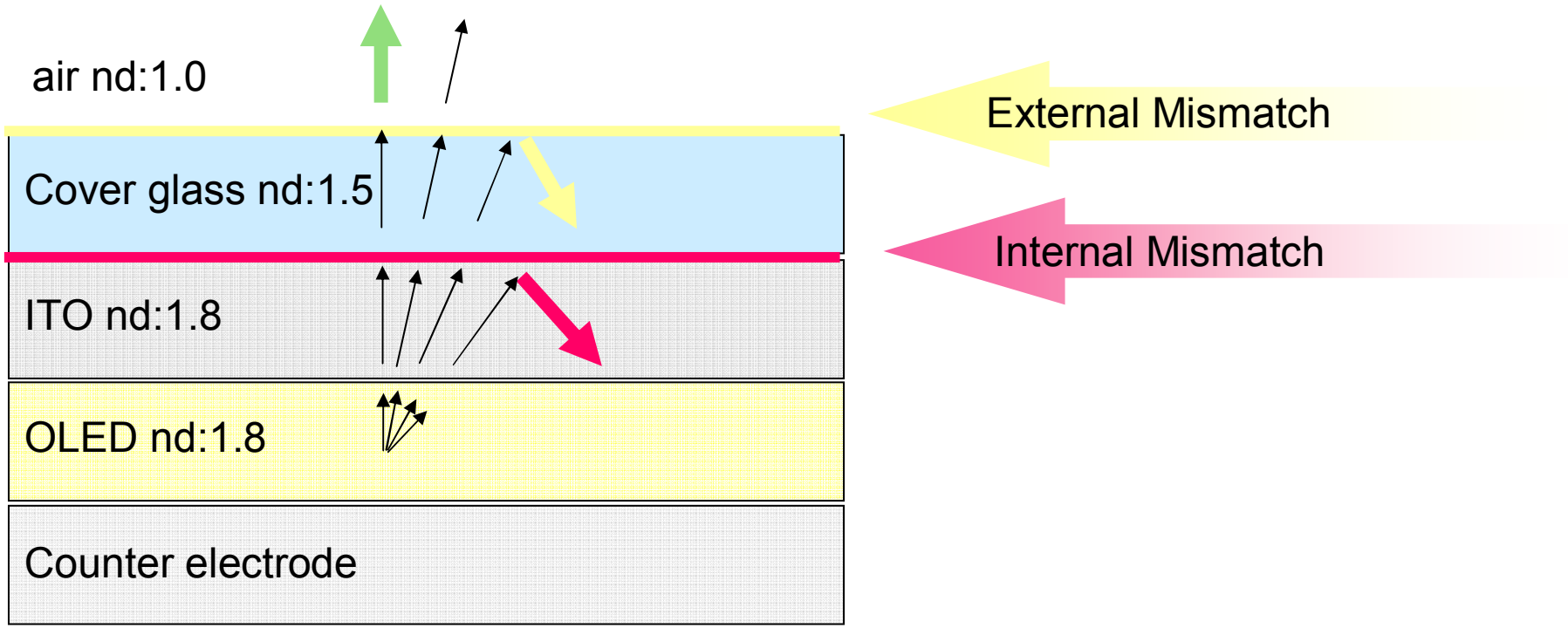
To suggest the glass product to satisfy the requirement
*for OLED lighting

*Improving efficiency / large area / thin / Flexible / low cost

Lowering factor of efficiency in OLED lighting

Only 20% of light from OLED layer can be extracted due to mismatch of refractive index

Key issue is mismatch of refractive index between each interface



Approach to reduce refractive index mismatch

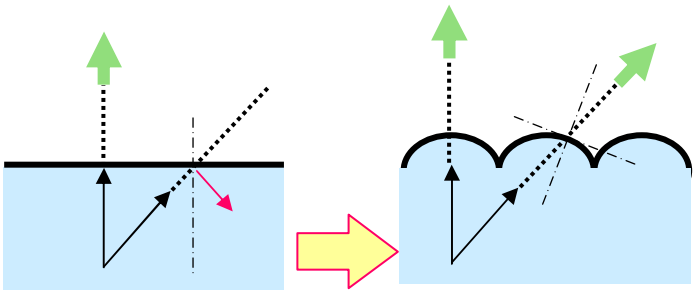
Light extraction geometry and index matched glass would be promising for thin and large area uniform lighting.

External Mismatch

-Light extraction geometry

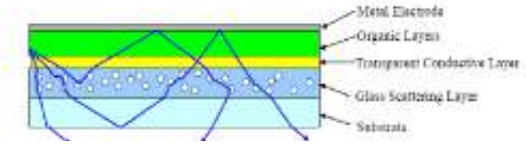
Rough surface (Sandblasted)

lens sheet



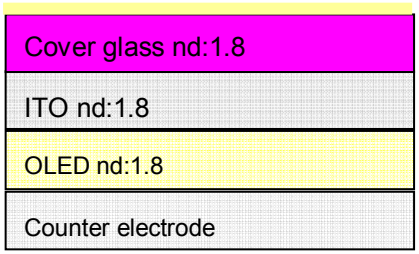
Internal Mismatch

-Scattering layer



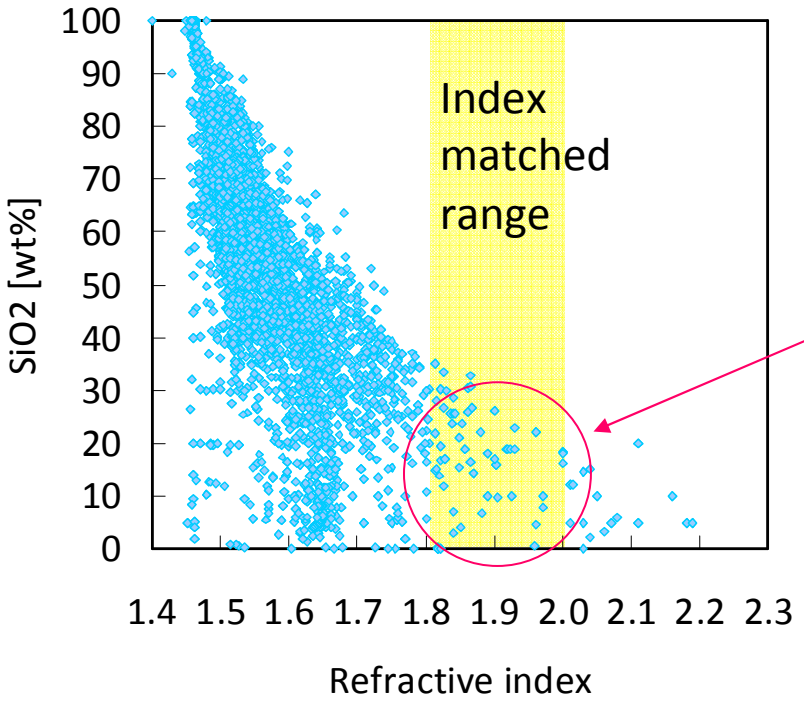
Nakamura et al SID 09 Digest, 609 (2009)

-Index matched (1.8-2.0) glass



Issue of conventional high refractive index glass (1)

Chemical durability would be deteriorated
Forming process would be limited due to the devitrification

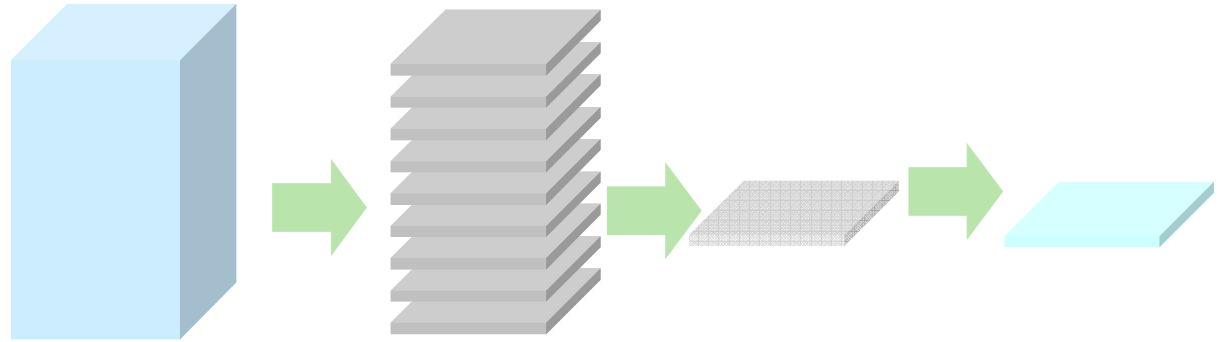


Lower contents of SiO2 leads to
Unstableness as glass forming process and
lower chemical durablity

Issue of conventional high refractive index glass (2)

It is hard to obtain thin, large and smooth surface with high productivity

Typical process of conventional high refractive index glass

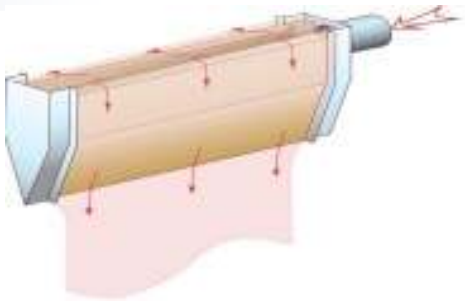


What is ideal process?

O/F down draw process is the ideal process for making thin, large size glass with smooth surface

Thin / Flexible

Large



Over flow down draw method

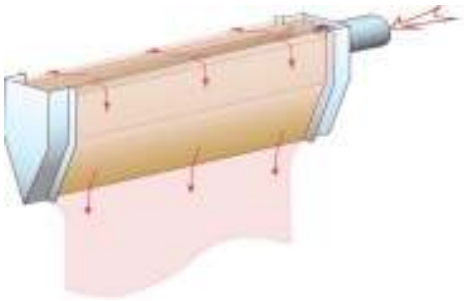
Smooth surface

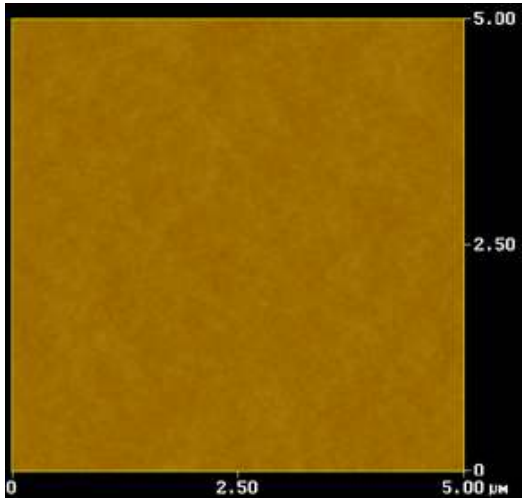
High productivity

Feature of O/F down draw process

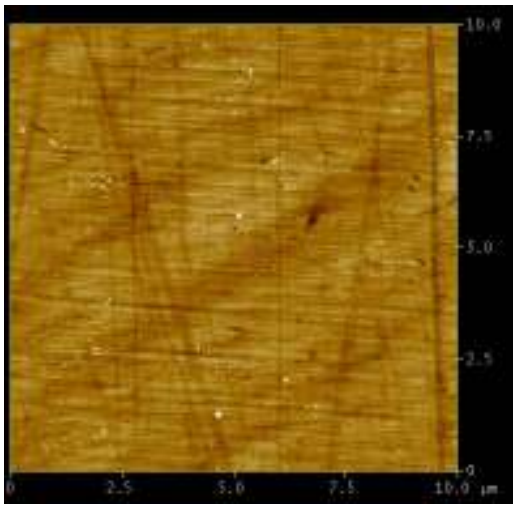
-Smooth surface

-Surface roughness of glass is quite small.
-The smooth surface will reduce defect of OLED device





O/F down draw
Ra: 0.1～0.2nm



Polished surface
Ra: 0.8nm

Feature of O/F down draw process

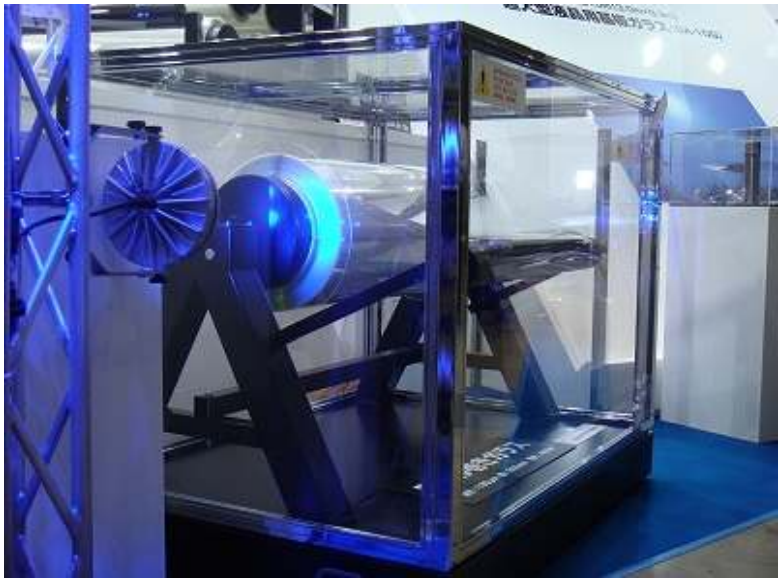
-Thickness and size

-Thin and large size glass sheet can be obtained

Large

2005 3.0m*2.5m 700um

Thin (flexible)

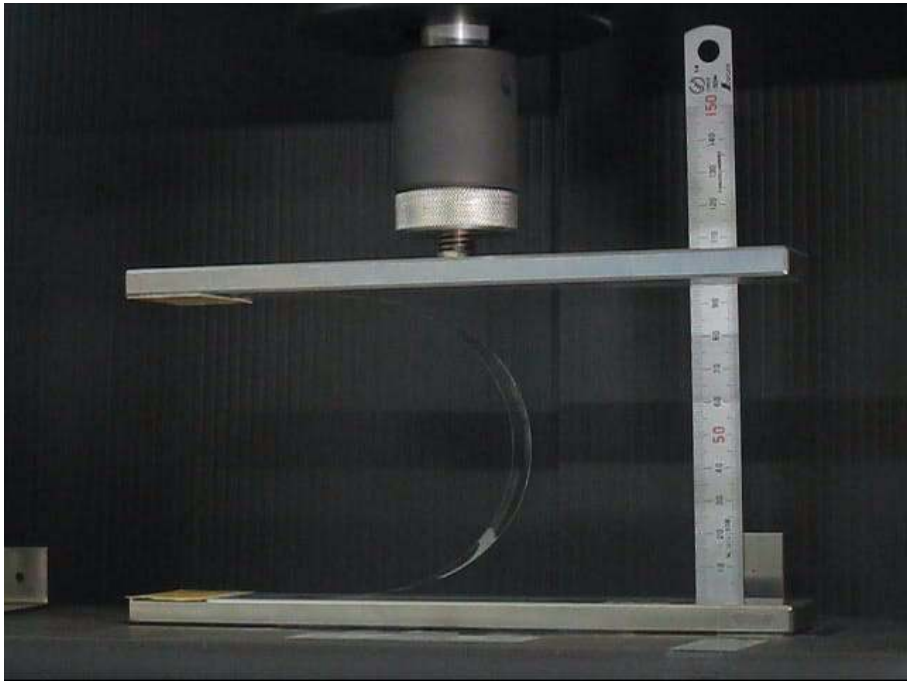


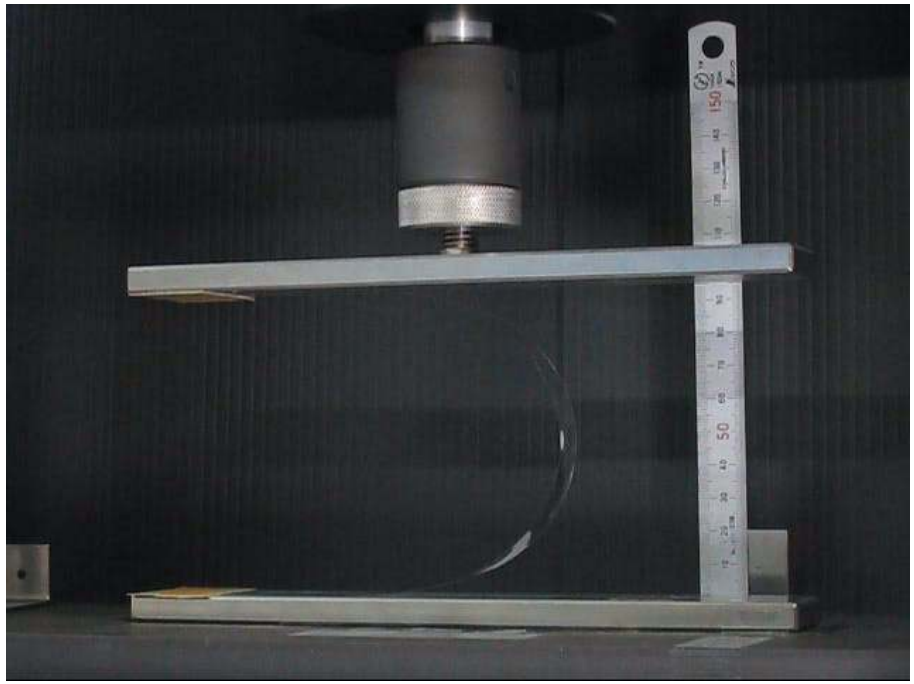
2009 100um thin glass roll (400m)

Feature of O/F down draw process

-Flexibility

Fine finish of the edge is crucial for obtaining the flexibility.
Thinner glass show exceptional flexibility.





Sample 100um,15mm x 200mm

Feature of O/F down draw process

-Flexibility

R2R process can be applied to making OLED device in future

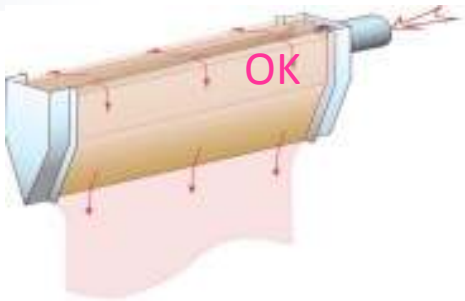
70um Glass roll (W:800mm、L:4m)

What is ideal process?

O/F down draw process is the ideal process for making thin, large size glass with smooth surface

Thin / Flexible

OK



Over flow down draw method

Large

OK

Smooth surface

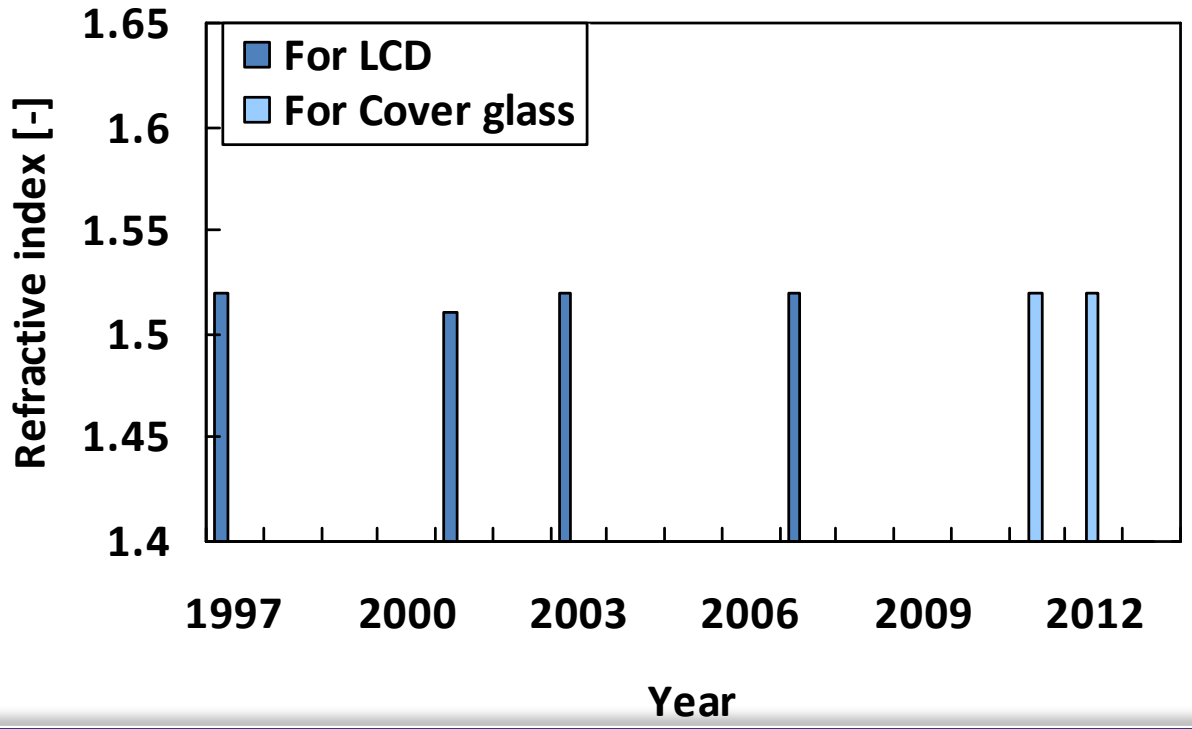
OK

High productivity

OK

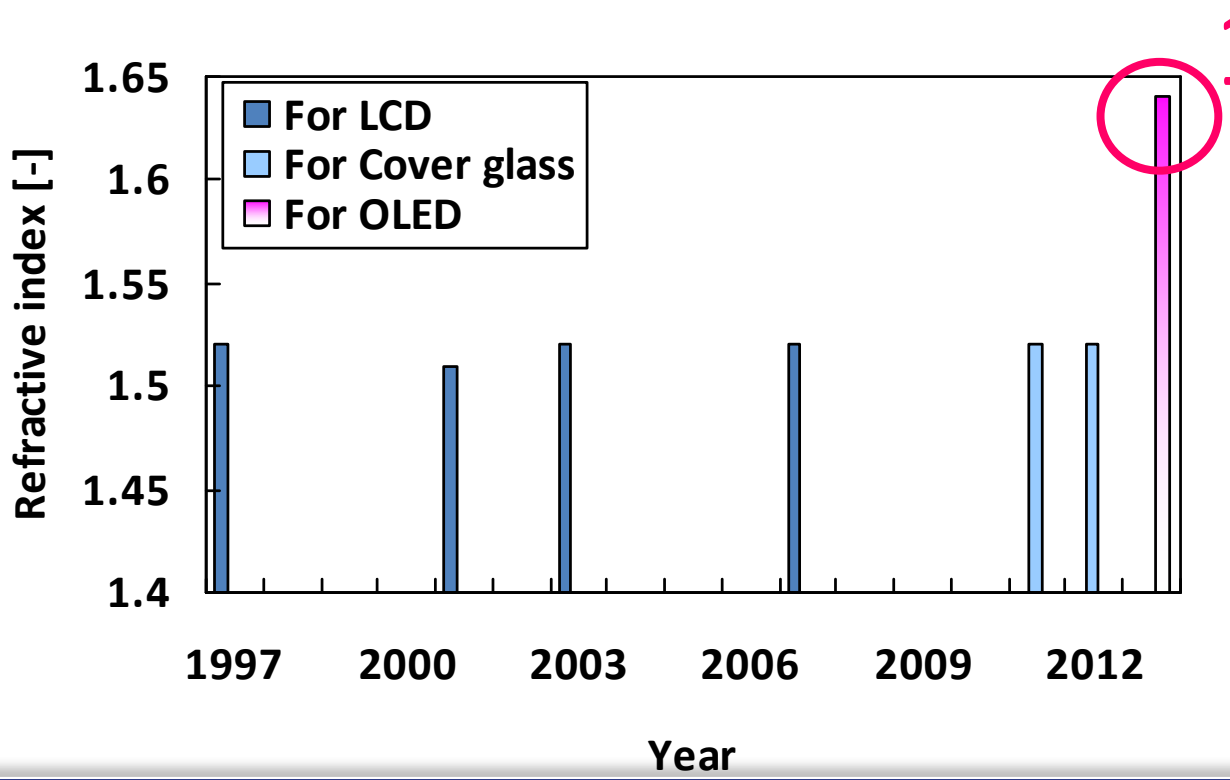
Issues of the glass for O/F down draw process

Conventional glass for O/F process has been designed for LCD and cover glass. Refractive index of both of the glass is low (1.52)



The world first high refractive index glass for O/F process

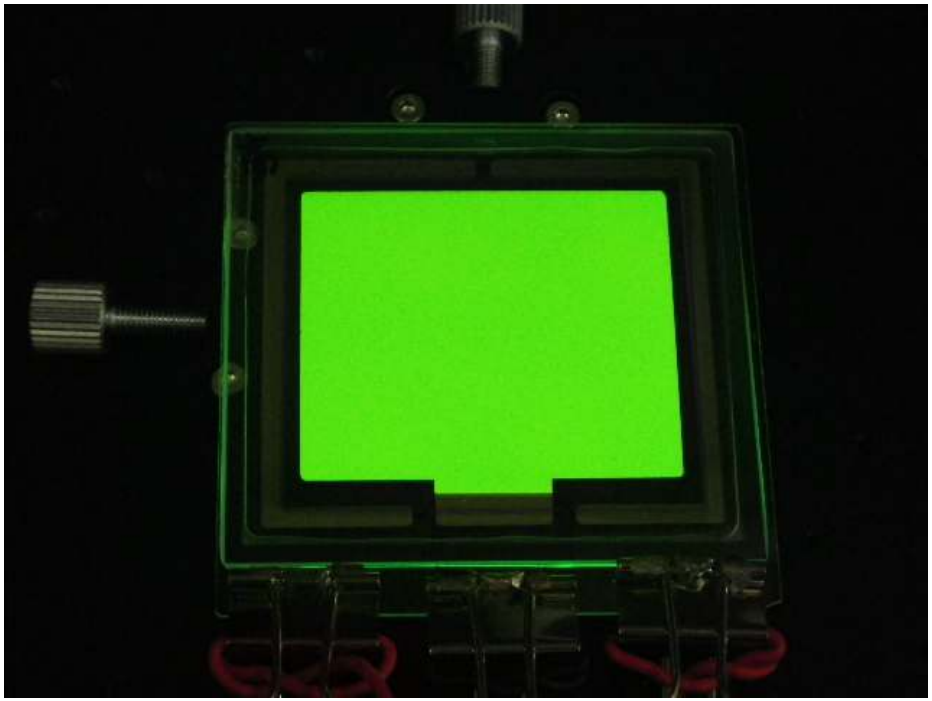
High refractive index glass (1.64), can be produced by O/F down draw method has been newly developed.



1.64

The world first highest refractive index glass (Alkaline free) for O/F down draw process

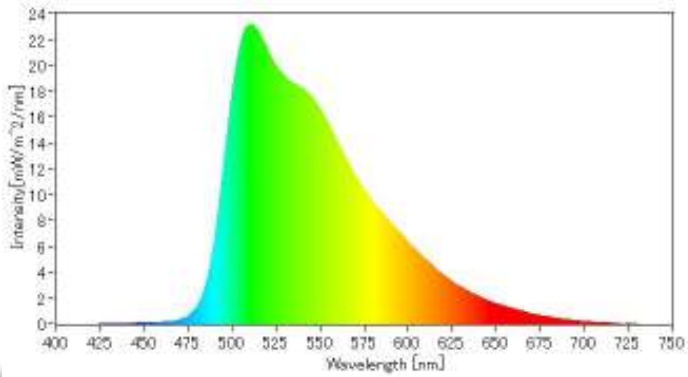
Efficiency of OLED device

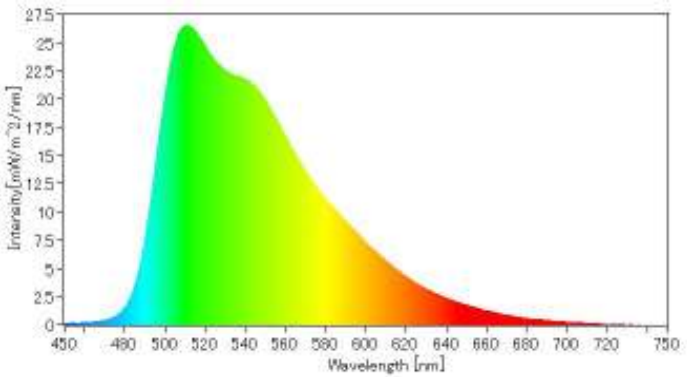


Device structure Glass /IZO,100/ND1501,40/NPD,50/Ir(ppy)3+CBP[6%],30/BAlq,10/Alq,30/LiF,0.8/Al,150

Emission of OLED device

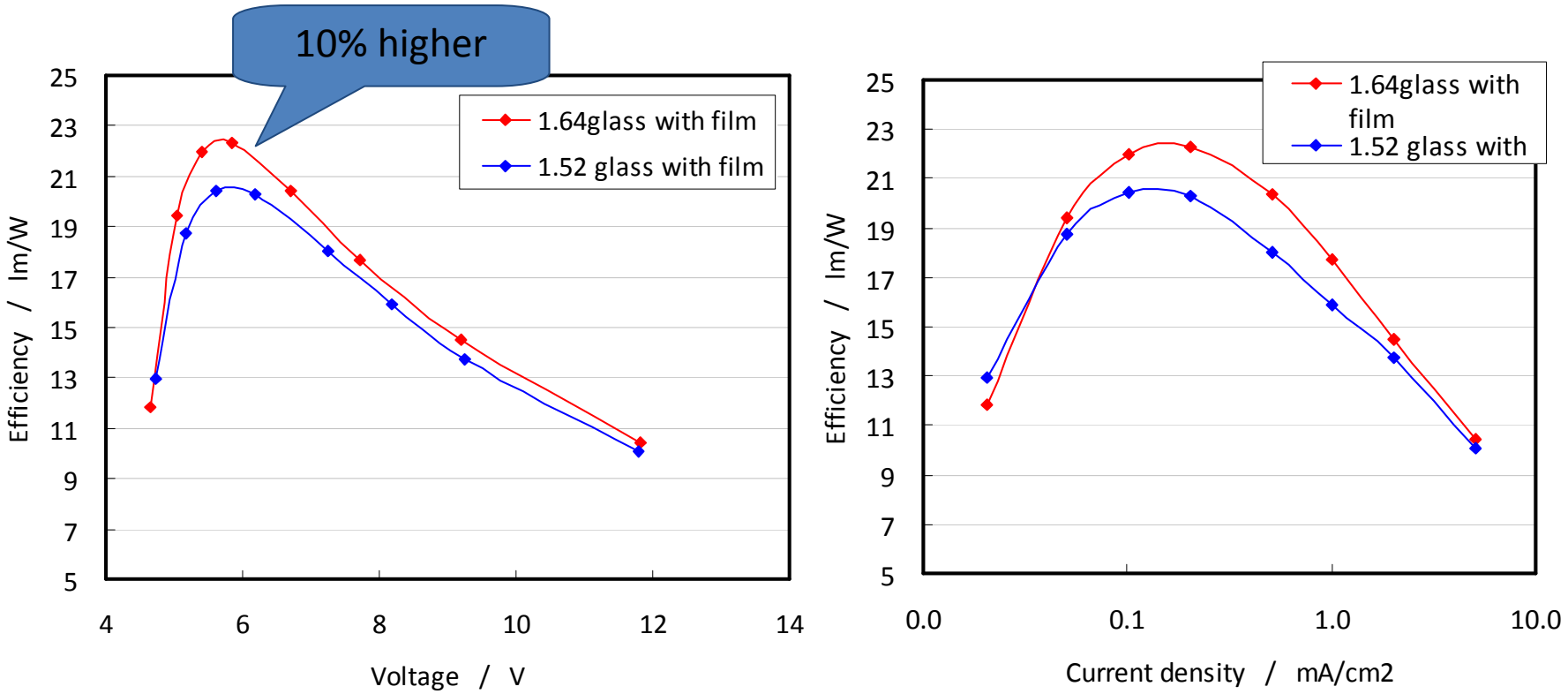
Uniform emission has been obtained.





Efficiency of OLED device

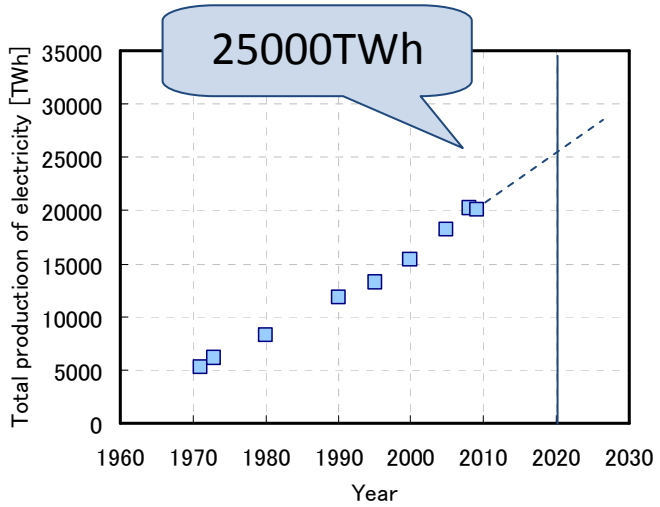
OLED device with high refractive index glass shows higher efficiency

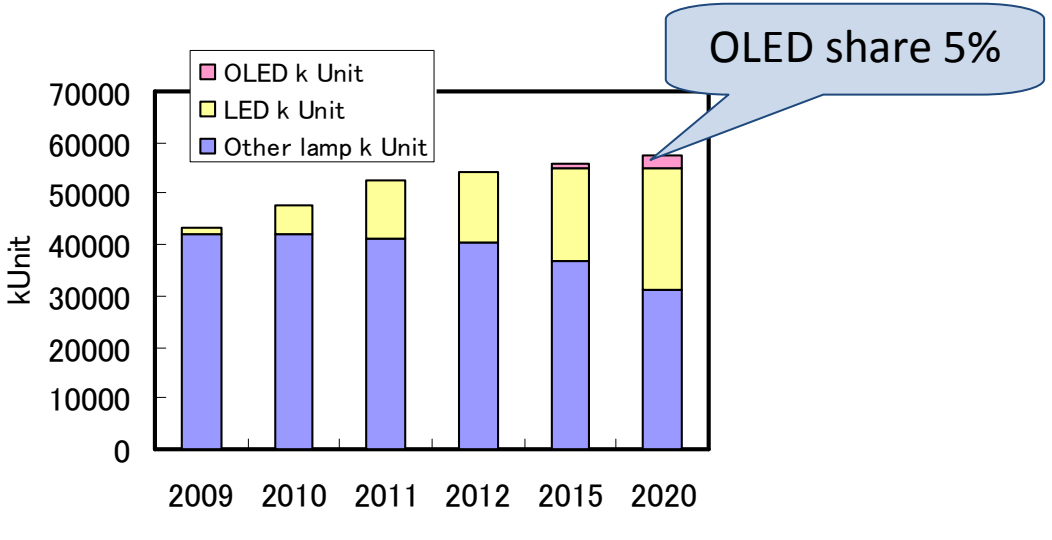


Device structure Glass /IZO,100/ND1501,40/NPD,50/Ir(ppy)3+CBP[6%],30/BAlq,10/Alq,30/LiF,0.8/Al,150

Impact for worldwide energy consumption

25 TWh of world wide energy consumption will be saved just using the 1.64 glass as substitution of conventional commercially available 1.52 glass sheet





*Rough expectation of saved energy
25000TWh : World wide energy consumption
5000TWh : energy consumption of lighting
250TWh : energy consumption of OLED lighting
25TWh : Saved energy consumption by using new glass

Life time of OLED device

Life time of OLED will be longer.
162TWh of energy consumption will be saved in total.

Life time of OLED device $T=T_0(I_0/I)^{1.6}=20000(1/0.9)^{1.6}=23672h$

T_0: life time
I_0: Driving current (of lower refractive index glass)
I: Driving current of higher refractive index glass

⇒ OLED life time 5.5year (using 1.52glass)

⇒ 6.5 year (using new glass)

⇒ 162TWh of energy will be saved

※Usage time for the device : 3650h / year (10h / day)

Summary

World first high refractive index glass can be produced by O/F down draw has been newly developed.

The glass realize…

-Improvement of the efficiency and life time of OLED lighting device
(Huge impact for the world wide energy consumption in the future)

-Thin, flexible, large area OLED device
(Creating the New lighting application)

Nippon Electric Glass