LCOS背投電視之設計與熱問題研究

莫啟能
中華映管公司
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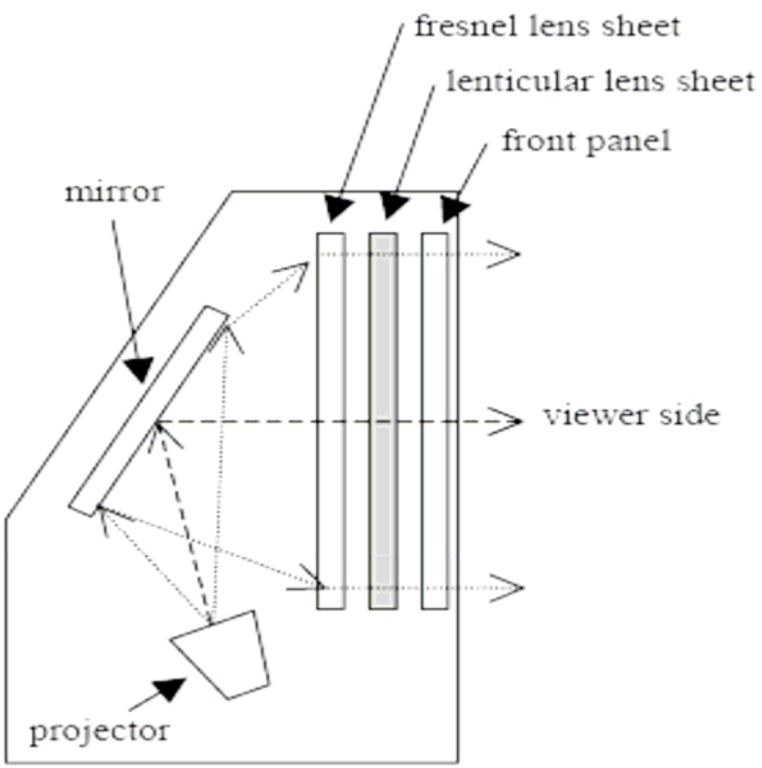
Outline

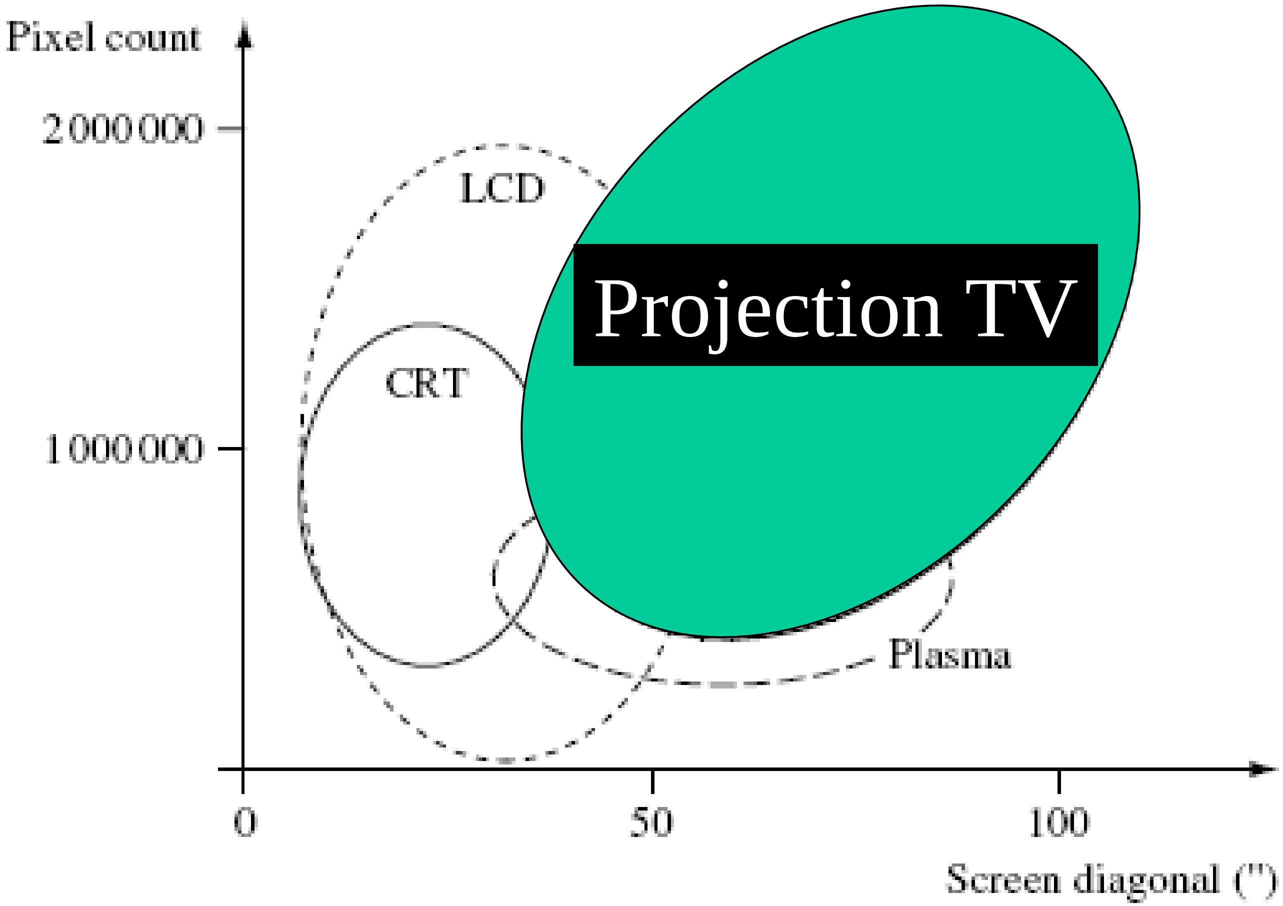
- Rear Projection TV Market Tendency.
- DMD, HTPS, LCOS technology
- LCOS panel manufacturing process
- Optical Engine structure
- LCOS rear projection TV
- Thermal Discussion
  - Thermal stress birefringecne
  - Thermal-electric cooler on LCOS
  - Thermal simulation of optical engine
  - Cooling system based on Fan, YAG, Cabinet
- CPT's LCOS Technical Road Map

Rear Projection TV structure

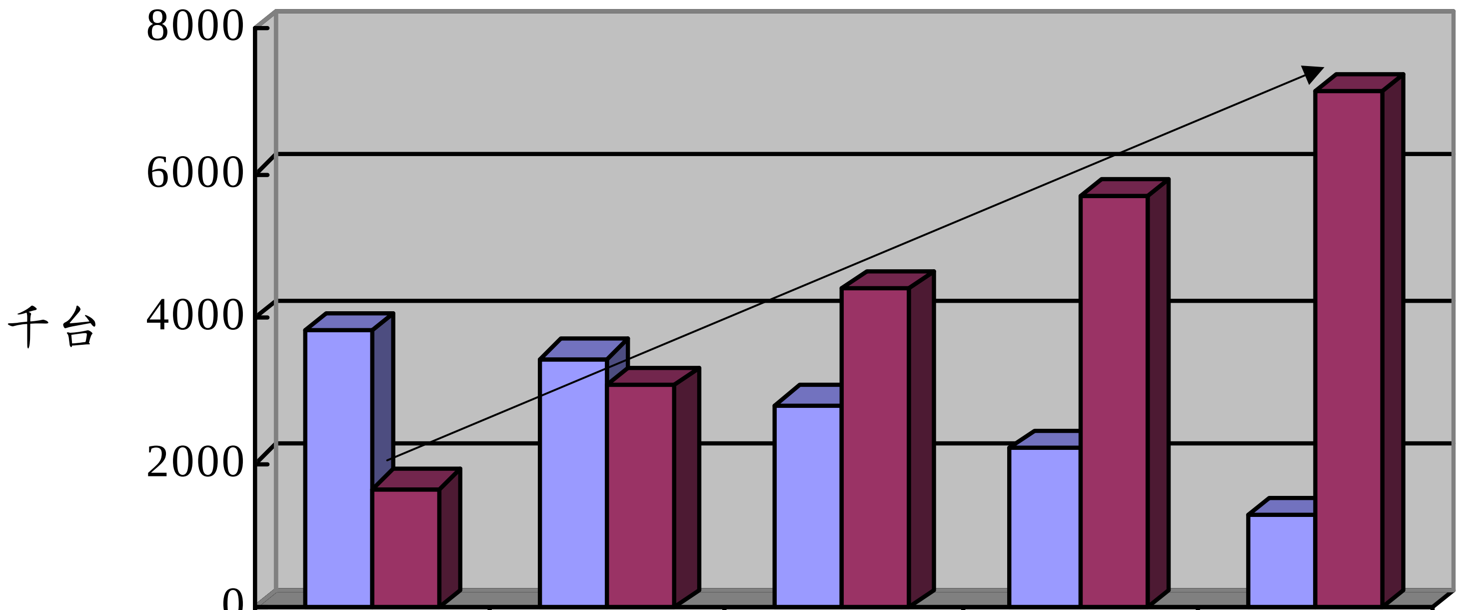


CPT 65”/1080p LCOS PTV

Display technologies
as a function of screen size and resolution



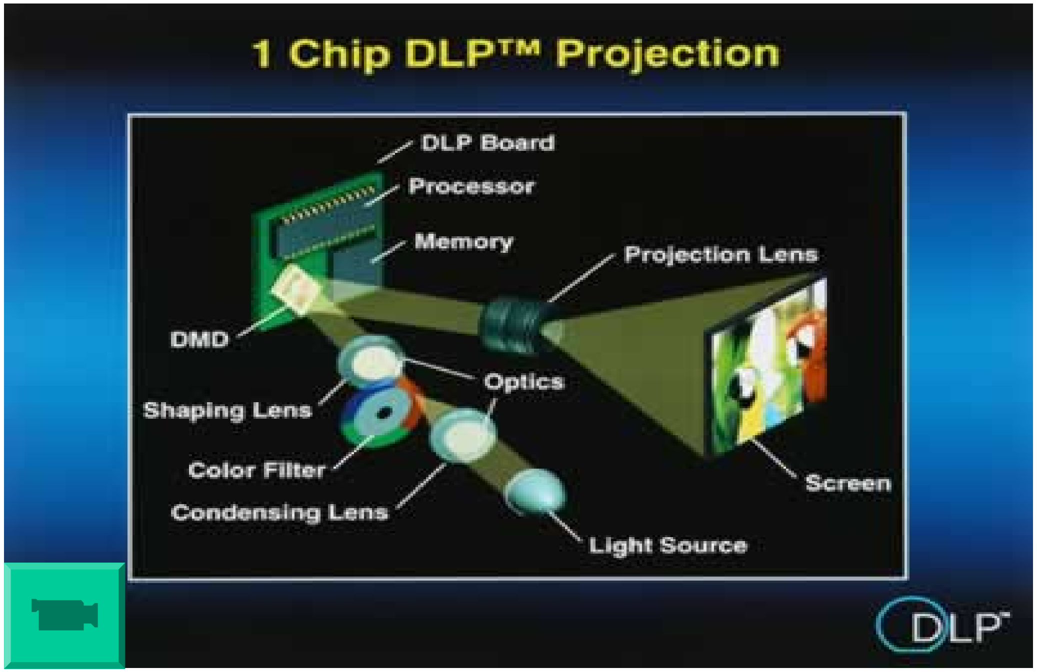
Micro-Display PTV Market



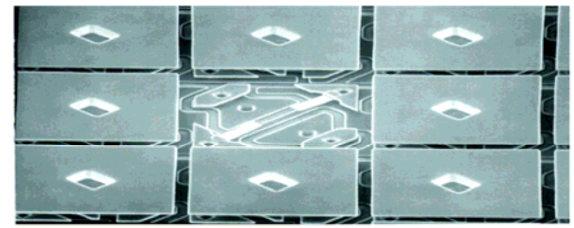
	2004	2005	2006	2007	2008
CRT-PTV	3850	3445	2808	2212	1260
MD-PTV	1650	3055	4392	5688	7140

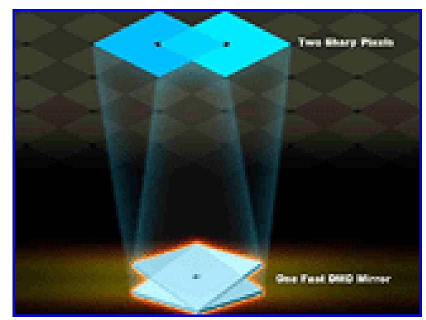
Displaysearch 2005/4

DMD & DLP-PTV



Digital Micromirror
by Texas Instrument



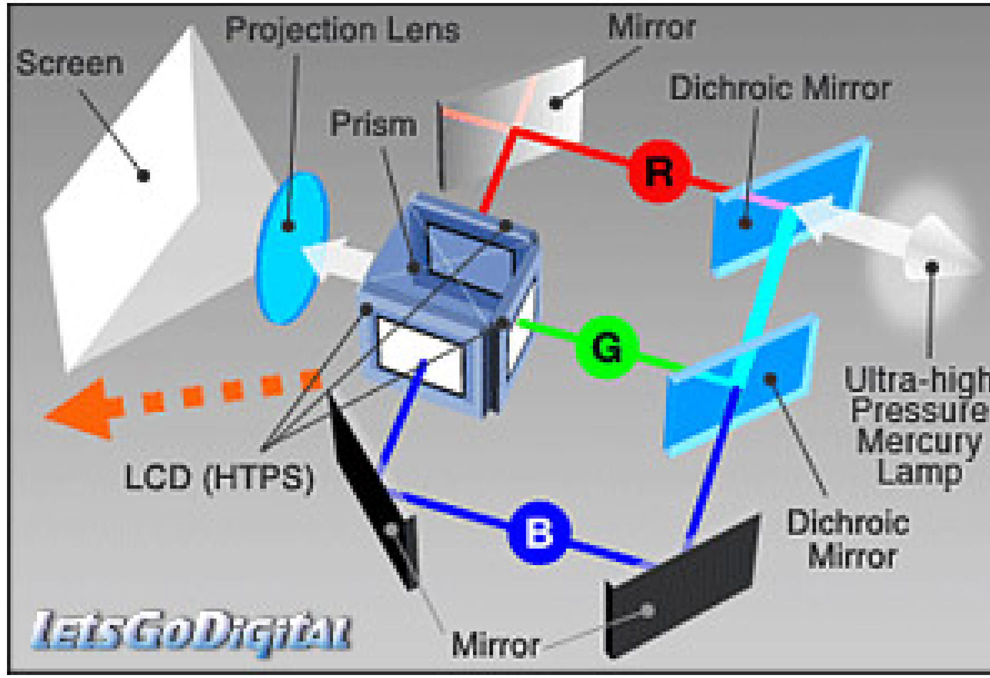


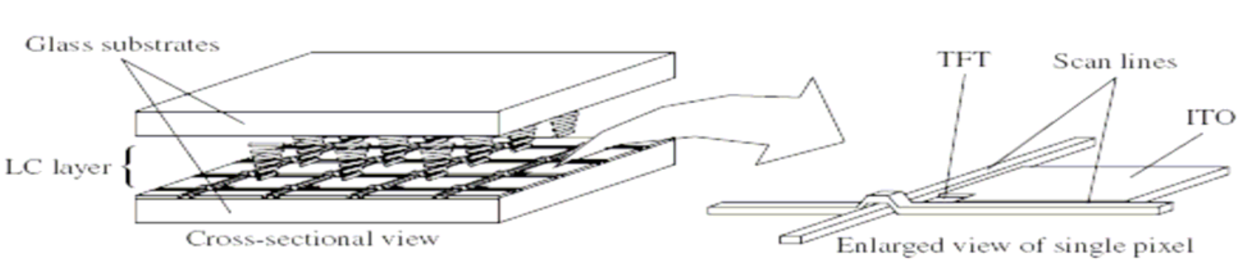
「SMOOTH PICTURE」の動作概念(TI提供)

1. DMD was developed by Texas Instrument Inc. (TI)
2. Manufacturing complexity.
3. Color break-up (rainbow effect).
4. Poor color saturation.

HTPS LCD-PTV

1. **Screen door effect (45% ~55% aperture ratio).**
2. **Low contrast (<1000:1).**





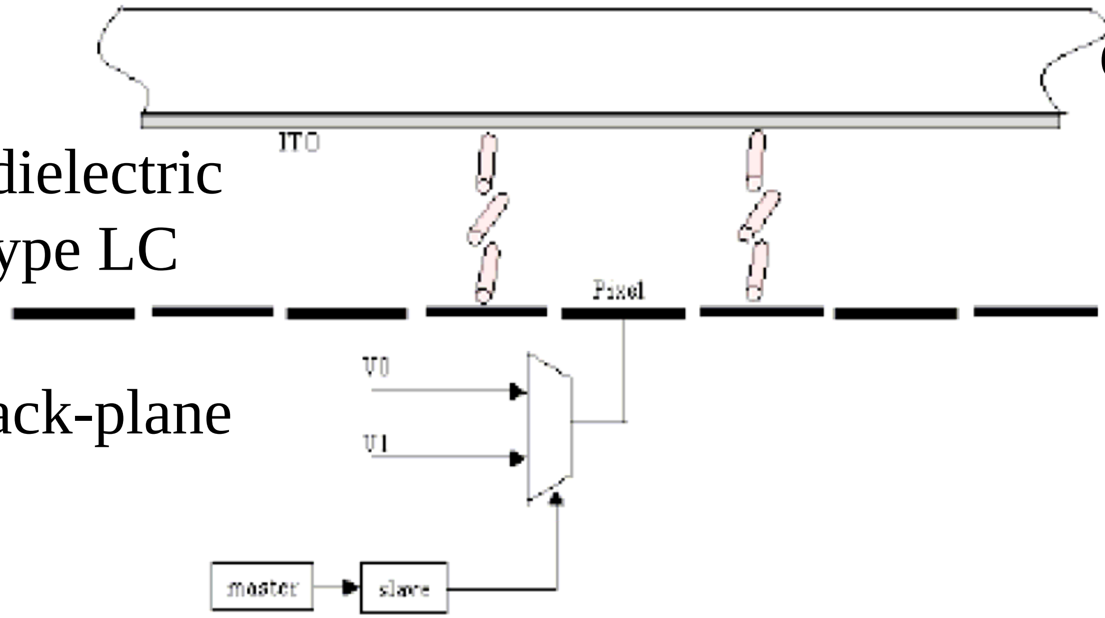
LCOS device operation principle

Glass subtract

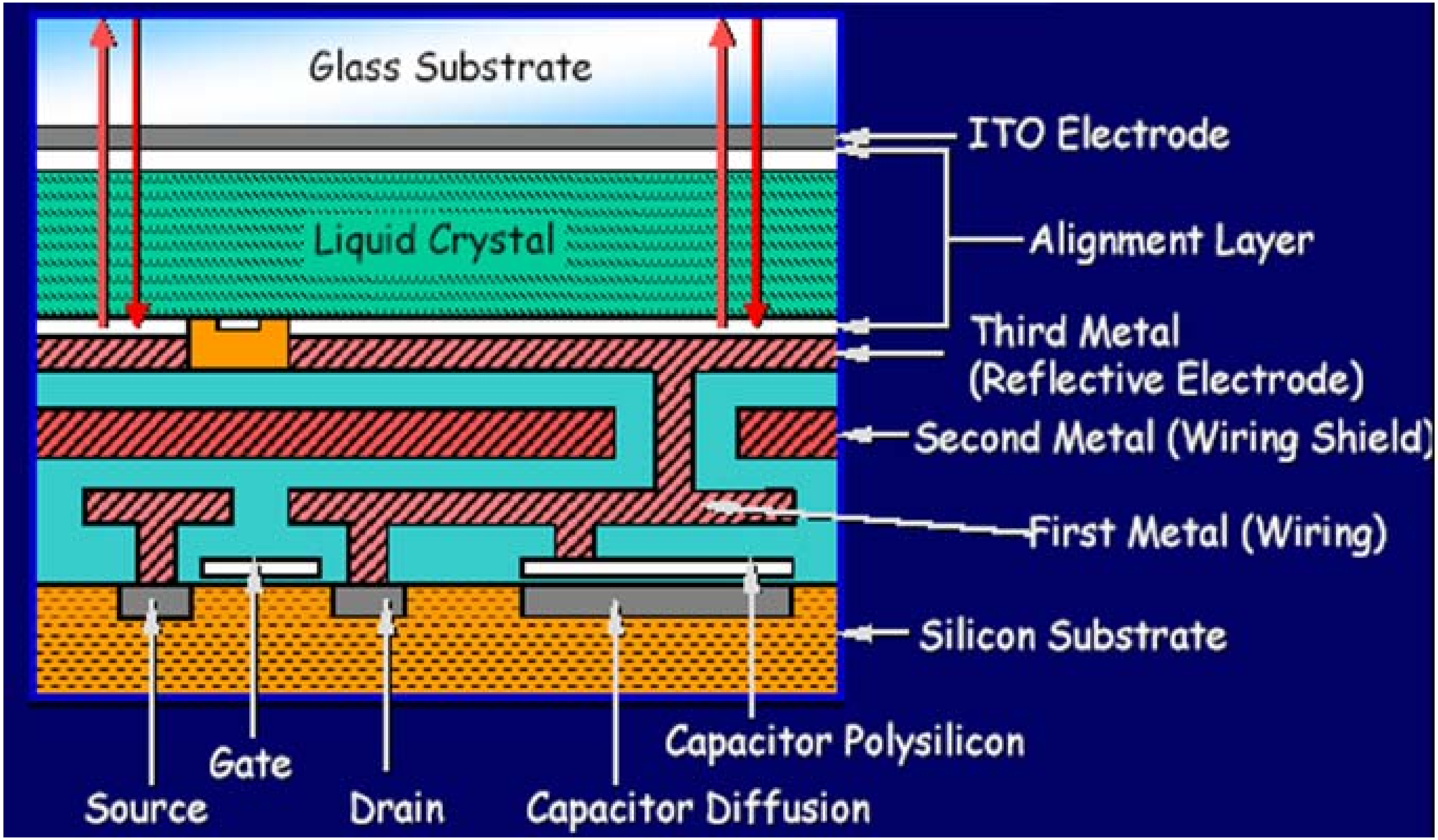
Negative dielectric
Nematic type LC

VAN mode

Silicon back-plane



LCOS: Liquid Crystal on Silicon

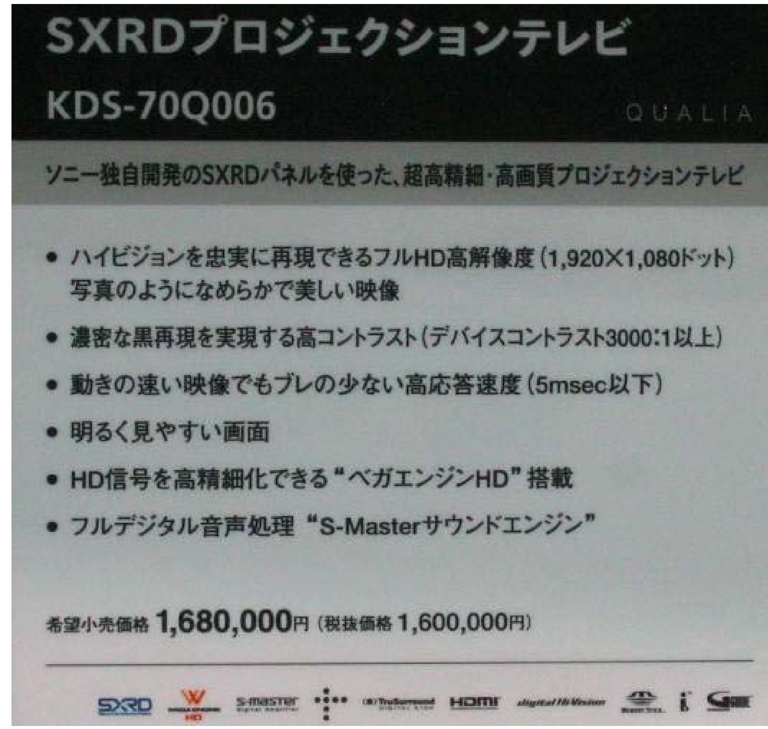


Power Consumption Evaluation based on 60+ screen size

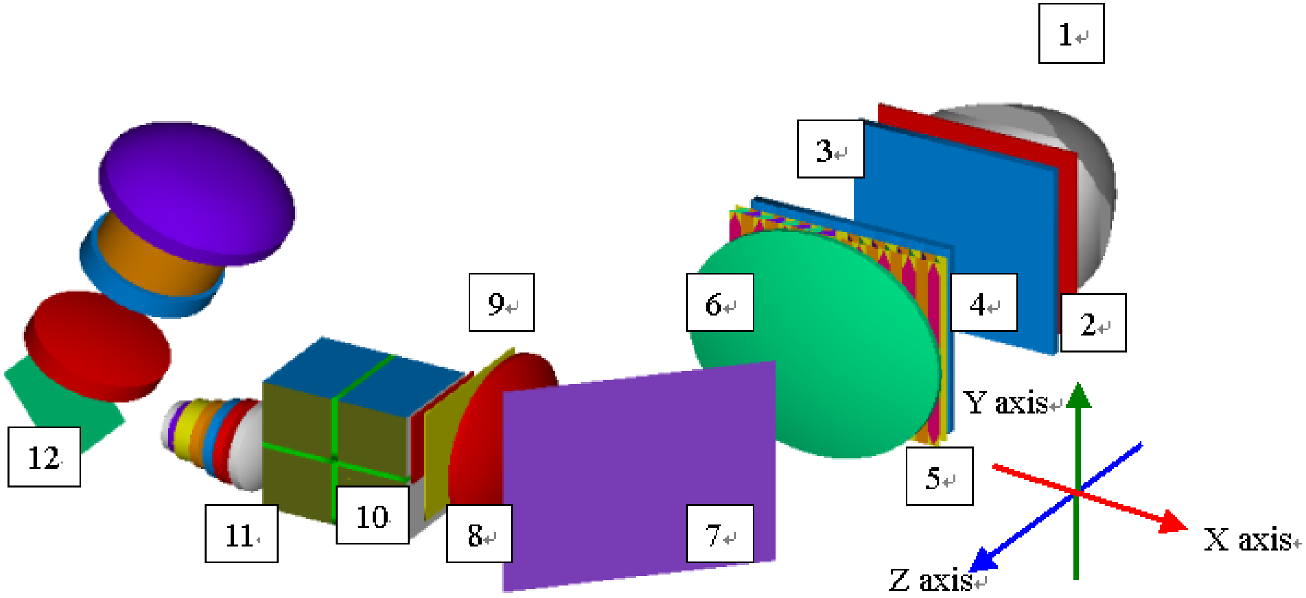
- 【日经BP社报道】(9/15'05)….在发布会上，作为背投电视相对于液晶电视和等离子电视的优势，**JVC**强调了低耗电量。现已完成产品发布的65英寸液晶电视为619W，65英寸等离子电视为745W，而此次的新产品中，70英寸为221W，61英寸和56英寸为217W。

65" LCD-TV	65" PDP	70" LCOS	61" & 56" LCOS
619 W	745 W	221 W	217 W

Sony 70”/1080p LCOS PTV @2004FPD



Optical Engine Model



1. Lamp Module
2. UV IR Filter
3. Lens Array A
4. Lens Array B
5. Condenser Lens
6. PS Converter
7. Fold Mirror
8. Collimator Lens
9. Pre-polarizer
10. Color Management
11. Panel
12. Projection Lens

Key components on LCOS-PTV

LCoS panel

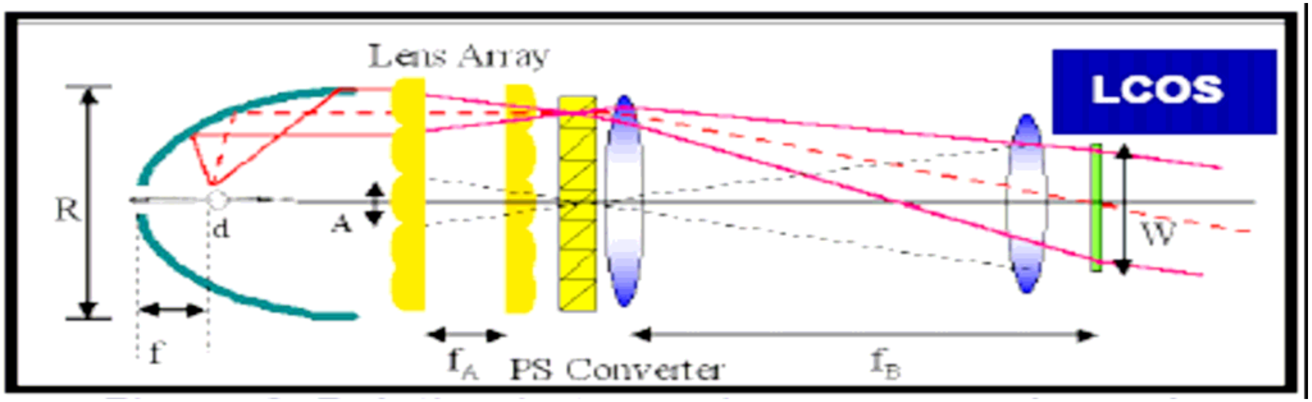
Color Management

Optical Engine

Video Board

65” LCOS PTV

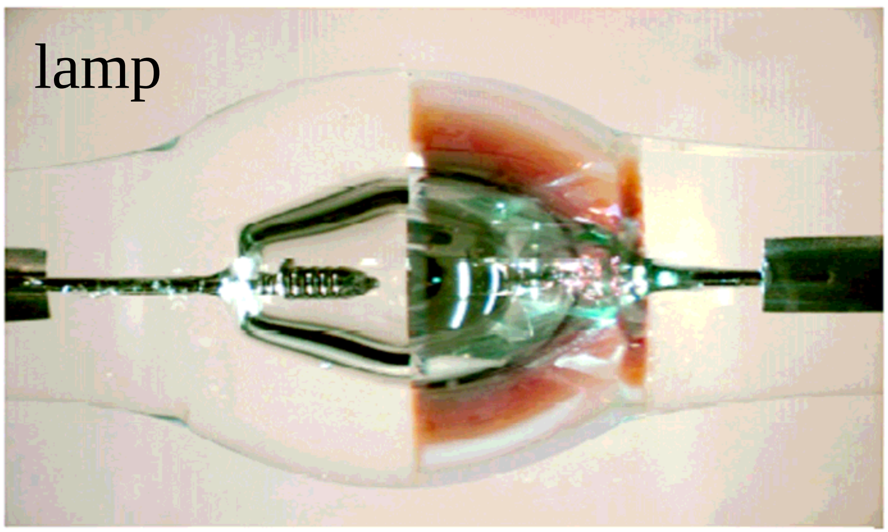
Thermal problems in the optical engine

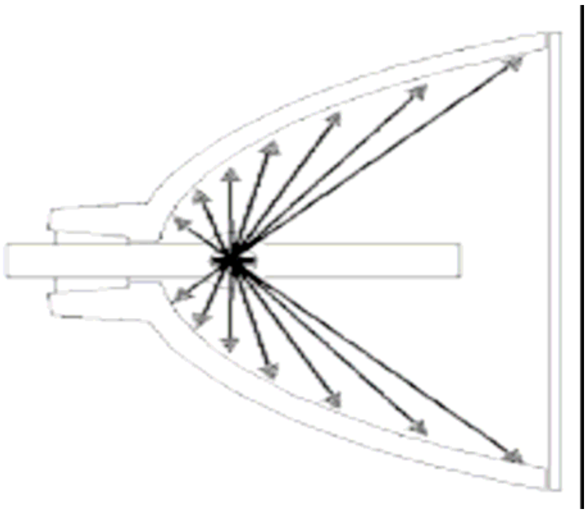


- Deformation of the holding structures.
- LCOS panel thermal effects, such as cell gap variations/ material thermal effects.
- Thermal GRIN effects for optical elements.
- Thermal birefringence effects of component
- Thermal deformations of elements, such as Dicromirror, PBS interface coating etc.

Case 1. Birefringence effects

Thermal stress birefrigence in LCOS projection displays





Thermal Stress Birefringence

- Optical Glass

  - Isotropic (annealed)

  - External Load or Non-uniform heating

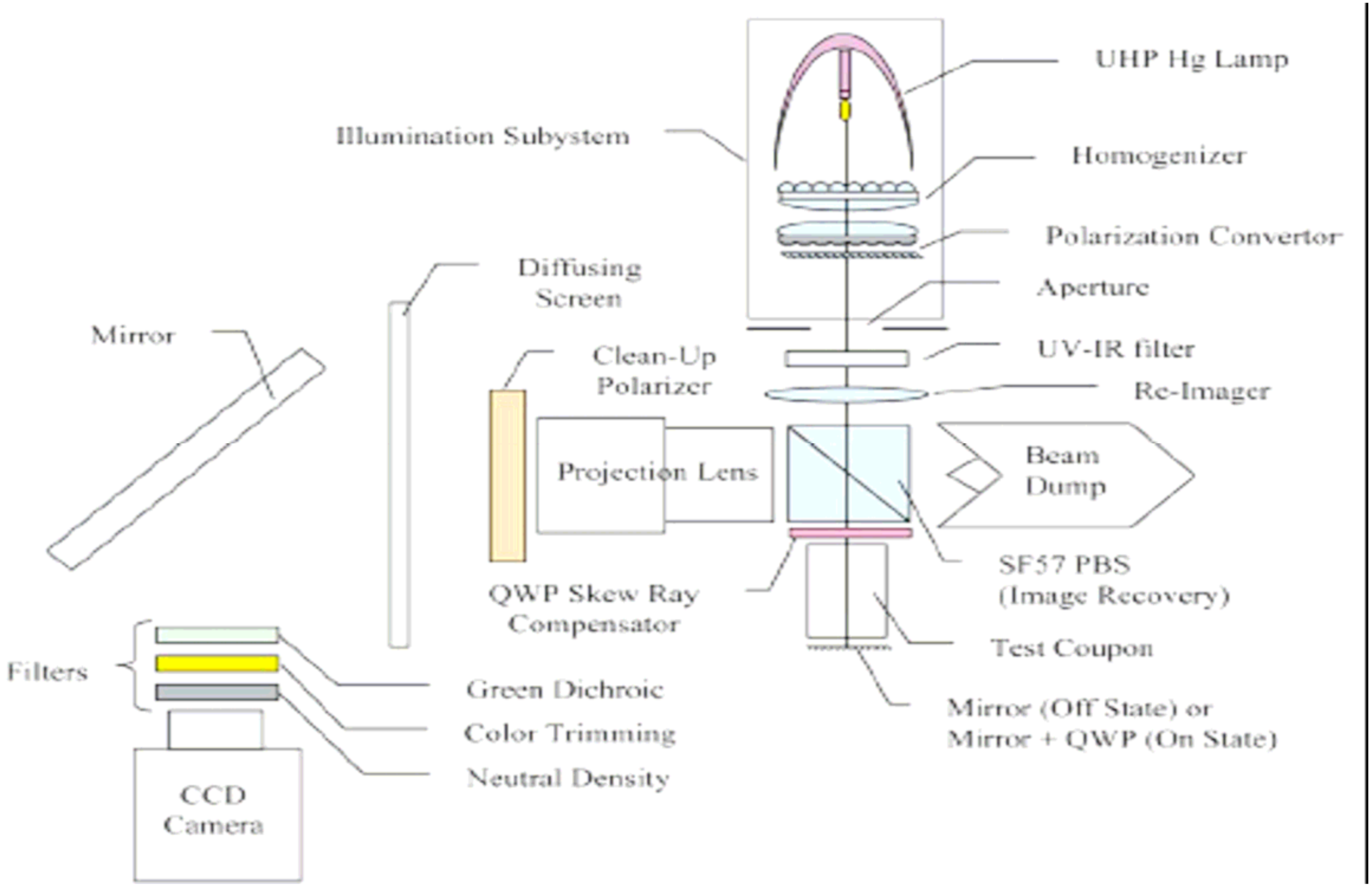
  - Anisotropic, Refractive index

- Stress birefringence

  The refractive index depends upon the direction of vibration of the light's electric field.

  The magnitude depends upon the material properties of the glass in addition to the amount of applied stress.

Thermal stress birefringence apparatus

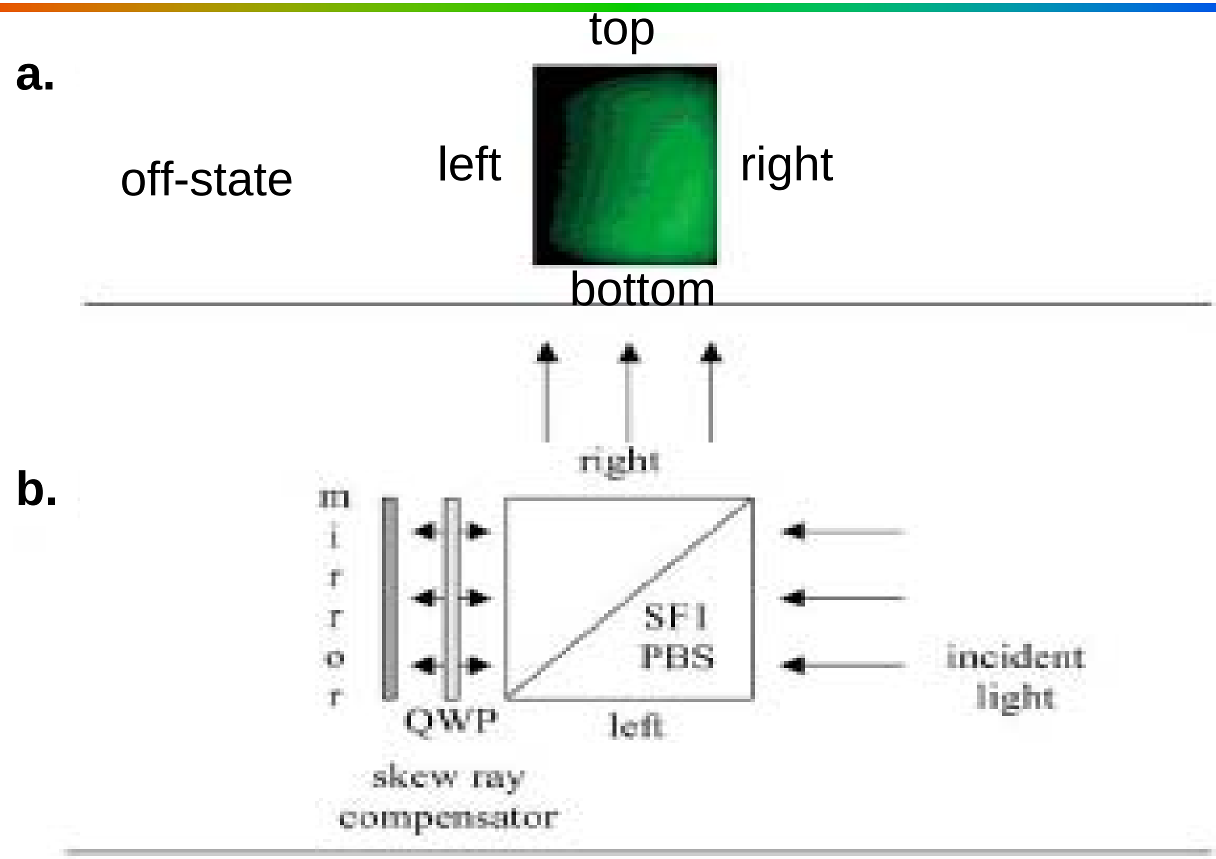


Thermal Contrast Ratio

$$\text{Thermal CR} = \frac{I_{on}}{I_{off}(t) - I_{off}(t=0)}$$

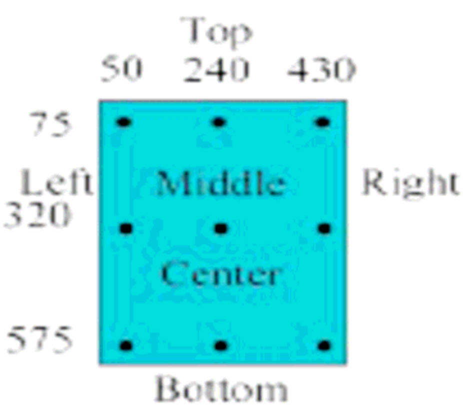
1. The contrast ratio (CR) is simply calculated as the ratio of the on-state and off-state intensities.
2. In the absence of thermal stress birefringence the Thermal CR will be infinite.

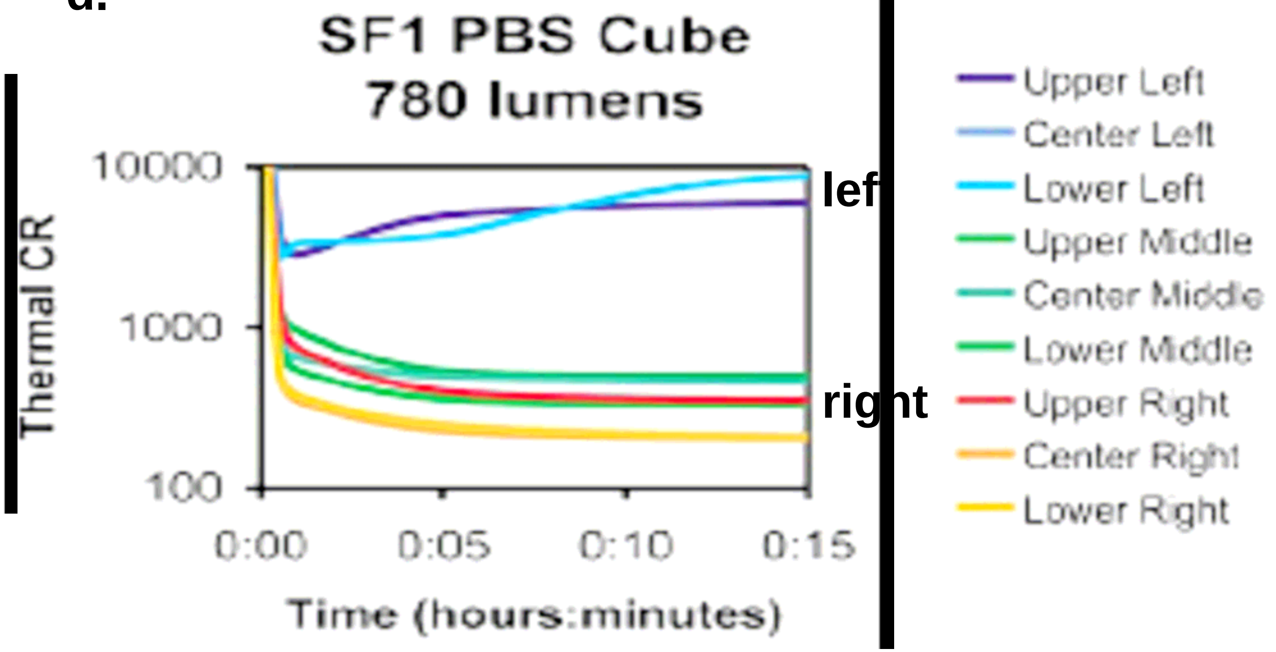
Off-sate on SF1 PBS



a. Off-state image from an SF1 PBS cube after 45 min of exposure to 780 lumens.
b. Schematic diagram to explain left/ right asymmetry.

On-state on SF1 PBS cube thermal Stress birefringence present



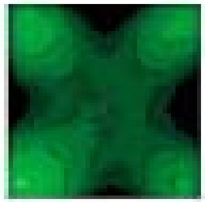


c. The rectangle represents the 480 x 640 pixel image.
d. Graph of thermal CR from an SF1 PBS cube for the first 15 min of exposure to 780 lumens.

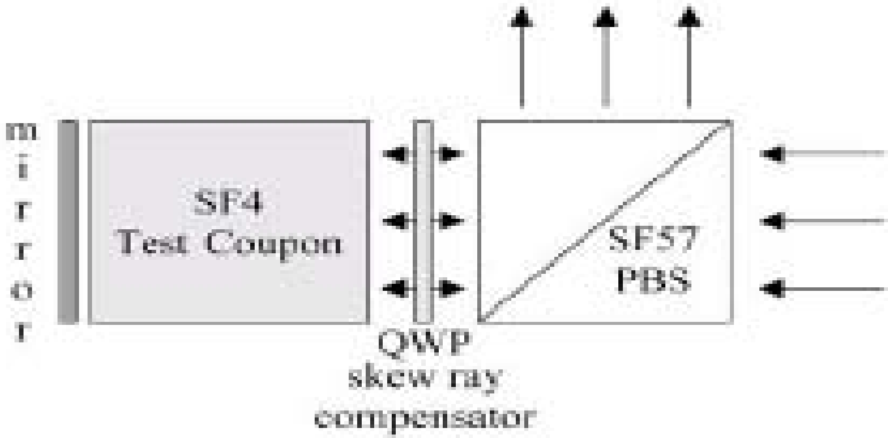
SF57
near-immunity to thermal stress birefringence

a.

Off-state



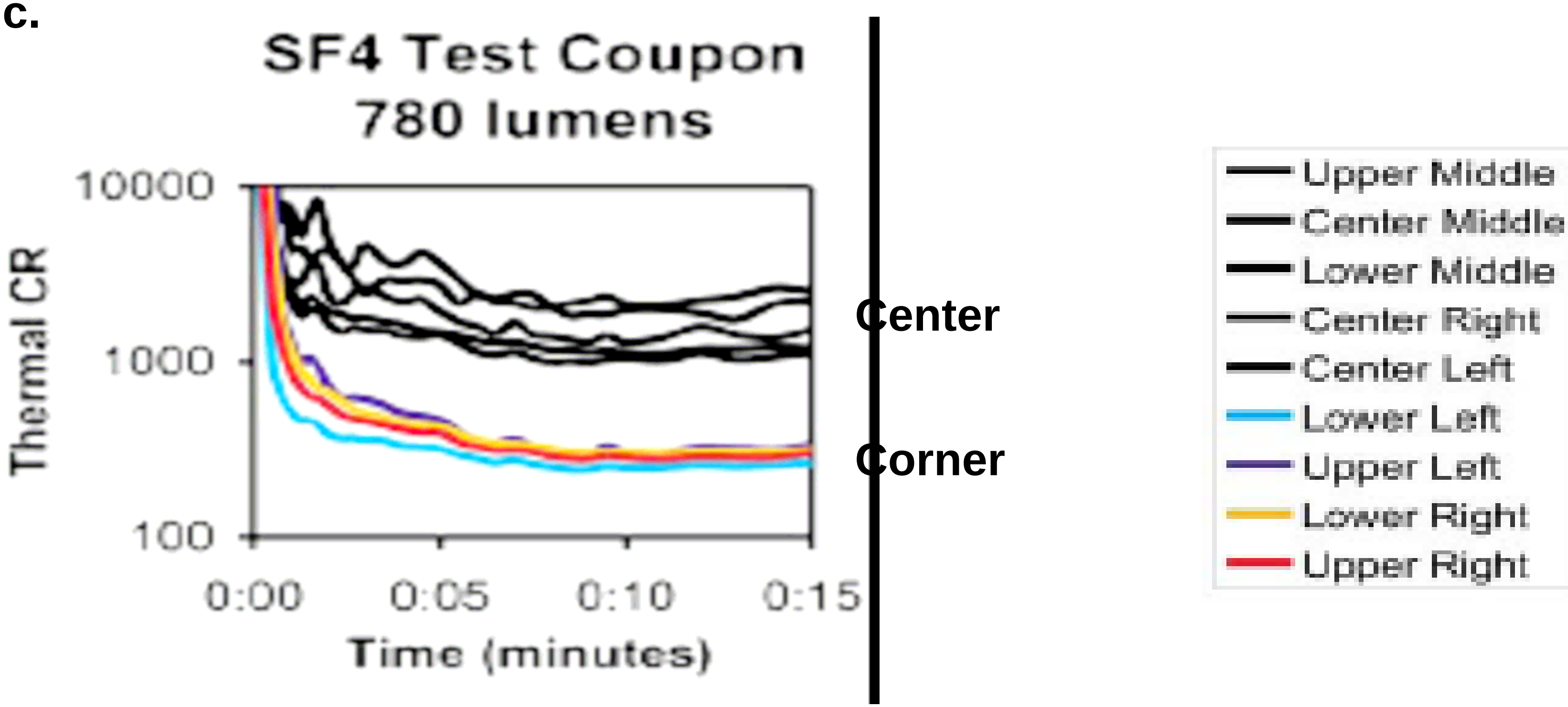
b.



a. Off-state image from an SF4 test coupon after 45 min of exposure to 780 lumens.
b. Schematic diagram to explain center/corner asymmetry.

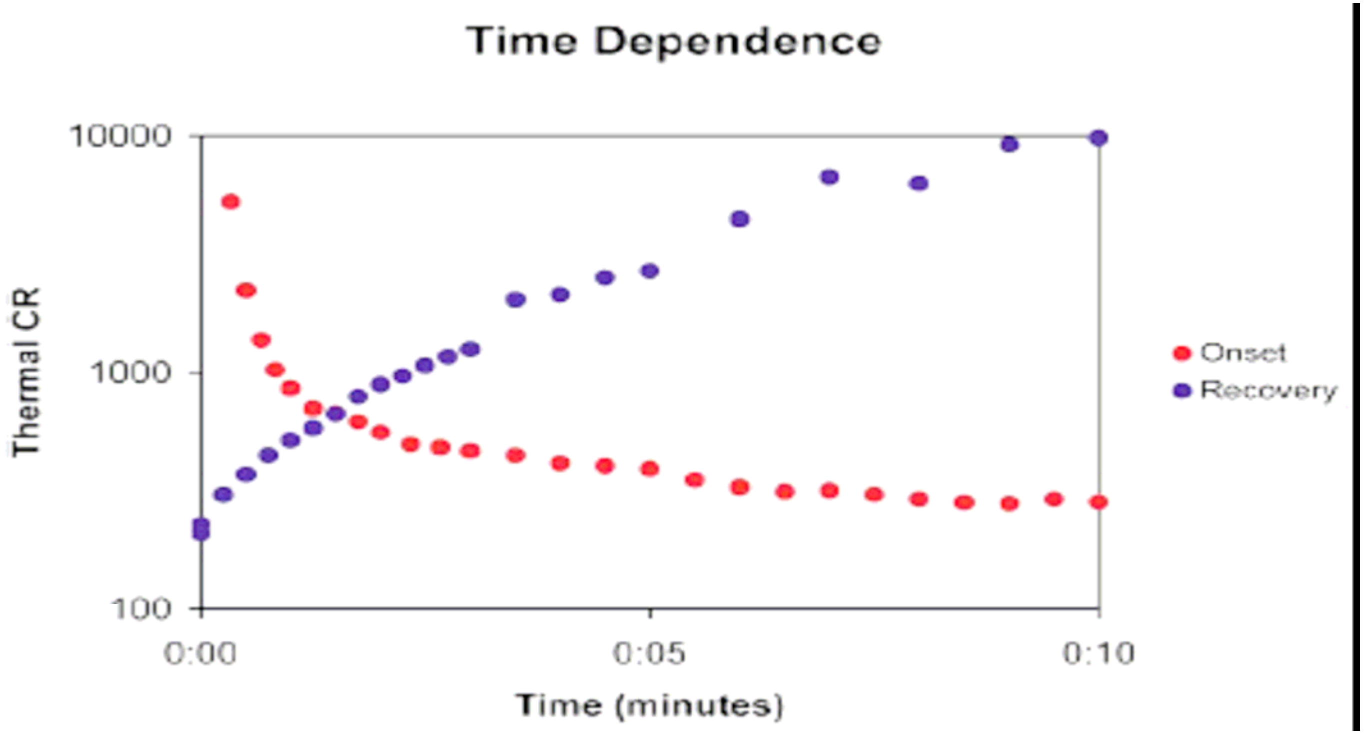
SF4 test coupon
thermal Stress birefringence present

c.



c. Graph of thermal CR from an SF4 test coupon for the first 15 min of exposure to 780 lumens.

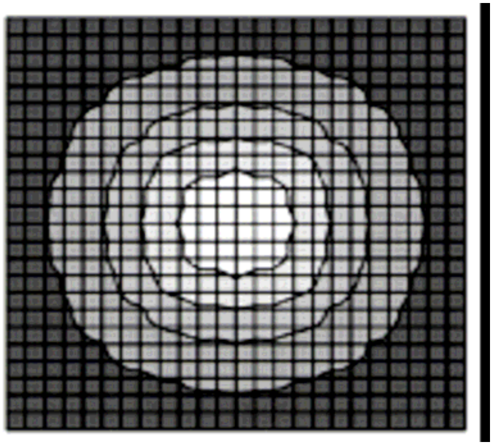
Time-dependent thermal CR Onset and Recovery



Time-dependent thermal contrast ratio of an SF4 test coupon exposed to 780 lumens, for both the heating (onset) and cooling (recovery) phase.

Simulation Model

Glass size: 25 mm x 25 mm
illuminating : 10 mm x 10 mm
FDM Mesh: 1mm cubes



$$\frac{\partial T}{\partial t} = \frac{k}{\rho c}\nabla^2 T + \frac{H}{c}.$$

T(x,y,z,t): temperature at a particular position ***(x,y,z)*** within the grid at a certain time ***t***

K: thermal conductivity

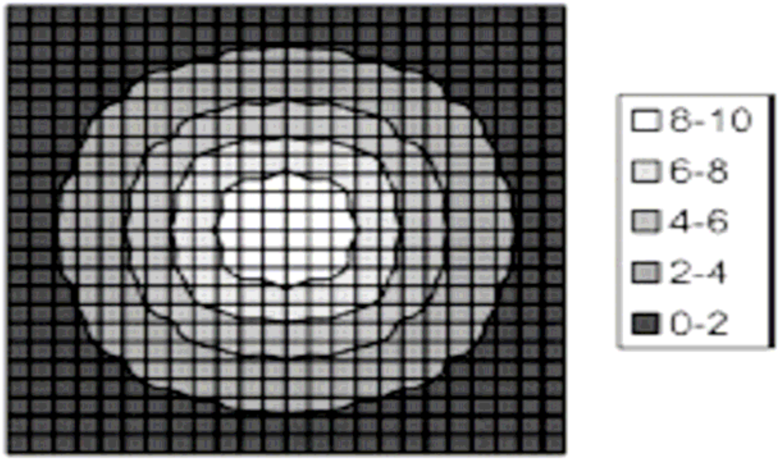
ρ: mass density

c: heat capacity

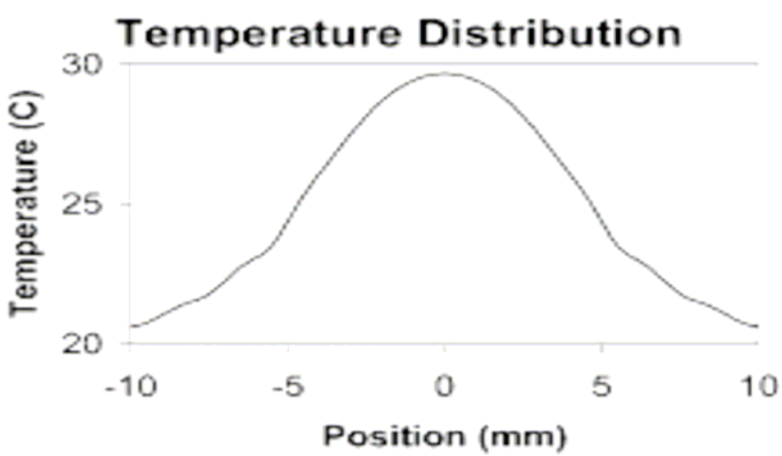
H: rate of heat production per unit mass due to optical absorption, unit ***W/Kg***.

The temperature inside the cube hottest in the middle of the illuminated region

a.



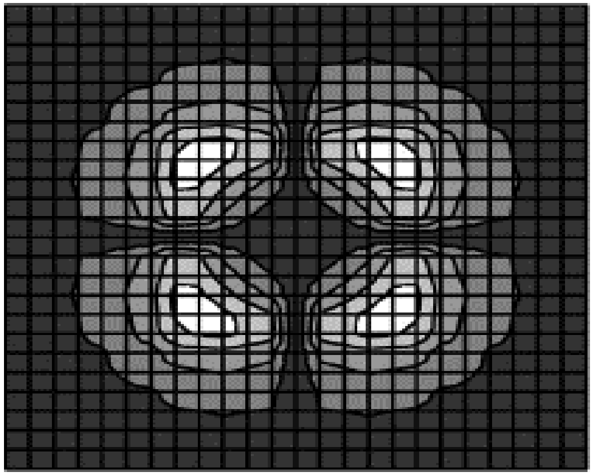
b.

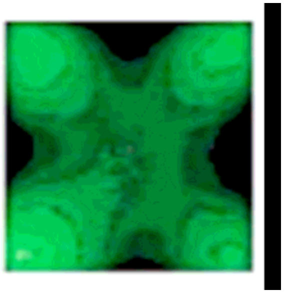


a. Spatial dependence of temperature for the central cross-section of the cube. The gray scale show the temperature increase above ambient (20℃). The 25 x 25 grid marks individual points within the simulation. The central 10 x 10 region is illuminated.
b. Spatial dependence of temperature along a horizontal line that intersects the center of the beam at right angles. The illuminated region is between ±5 mm.

Simulation of an off-state image

c.





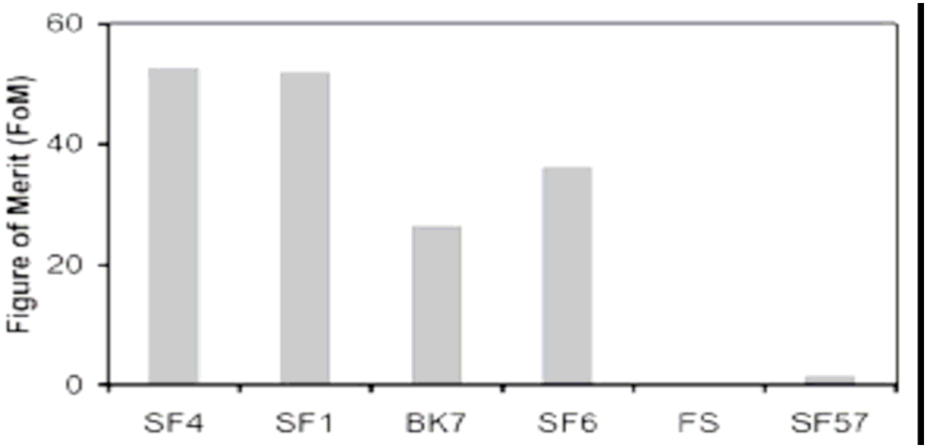
Off-state

c. Simulation of an off-state image. The values displayed are proportional to the square of the stress oriented at ±45° to the horizontal. Lighter shades of gray correspond to regions of higher stress. The actual calculated value is the square of the temperature difference between diagonally adjacent cells in the spreadsheet.

Figure of Merit (FoM)

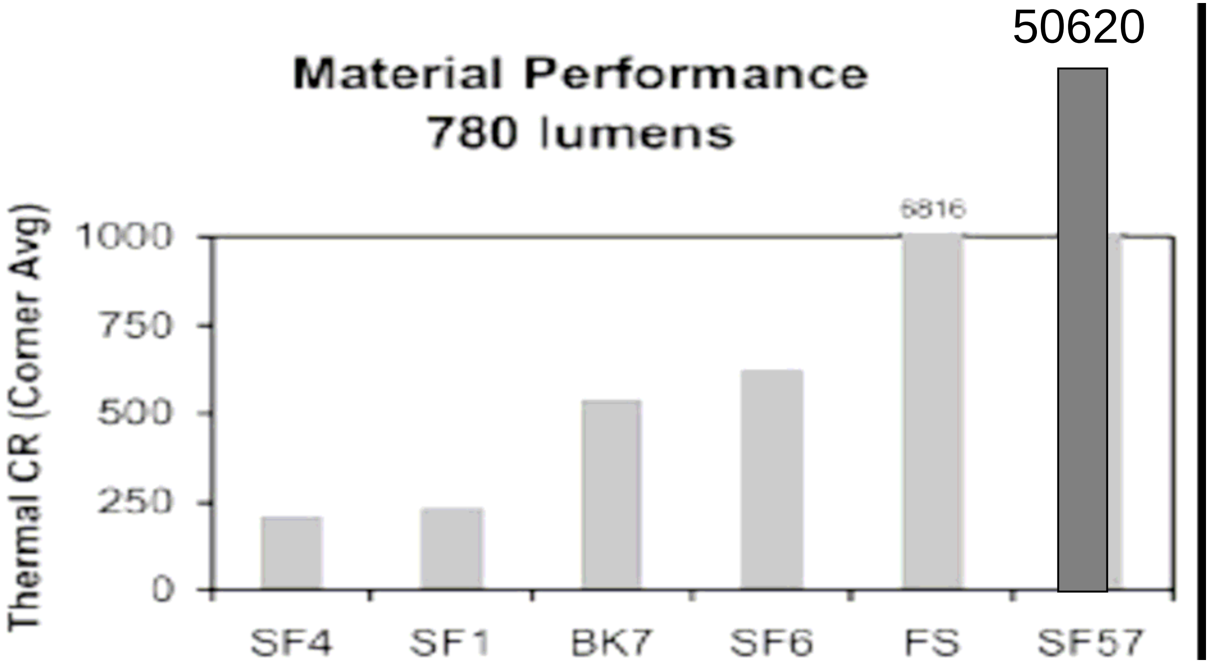
$$\mathrm{FoM} = \left(\frac{\gamma}{k}\right)\left(\frac{\alpha E}{1-\mu}\right)(K).$$

γ : fractional absorption of glass
k: thermal conductivity of a glass
α : thermal coefficient of expansion
E: Yaung's modulus
μ : Poisson's ratio
K: stress optic coefficient



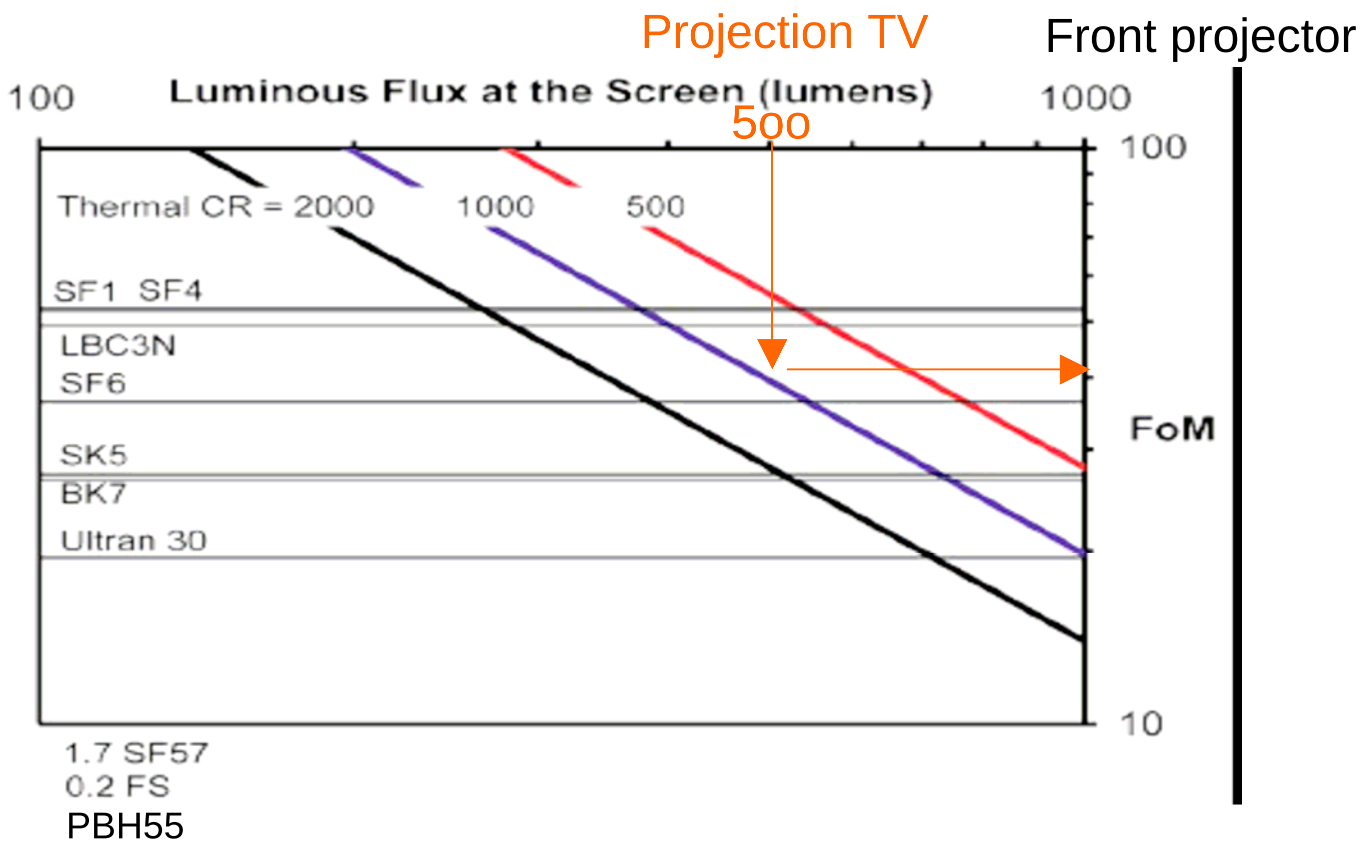
1. FoM is positively correlated with susceptibility to thermal stress birefringence.
2. Fused silica has a small FoM because of its low absorptance and low thermal expansion.

Material performance at 780 lumens



1. Measured value after 45 min of exposure to 780 lumens. The four corner positions have been averaged to give a single number for each sample. The thermal CRs for fused silica (FS) and SF57, too large to be displayed on this scale, are written in above their bars.
2. Samples with a large amount of thermal stress birefringence have small values for the thermal CR.

Decision map for glass selection



Decision map shows relation between thermal CR, FoM, and power.

Discussion

- The glass selection guidelines developed only to the suitability of a material with regard to the amount of ***thermal stress birefringence*** it displays as a result of visible light absorption.
- Materials with a high stress-optic coefficient will exhibit a significant amount of birefringence due to assembly and ***mounting-induced stress*** that can reduce contrast in the system.
- Thermal stress can also be introduced by other ***mechanisms*** such as

  cooling fans,

  heat from electronics,

  heat absorbed and radiated by the reflective imager.

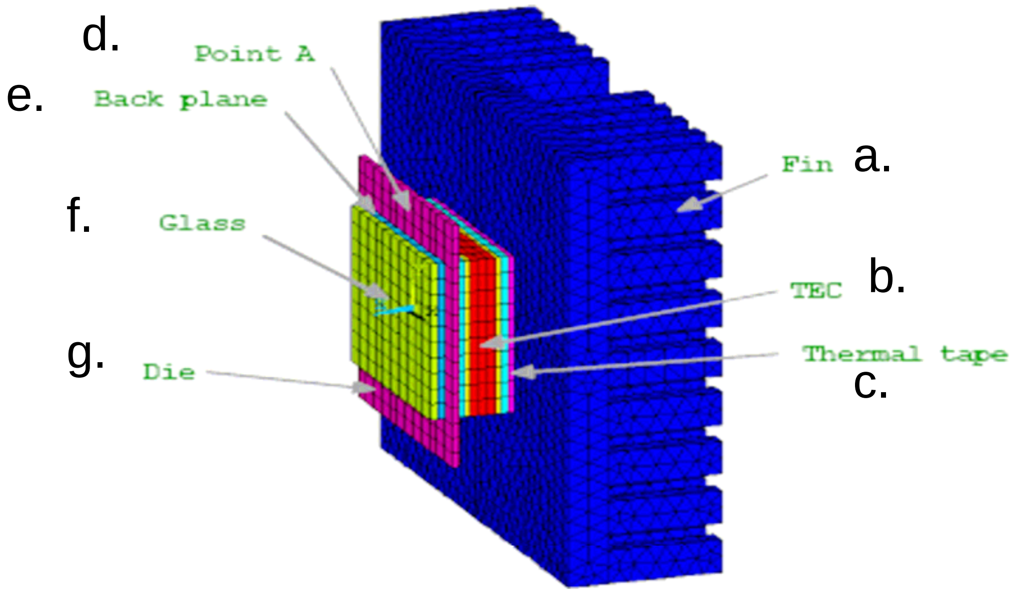
Case 2. Cooling system on LCOS panel

Thermal analysis and design for cooling system on LCOS imager

Cooling system on LCOS

- Cooling system on LCOS
  - **thermo-electric cooler (TEC)**
  - heat sink
- Heat transfer
  - conduction
  - convection
  - radiation
- Raised temperature
  - bad effect on liquid crystal in the imagers
  - optical engine performance can be seriously degraded

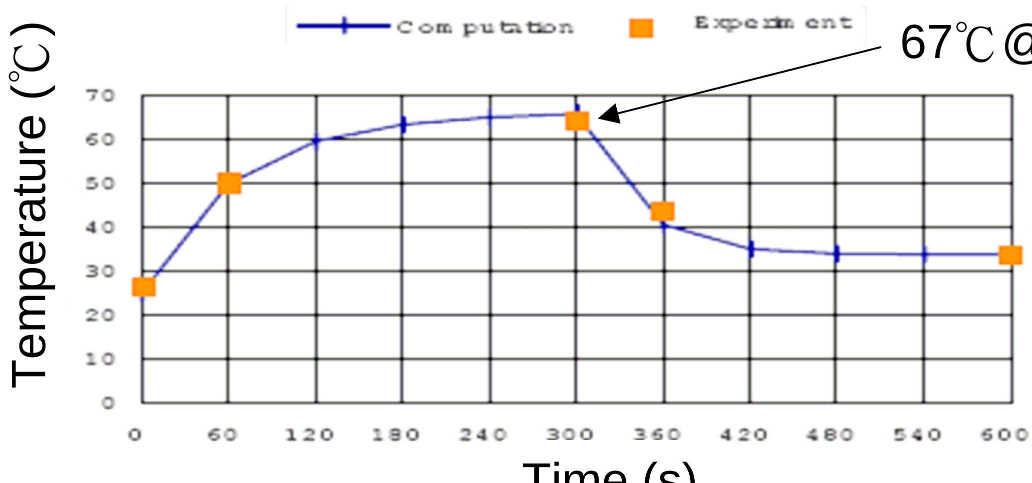
Thermal analysis model



a. Heat sink
b. TEC
c. Thermal tape
d. Point A
e. Back plane
f. Glass
g. Die

1. TEC: Bi_2Te_3 (Thermotek Co. Ltd.)
2. ***Convection*** heat transfer from the light of lamp.

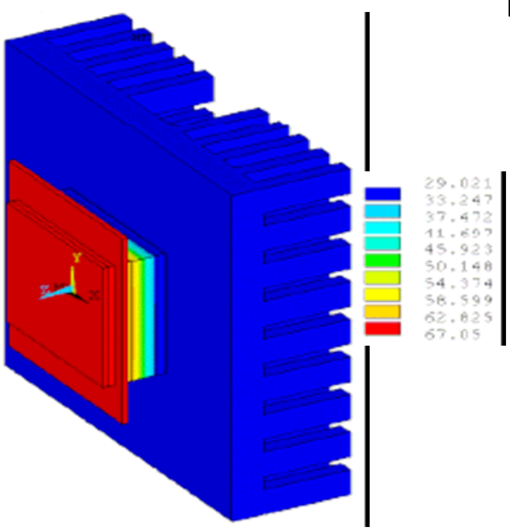
TEC (1.5V&1.5A)is turned on after 300s
Q_i =3.5W, $Temp_{\infty}$=25℃



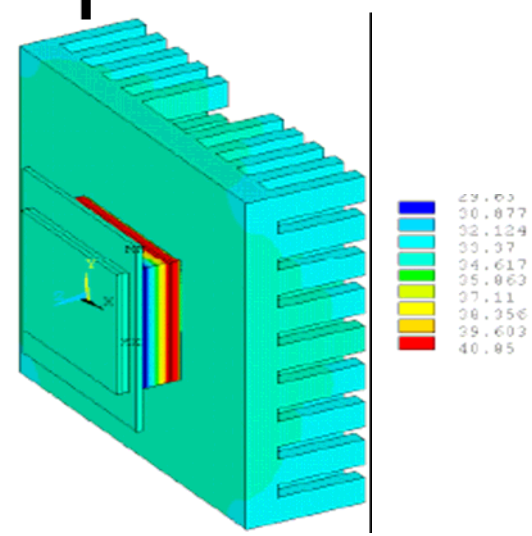
67℃@300s

34℃@600s

t=300s

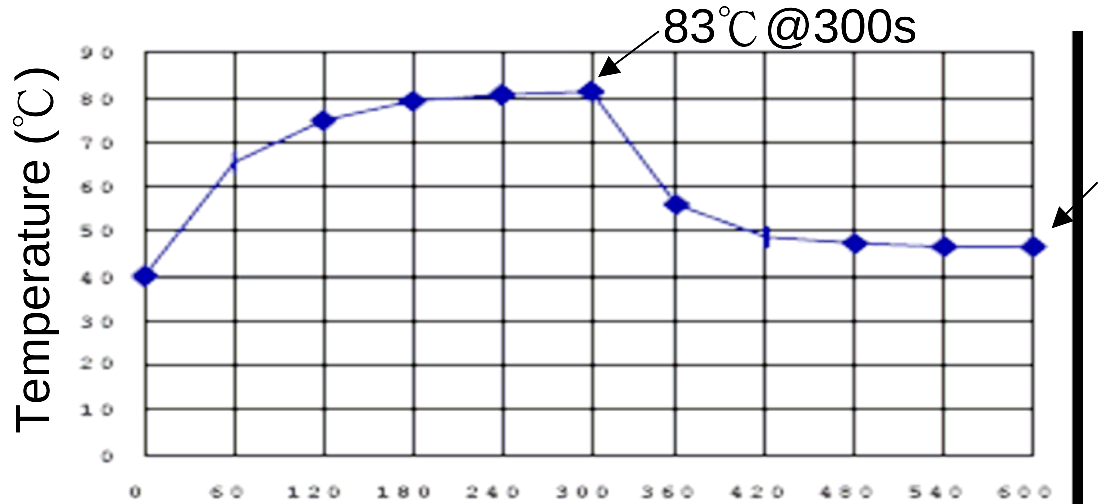


t=600s



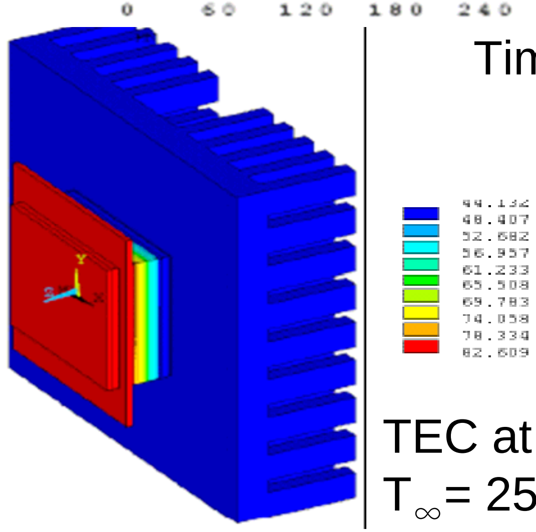
TEC (1.5V&1.5A)is turned on after 300s

Q_i =3.5W, $Temp_\infty$=40℃

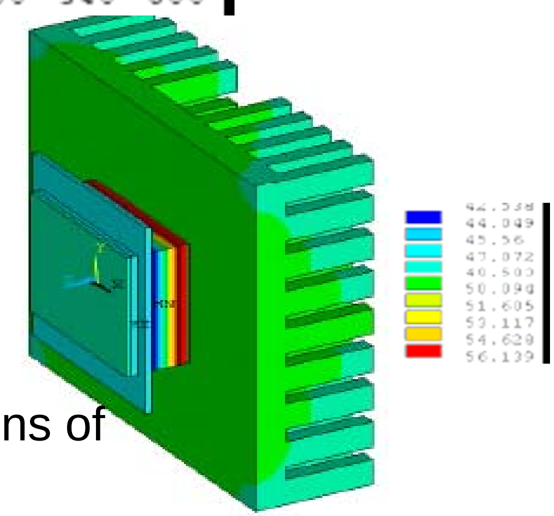


Time (s)

t=300s



t=600s



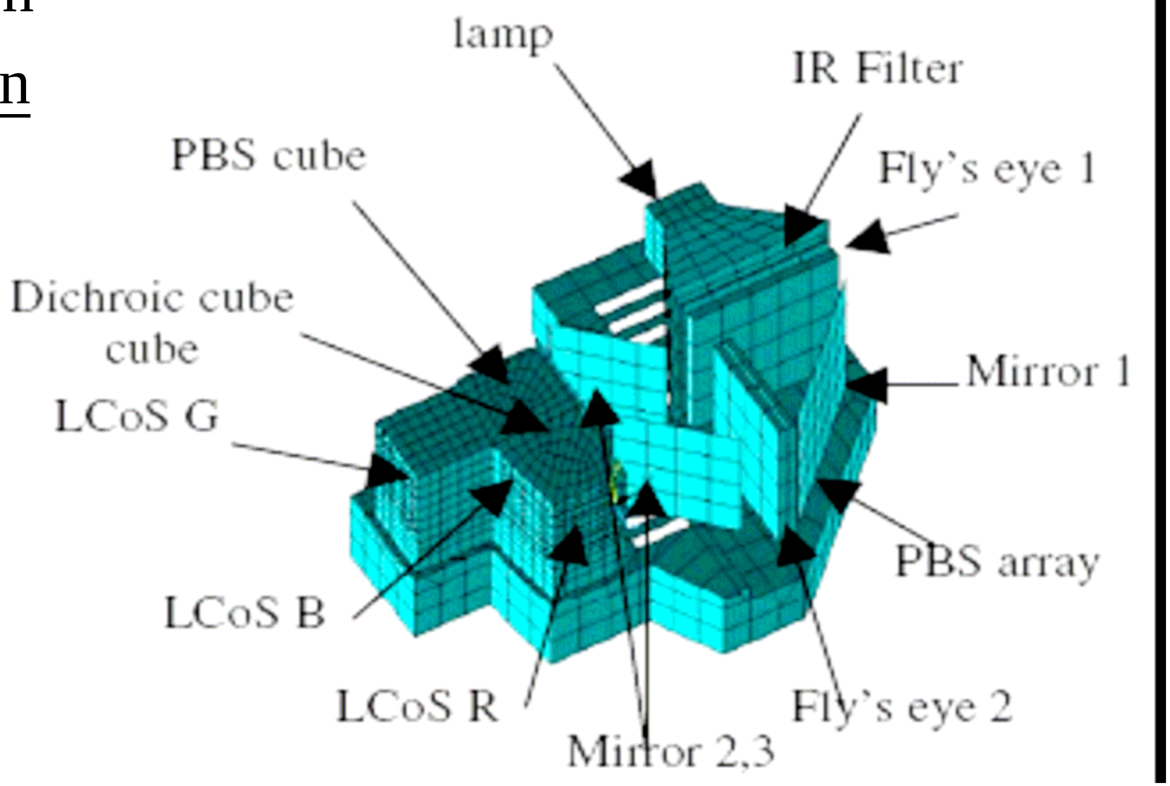
TEC at same conditions of

T_∞= 25℃

Thermal analysis for LCOS engine

LCOS engine cooling system

- Heat transfer mode
  - Conduction
  - Convection
  - Radiation

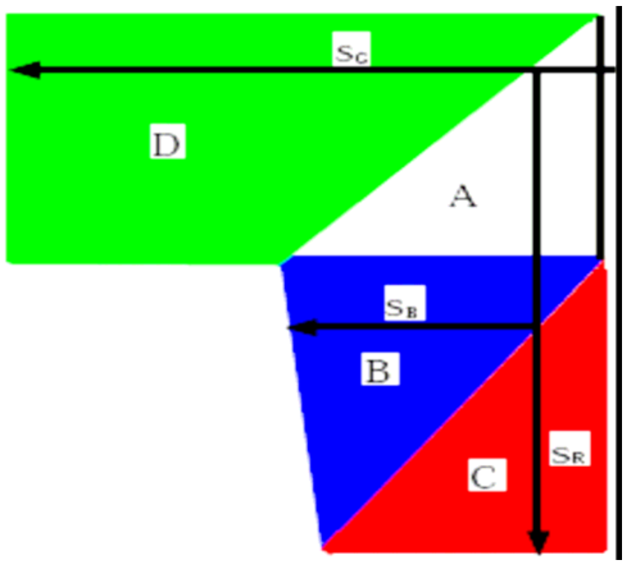


Assumption

- Input electric power 100% =
  Visible band 24% + ***UV,IR 76% (heat source)***
- The absorption rate $=1-e^{-kt}$,
  k: absorption coefficient of the device
  t: thickness of the device
  device: IR filter, fly's eye, PBS array, polarizer, PBS cube,
  Dichroic cubes.
- PBS array . S-wave 80~ 95% (transmitted)
  P-wave 20% (maximum value) of the incoming light energy from the PBS array to the polarizer as heat source.

Assumption

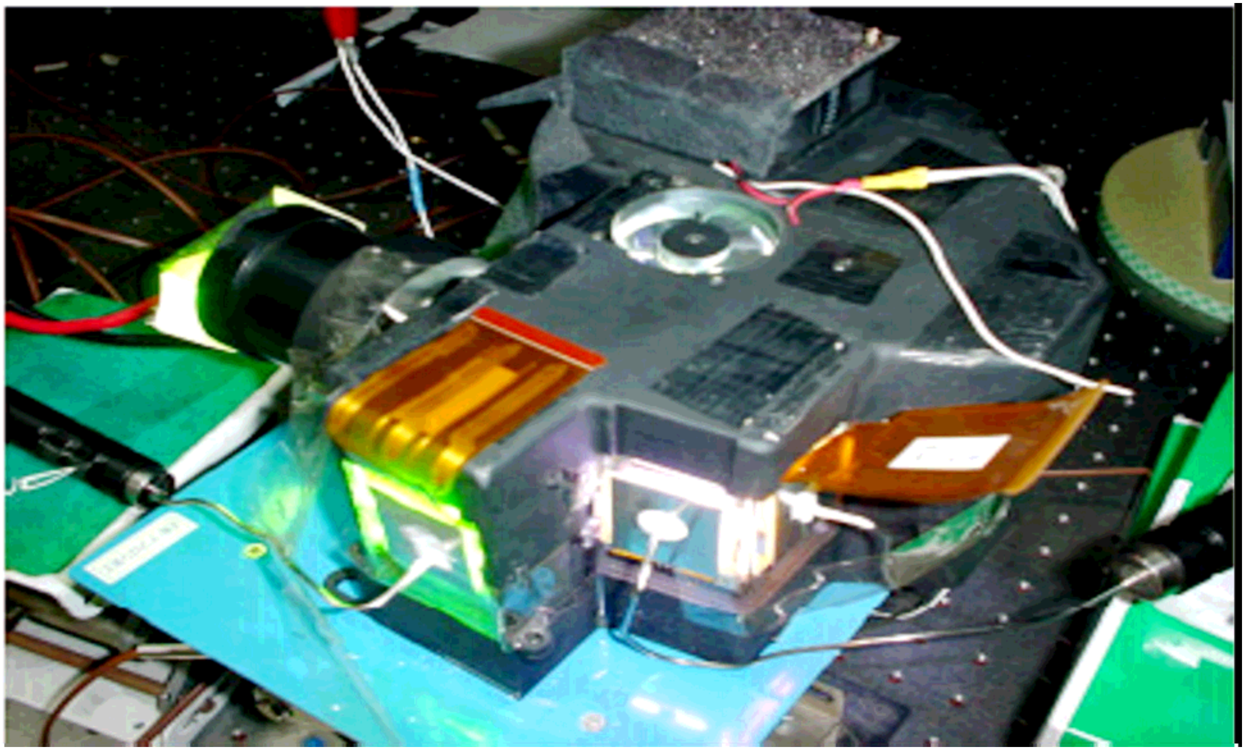
- Light passed through the polarizer is separated into R,G,B components through PBS and dichroic cubes and three components are reflected by each LCOS imager and recombined in white light.



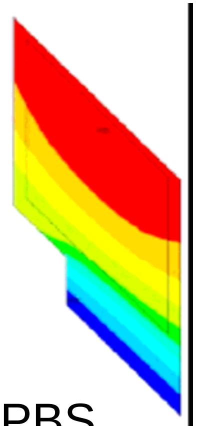
Region A.	$\dot{q}_R(s_R)+\dot{q}_G(s_G)+\dot{q}_B(s_B)$
Region B.	$\dot{q}_R(s_R)+\dot{q}_B(s_B)$
Region C.	$\dot{q}_R(s_R)$
Region D.	$\dot{q}_G(s_G)$

The absorption (hear generation) rate per unit volume for each q_R, q_G, q_B, along each ray s_R, s_G, s_B.

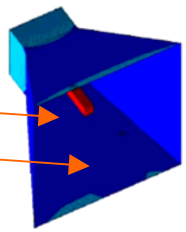
Experimental setup for measuring temperature



Computed temperature distribution



PBS
Max. 89℃

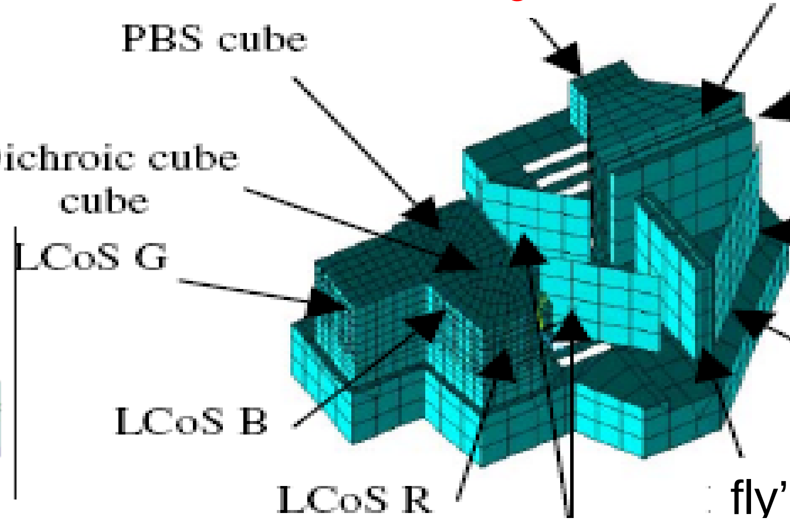


quartz. 1187℃
reflector. 43℃

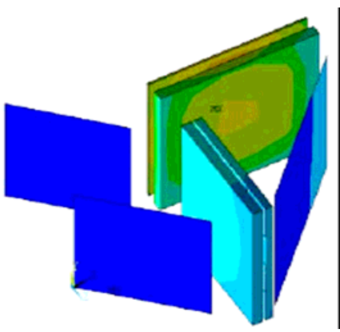
lamp quartz
1187℃

IR. Filter 453℃

fly's eye1. 345℃



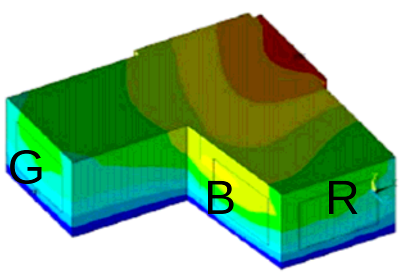
Mirror 1.
96℃



PBS array.
182℃

fly's eye2. 189℃

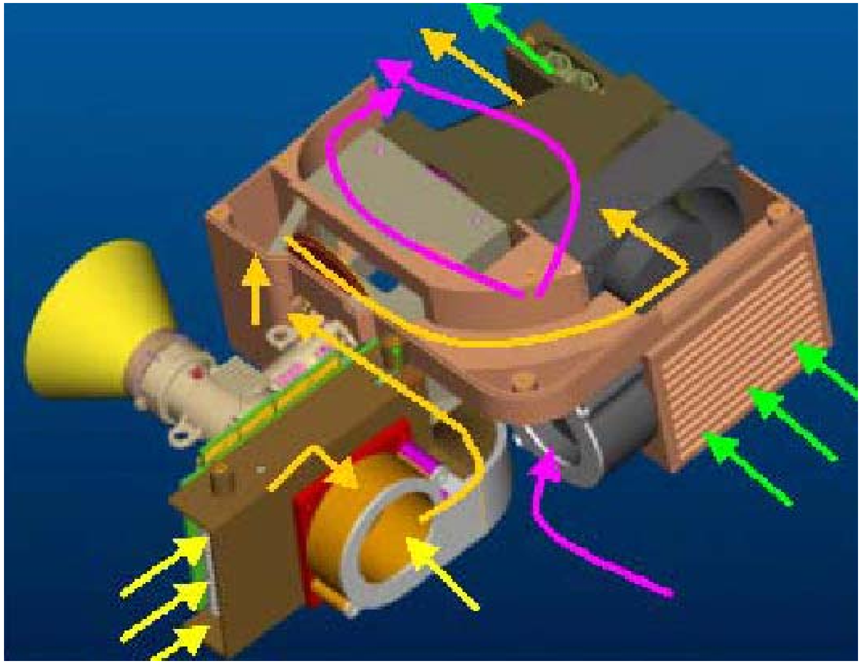
Mirror 2. 32℃
Mirror 3. 66℃



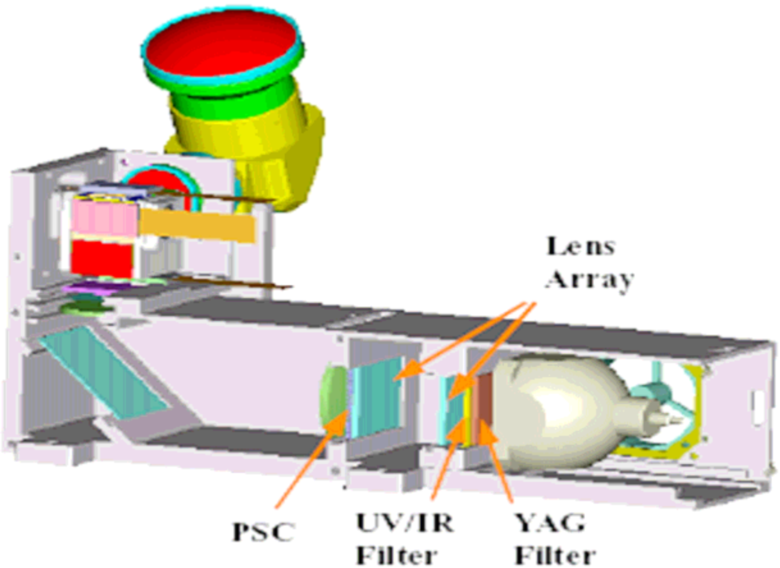
cube temp.
Max. 89℃ min. 54℃

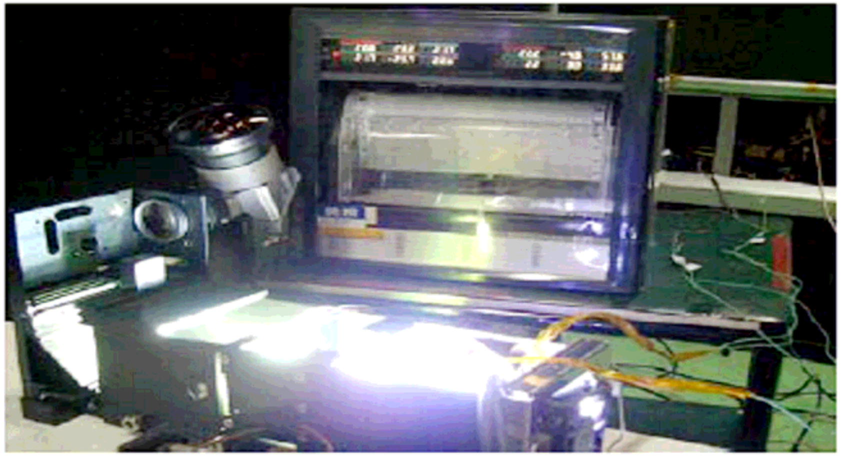
Case 4. Cooling system on LCOS engine

1. Fan
2. The application of the YAG filter in LCOS optical engine



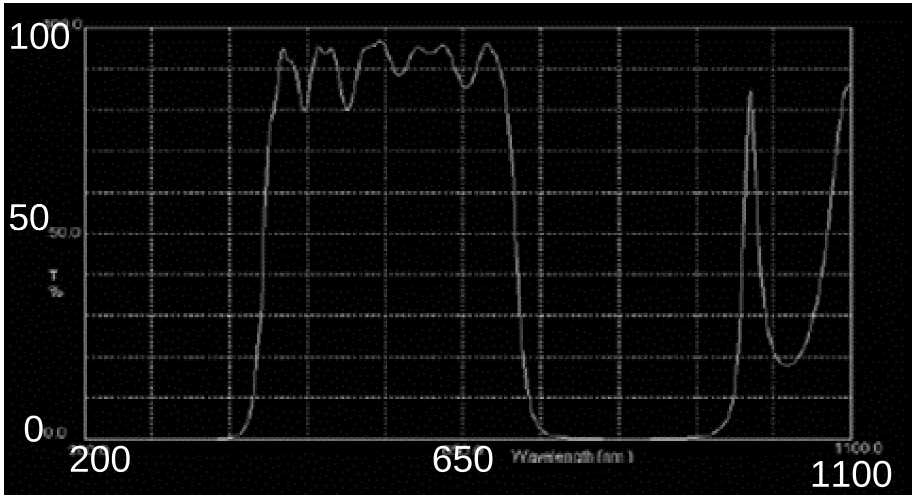
Experimental Setup





Optical component spectrum (UV/IR)

T (%)



Wavelength (nm)

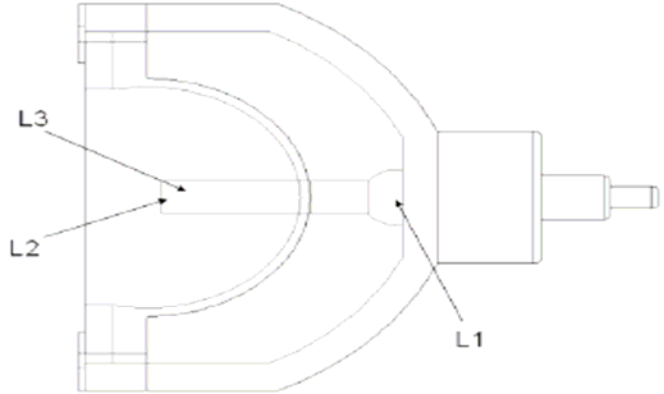
a. Conventional UV/IR filter spectrum.

T (%)

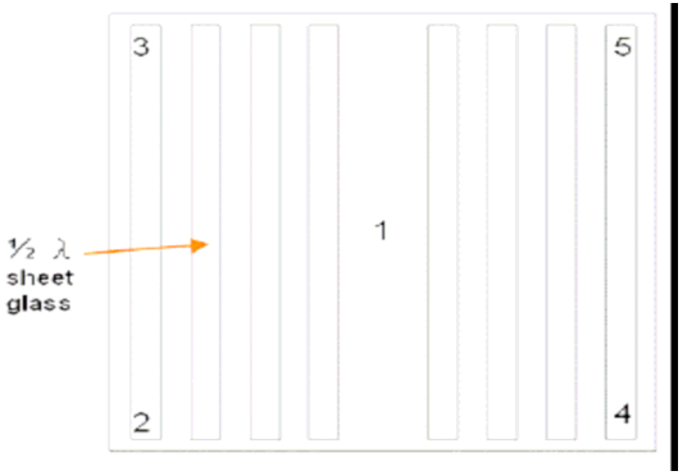
Wavelength (nm)

b. YAG filter spectrum.

YAG filter's result



a. Measuring point on lamp.

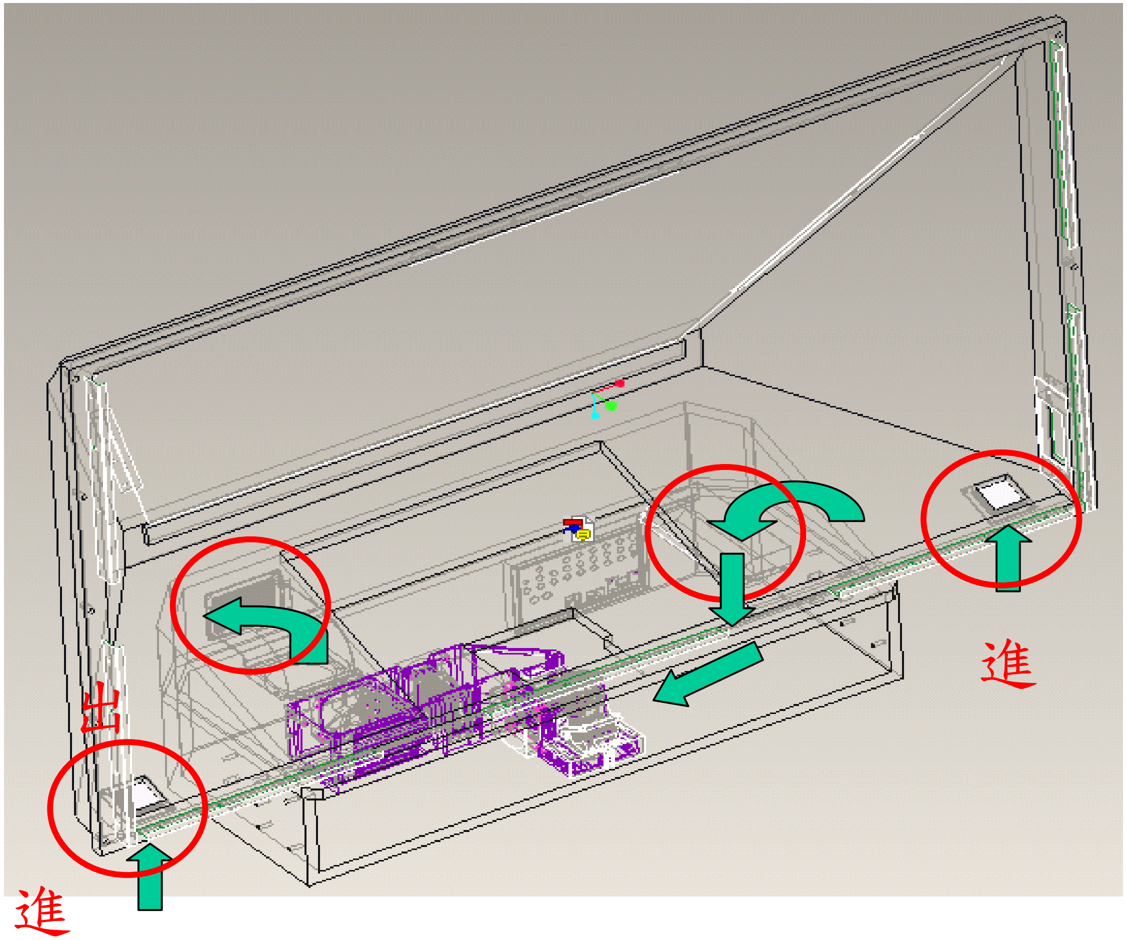


b. Measuring point on PS converter.

℃	L1	L2	L3	P1	P2	P3	P4	P5
No-YAG	649	274	339	45.2	34.1	38.6	32.6	47
YAG	594	238	307	40.7	32.6	36.1	31.1	44

Room temperature ： 25℃

Case 5. PTV cabinet



CPT 52”/720p LCOS-PTV @Taipei FPD’04

2004.6.9.

CPT 65” LCOS-PTV @Yokohama FPD’04

財經焦點

自由時報 第 25 頁 中華民國九十三年十月二十日 星期三

集中市場 35.67 昨日收盤指數5807.79成交金額632.06億元

店頭市場 1.36 昨日收盤指數113.76成交金額84.13億元

優利可圖 定存利率最高可達4.9%

橫濱光電展 台灣廠商秀技術

友達光電將展示全球首片全彩雙面發光OLED 奇美發表平均灰階切換時間僅3.6毫秒技術 華映則推出65吋LOCS電視面板

〔記者陳梅英／台北報導〕日本橫濱光電大展即將於今（20）日展開，今年參展的台灣面板廠商

以自有品牌漢斯寶麗的3大系列30款液晶電視參展，華映除了液晶電視外，在LCOS電視面板上研發

著重於個別廠商的風格展現。

友達在這次展覽中，就首次嘗試以產品及技術分區的方式展出

在產品區，友達將旗下1.5吋至46吋近30款全尺寸及應用範圍廣泛的TFT-LCD模組產品一次展出

品牌漢斯寶麗為重點，將展出30款個性化造型的液晶電視，由於造型獨特，彩晶表示，將會成為

今年展覽廠上最

華映此次也將展示即將推出的26吋、32吋、37吋等液晶電視面

板……65吋LOCS的技術再度精進，也是此次華映展覽的重頭戲。

2004.10.20.

CPT 65”/1080p LCOS-PTV @Taipei FPD’05

2005.6.9.

2005.6.8. 經濟部工業局 顯示元件傑出產品獎 (65”/1080p LCOS PTV)

CPT 65”LCOS/1080p @Yokohama FPD’06

THANK YOU