

分子動力學在工程上的應用

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財團法人國家實驗研究院

國家高速網路與計算中心

NATIONAL CENTER FOR HIGH-PERFORMANCE COMPUTING

顯示器產業

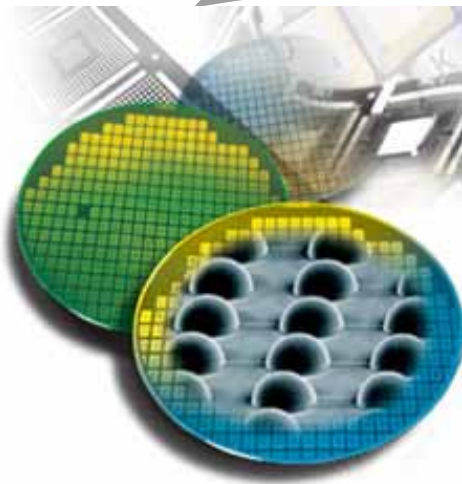


數位內容產業

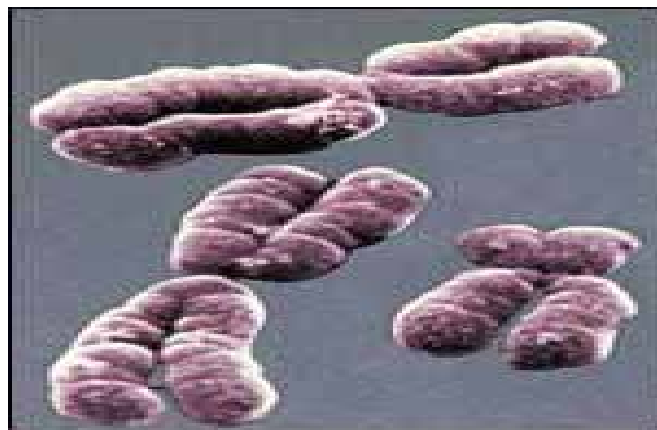


兩兆雙星

半導體產業



生物技術產業



顯示器科技

顯示器發展趨勢

傳統顯示器

電視機CRT AD.1920~



http://www.benq.com.tw/news/00/1109_2.htm

液晶顯示器LCD AD.1970~



平面顯示器

電漿顯示器PDP AD.1990~



<http://www.missioncreep.com/tilt/television.html>

有機發光二極體OLED AD.1998~



<http://www.selectronic-uk.com/organic.htm>

•電漿顯示器

電漿顯示器缺點為製作成本高、良率低、亮度及對比不如CRT、耗能較大、使用壽命少於CRT，最大的缺點是售價一直無法大幅下降，業者目前的理想價位期望能降低至每吋約新台幣2,500元，與現在價格相差約3倍，想要達到恐非易事，且讓我們拭目以待。

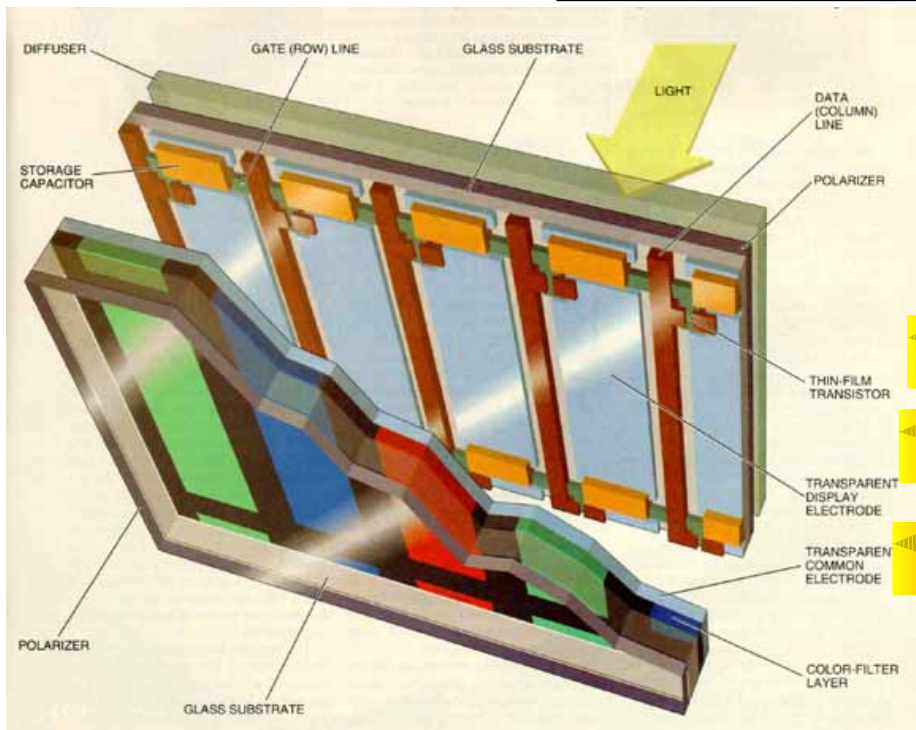
有機發光二極體

- 紅藍綠三個畫素需要不同驅動電壓、色彩平衡性較差及精細度有待加強。
- 為朝大尺寸面板發展會產生耗電遽增、壽命降低及顯示元件劣化等現象。
- 產品壽命短、成本較高及耗電量較大

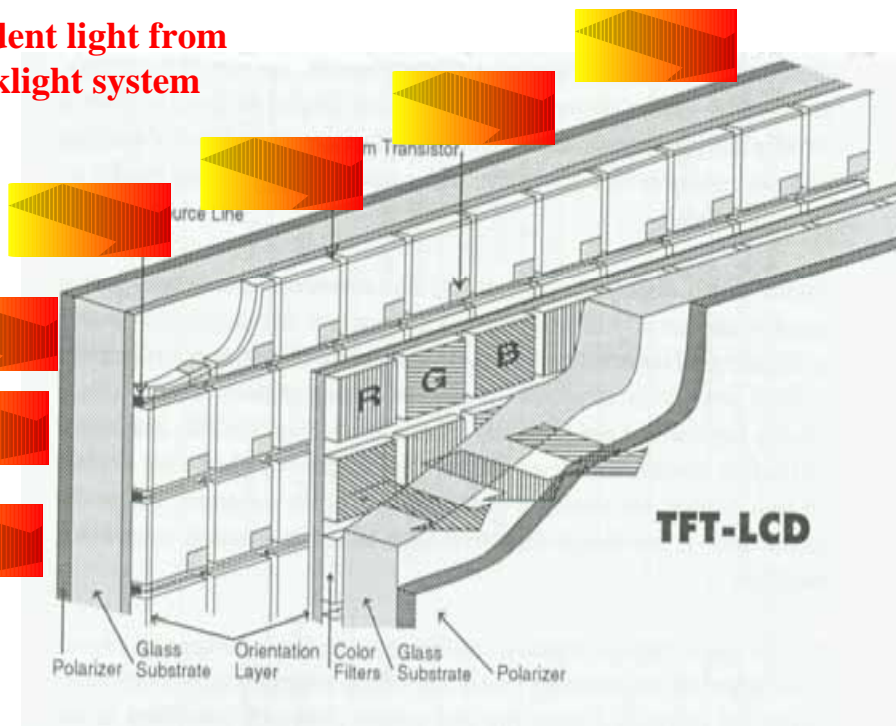
• 何謂背光模組？

- 因LCD為非自發光材料，所以需額外之供應光源。
- 光源一般位於液晶裝置之後，又稱背光模組(backlight system)

backlight system



Incident light from backlight system



Source: <http://www.chipcenter.com/circuitcellar/june01/c0601rr1.htm>

■ 背光模組之應用

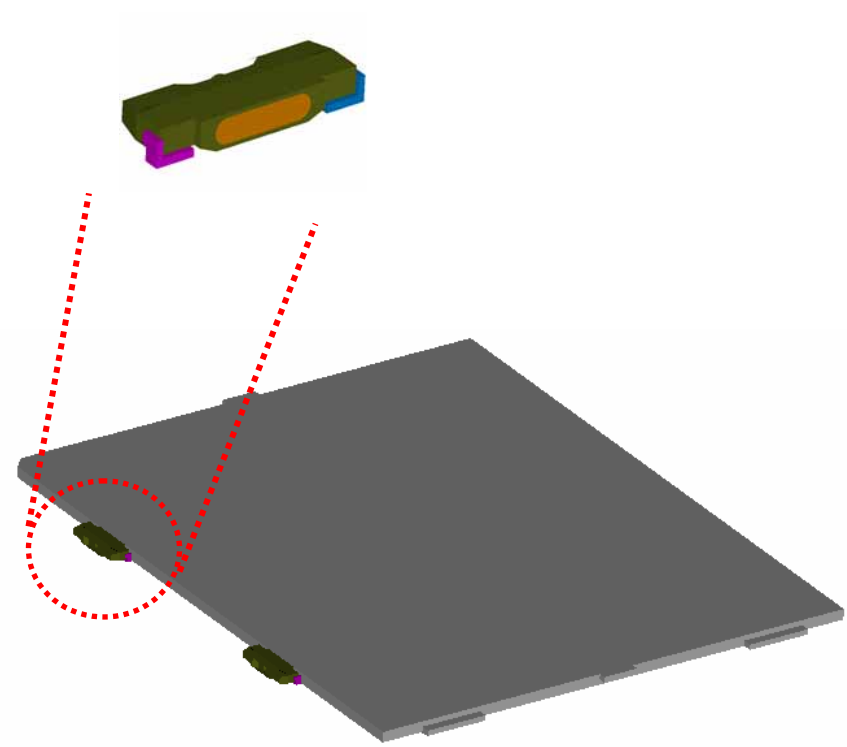
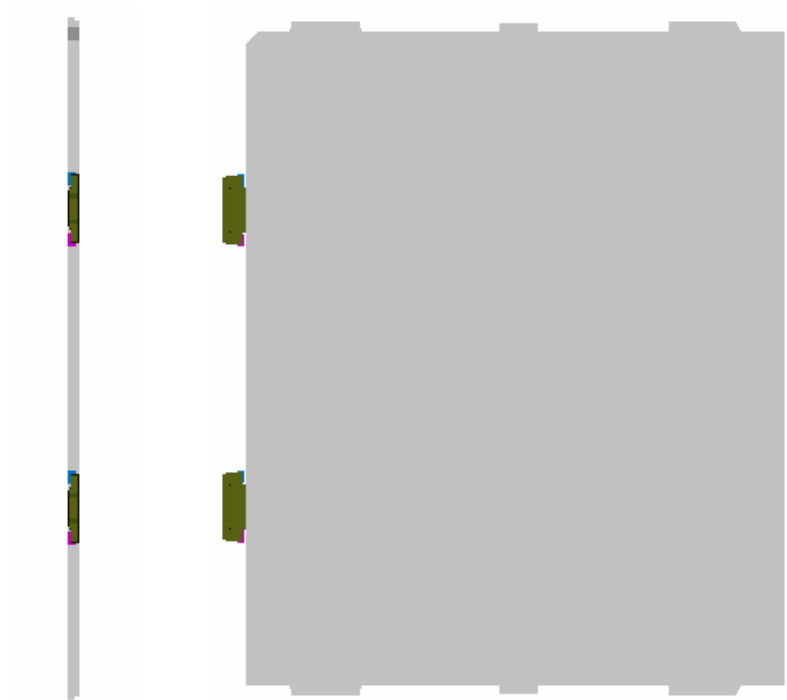


背光模組介紹

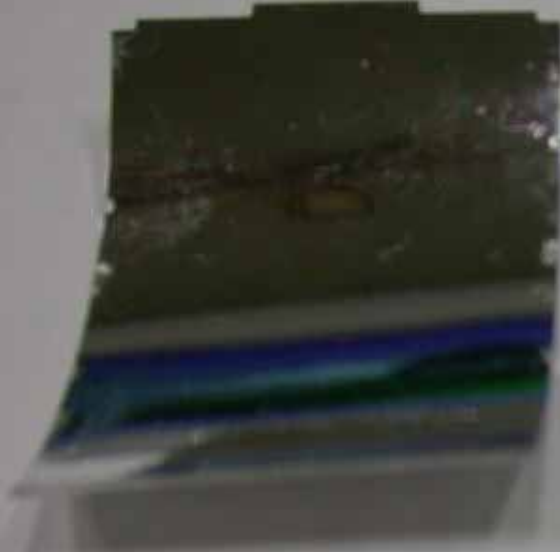
- 依光源種類可分為
 - CCFL背光模組
 - LED背光模組
- 依光源位置可分兩種形式
 - CCFL直下式(bottom lighting)
 - CCFL邊光式(edge lighting)



□ LED邊光式(edge lighting)



反射片



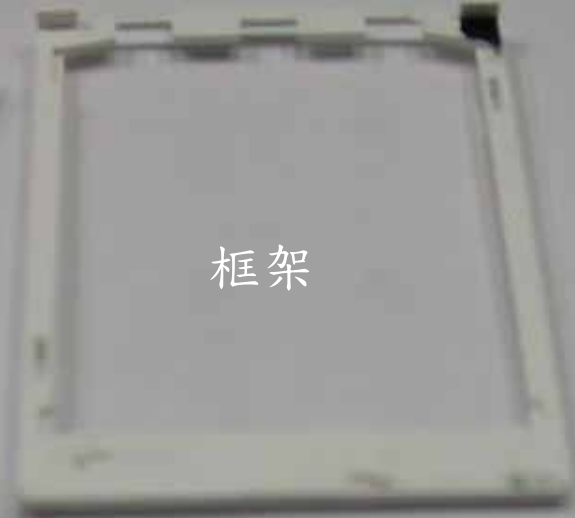
LED



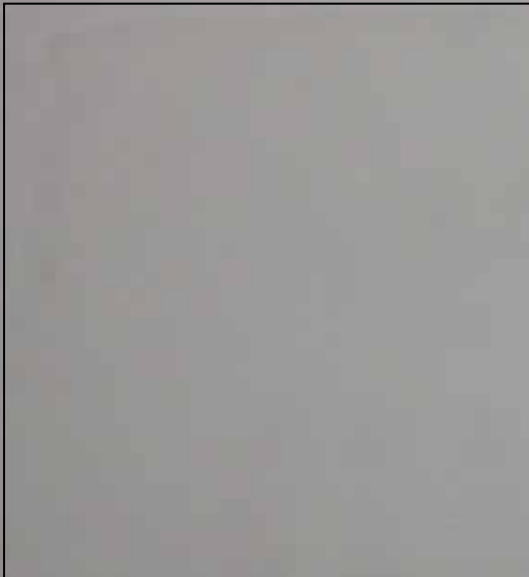
導光板



框架



擴散膜



增亮膜



反射片



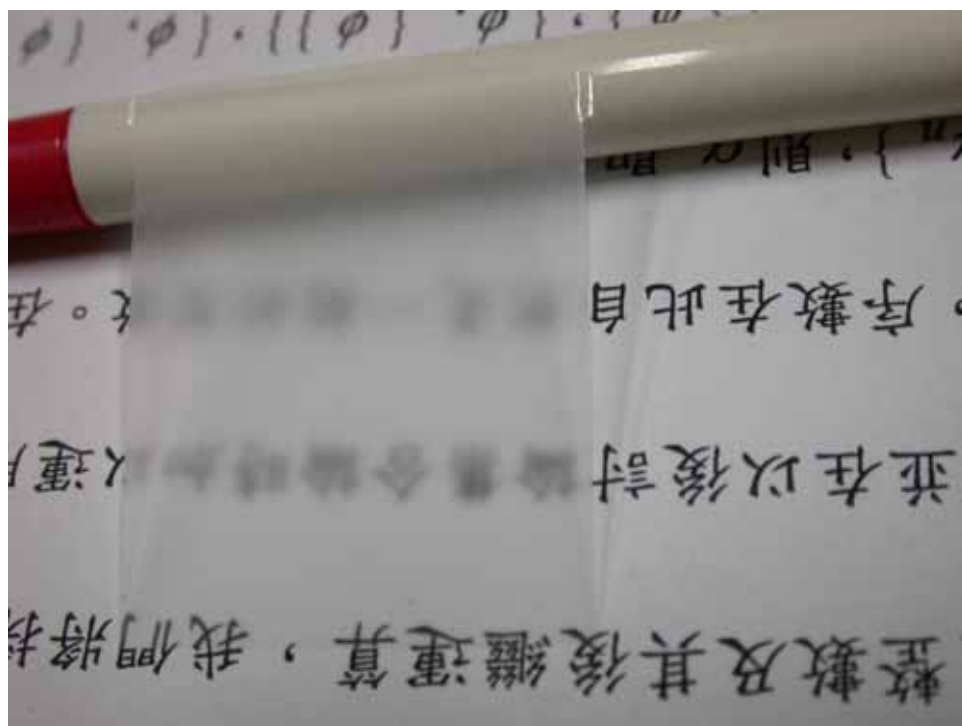
框架



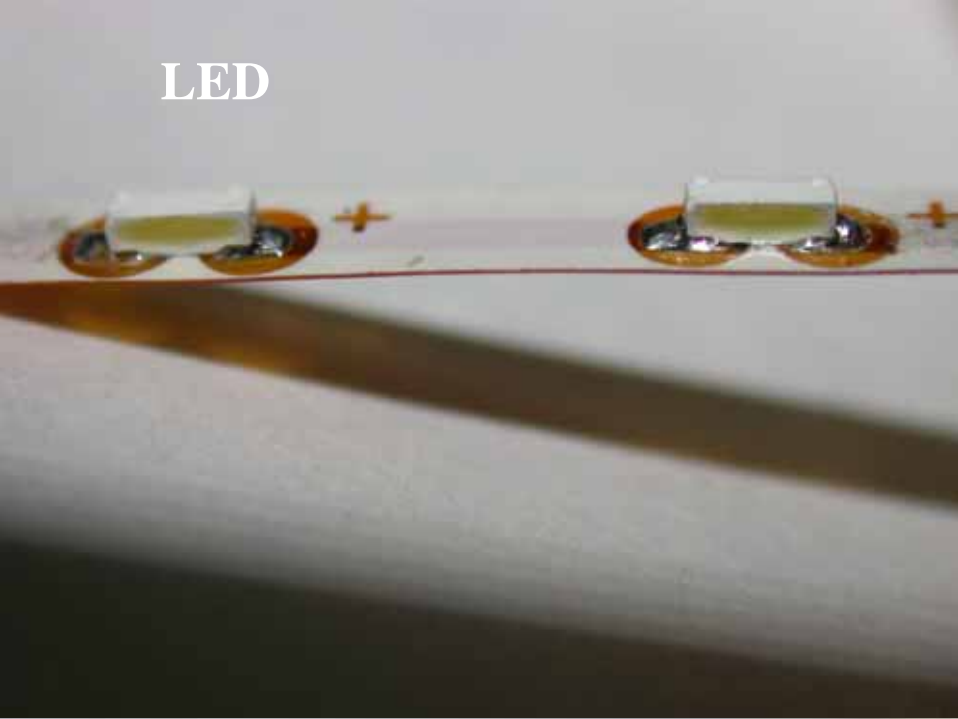
導光板



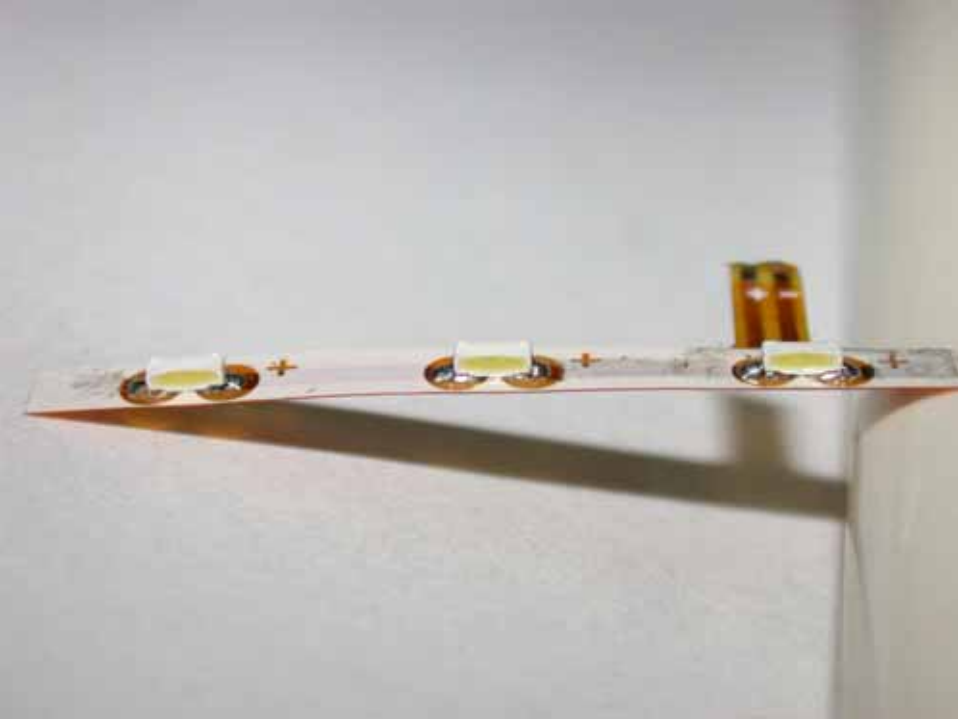
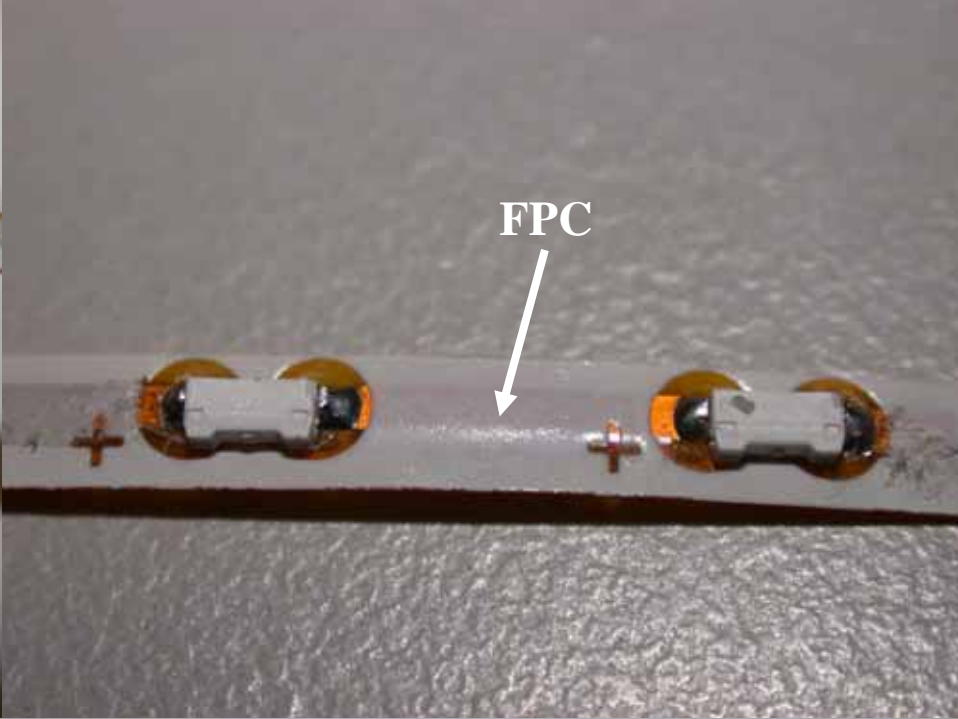
擴散膜

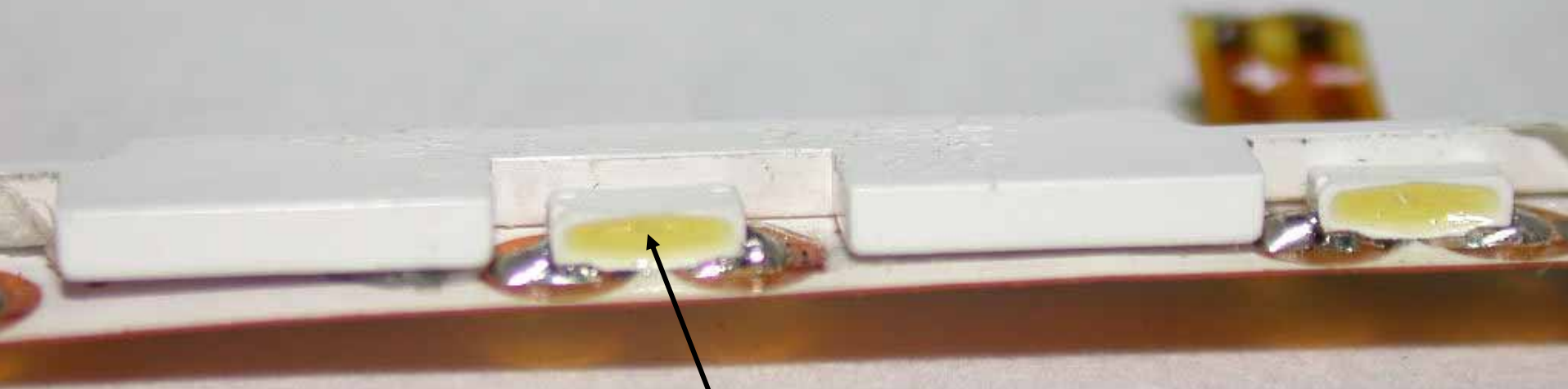


LED



FPC



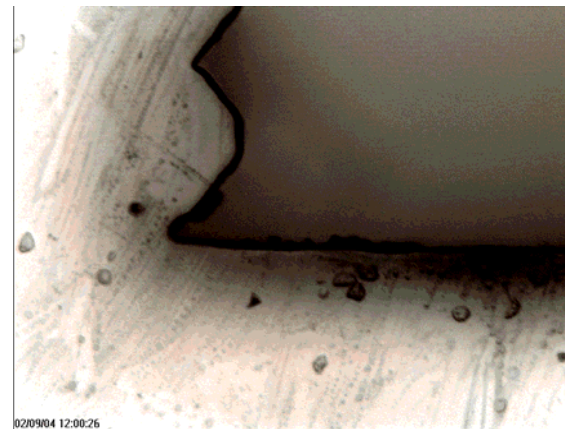
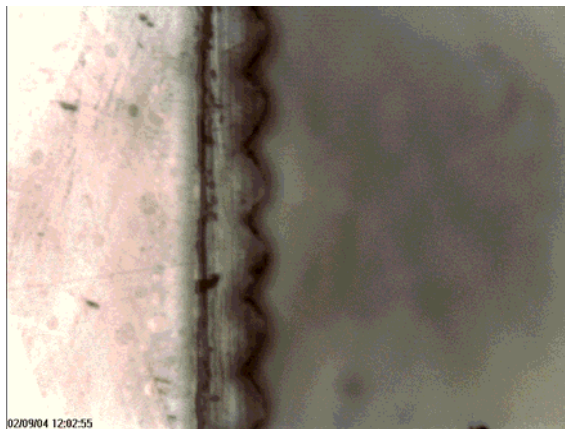
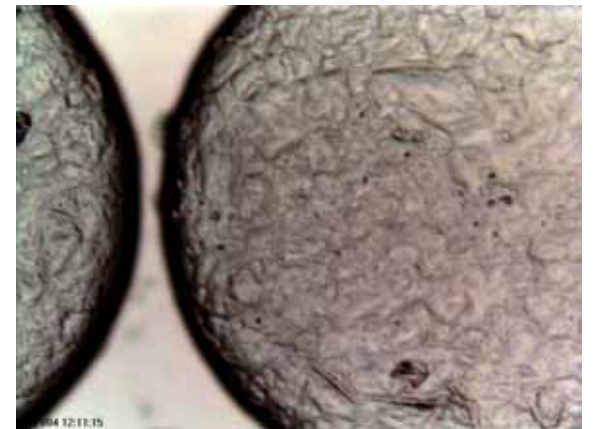
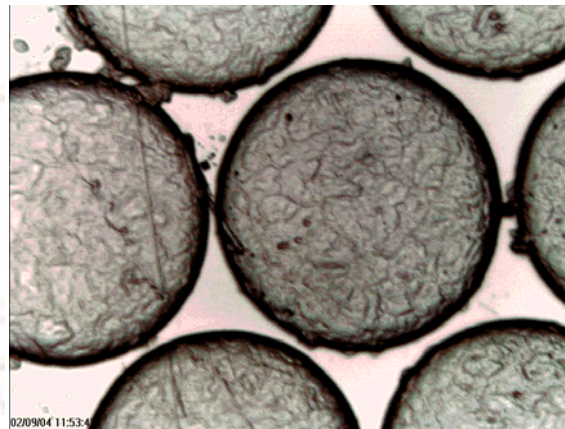
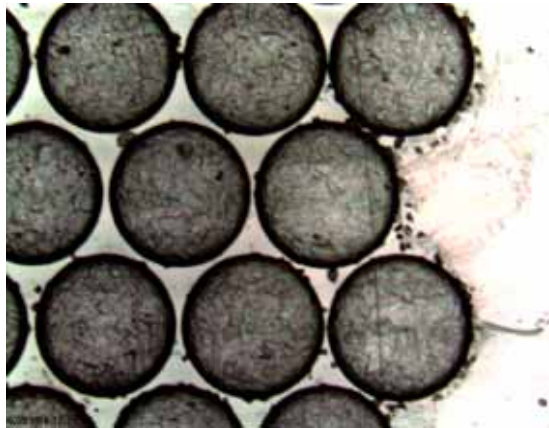
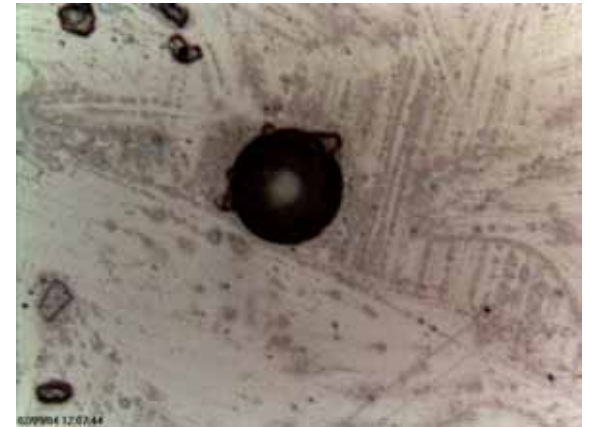
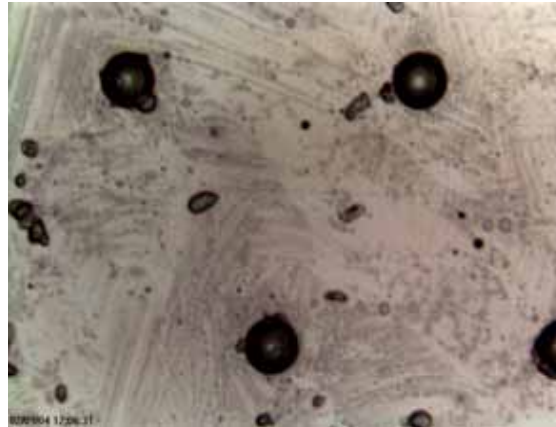
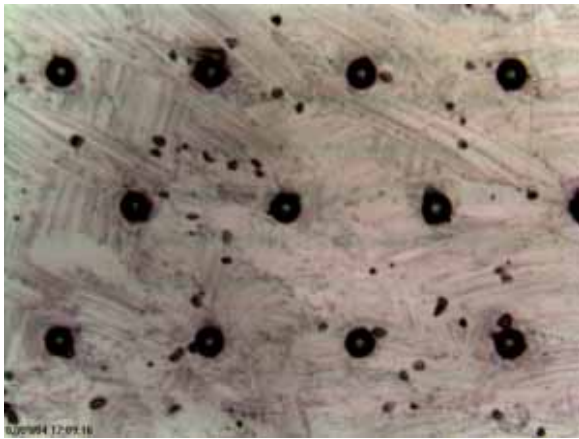


黃色螢光粉

導光板

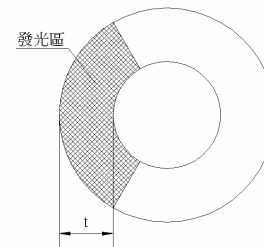
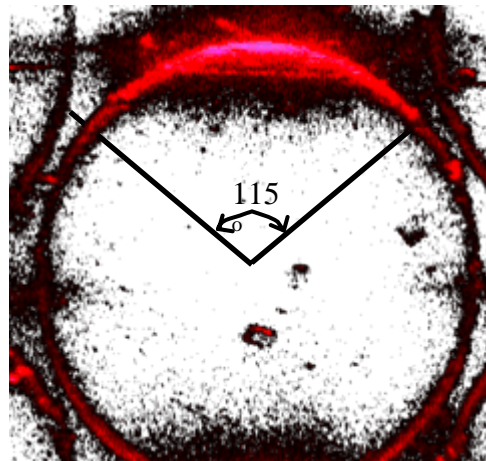
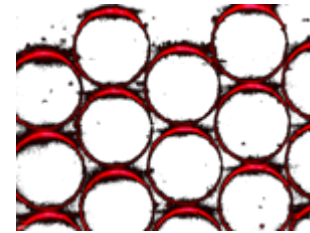
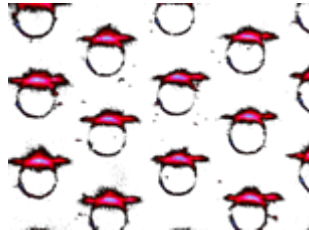
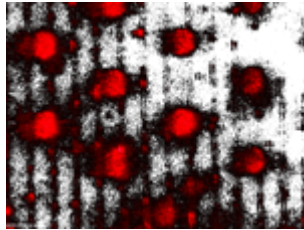


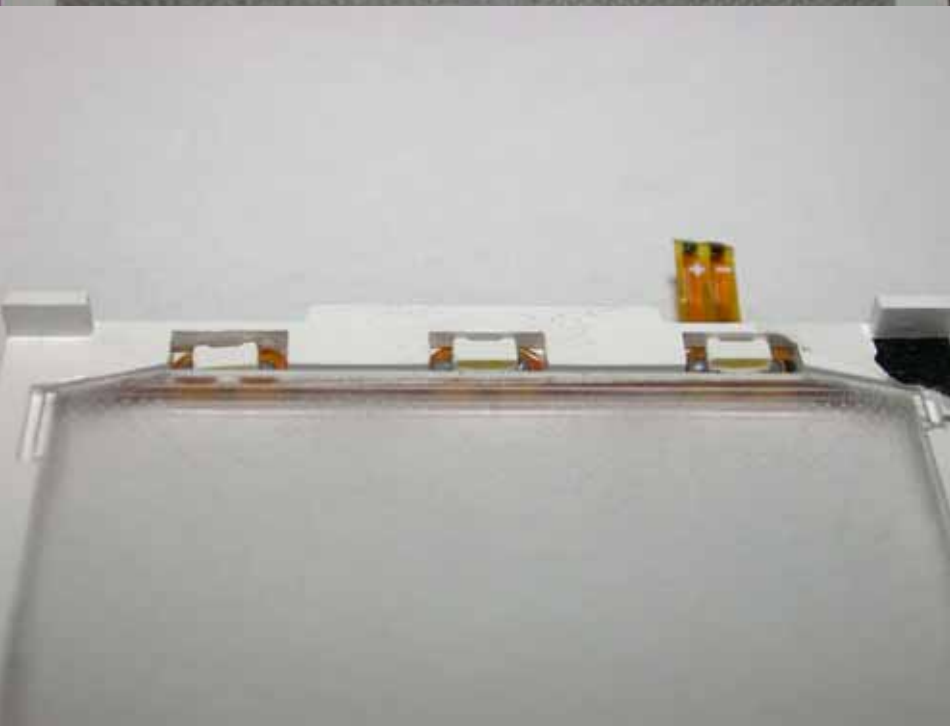
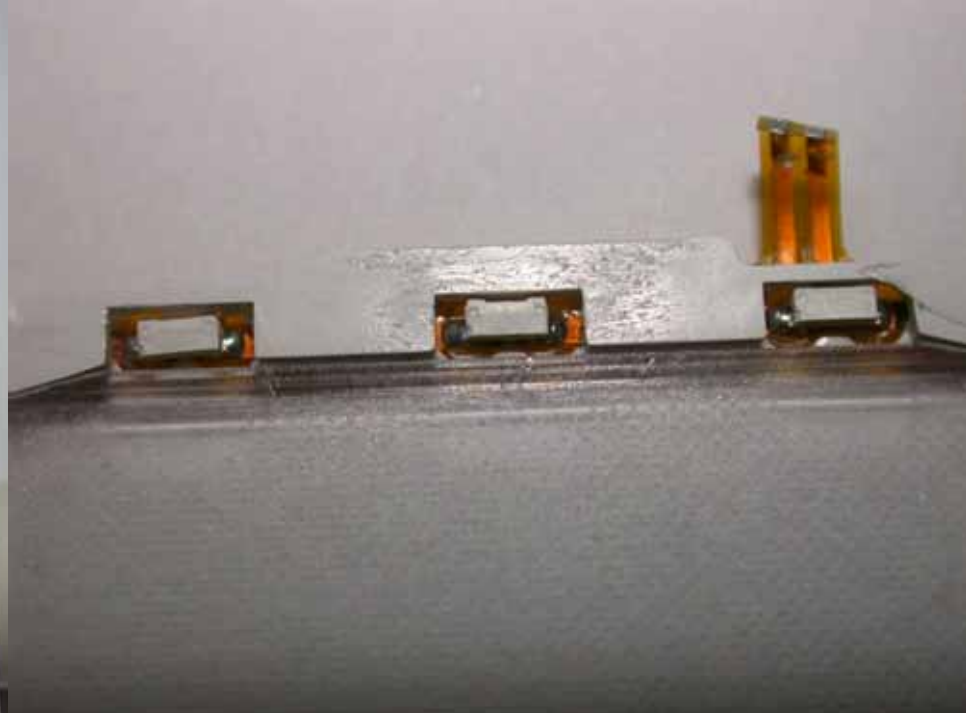
微結構



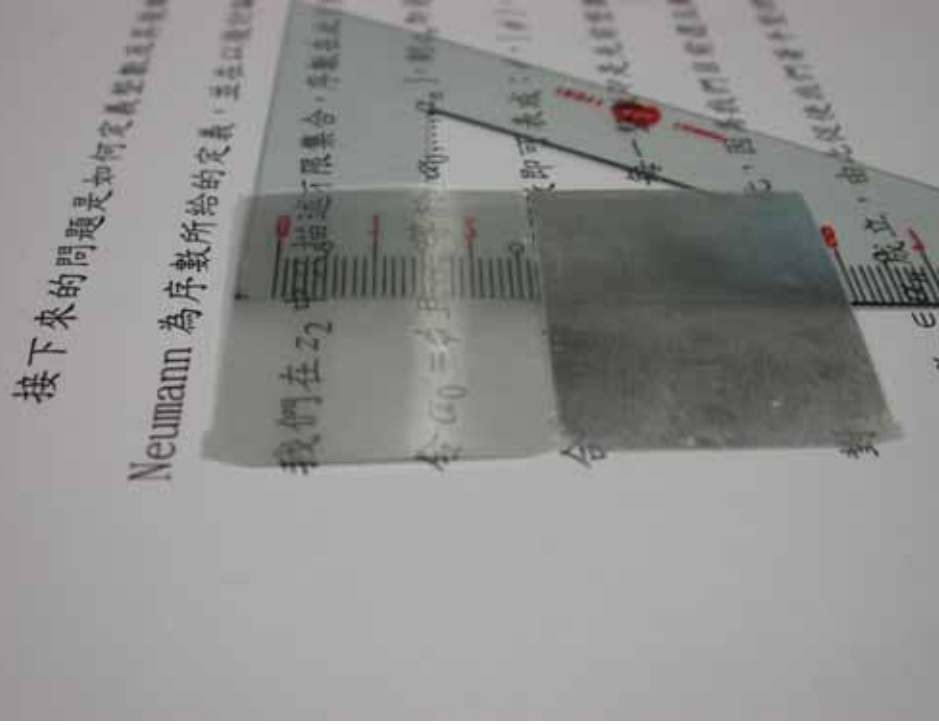
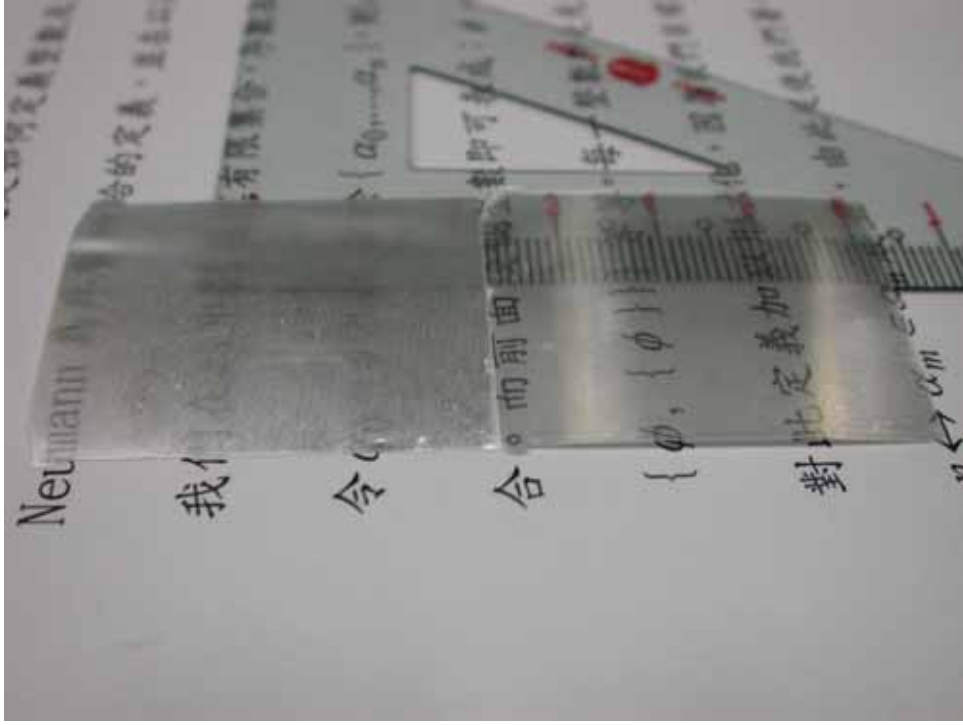
Pattern 發光量測

光源：紅外線pointer，傾斜入射





增亮膜



導光板



加反射膜



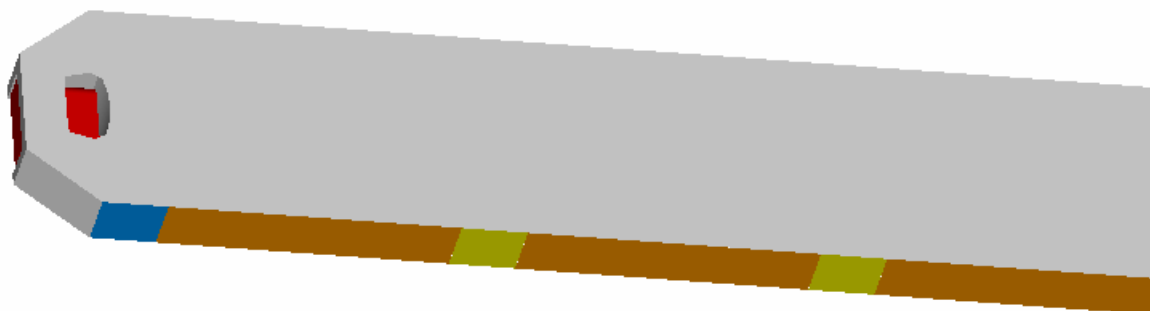
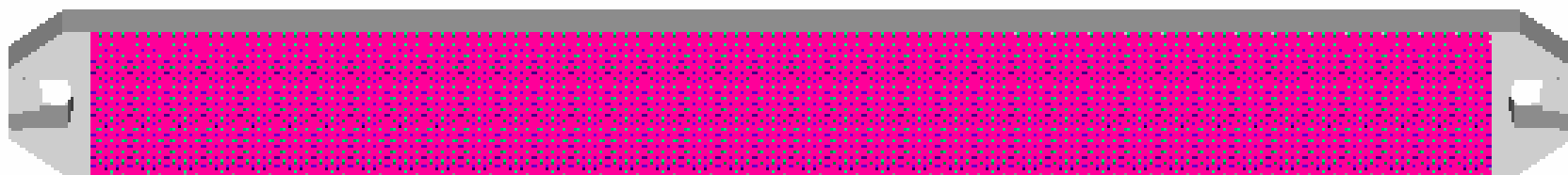
加擴散膜



加增亮膜

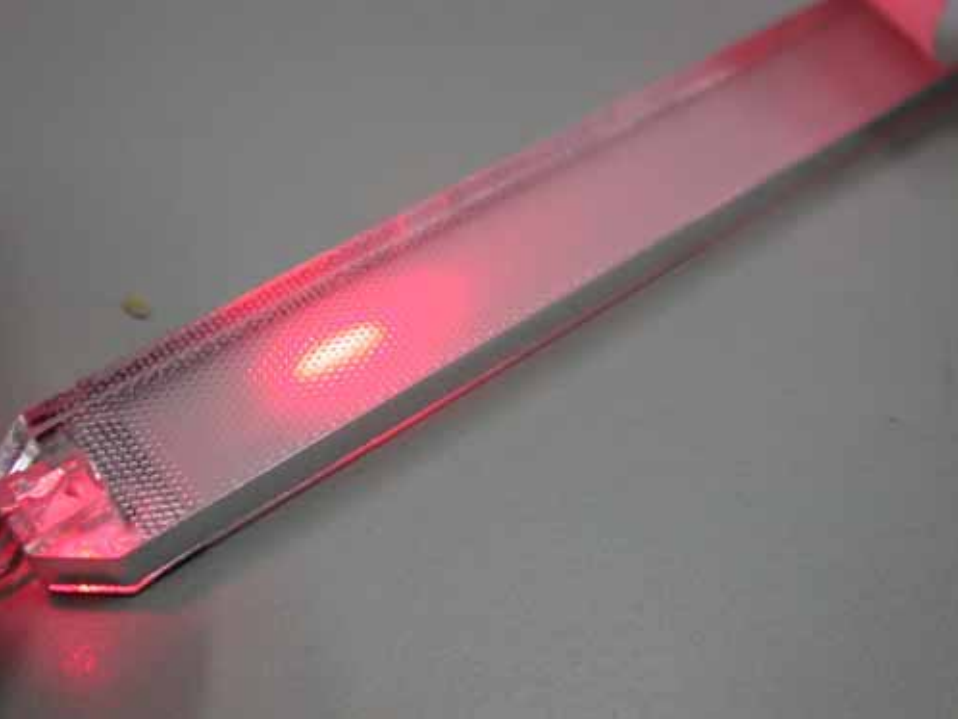
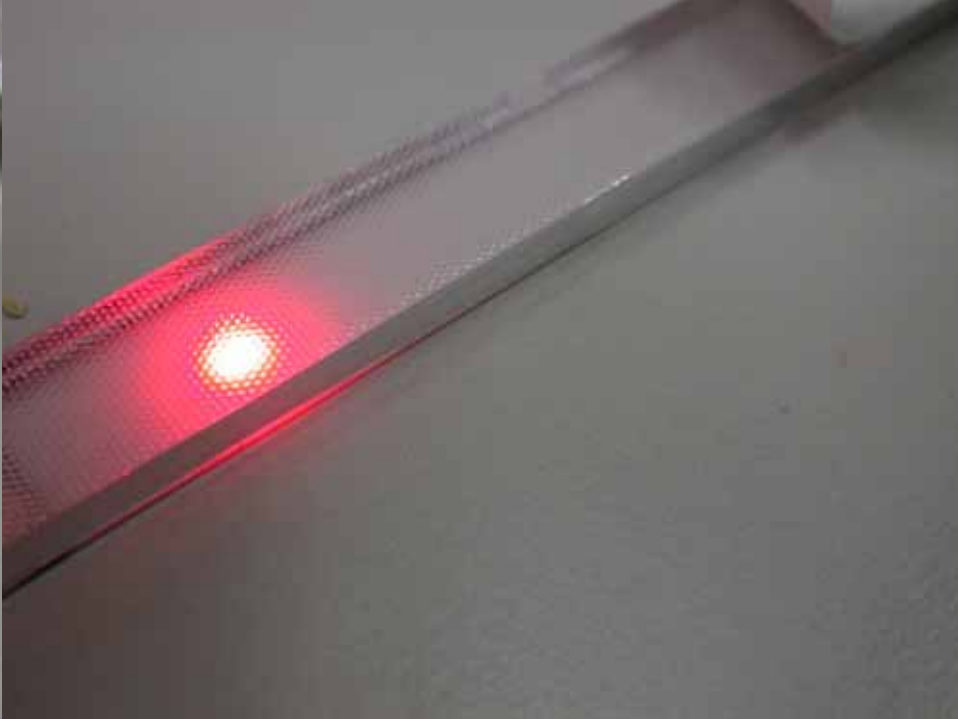


- DVD顯示背光板

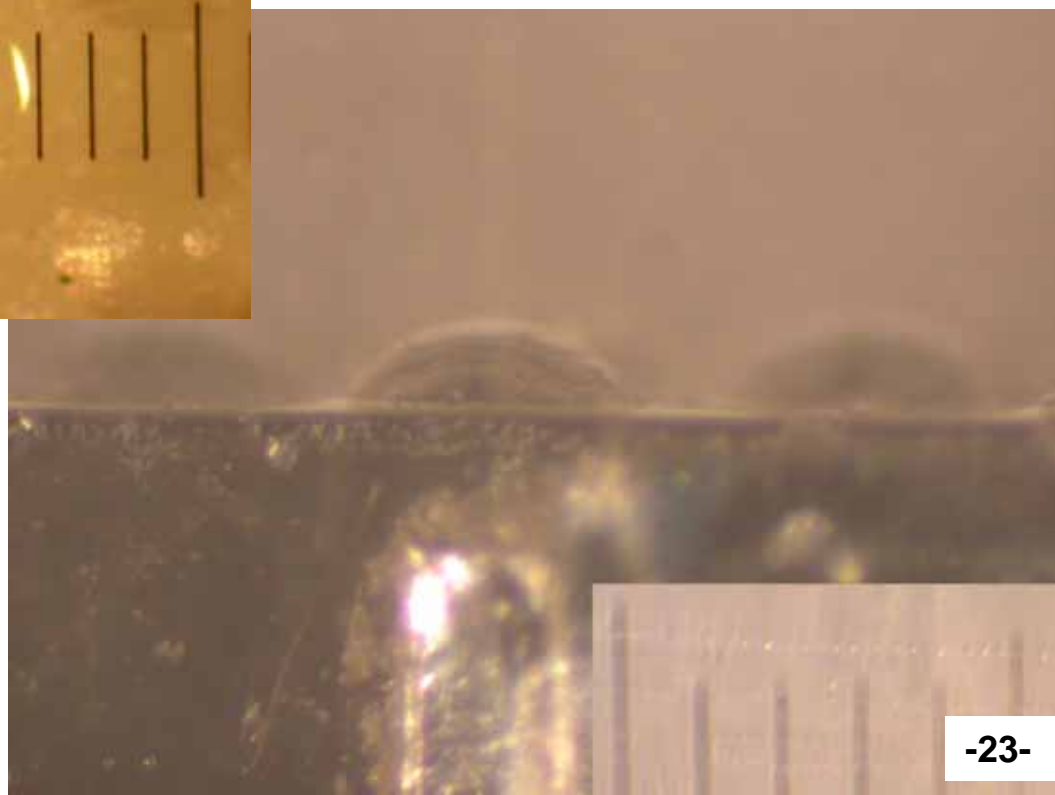
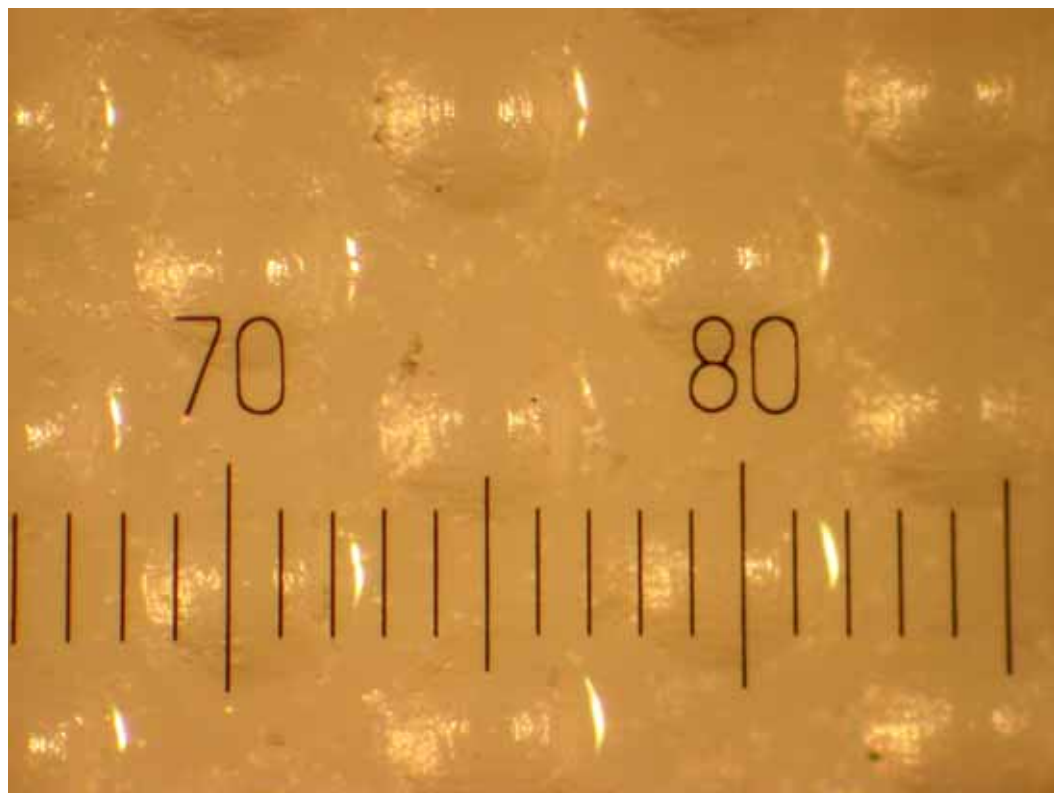


LED背光模組

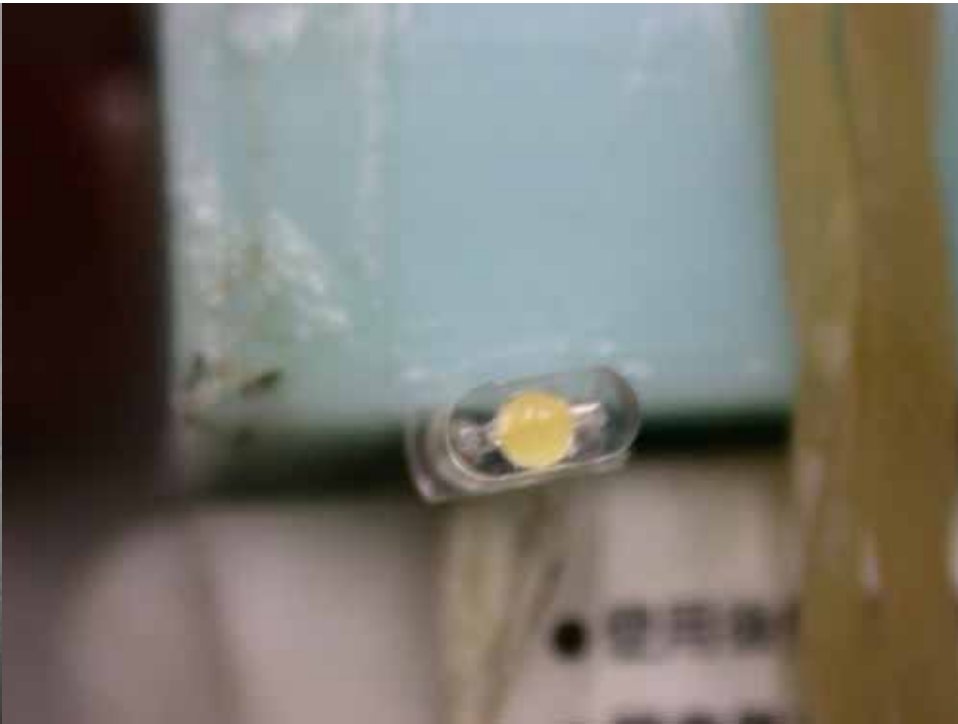




- 背光板下緣微結構

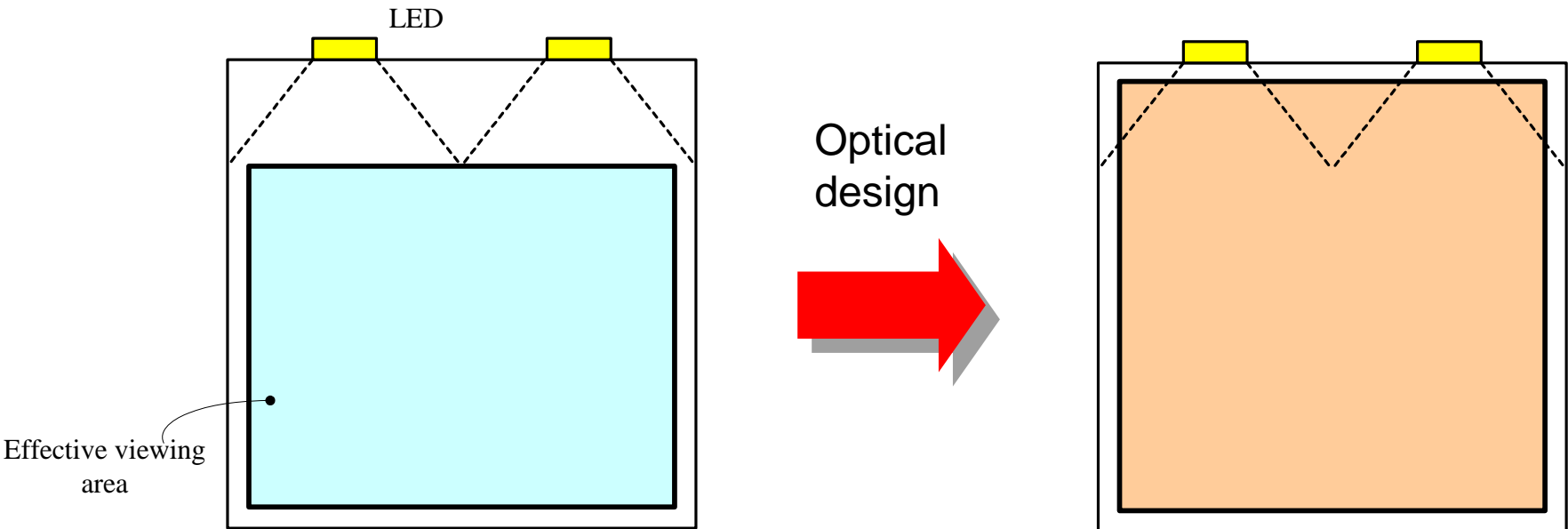


LED



背光模組設計之挑戰

- 邊光式背光模組設計之挑戰
 - 照明面積小，均勻度要求高



導光光學原理

Basic optical principle of lightguide

– Law of reflection

$$\theta_i = \theta_r$$

– Snell's law of refraction

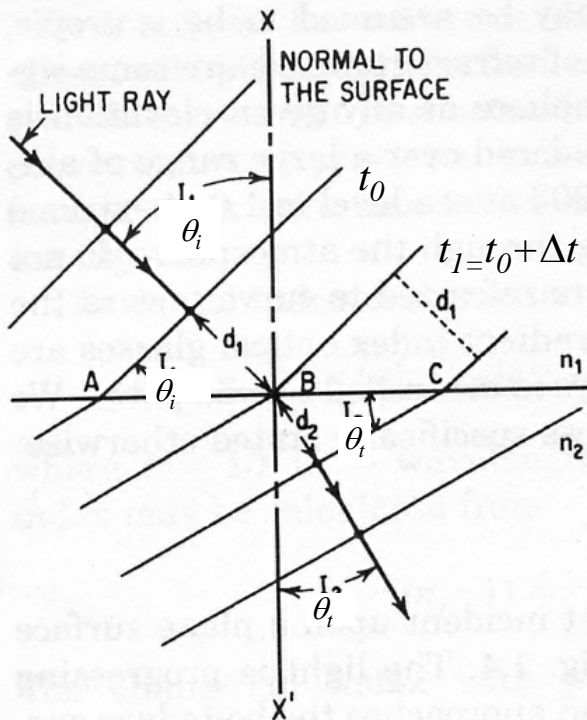


Figure 1.5

Index of refraction $n = \frac{\text{Velocity in vacuum}}{\text{Velocity in medium}}$

$$d_1 = u_1 \Delta t = \frac{c}{n_1} \Delta t \quad d_2 = v_2 \Delta t = \frac{c}{n_2} \Delta t$$

$$AB = \frac{d_1}{\sin \theta_i} = BC = \frac{d_2}{\sin \theta_t}$$

$$\frac{c \Delta t}{n_1 \sin \theta_i} = \frac{c \Delta t}{n_2 \sin \theta_t}$$

$$n_1 \sin \theta_i = n_2 \sin \theta_t$$

- Total internal reflection
 - Snell's law of refraction

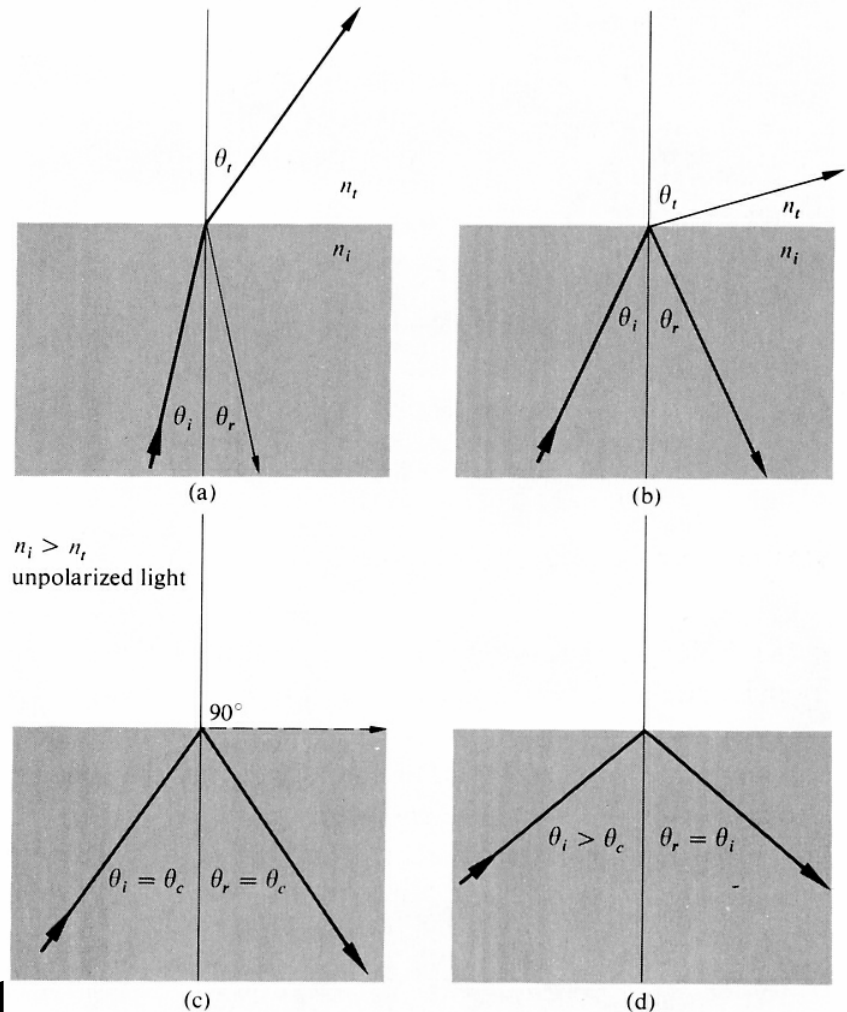
$$n_i \sin \theta_i = n_t \sin \theta_t$$

$$\text{or } \sin \theta_i = \frac{n_t}{n_i} \sin \theta_t$$

- If $n_i > n_t$, $\theta_t > \theta_i$, when $\theta_t = 90^\circ$, $\theta_i = \theta_c$, so-called critical angle

$$\theta_c = \sin^{-1} \left(\frac{n_t}{n_i} \right)$$

- i.e., when $\theta_i > \theta_c$, total internal reflection occurs, no transmitted ray



– Example

- For glass $n=1.5$, so

$$\theta_c = \sin^{-1}\left(\frac{n_a}{n_g}\right) = \sin^{-1}\left(\frac{1}{1.5}\right) = 41.8^\circ$$

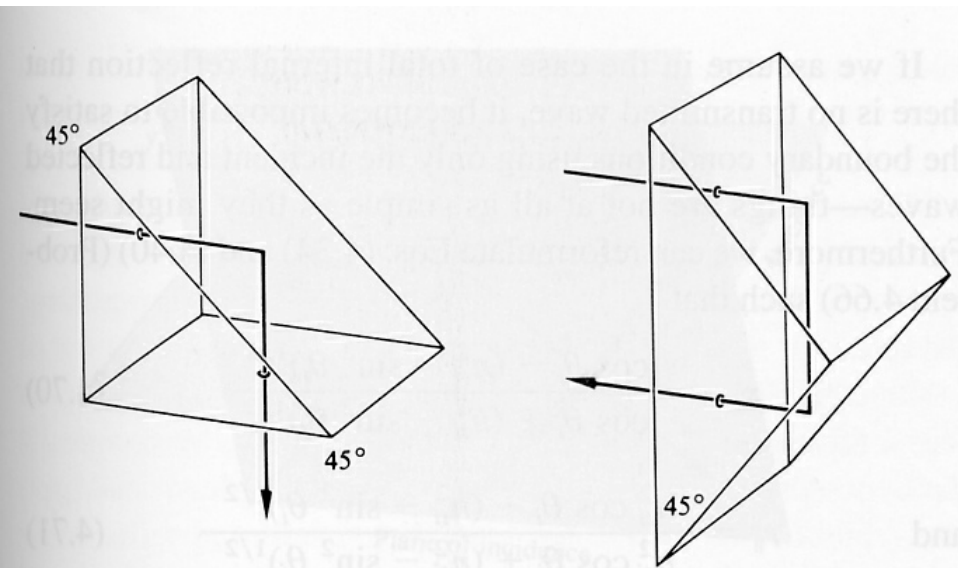


FIGURE 4.53 Total internal reflection.

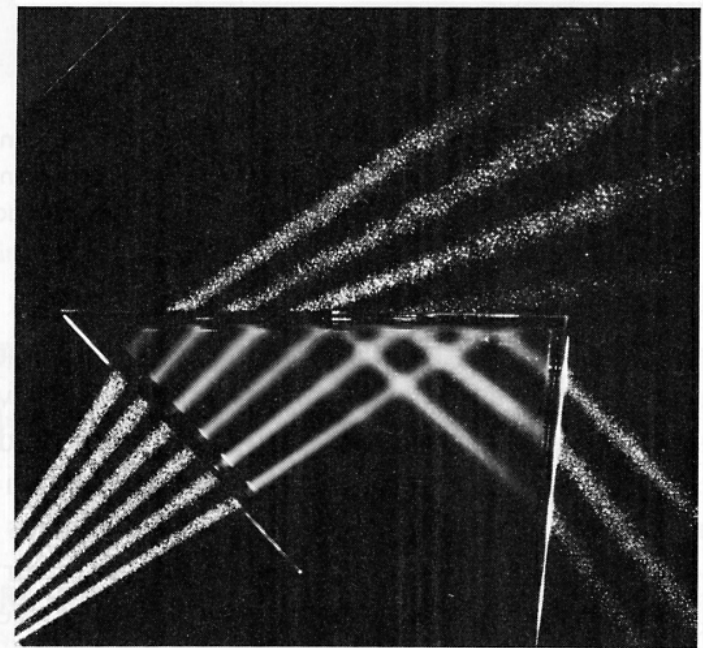
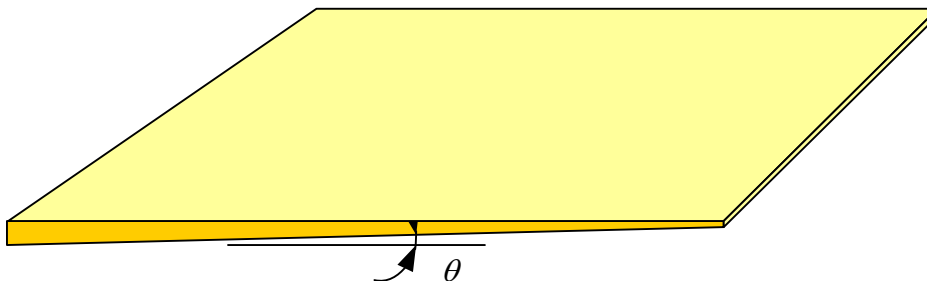
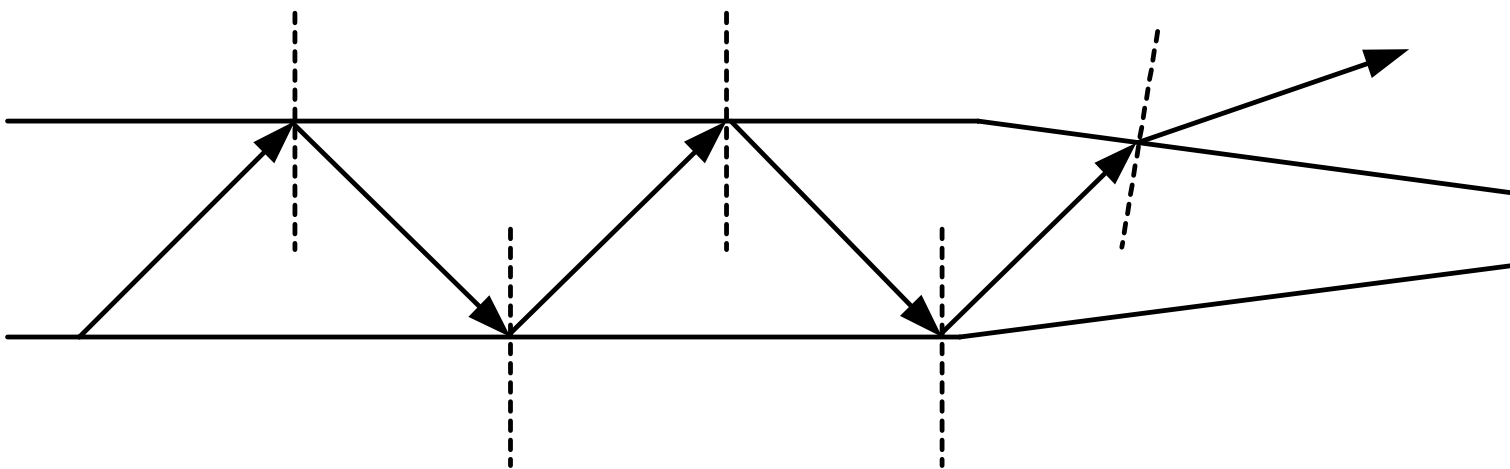


FIGURE 4.51 Internal reflection and the critical angle. (Photo courtesy of Educational Service, Inc.)

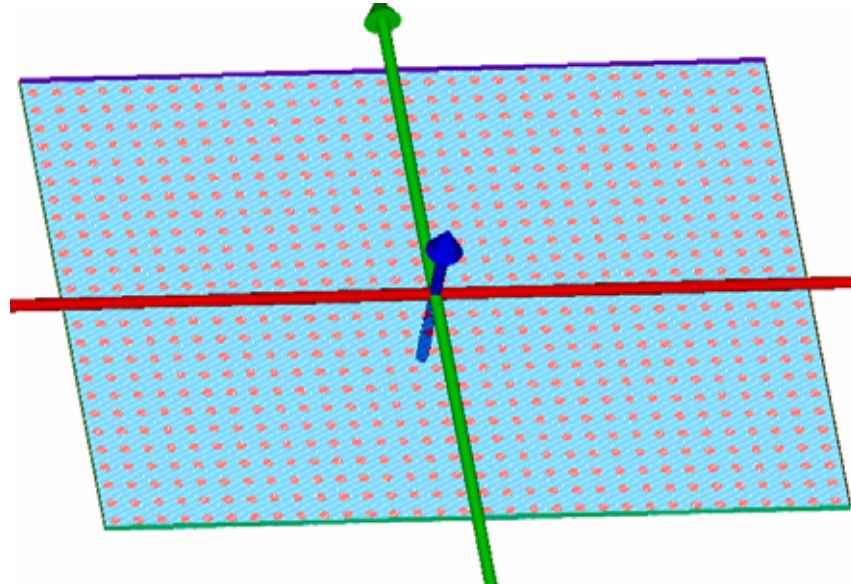
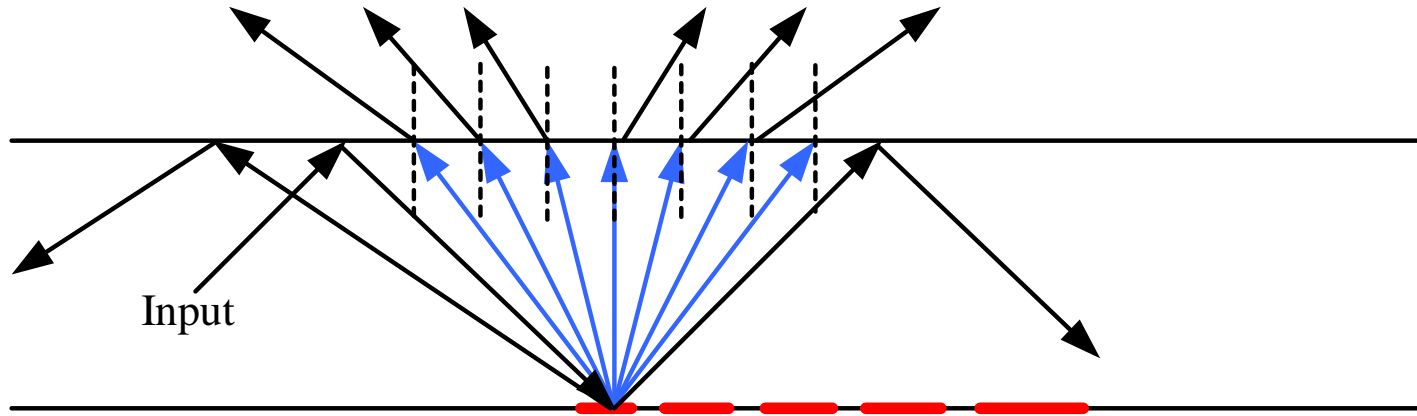
Methods of frustration TIR

-lightguide design basic principal

- Narrowing



- Diffuser dot



背光模組最佳化設計

規則網點

(位置固定，大小不固定)

- 背光模組光學設計
 - 你將遇到之問題

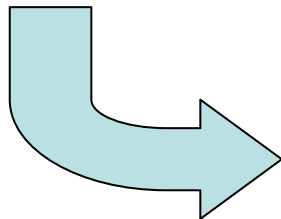
- 全尺寸分析

- 百萬級之網點數

- 需要多少計算時間?
 - 如何建立百萬級之網點外型?

- 網點大小之調整與最佳化問題

- 到底可以做多微細之調整?

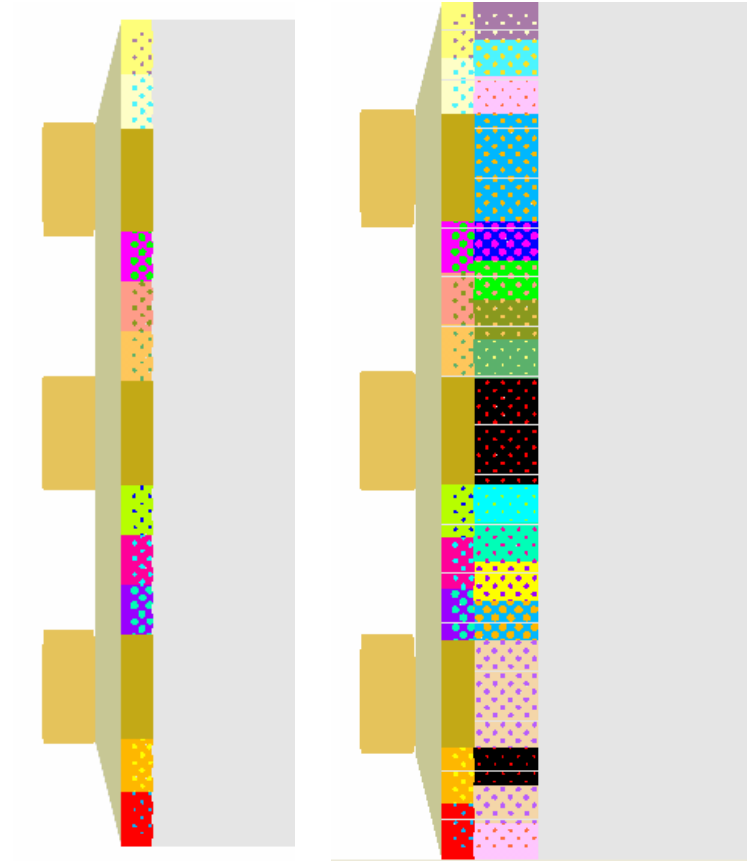


That all your design ability

- 最佳化分析實例



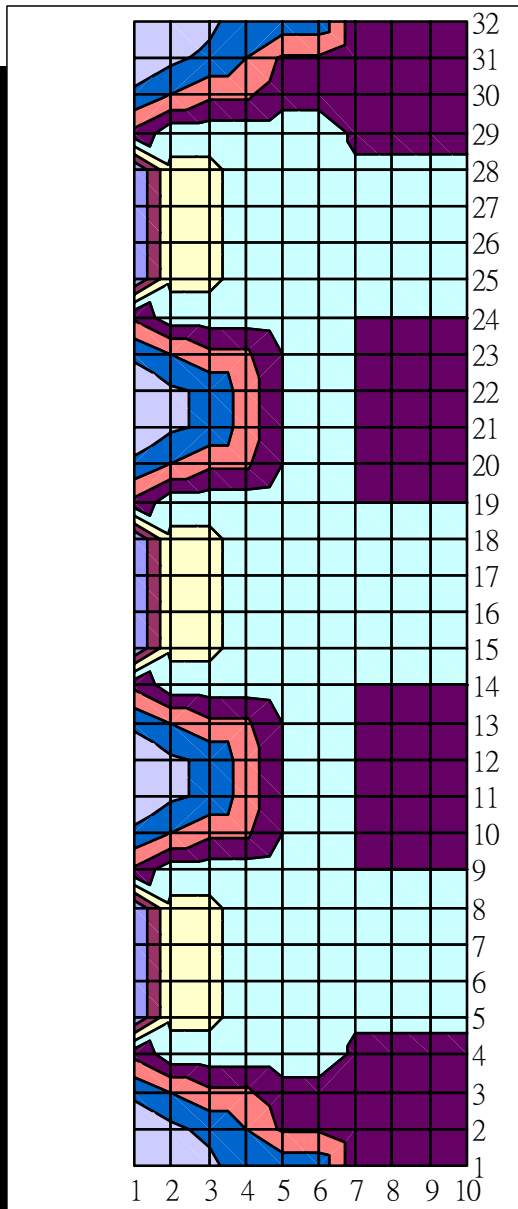
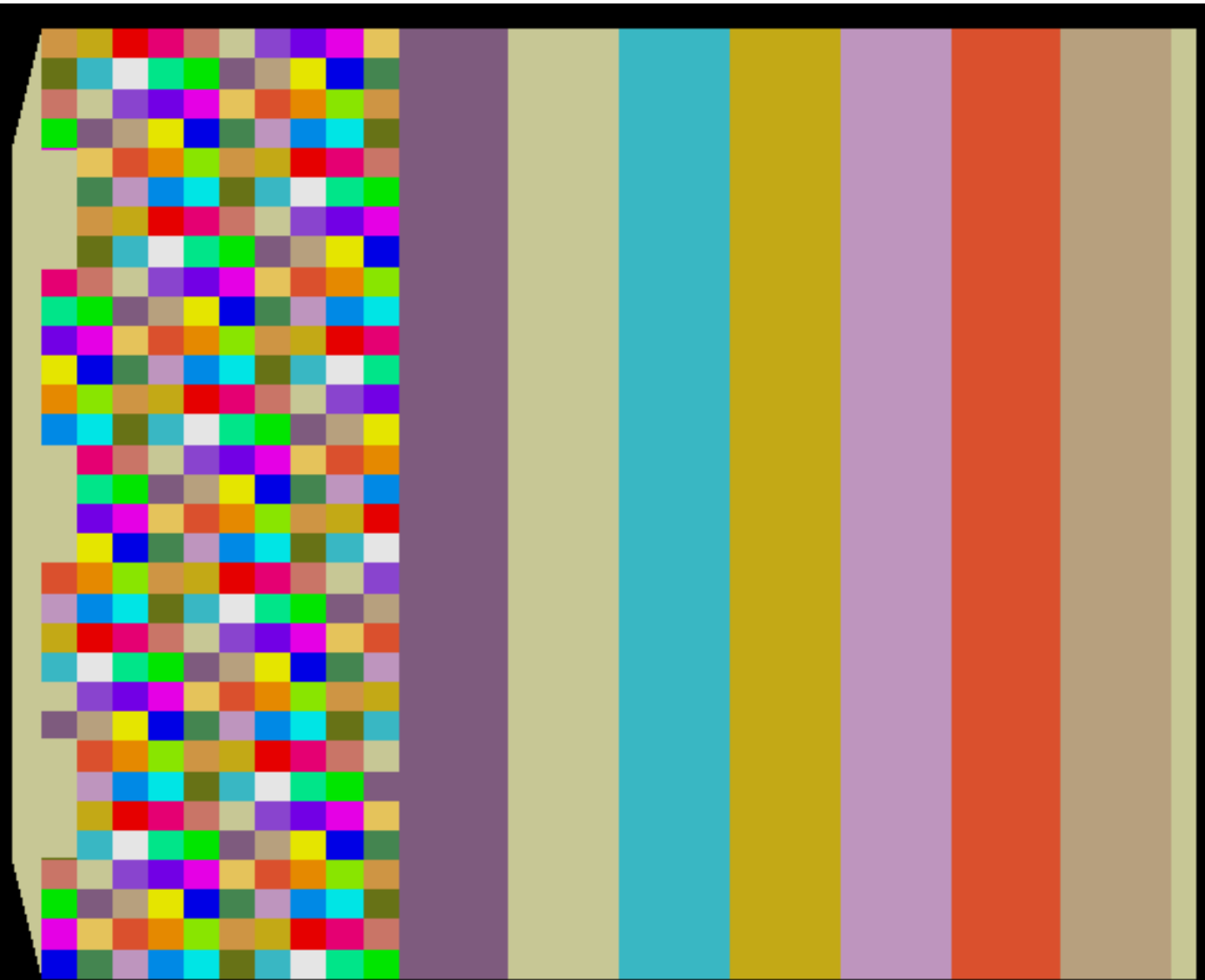
粗分



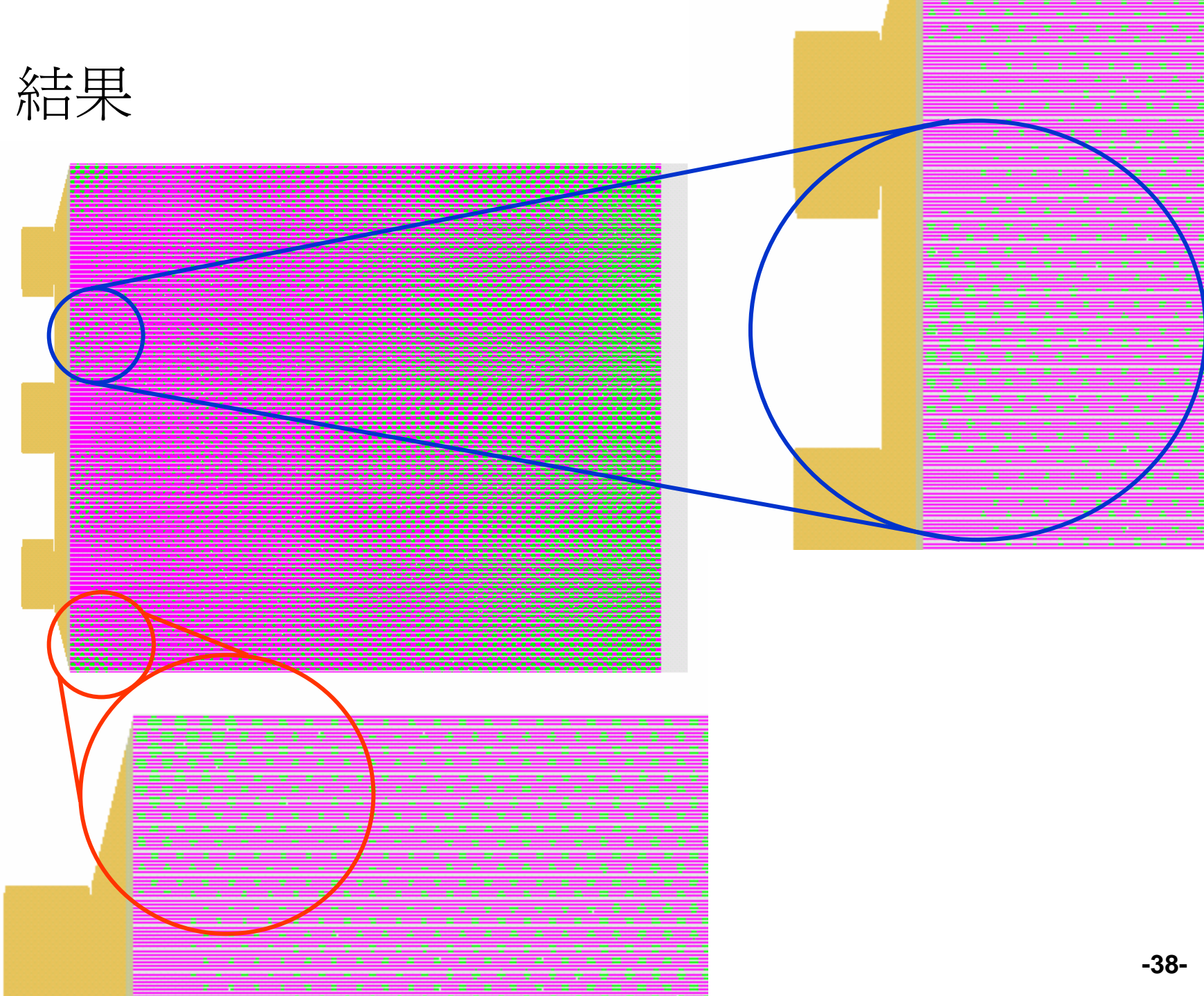
入口處細分

入口處超細分

入口處網點大小等高線圖

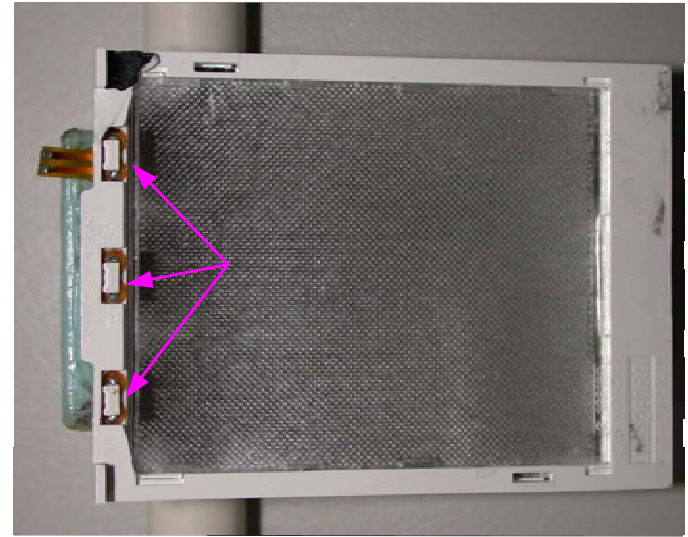
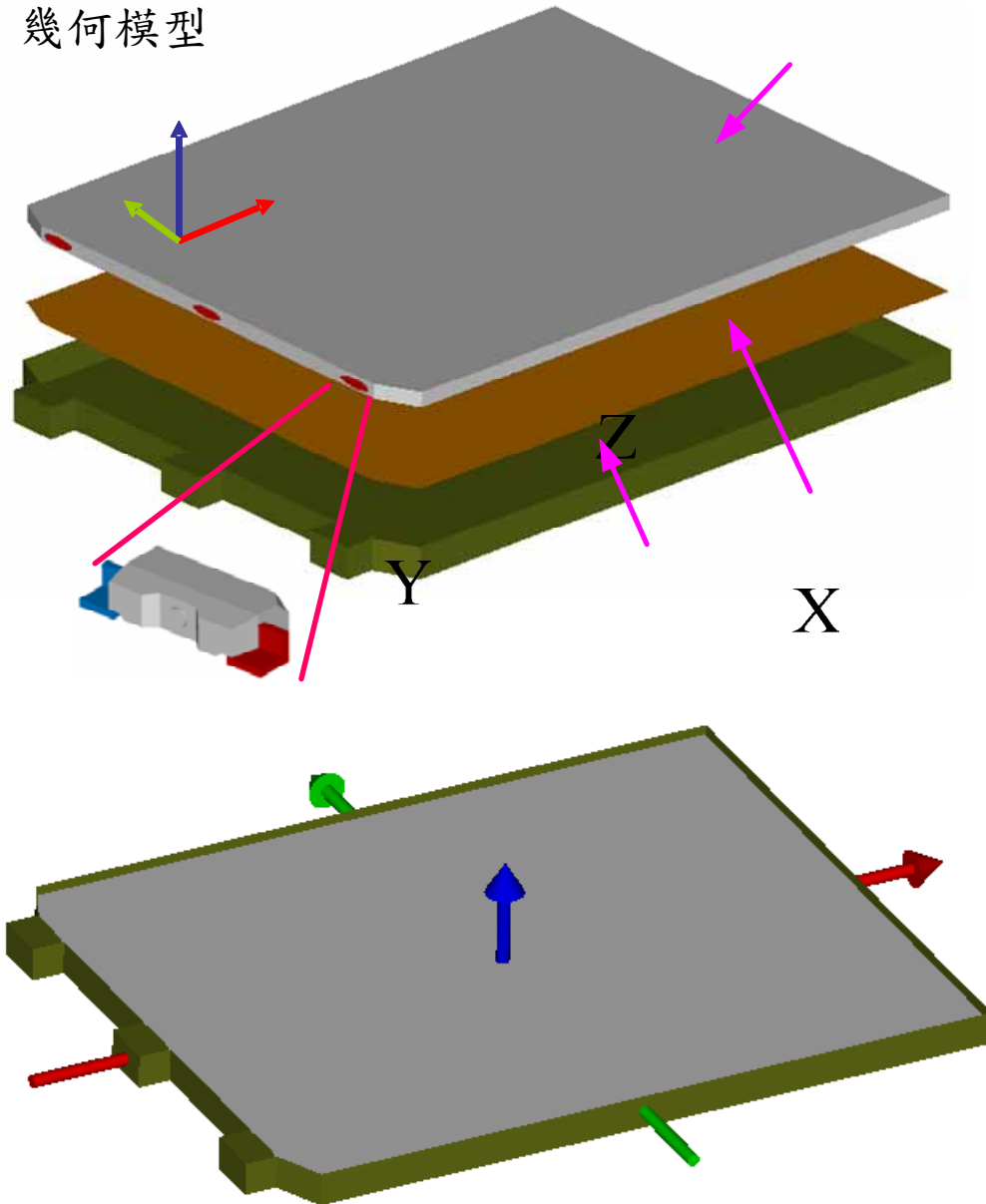


- 結果

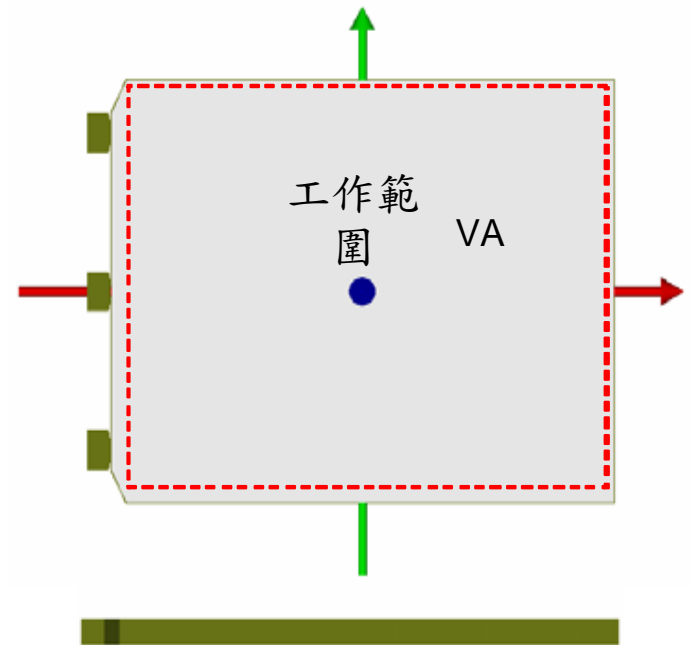


LED背光模組之最佳化設計

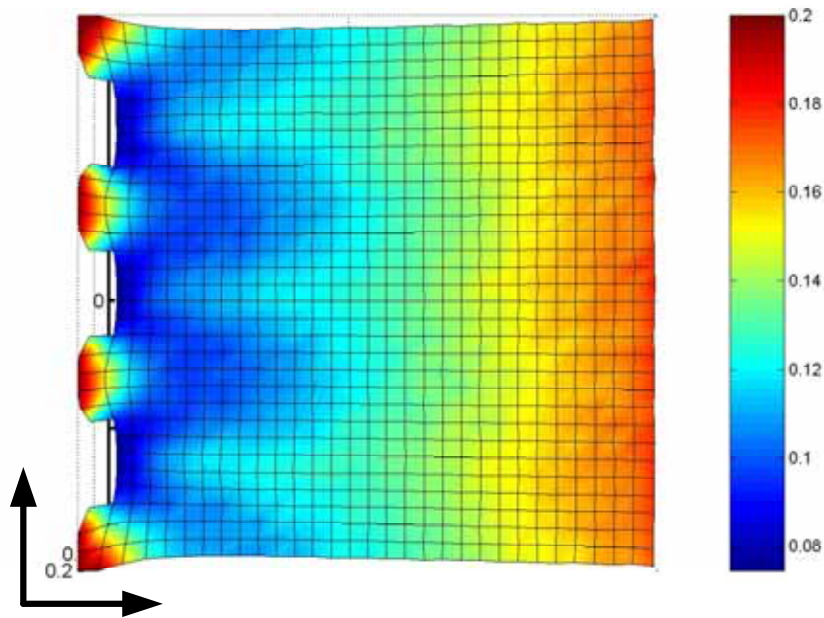
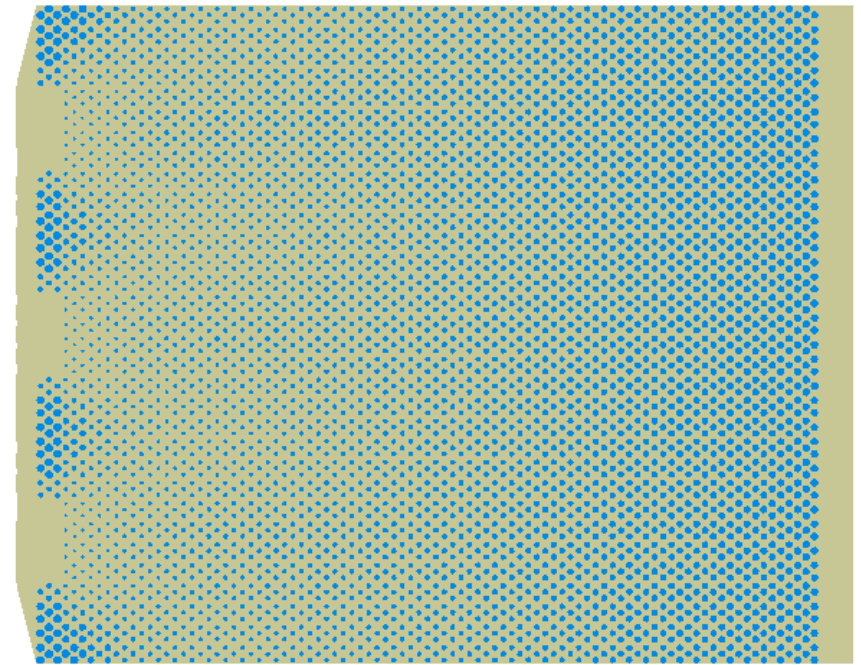
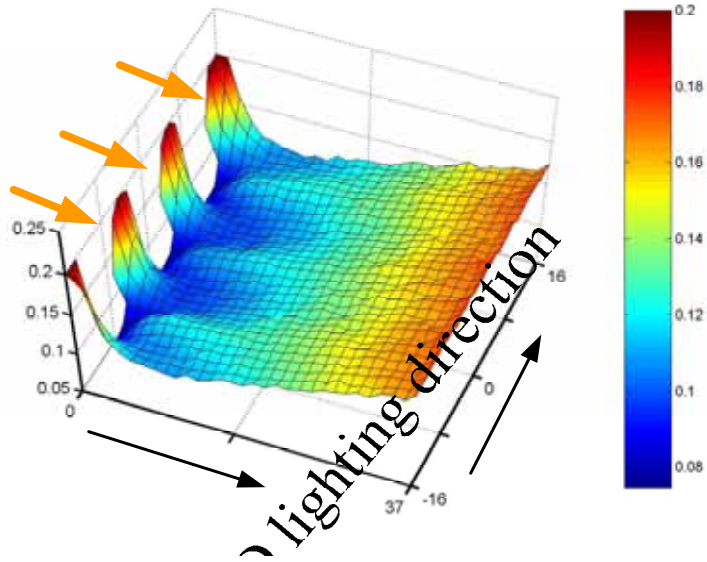
幾何模型



GUN



最佳化網點分布



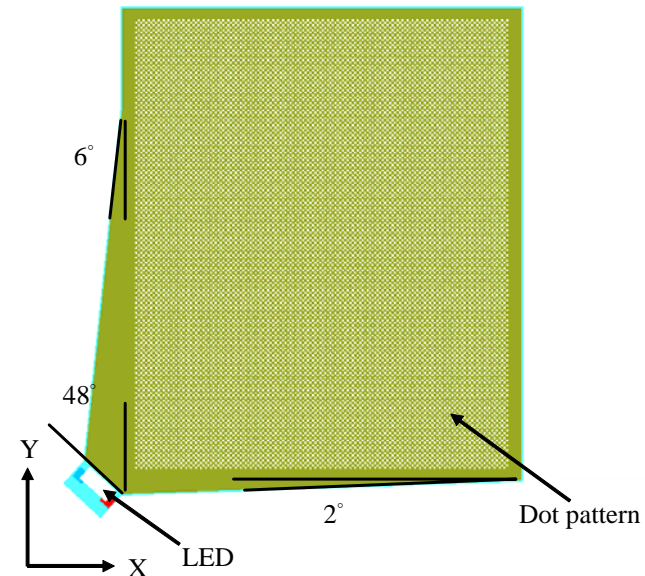
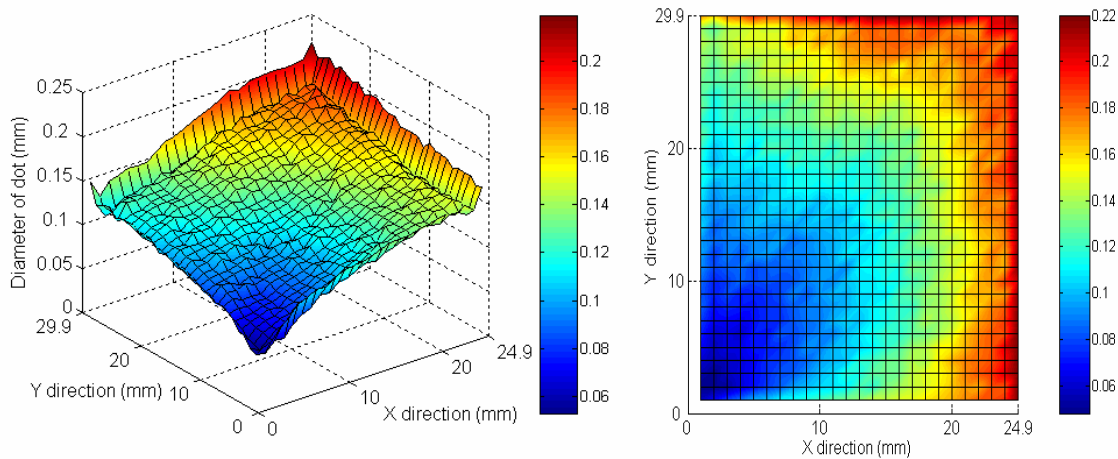
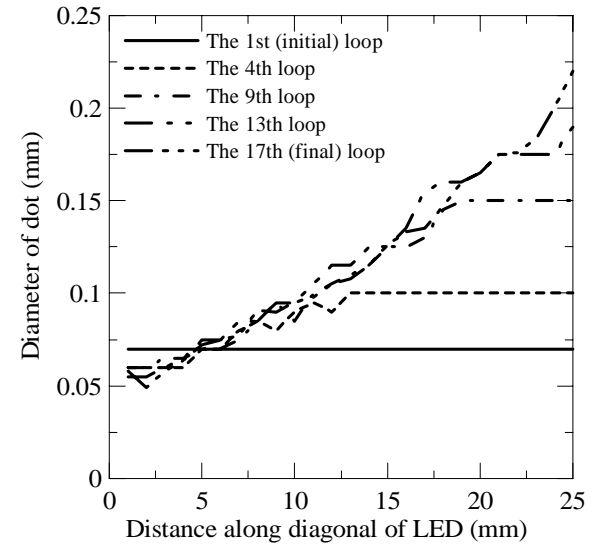
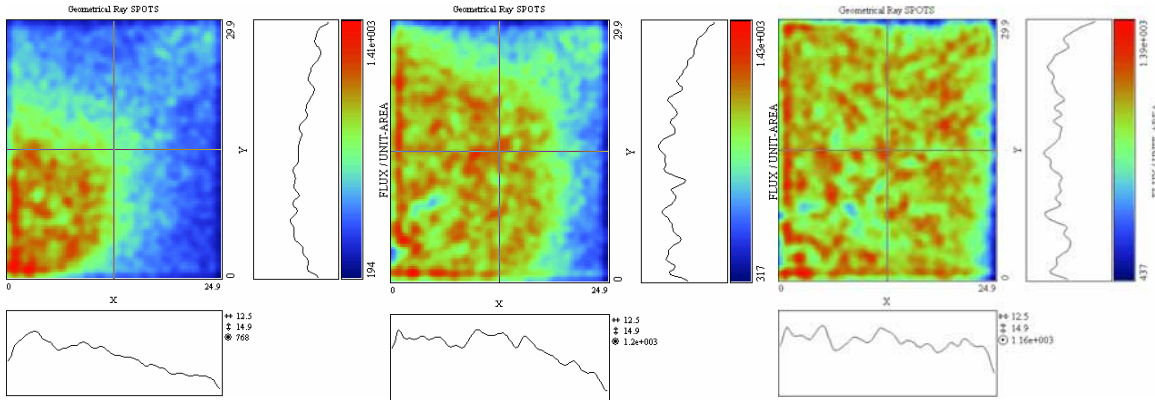
	A	B	C
3	93.798	91.32	97.964
2	92.569	93.795	92.852
1	93.678	88.15	94.205

Dot radius (mm)

均齊度 uniformity $\frac{88.15}{97.964} = 91.1\%$

Y (mm)

• Other 1LED backlight



亂數網點

(大小固定，位置不固定)

- 微結構排列

- 亂數排列運算法則

- 分子動力學法

- » 將網點(或微結構)視為原子，利用原子相吸及相斥原理達到均勻之亂數排列

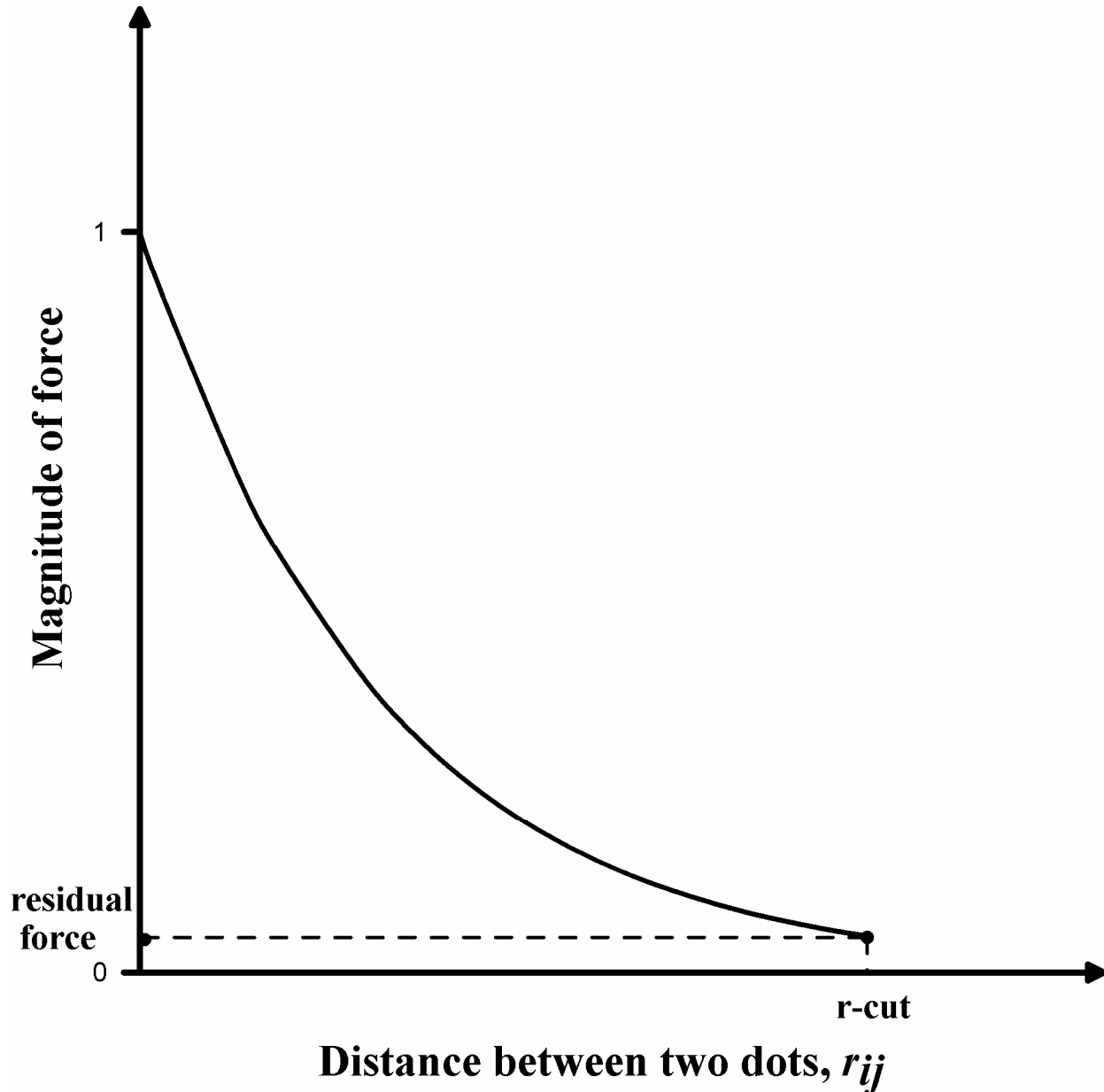
$$m \frac{d^2 \mathbf{r}_i}{dt^2} + c \frac{d\mathbf{r}_i}{dt} = \sum_j^n \mathbf{f}_{ij}(r_i, r_j)$$

其中

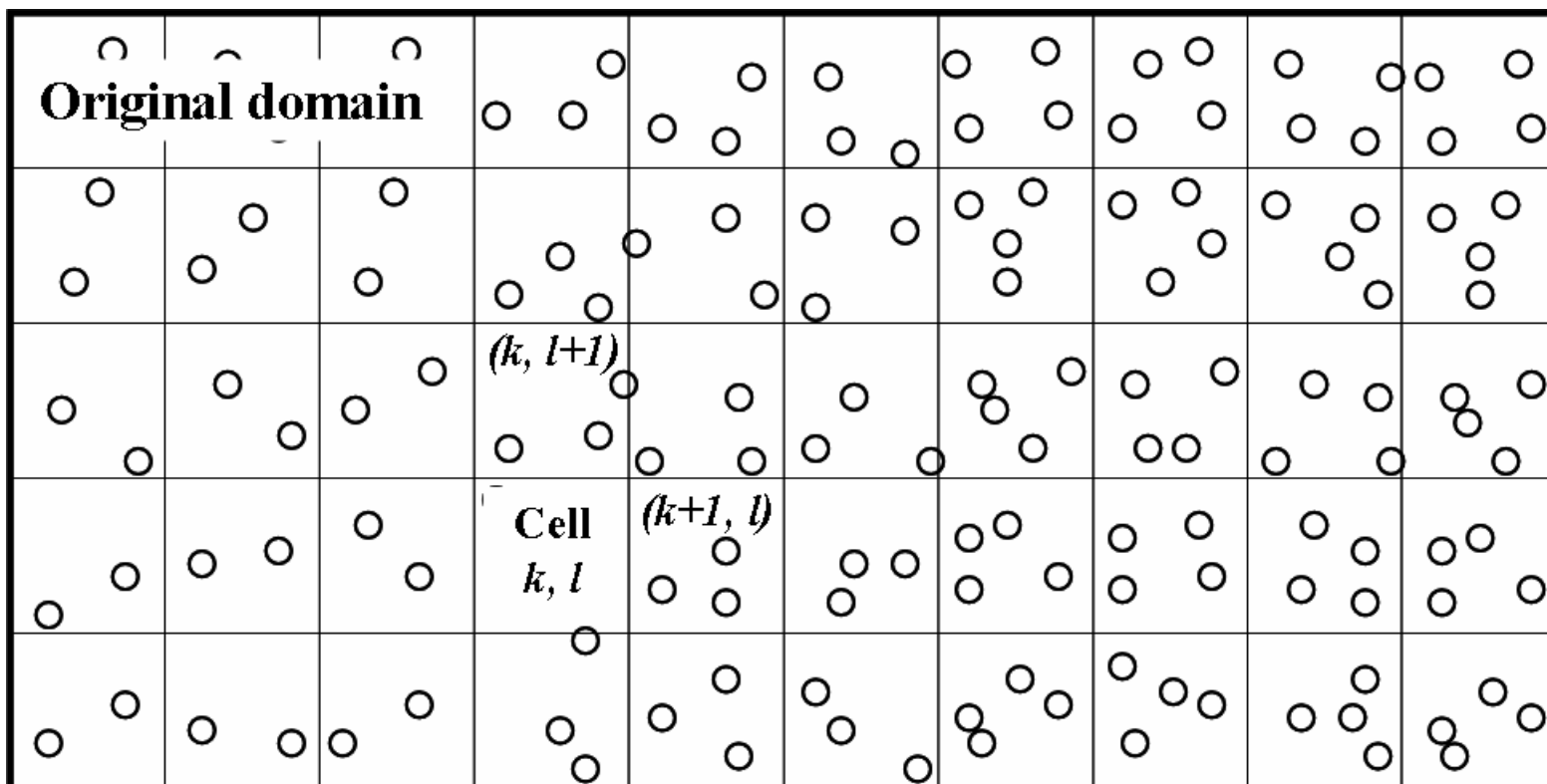
$$\mathbf{f}(r_{ij}) = \frac{\mathbf{r}_{ij}}{r_{ij}} e^{-(r_{ij} c_{kl})}$$

$$c_{kl} = \frac{-\ln f_{re}}{r_{cut,kl}}$$

- 網點間作用力與距離之關係

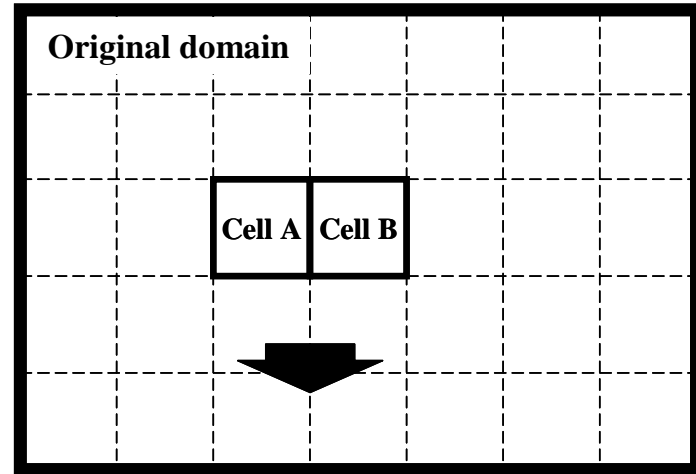


- 細胞技巧(cell technique)
 - 將分析週區分成許多細胞(cell)



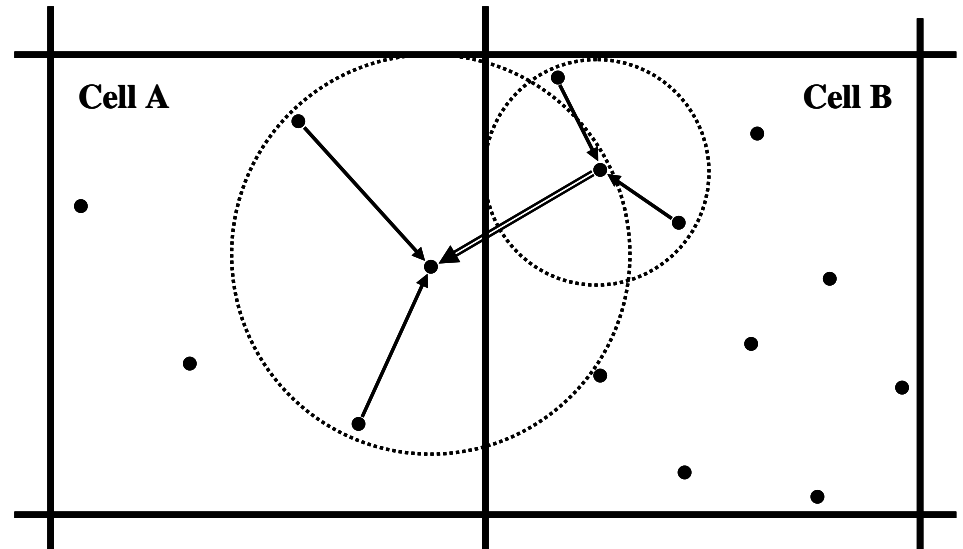
- 變動r-cut 技巧 (variable r-cut technique)

- 密度高之區域，
有較小之r-cut
- 密度低之區域，
有較大之r-cut



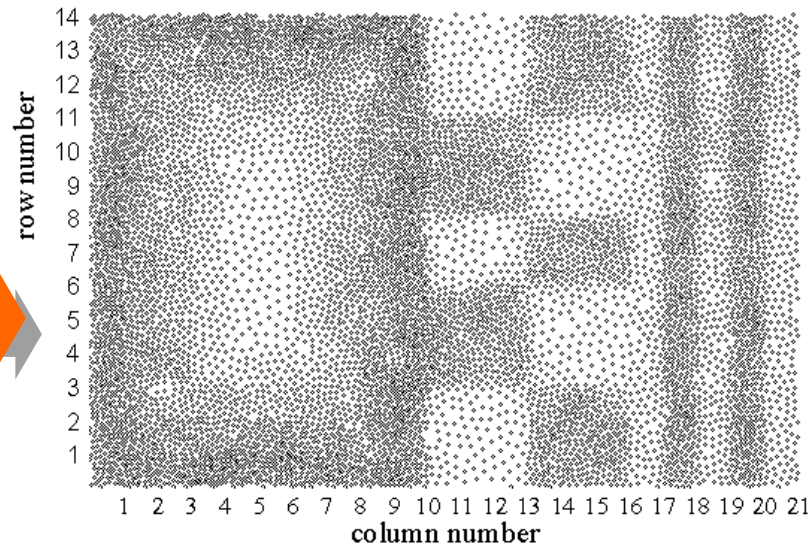
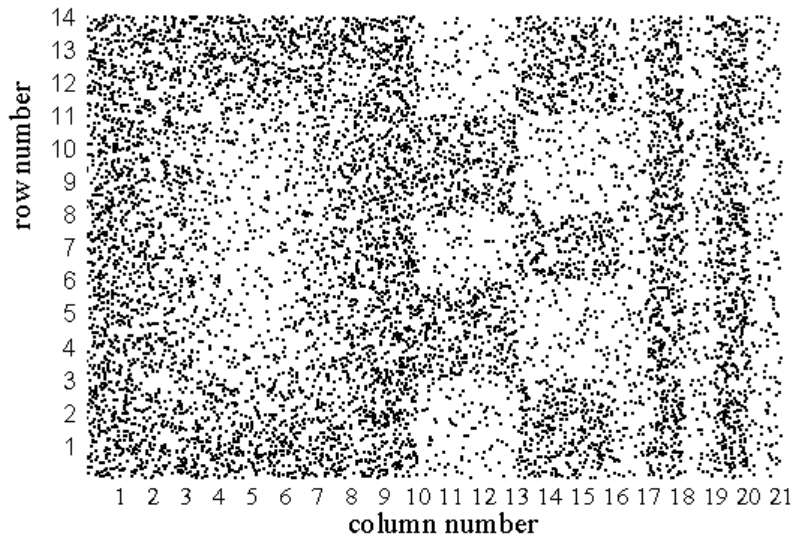
$$r_{cut_x} = a_m \sqrt{\frac{A_{cell}}{\pi \cdot m_{kl}}}$$

$$D_k = \frac{A_{dot}}{A_{cell}} = \frac{\sum_i^{m_k} \pi \cdot \bar{r}_i^2}{A_{cell}}$$

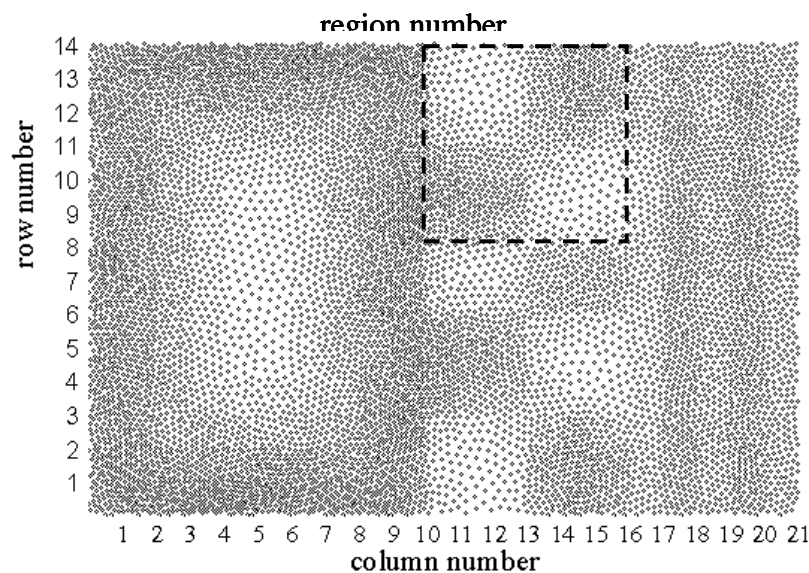
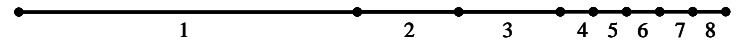
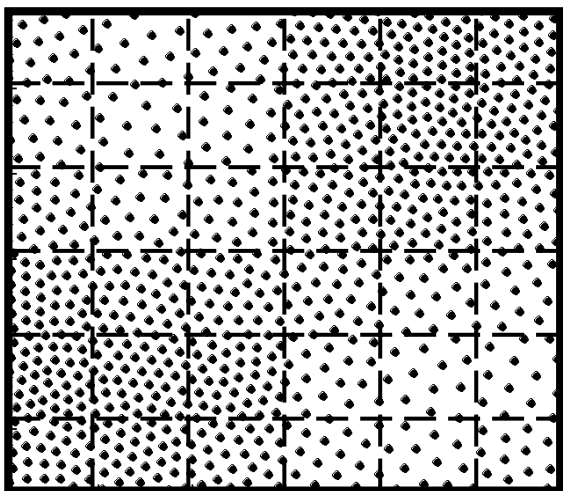


—— cell boundary ← force by C_k ← force by $C_{boundary}$

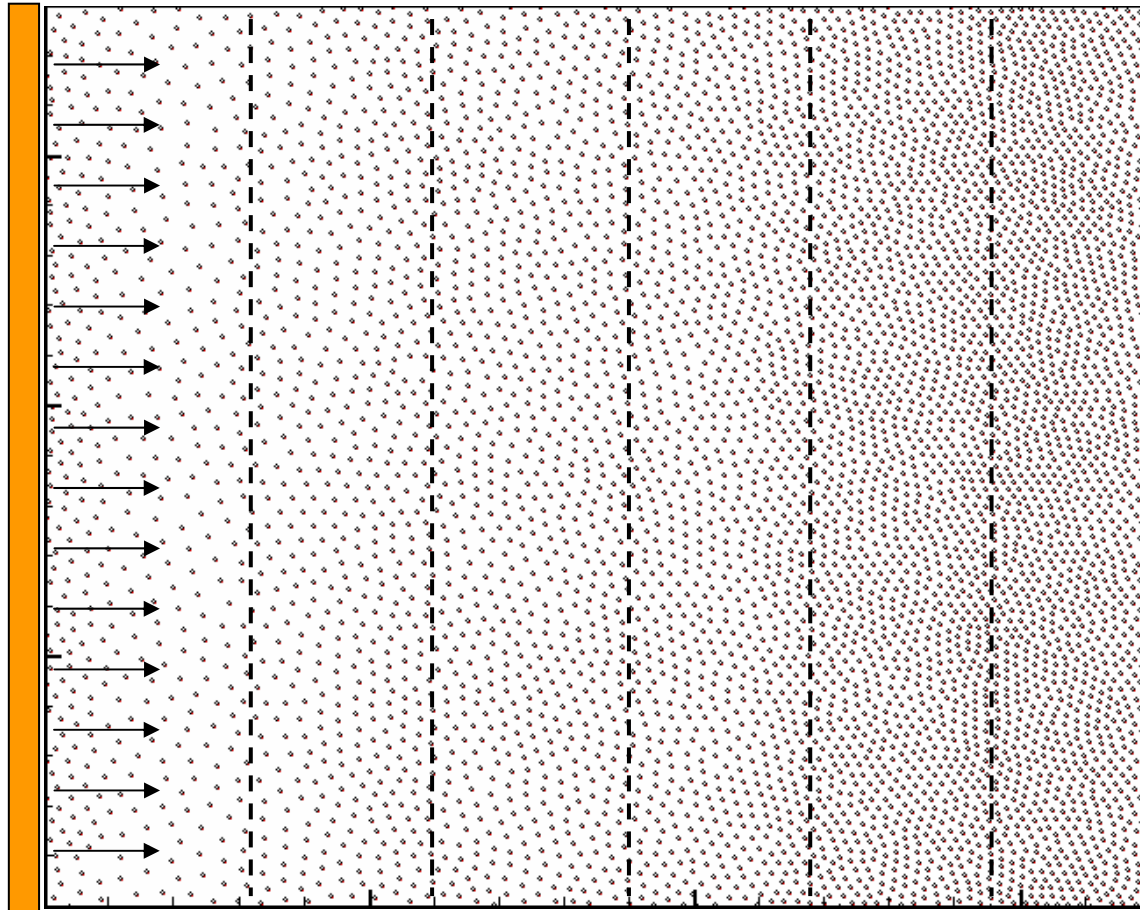
- 範例：排列位置之調整



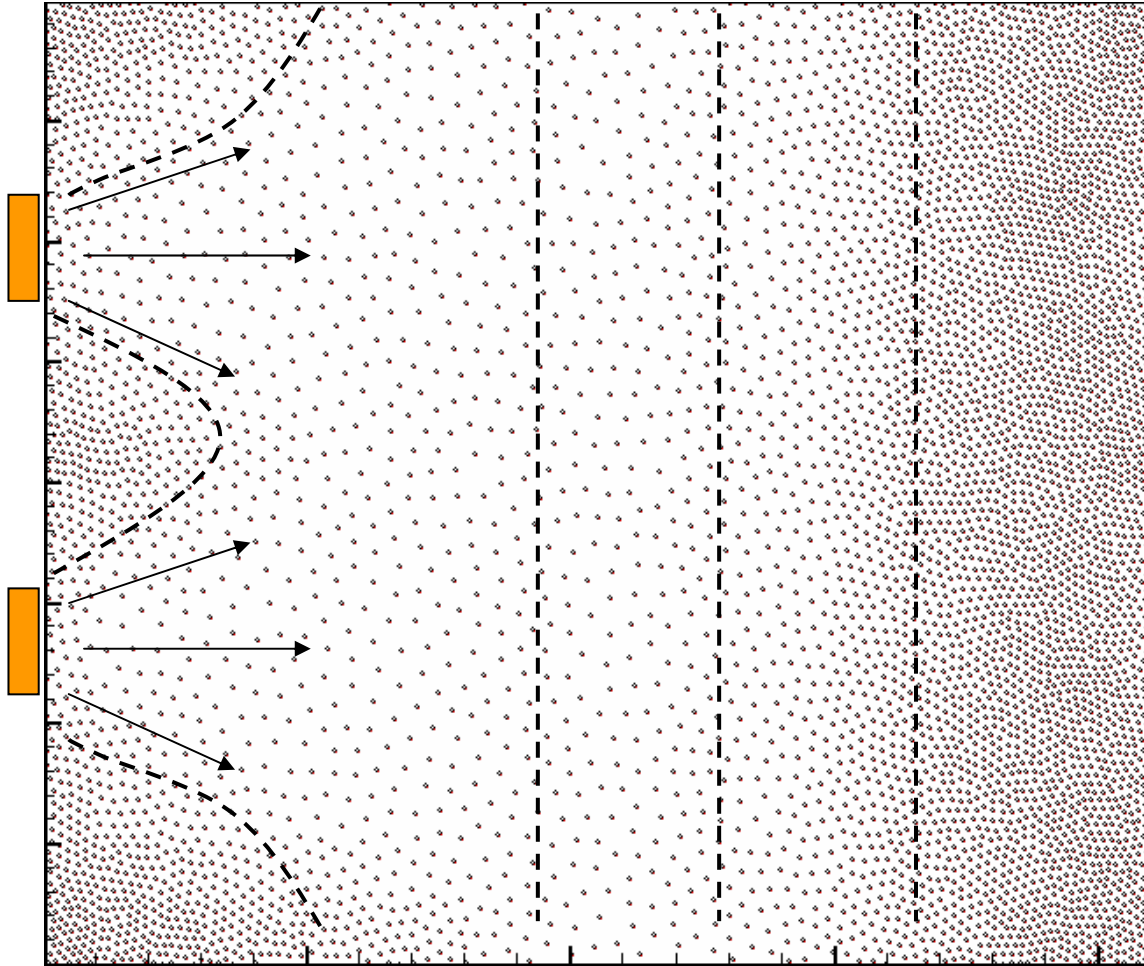
Enlarge view



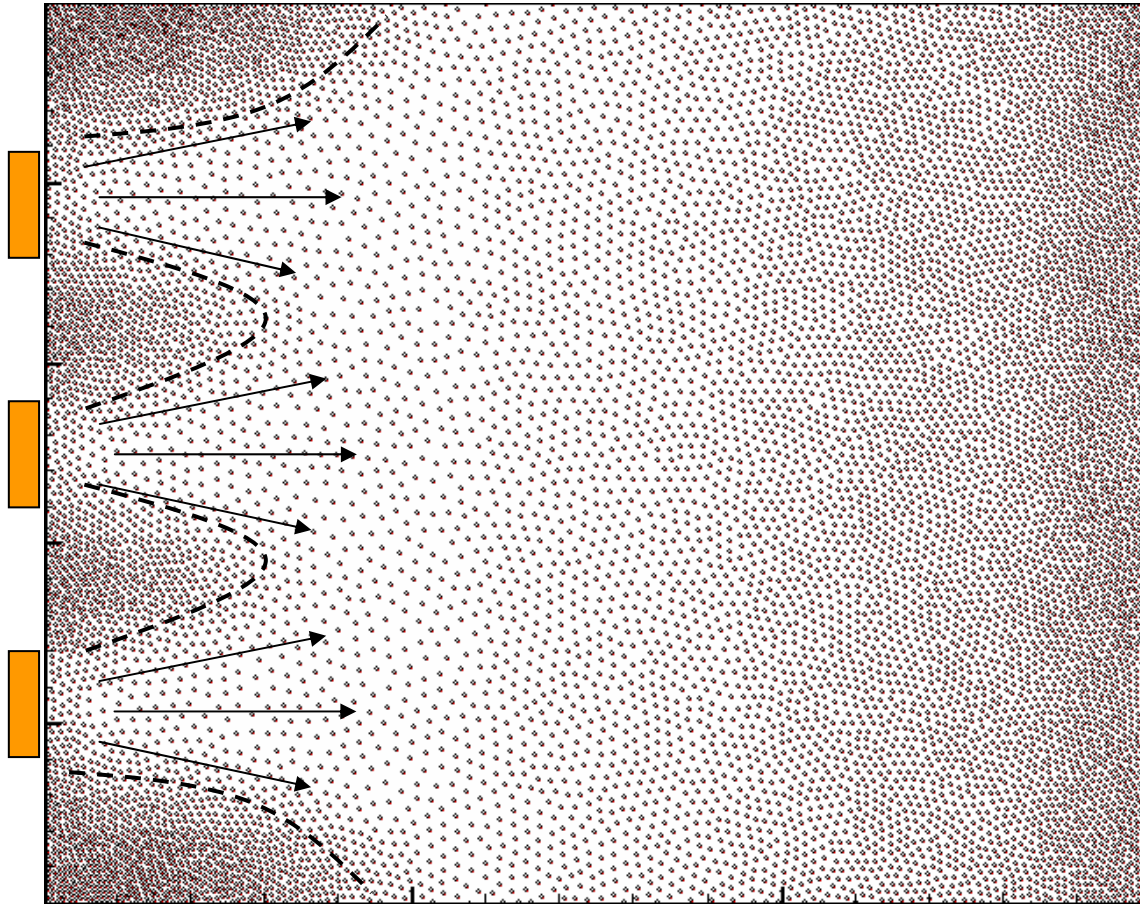
- CCFL 背光板網點分佈



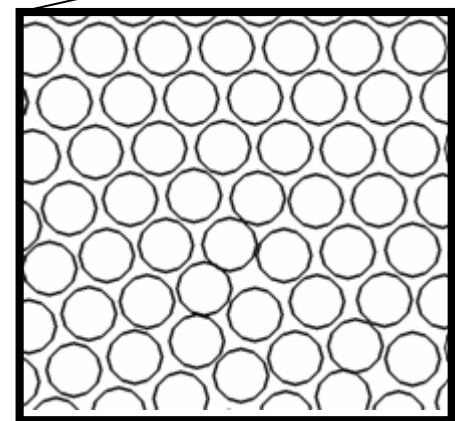
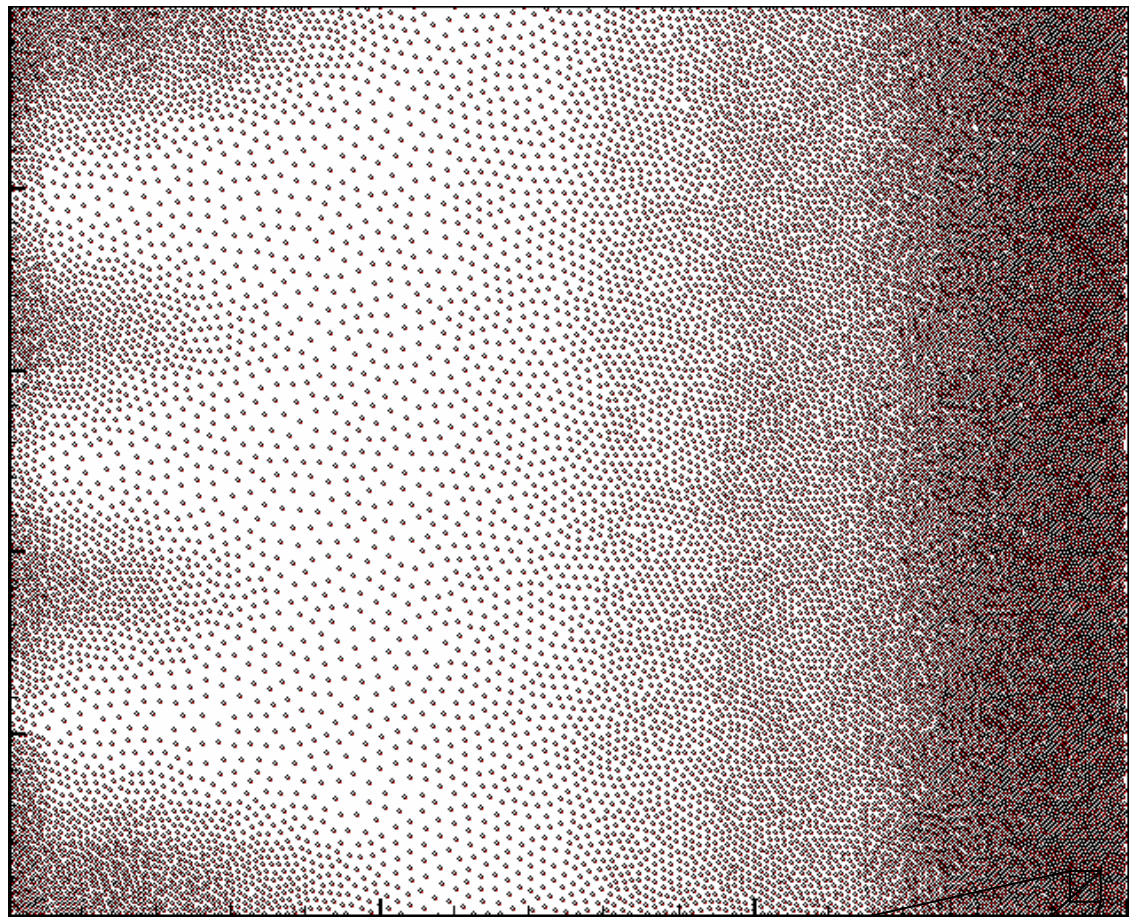
- LED 背光板網點分布(1)



- LED 背光板網點分布(2)

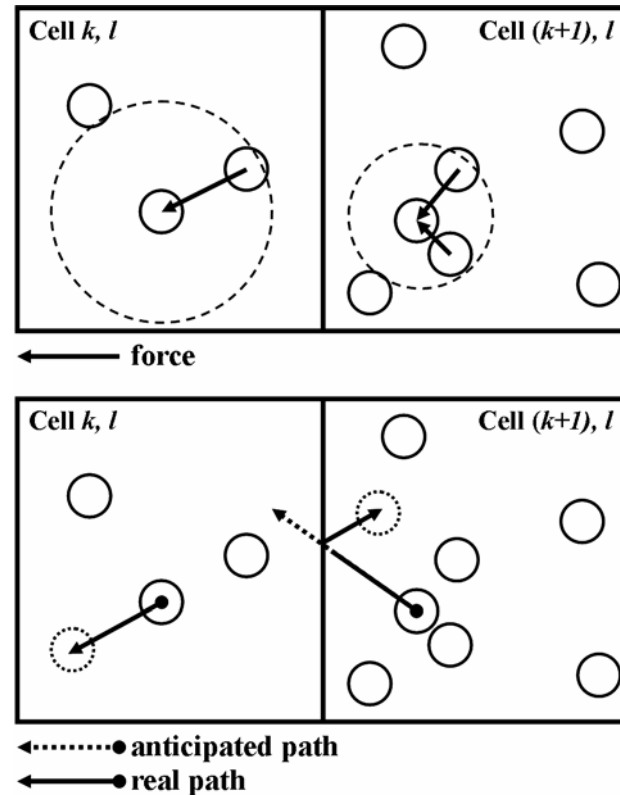


- LED 背光板網點
分布(2)

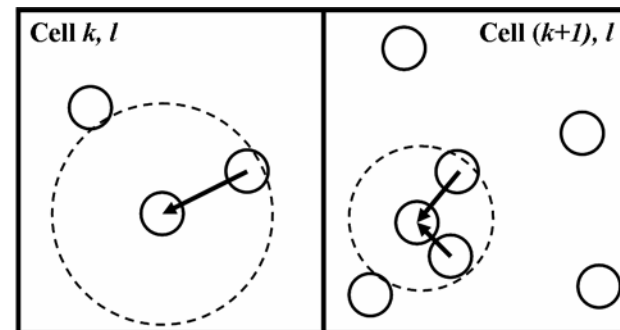
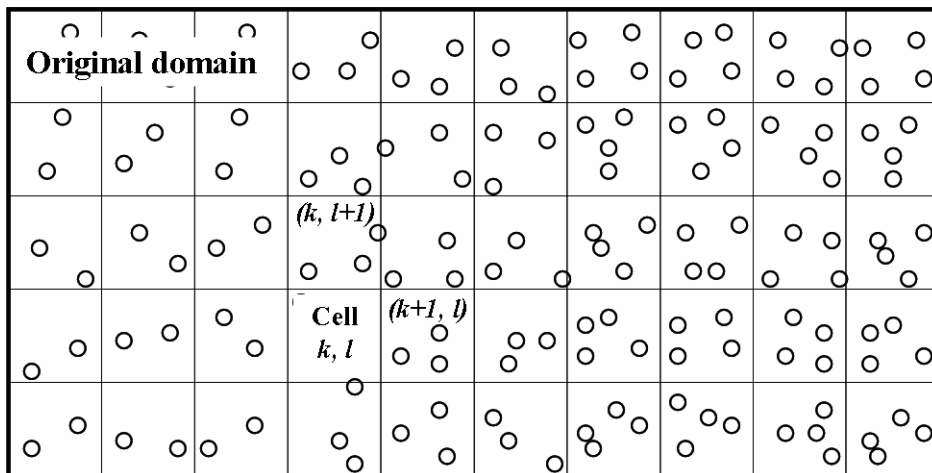


- 上述演算法之缺點為
 - 網點會由密度高之 **cell** 往密度低之 **cell** 跑
 - 無法針對特定區 **cell** 做單一之網點密度修正

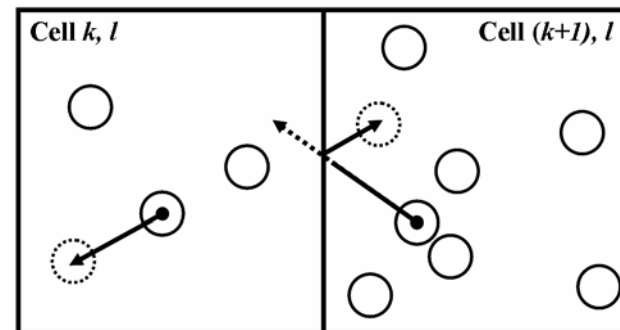
- 針對上述缺點
 - 反射性邊界條件
(reflective boundary condition)



亂數網點演算法之定量分析



← force

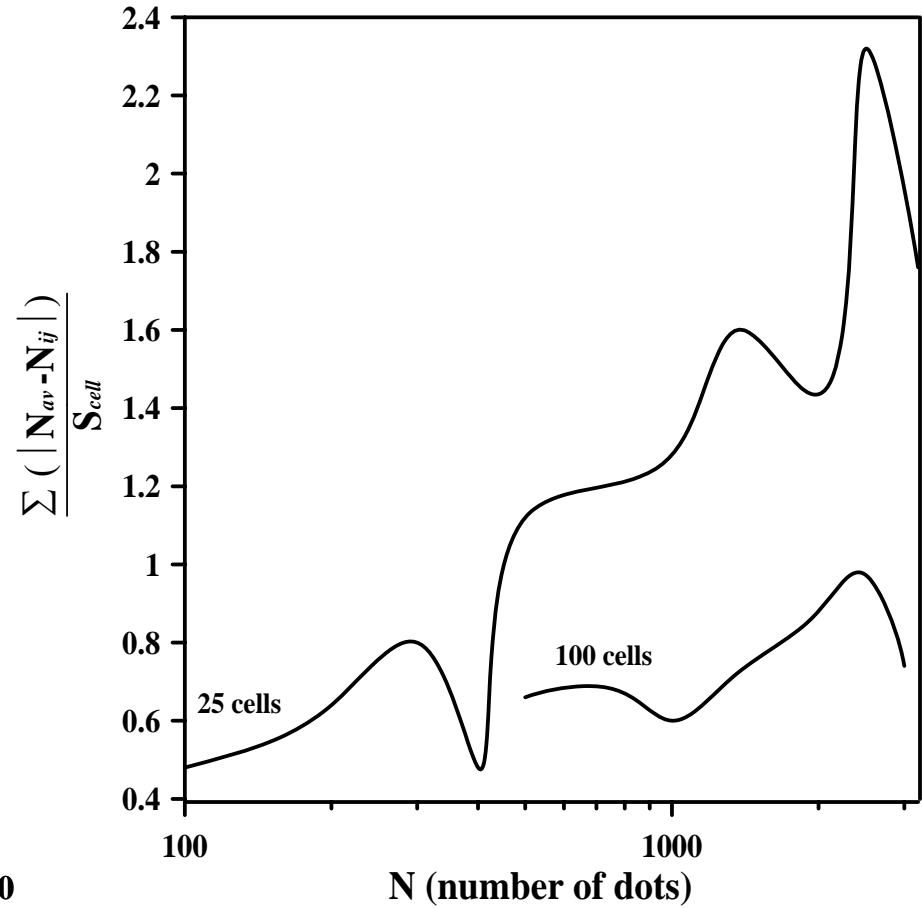
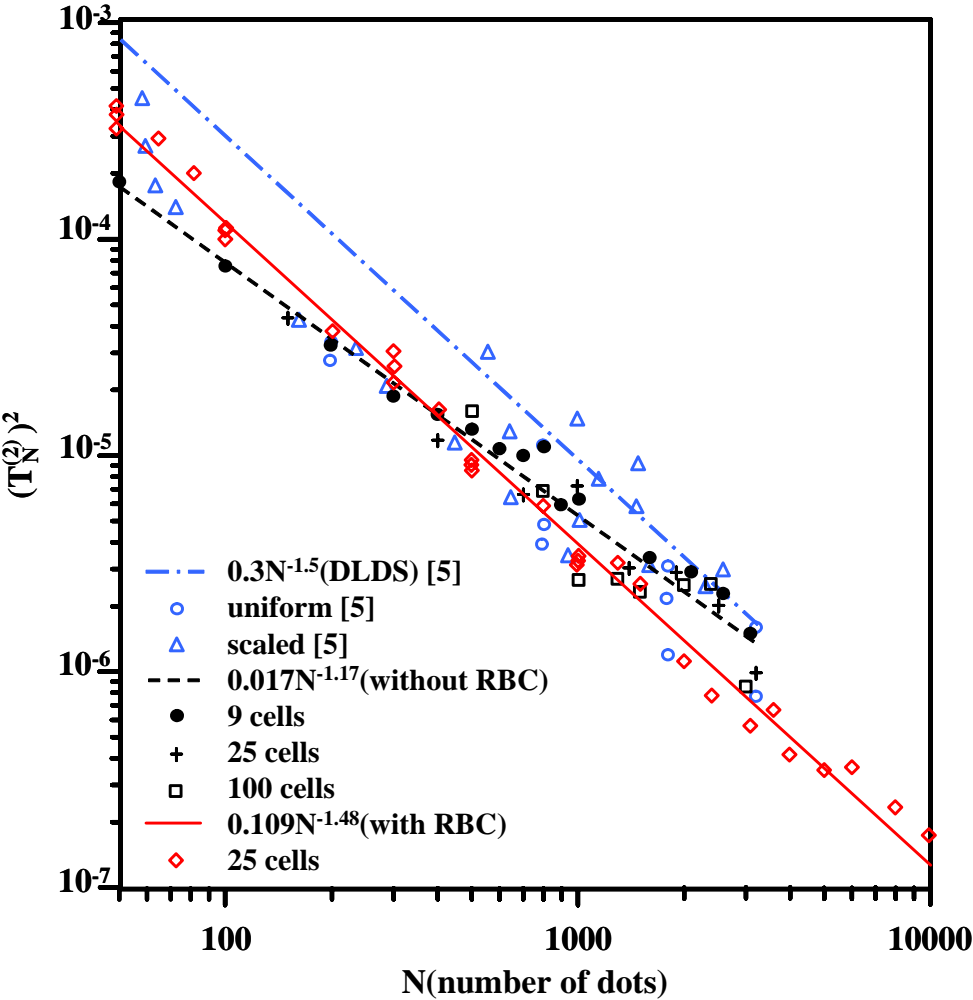


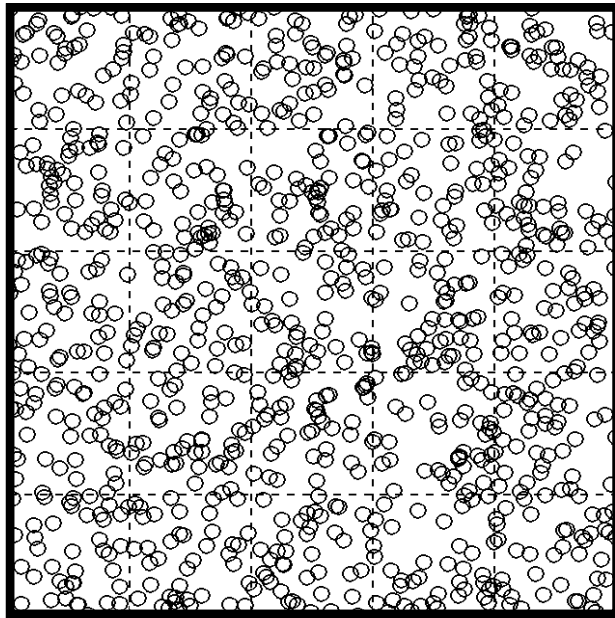
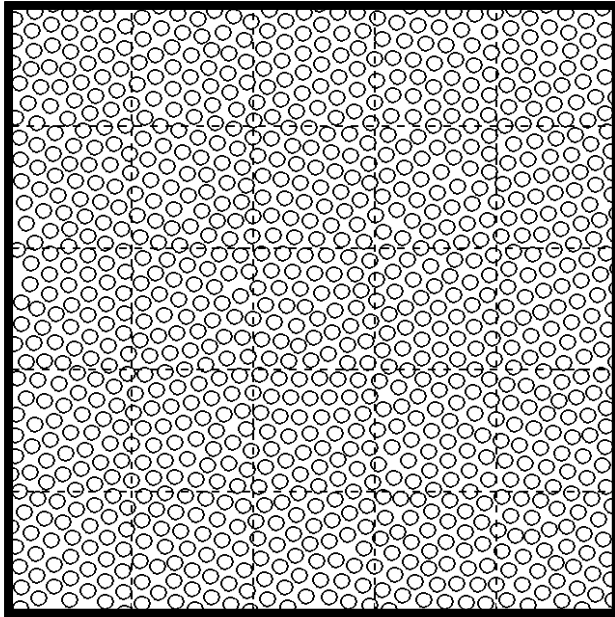
←.....● anticipated path

←——● real path

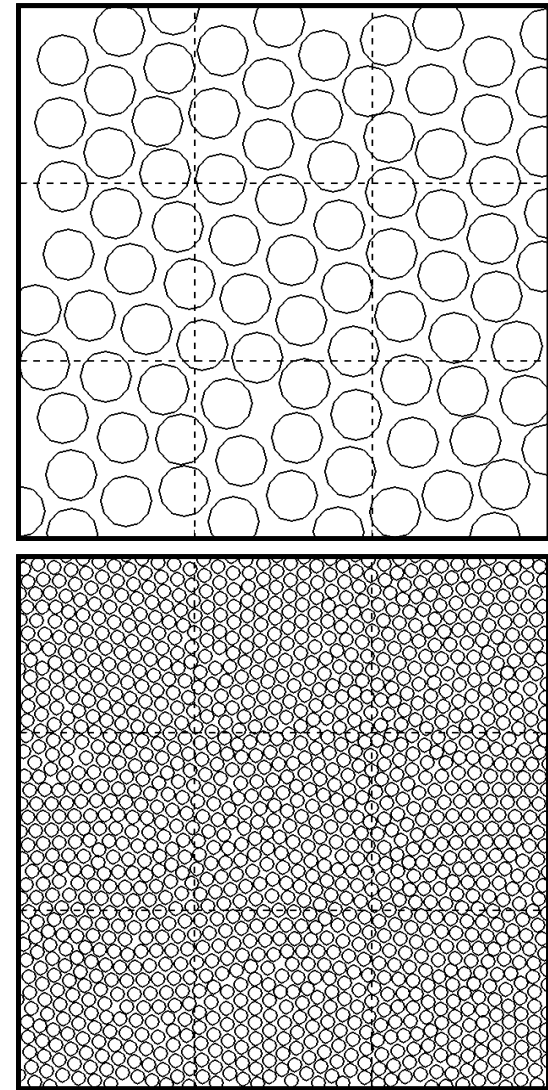
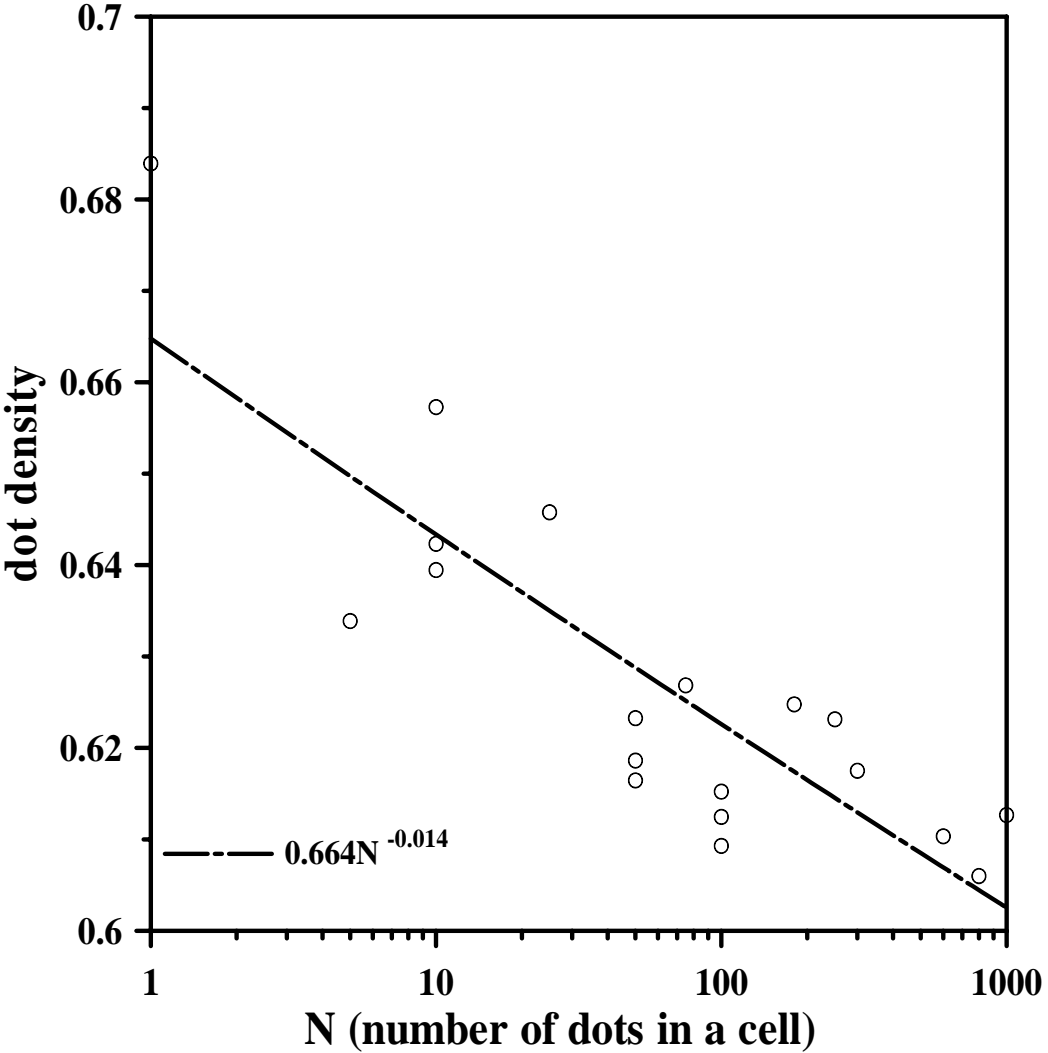
• Uniformity

$$(T_N^{(k)})^2 = \frac{1}{N^2} \sum_{n=0}^{N-1} \sum_{m=0}^{N-1} \prod_{i=1}^k (1 - \max(x_n^{(i)}, x_m^{(i)})) - \frac{2^{1-k}}{N} \sum_{n=0}^{N-1} \prod_{i=1}^k (1 - (x_n^{(i)})^2) + 3^{-k}$$

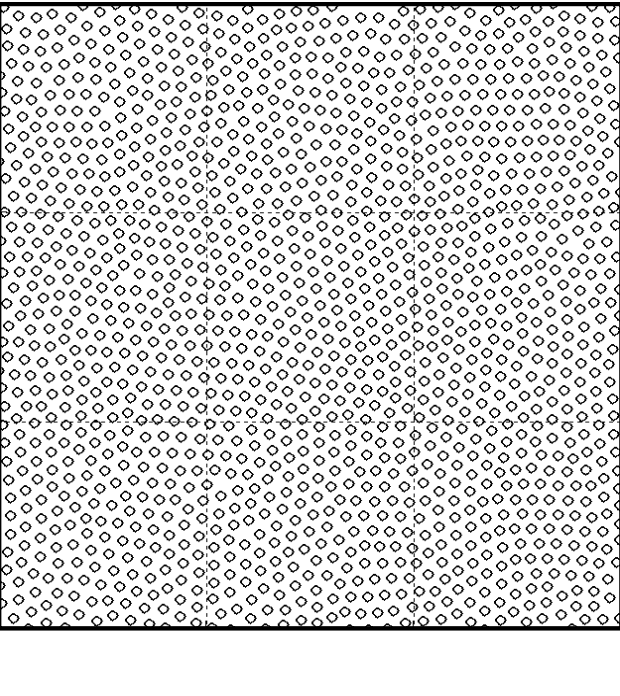




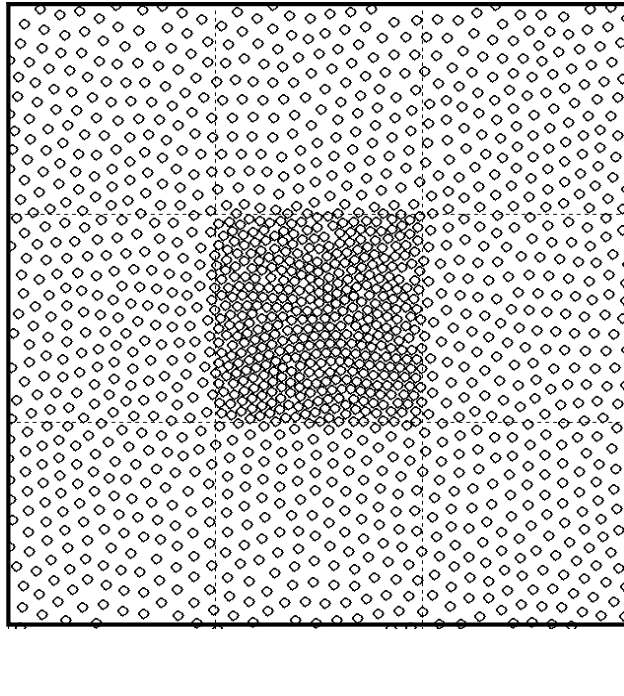
dot distributions obtained by MD scheme for simulation domains containing 1000 dots in 25 cells with reflective boundary condition (upper). Note bottom panel shows initial random dot distribution before force regulation process.



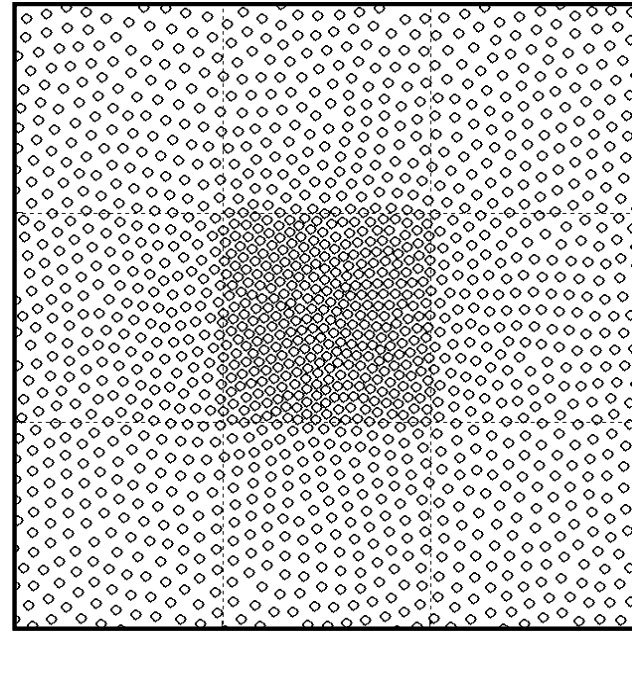
dot distributions for cells containing 10 dots with dot density of 0.640 (upper) and cells containing 150 dots with dot density of 0.614 (lower).



(a) fixed r-cut value

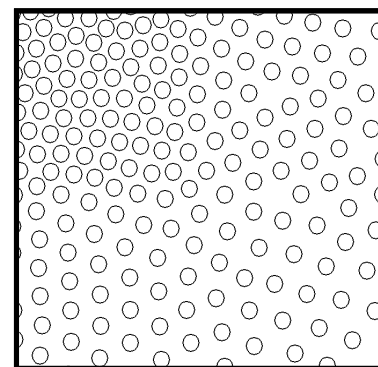
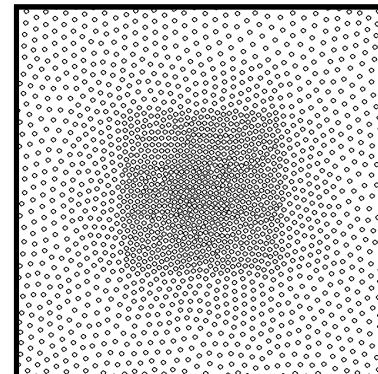
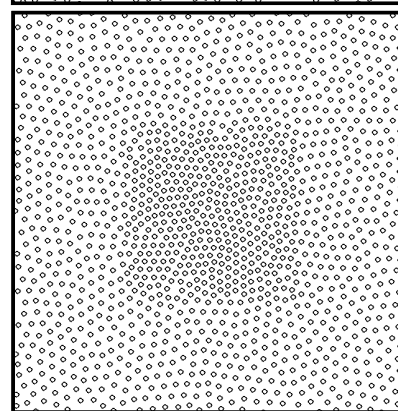
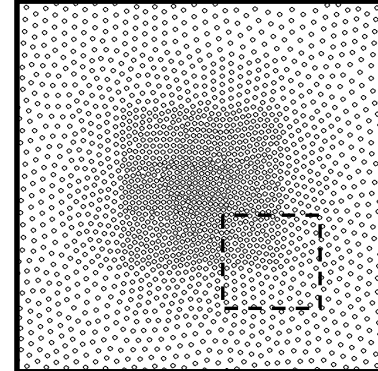
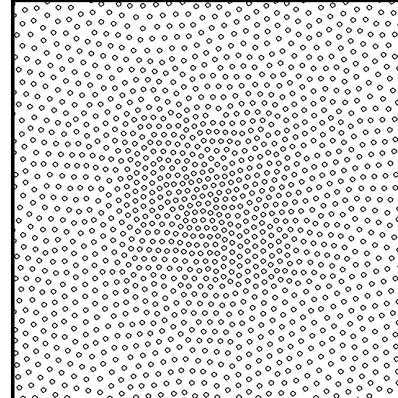
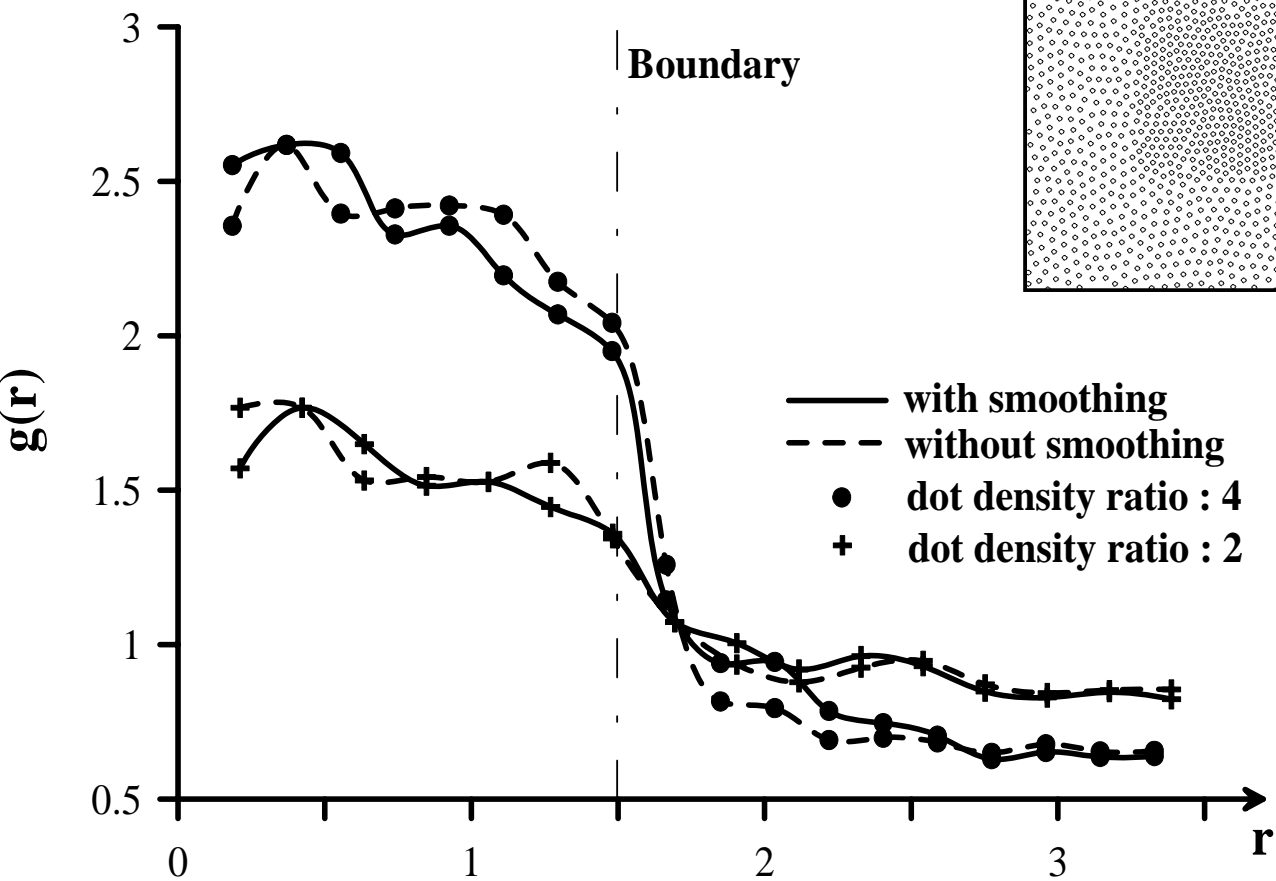


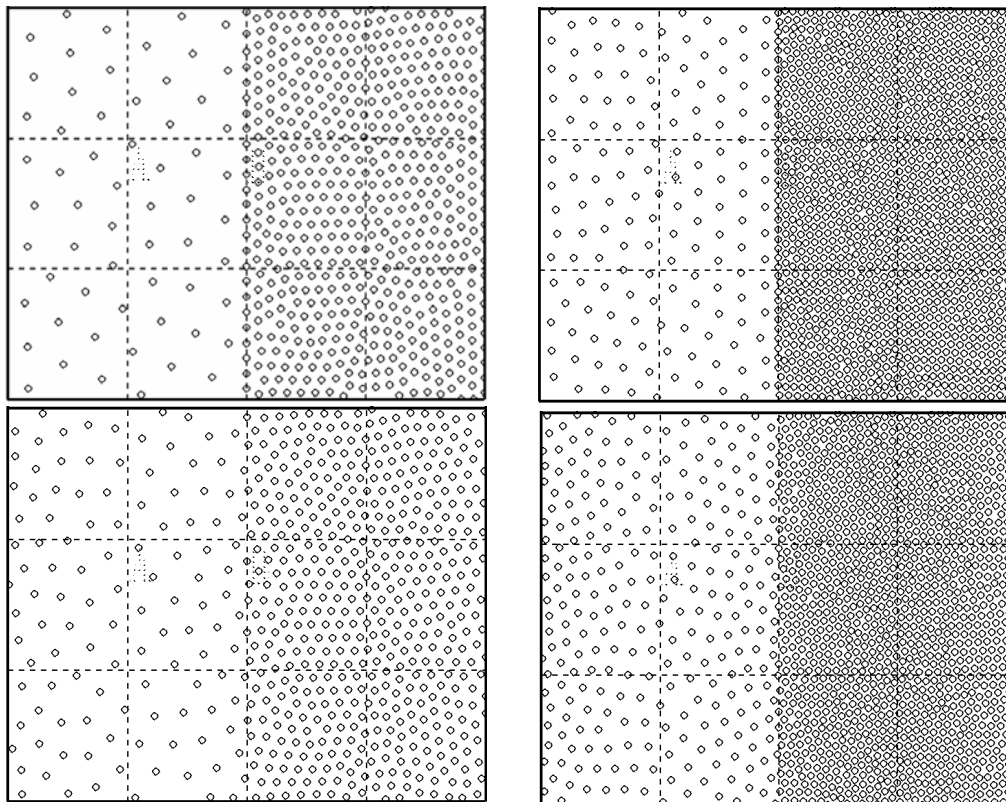
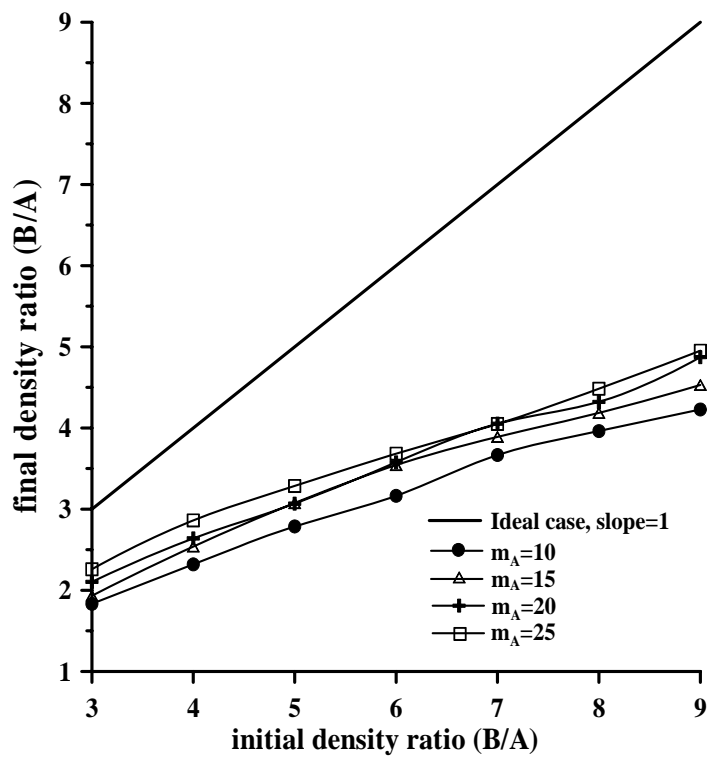
(b) predefined r-cut value

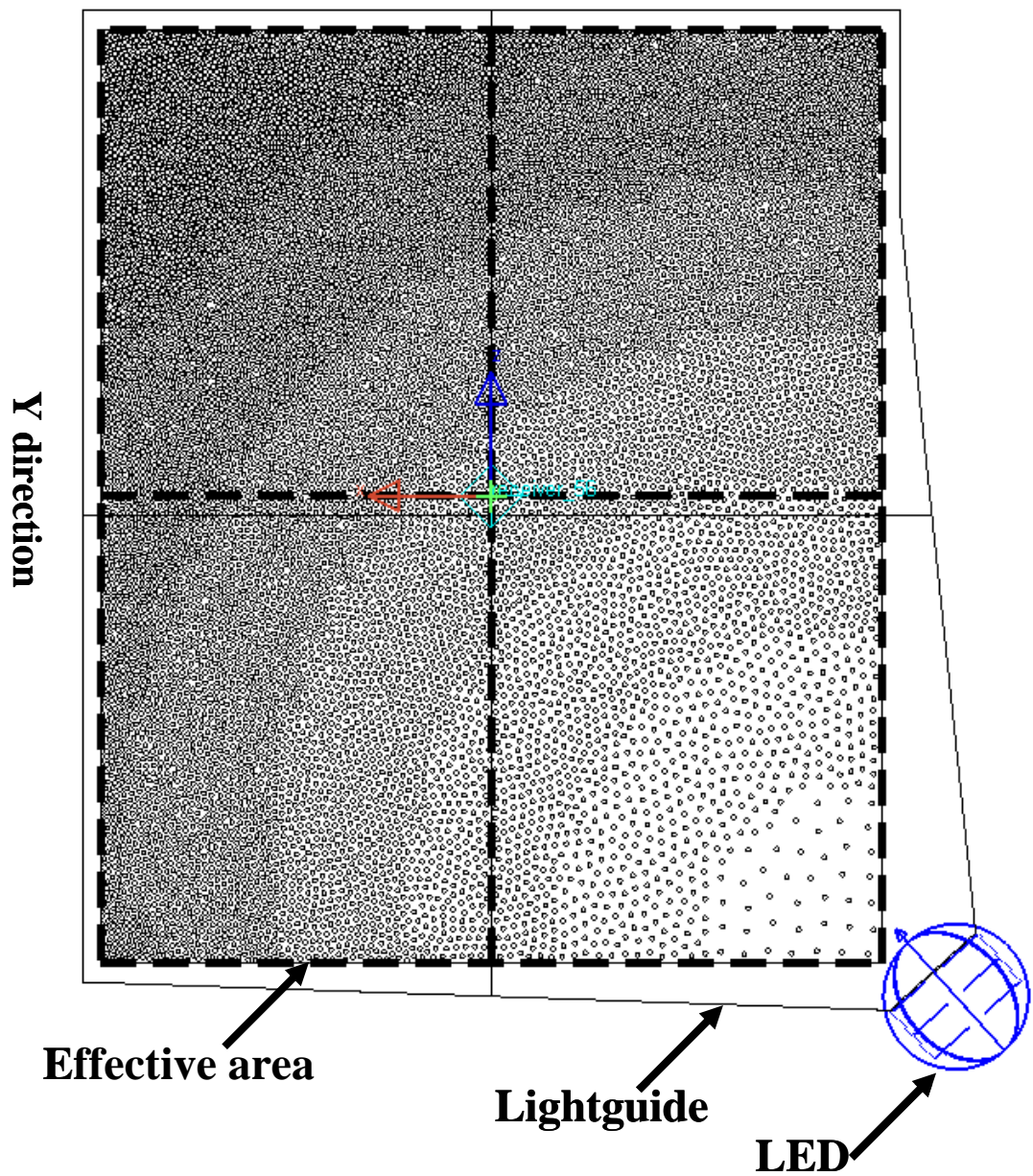
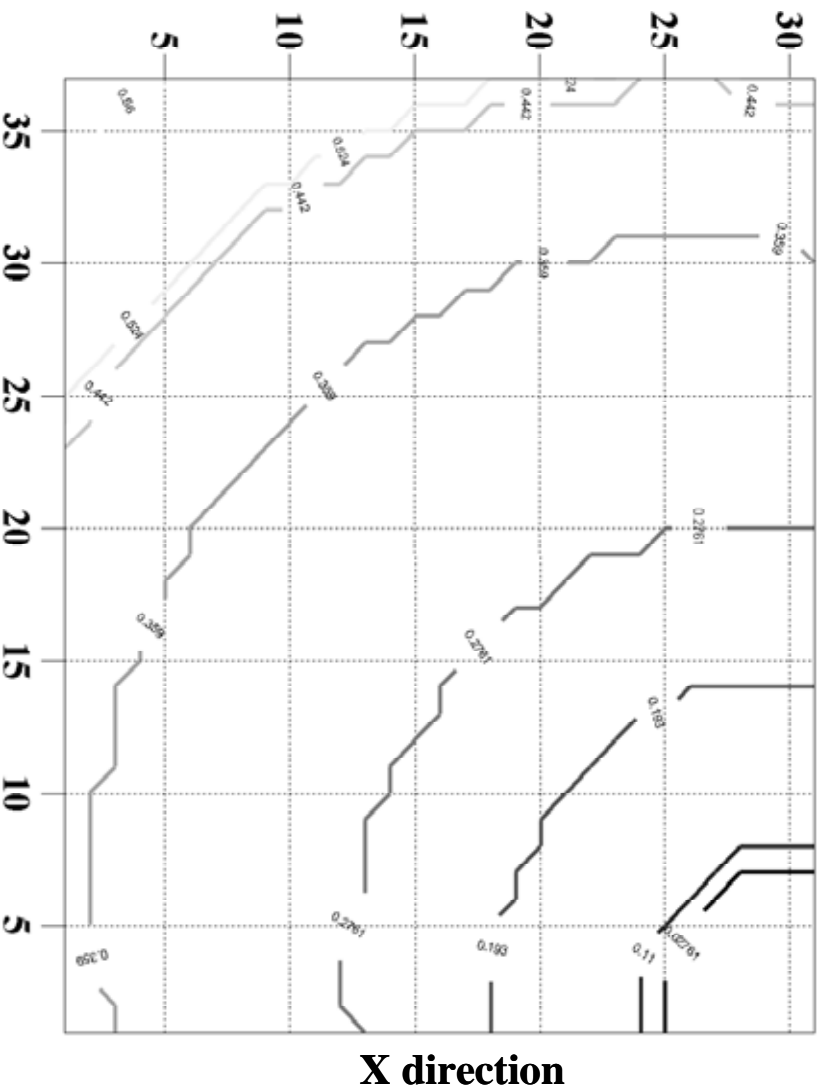


(c) variable r-cut value

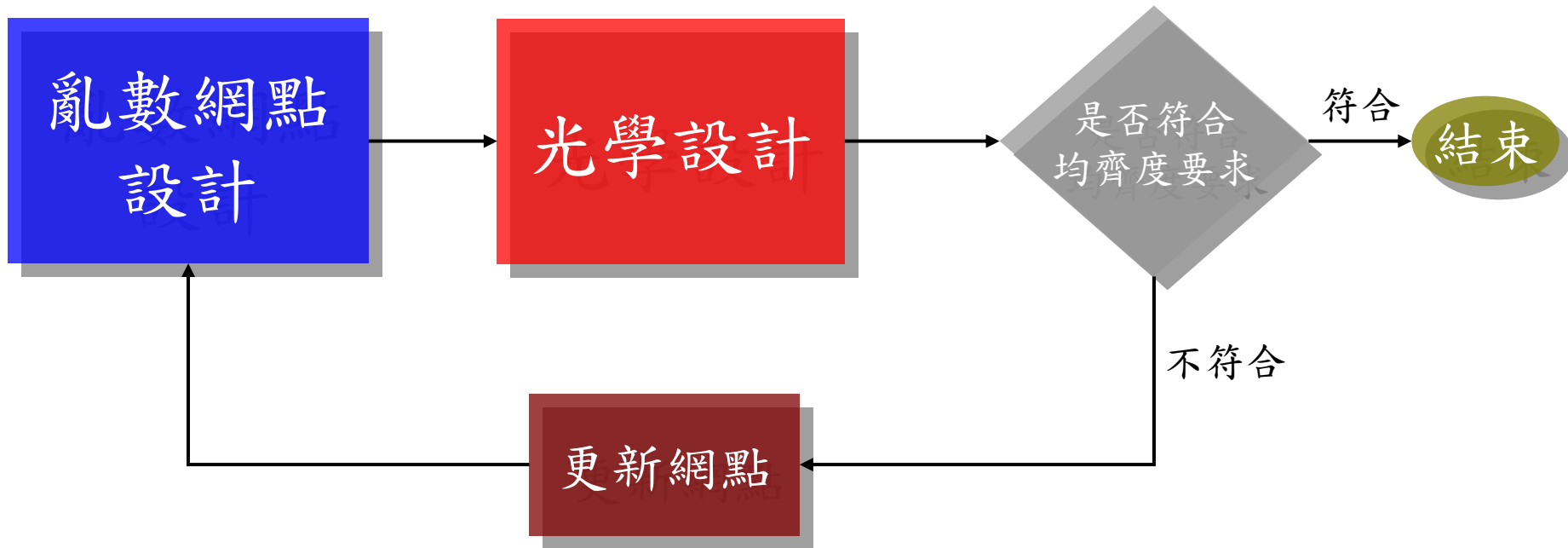
with RBC



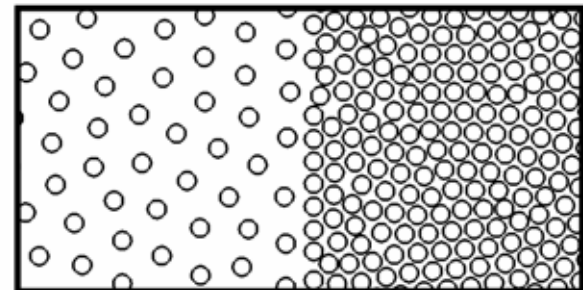
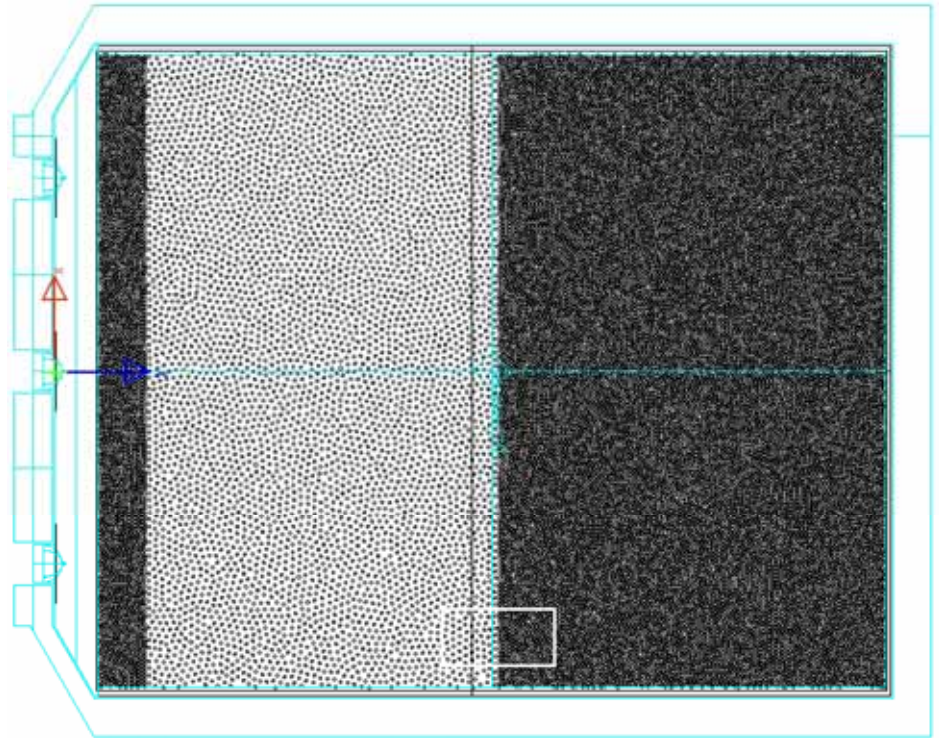
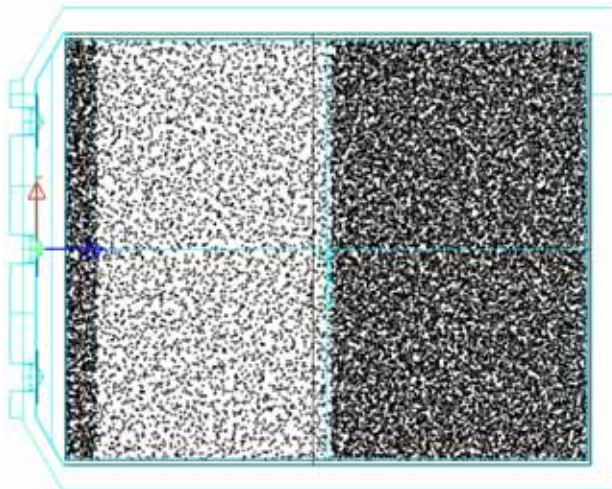
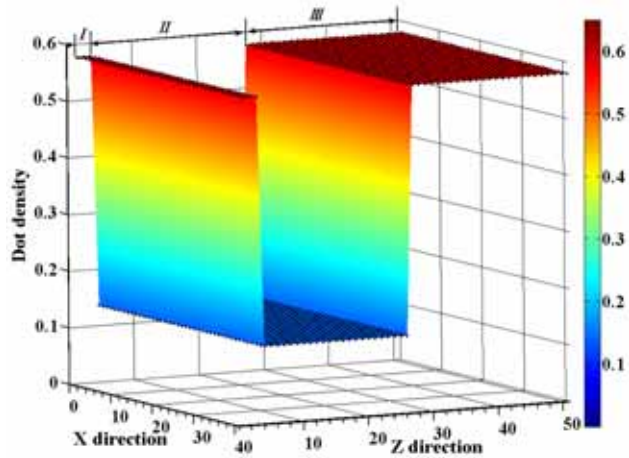




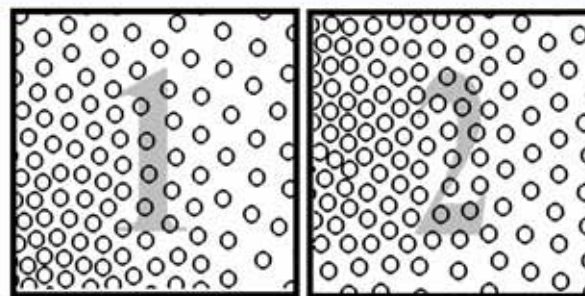
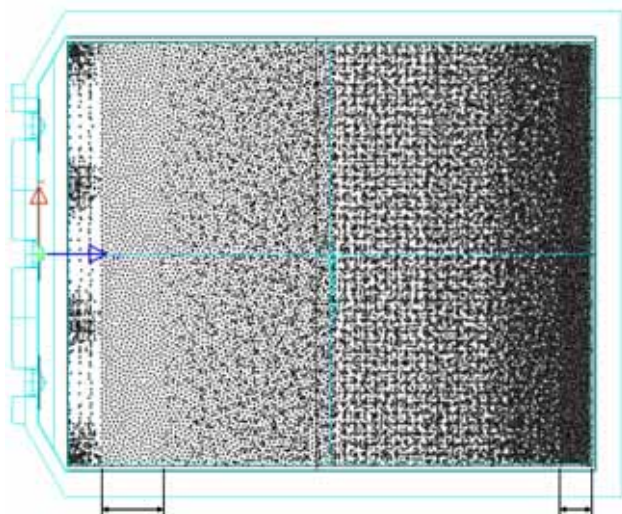
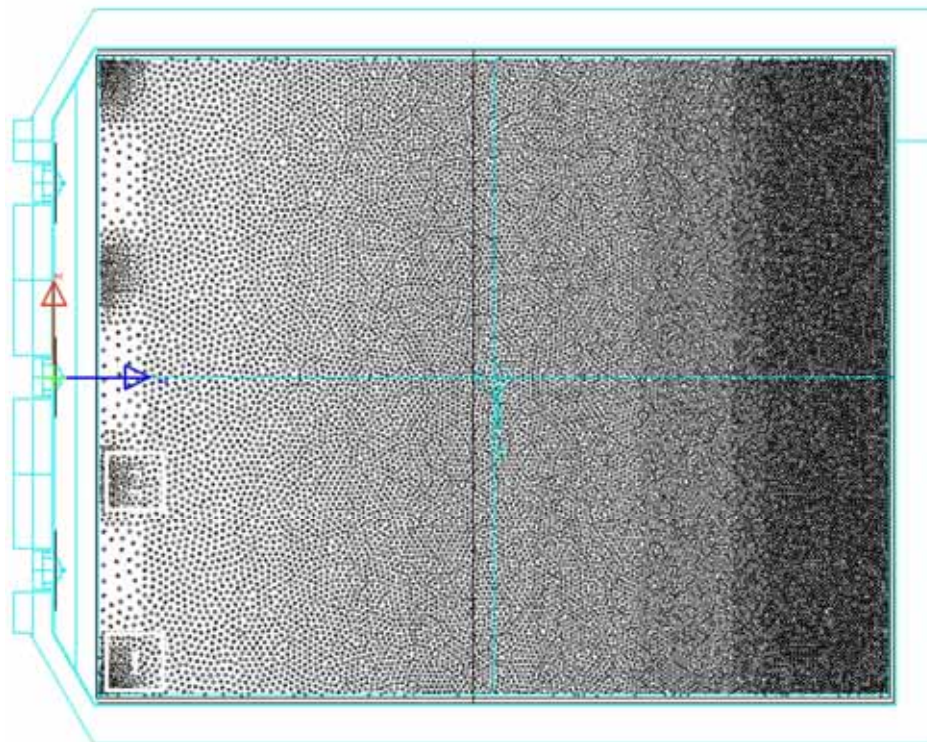
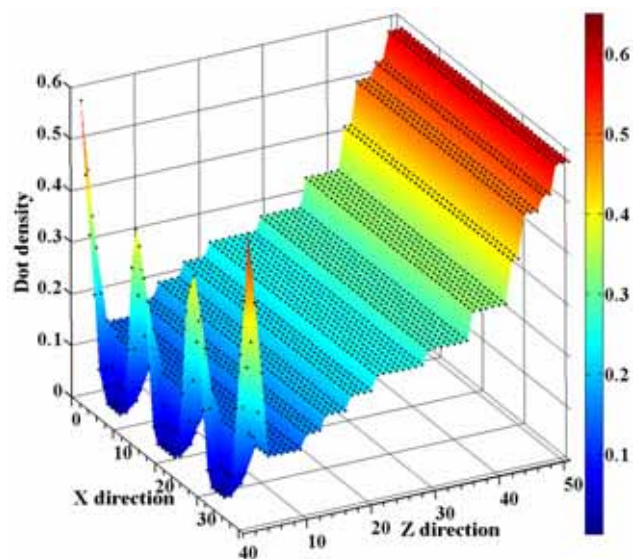
- 亂數網點光學設計流程



- 範例
 - 一 亂數網點設計



- 特定區域之網點修正



整合亂數網點排列演算法及光 學設計

- 光學設計最佳化法則

$$E_{av} = \frac{\sum_{k,l=1}^{n',m'} E_{kl}}{n' \cdot m'}$$

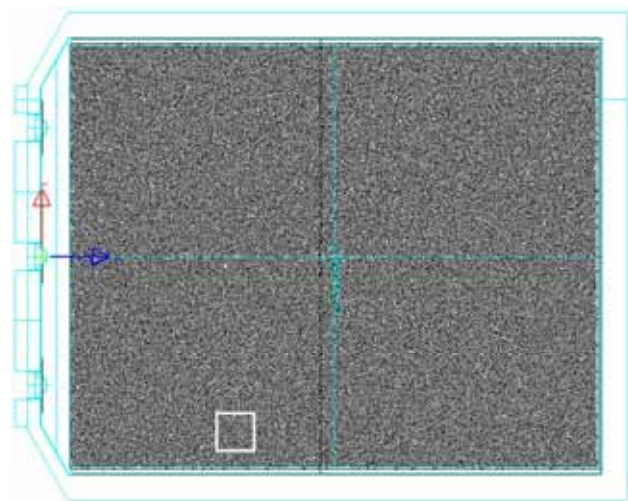
$$E_{kl} = D_{kl} \cdot \frac{A_{cell}}{\pi r^2} \cdot E_{dot} \quad \left(m_{kl} = D_{kl} \cdot \frac{A_{cell}}{\pi r^2} \right)$$

$$\Delta D_{kl} = \frac{\pi r^2}{A_{cell}} \cdot \frac{E_{av} - E_{kl}}{E_{dot}} = D_{kl} \left(\frac{E_{av}}{E_{kl}} - 1 \right)$$

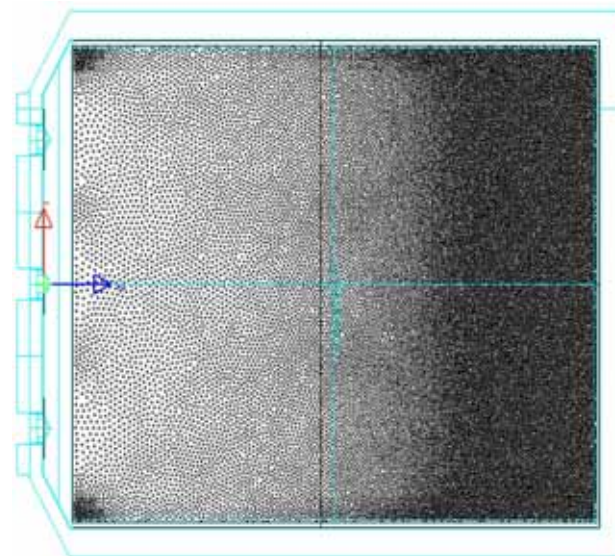
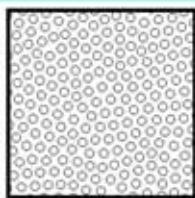
$$\bar{D}_{kl} = D_{kl} + \Delta D_{kl} = D_{kl} \cdot \frac{E_{av}}{E_{kl}}, \quad \bar{m}_{kl} = m_{kl} + \Delta m_{kl} = m_{kl} \cdot \frac{E_{av}}{E_{kl}}$$

$$U(\%) = 100 \cdot \frac{\min(E_{kl})}{\max(E_{kl})}$$

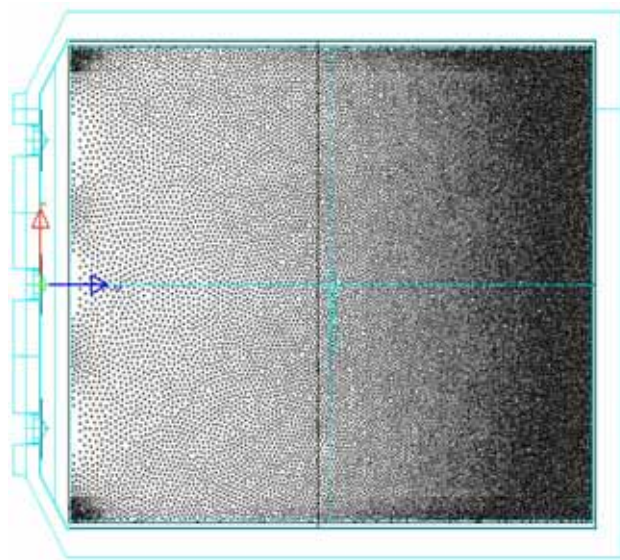
• 疊代過程



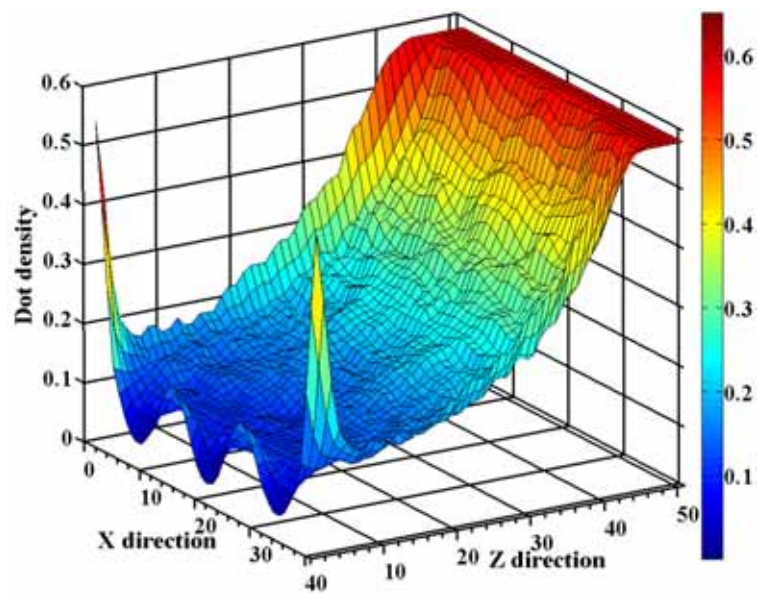
(a)



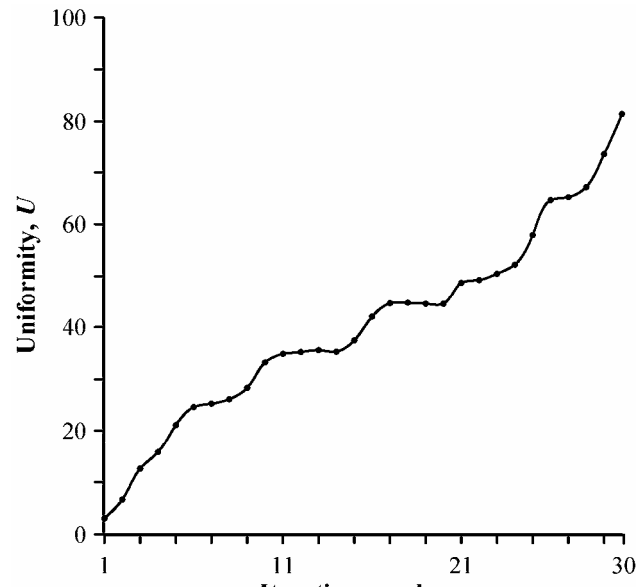
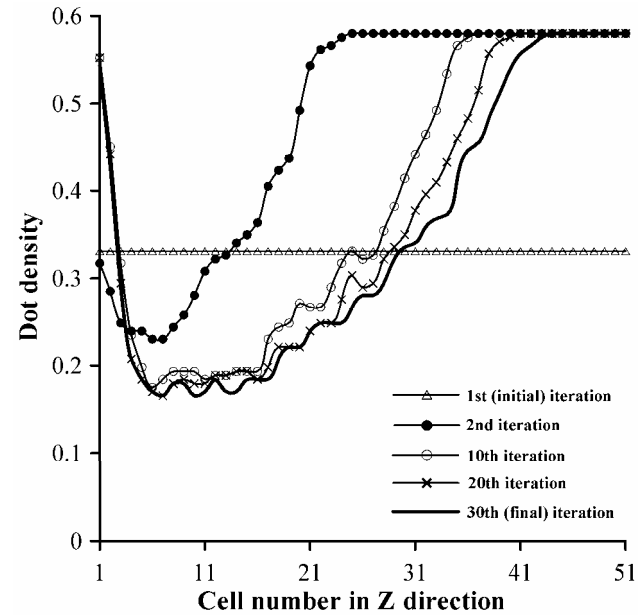
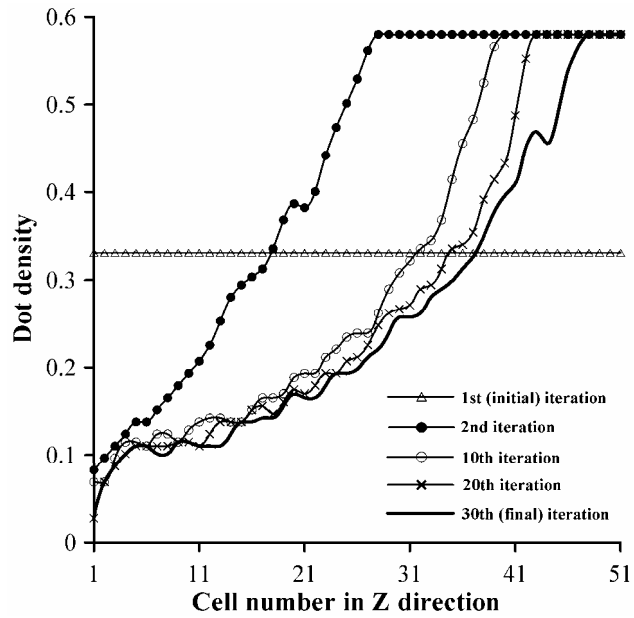
(b)



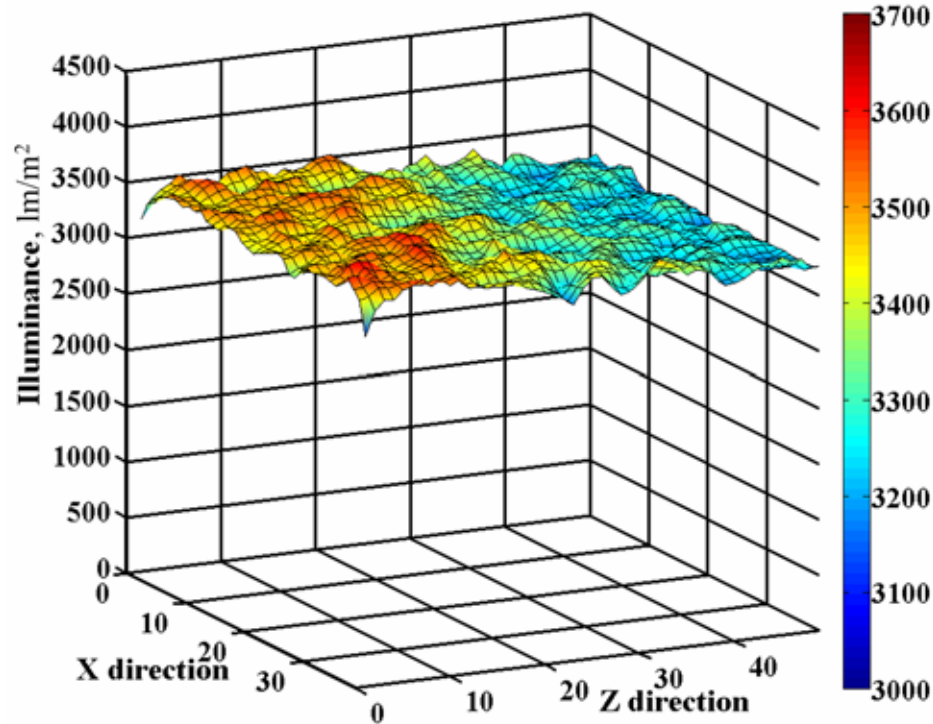
(c)



疊代過程

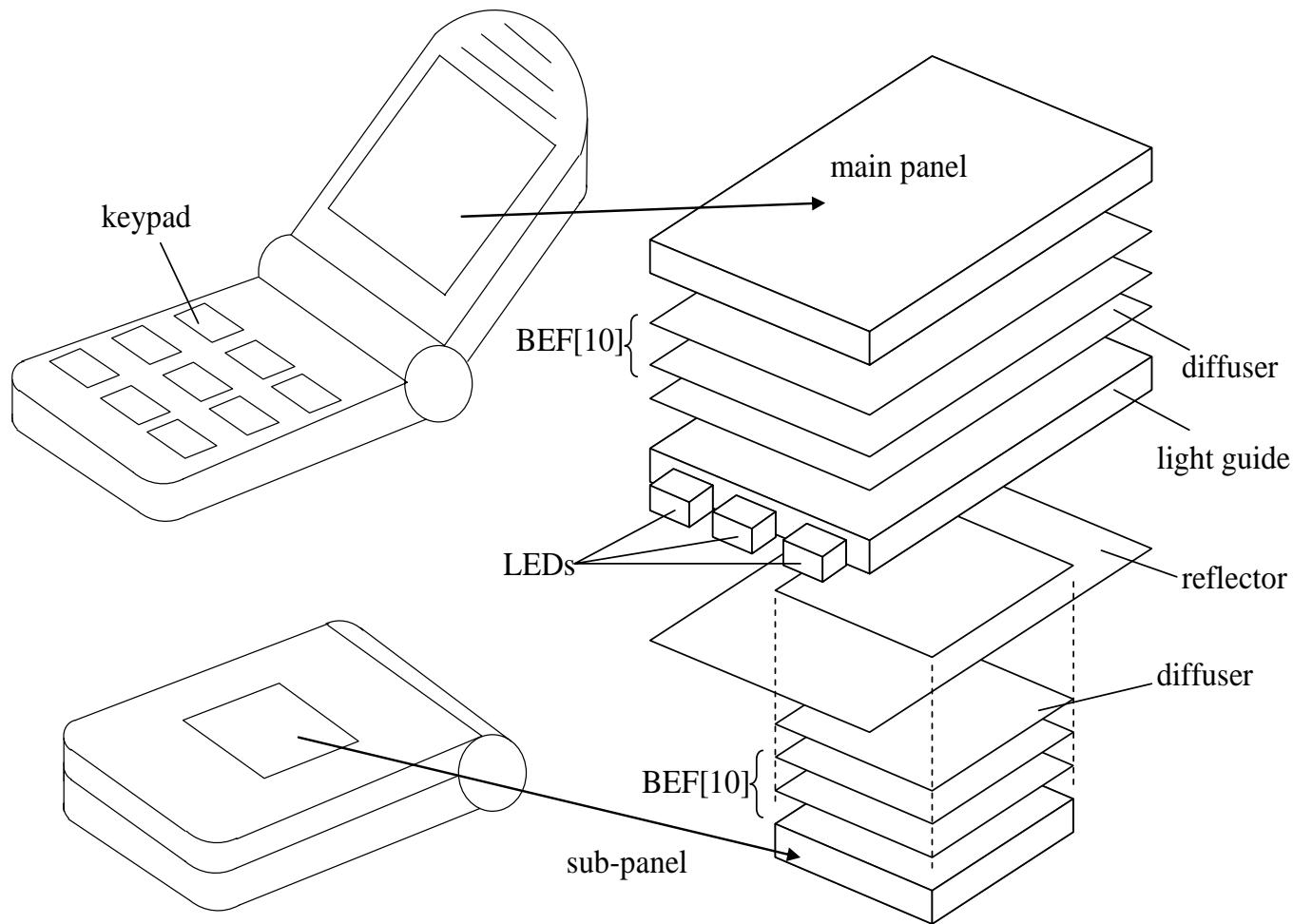


- 最後照度(illumination)

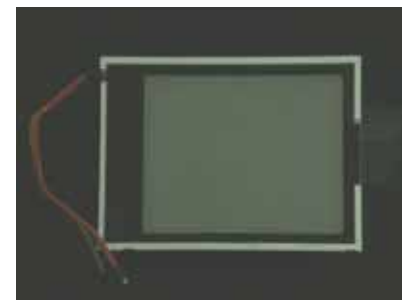


$$L_{0,ij} = -\frac{4}{\sqrt{2} \cdot \pi^{3/2}} \cdot \frac{1}{\sigma \cdot e^{-2\sigma^2}} \cdot \frac{1}{\left[\operatorname{Erfi}\left(\frac{2\sigma^2 + i\theta}{\sqrt{2}\sigma}\right) - \operatorname{Erfi}\left(\frac{-2\sigma^2 + i\theta}{\sqrt{2}\sigma}\right) \right]^{\pi/2}} \cdot \frac{\Phi_{ij}}{A_{ij}}$$

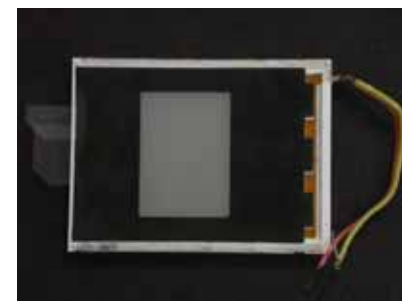
• 雙面背光模組



LED 雙面邊光式背光模組



主屏

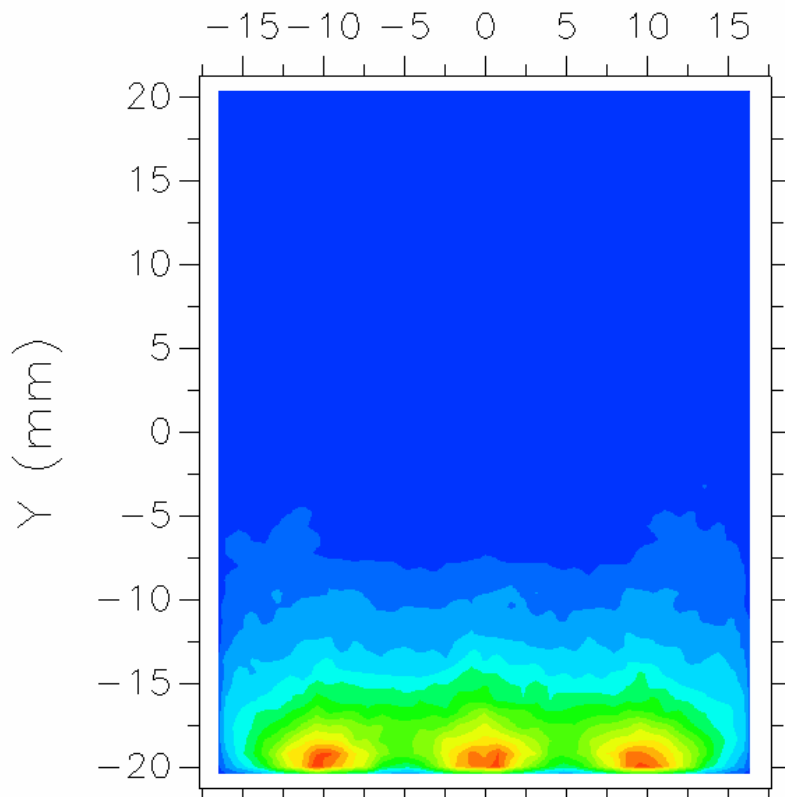


副屏

- 雙面背光模組等密度網點分佈之光學模擬結果

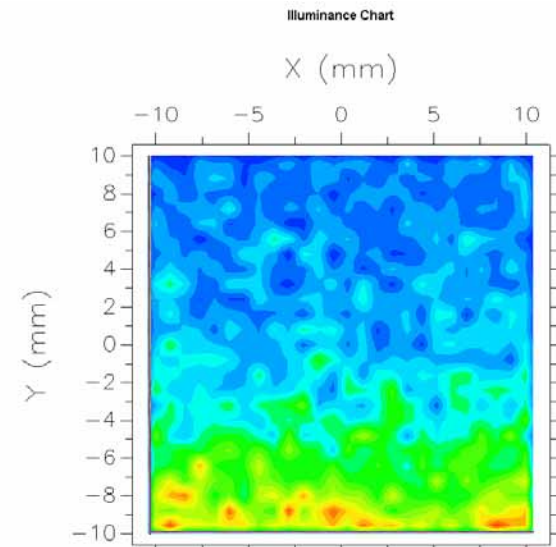
第一次疊代(等密度)

主屏光學模結果

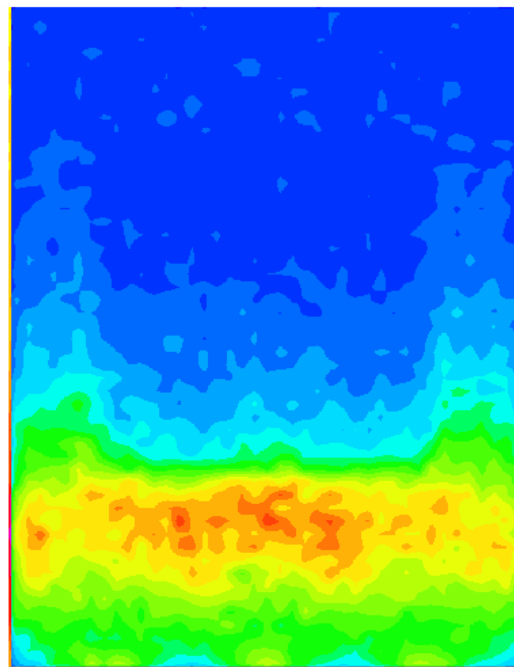
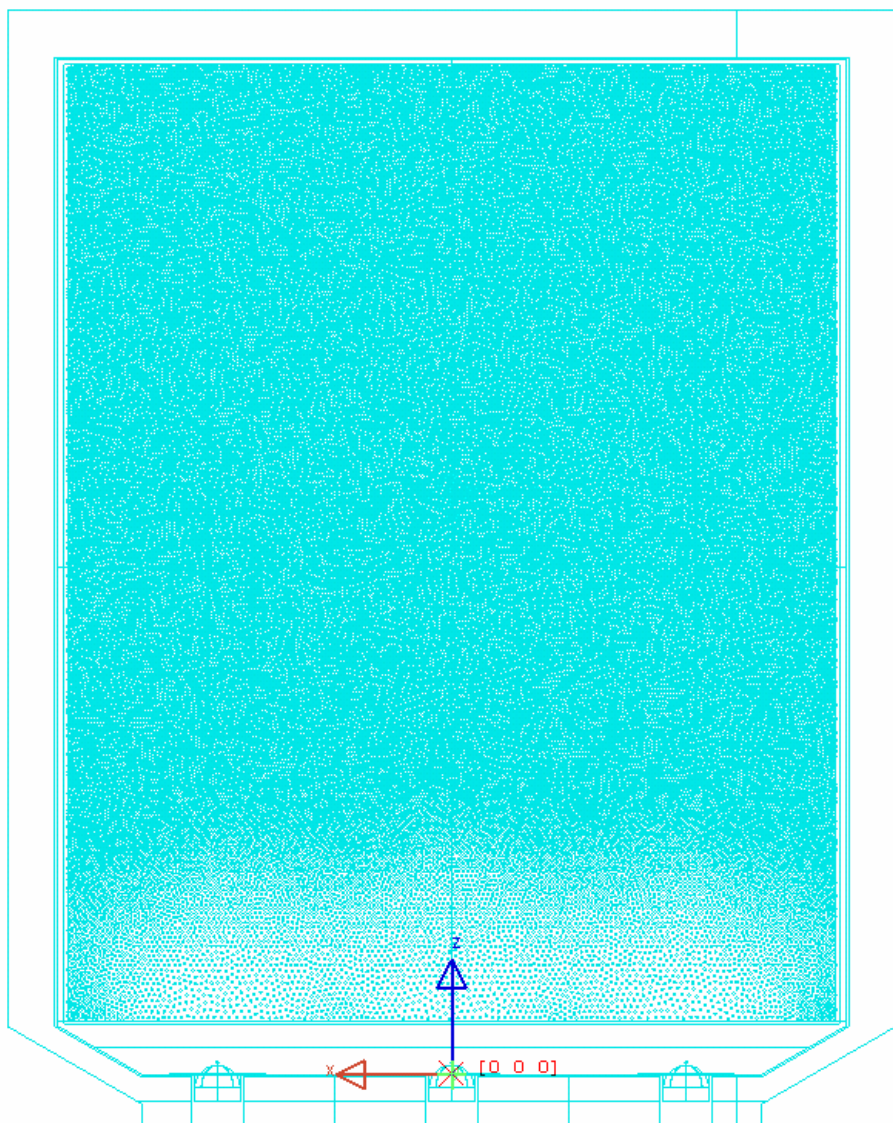


第一次疊代(等密度)

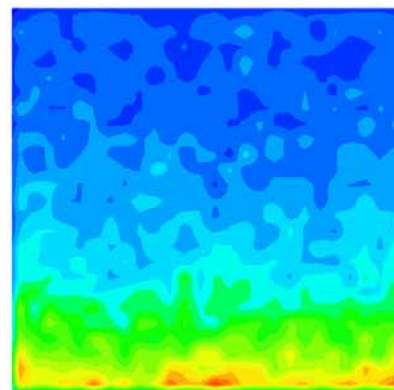
副屏光學模結果



第二次疊代網點分佈圖及 主副屏光學模結果



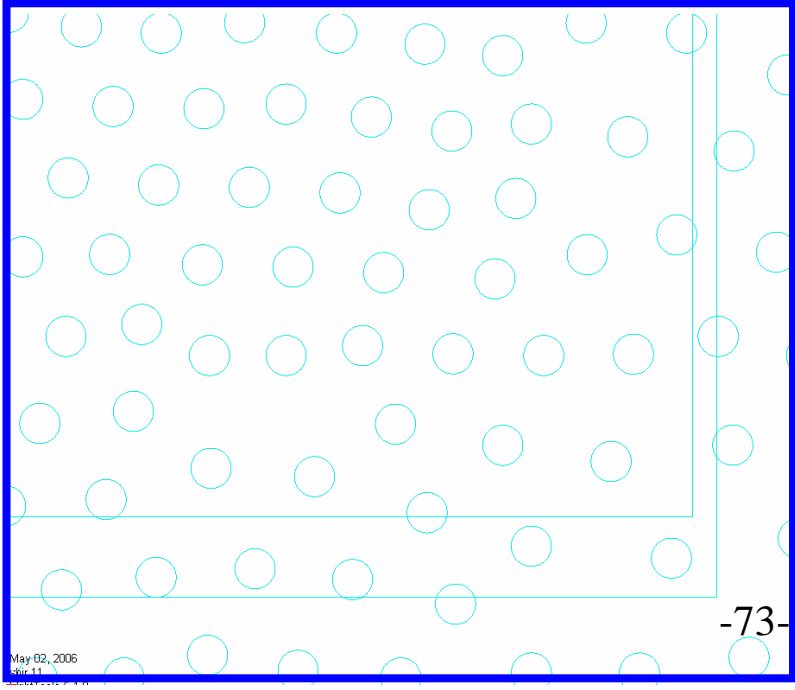
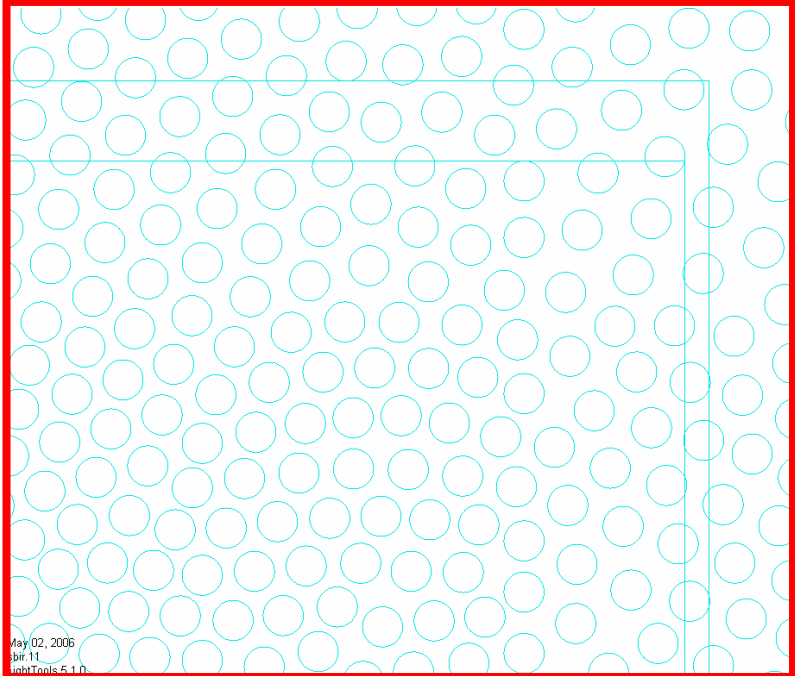
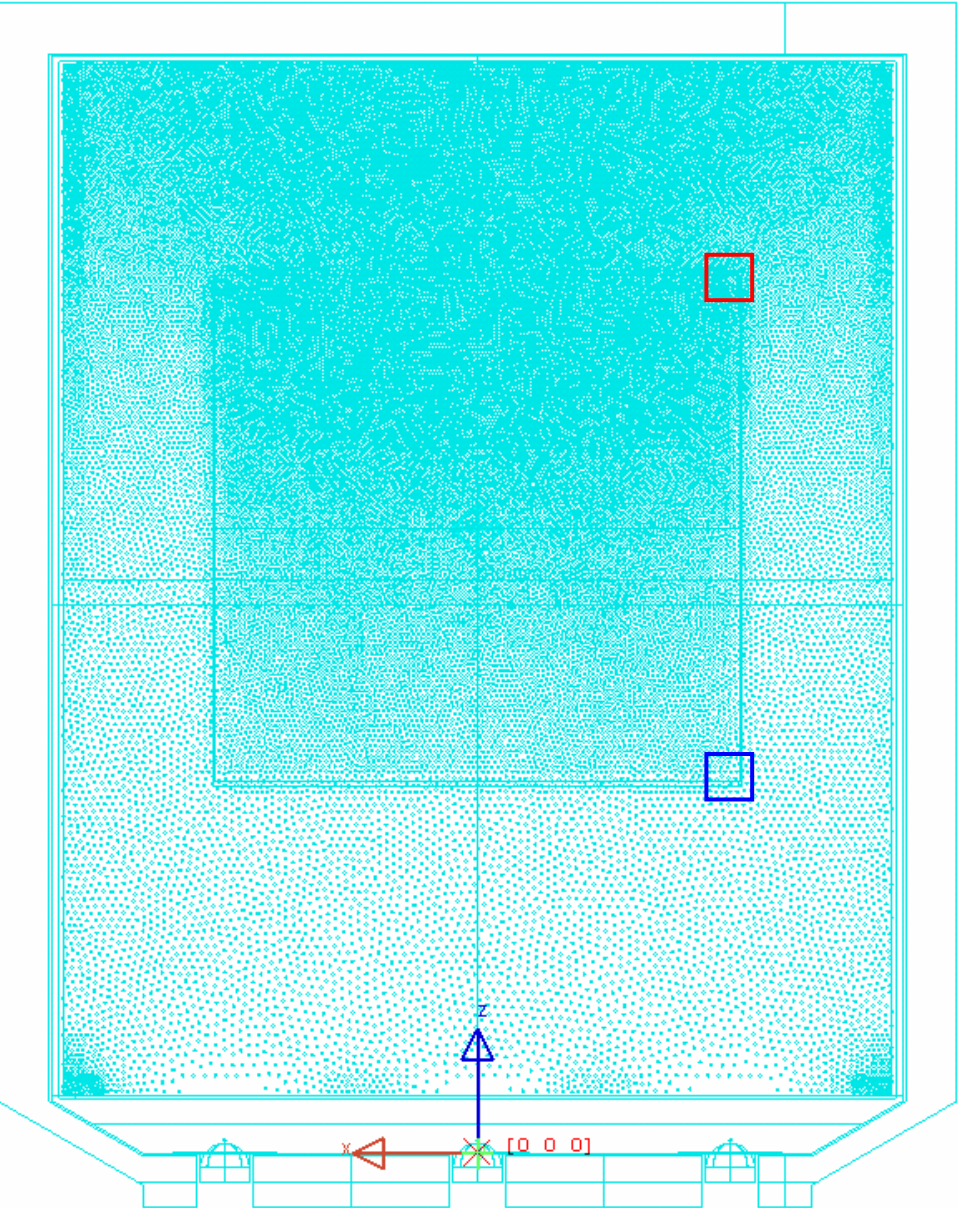
主屏



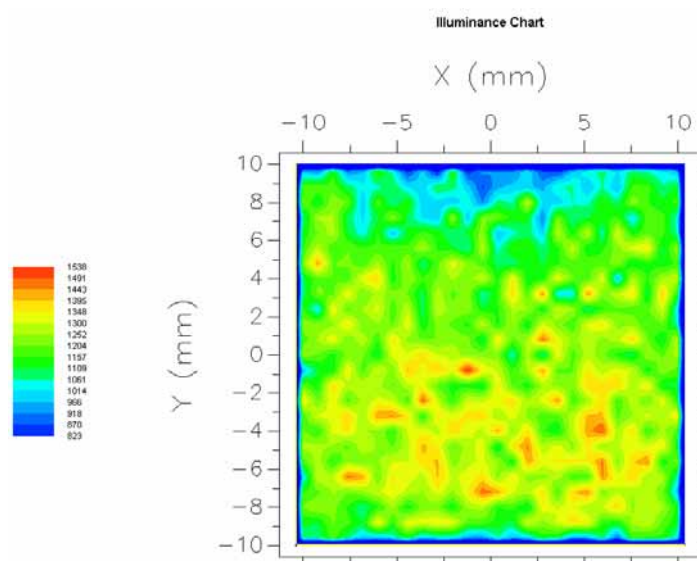
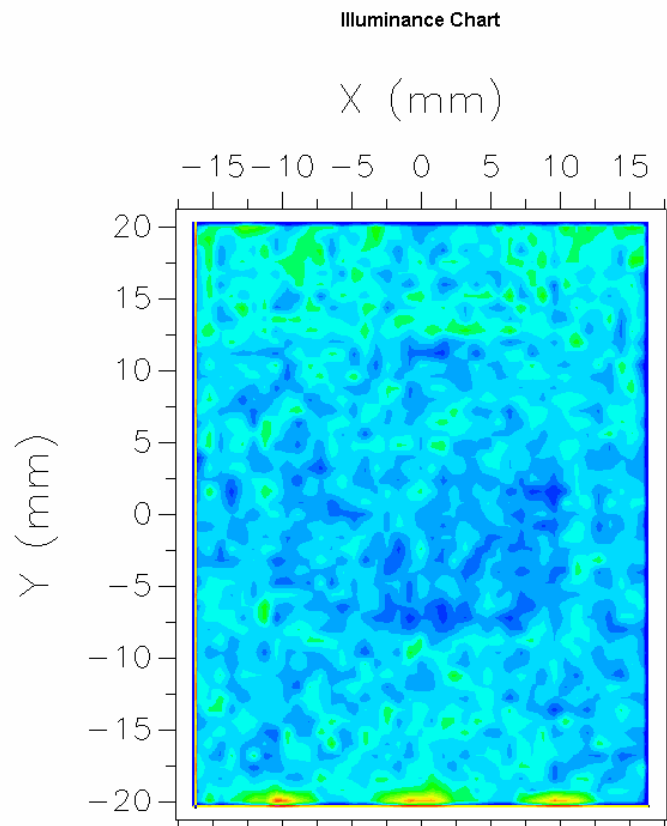
副屏

達成設計需求之雙面導光板網點分佈

(疊代11次)



• Illumination 分佈

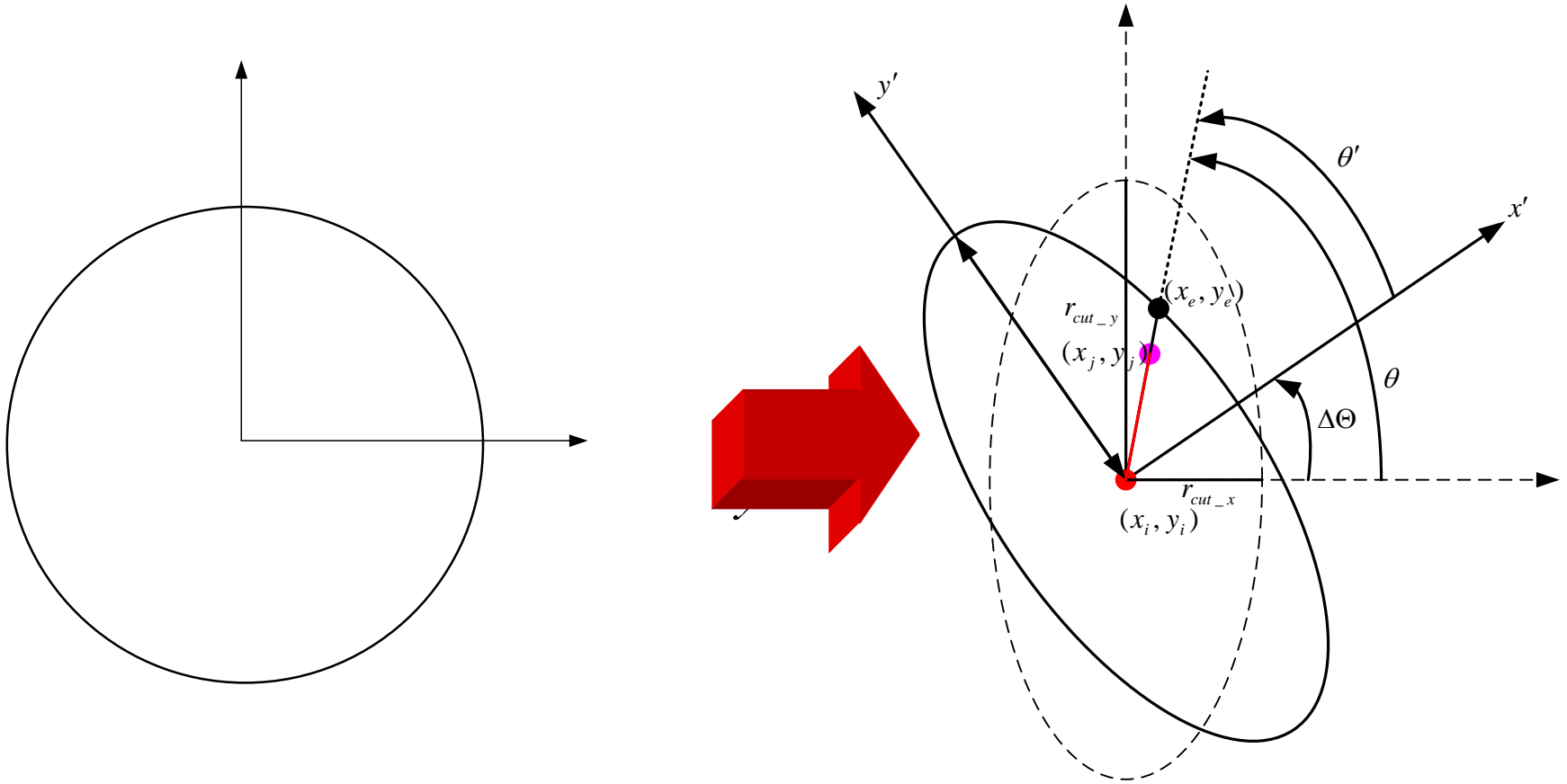


達成設計需求之主屏光學模擬結果
(疊代11次)

達成設計需求之副屏光學
模擬結果(疊代11次)

間距可調式亂數微結構排列方法

- 可調式力場



• 橢圓力場方程式

$$\theta' = \theta - \Delta\Theta$$

$$\theta = \tan^{-1} \left(\frac{y_j - y_i}{x_j - x_i} \right)$$

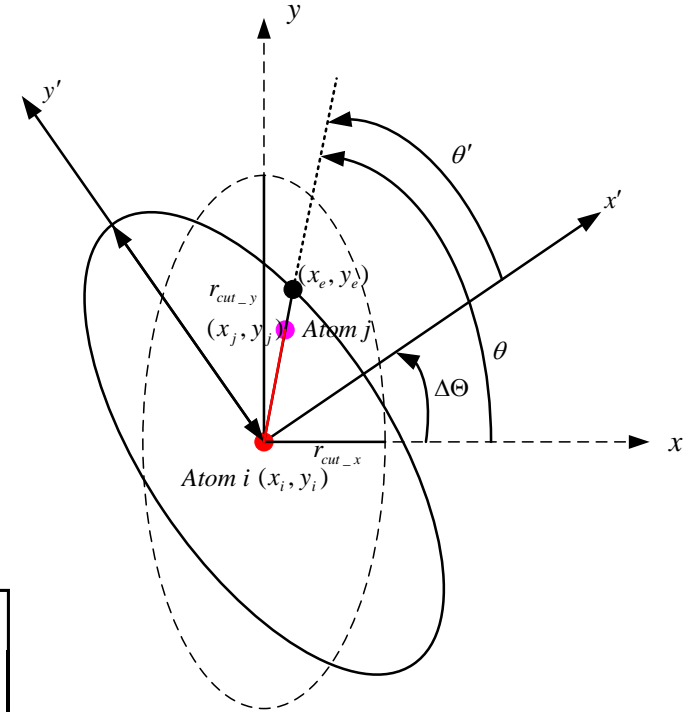
$$x'_e = r_{cut_x} \cos \theta' \quad y'_e = r_{cut_y} \sin \theta'$$

$$\begin{bmatrix} x_e - x_i \\ y_e - y_i \end{bmatrix} = \begin{bmatrix} \cos \Delta\Theta & -\sin \Delta\Theta \\ \sin \Delta\Theta & \cos \Delta\Theta \end{bmatrix} \cdot \begin{bmatrix} x'_e \\ y'_e \end{bmatrix}$$

$$r_{cut_e} = \sqrt{(x_e - x_i)^2 + (y_e - y_i)^2} \quad r_{ij} = \sqrt{(x_j - x_i)^2 + (y_j - y_i)^2}$$

$$\mathbf{f}(r_{ij}) = \frac{\mathbf{r}_{ij}}{|\mathbf{r}_{ij}|} e^{-(r_{ij} c_{kl})}$$

$$c_{kl} = \frac{-\ln(f_{re_x} \cos \theta' + f_{re_y} \sin \theta')}{r_{cut_e}}$$



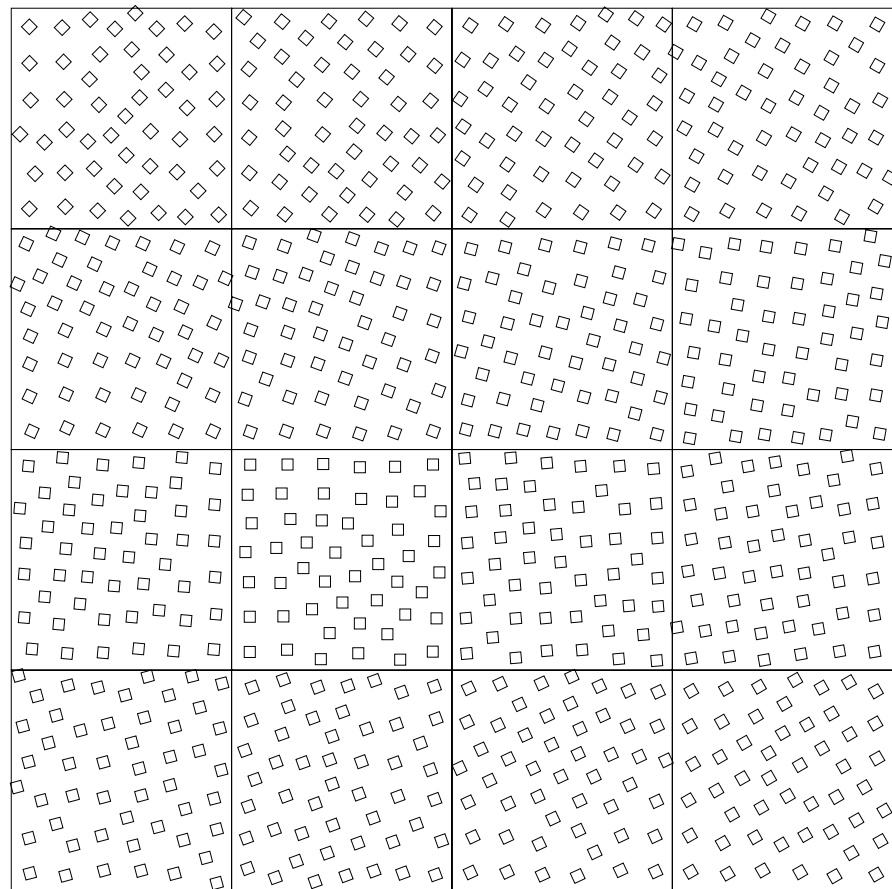
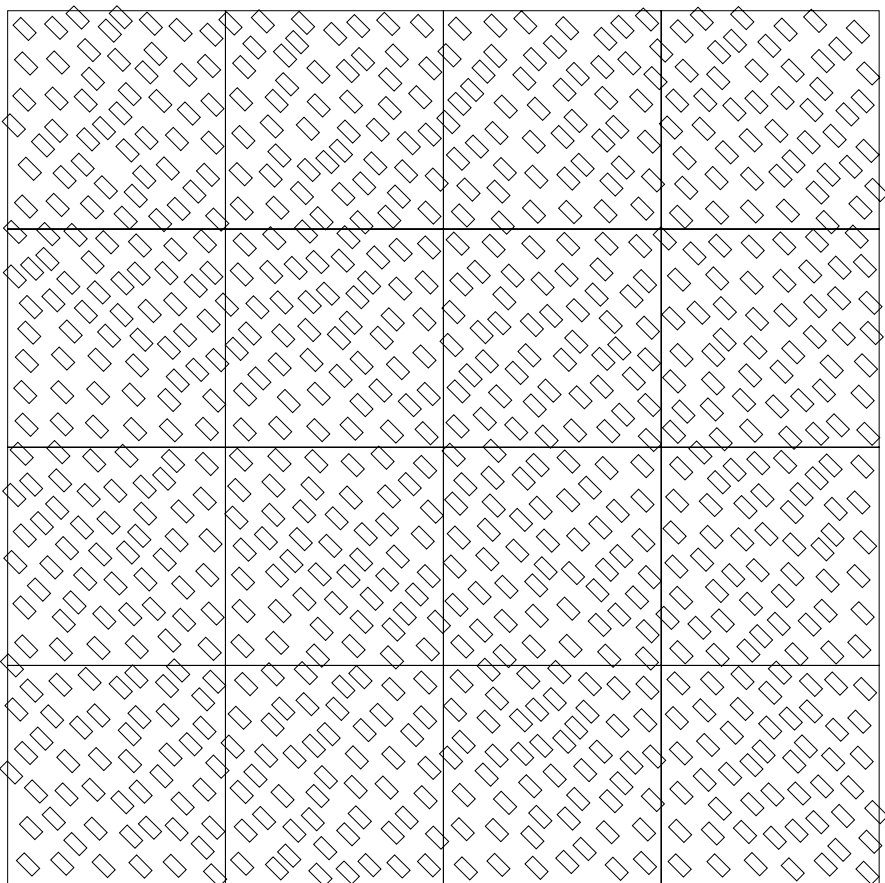
- r-cut 求法

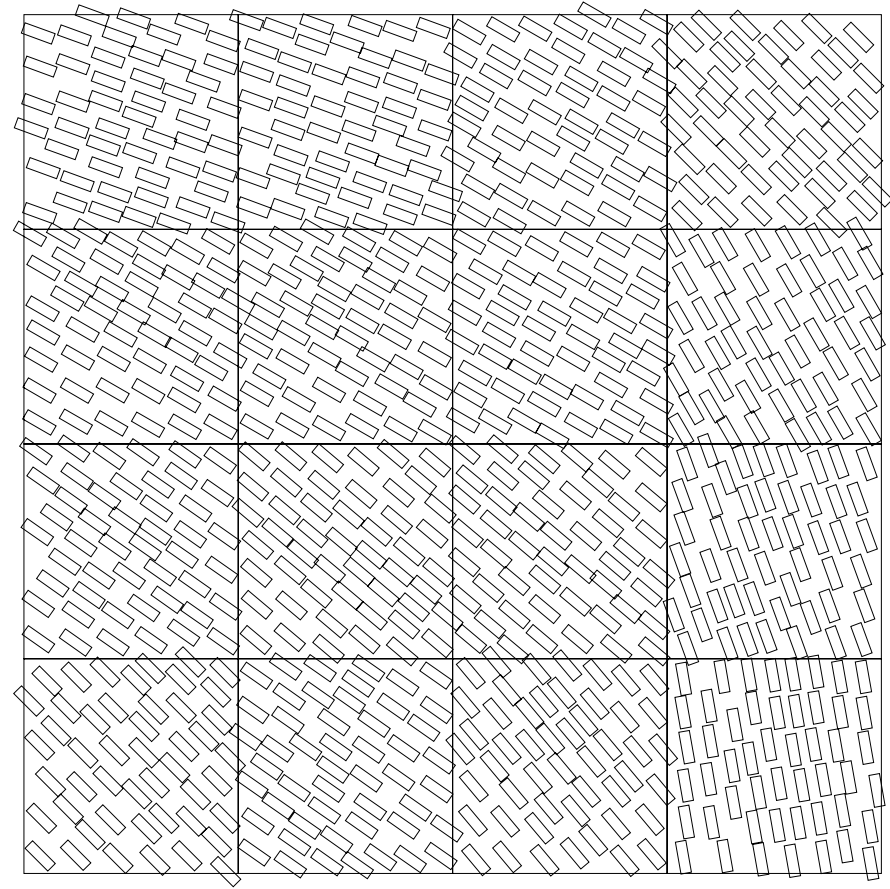
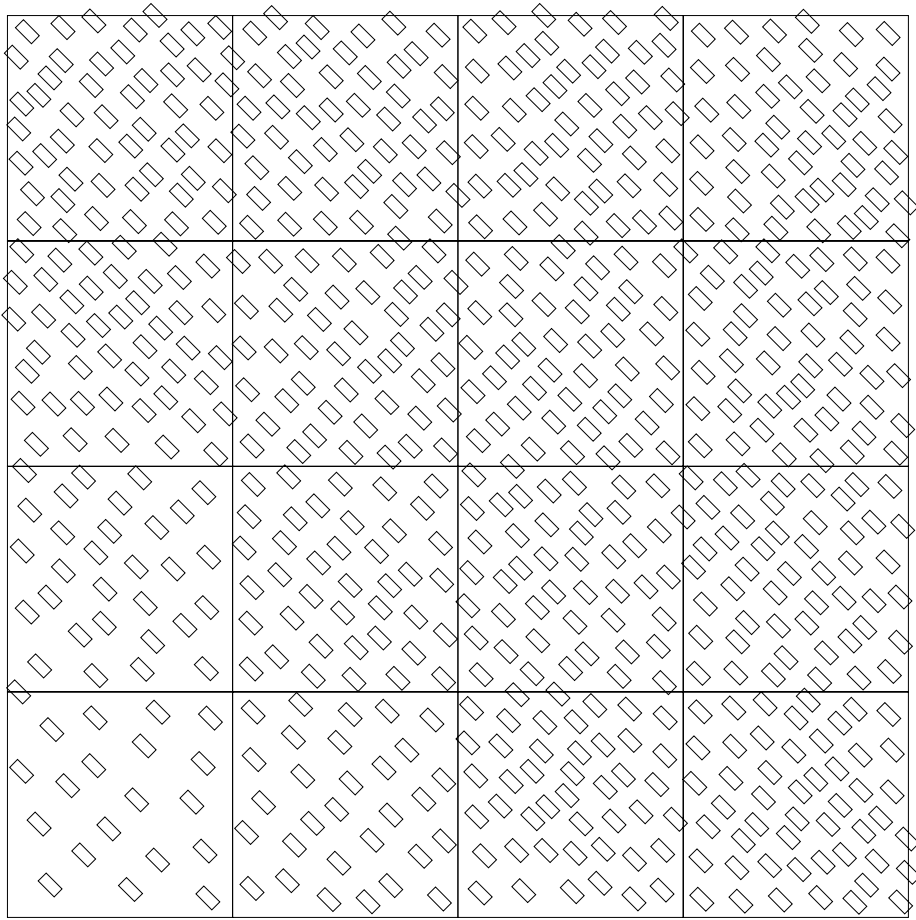
$$r_{cut_x} = \sqrt{\frac{A_{cell}}{m_{kl} \cdot \pi \cdot ell_r}}$$

$$r_{cut_y} = \sqrt{\frac{A_{cell} \cdot ell_r}{m_{kl} \cdot \pi}}$$

$$r_{cut_y} = ell_r \cdot r_{cut_x}$$

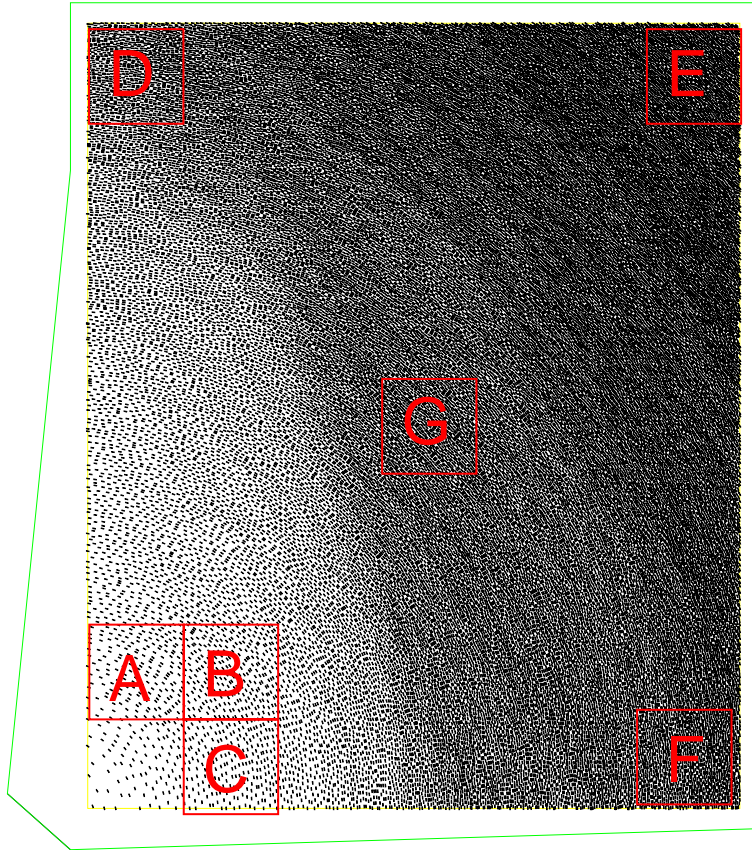
- 範例
 - 非等向力場之排列



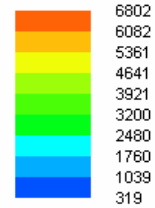


- 範例
 - 光學結合網點排列

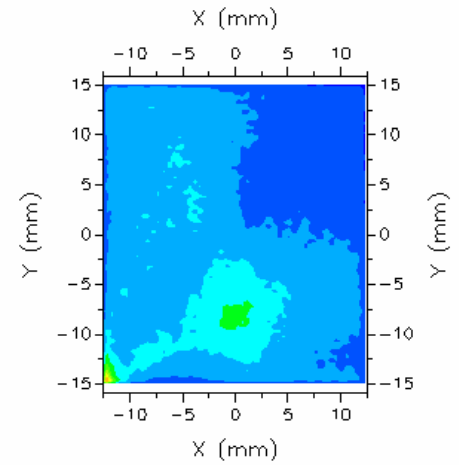
- 起始網點



Illuminance	
Min	318.957 Lux
Max	6802.100 Lux
Average	1339.869 Lux
Total Flux	
Units	Lumen
Incident	0.997 Lumen

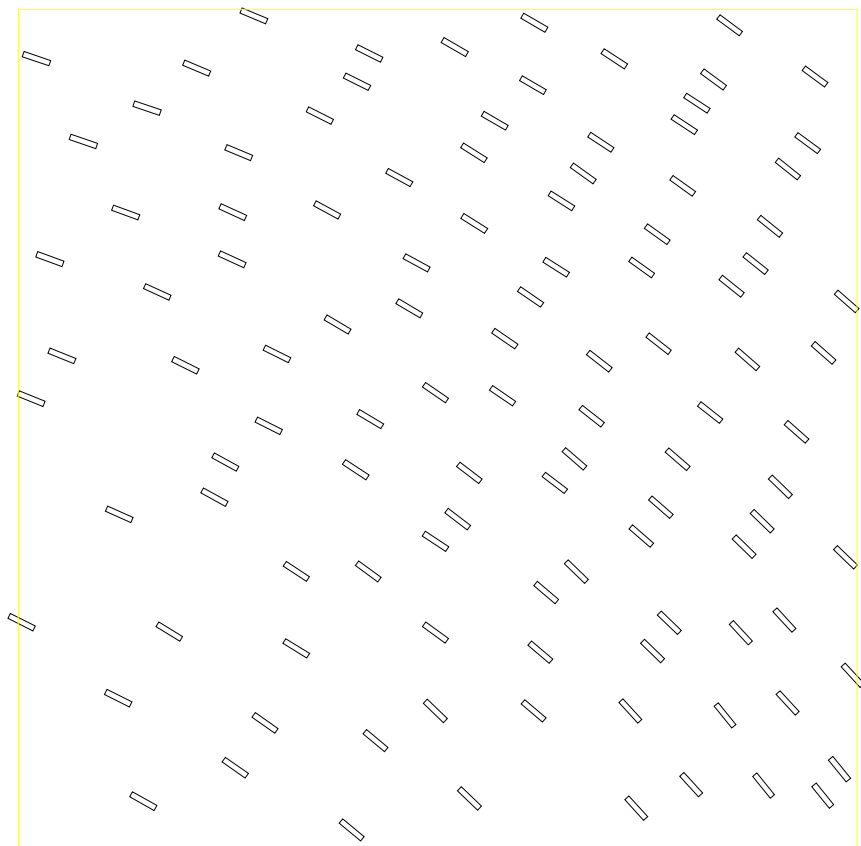


Illuminance Chart

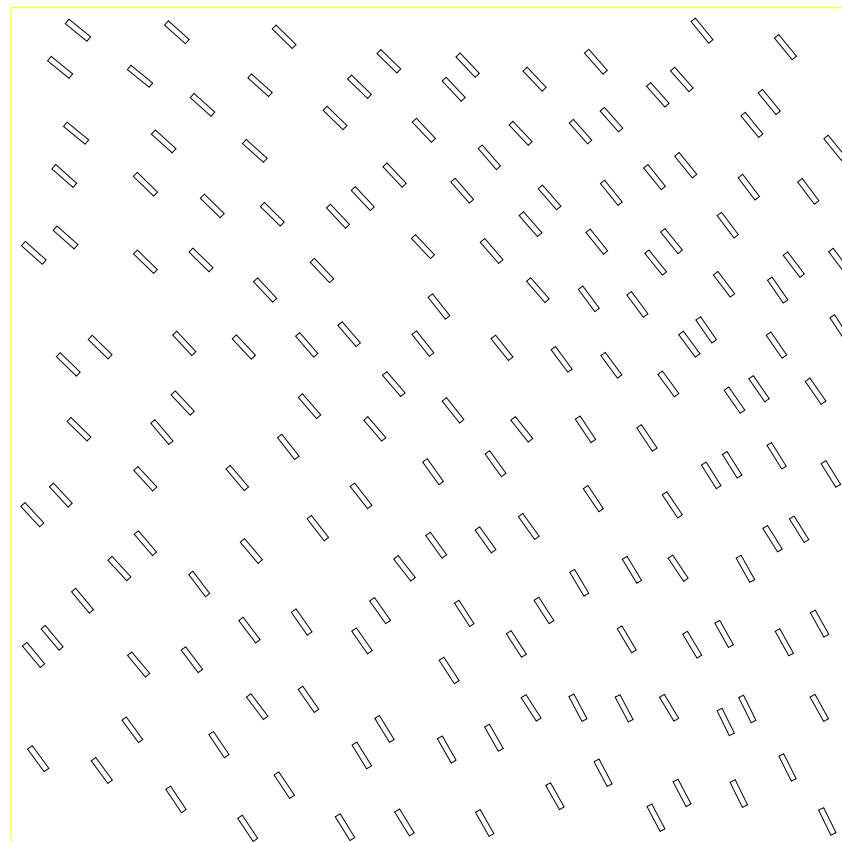


X (mm) = -0.422778, Y (mm) = -0.372381, Value = 1344.13

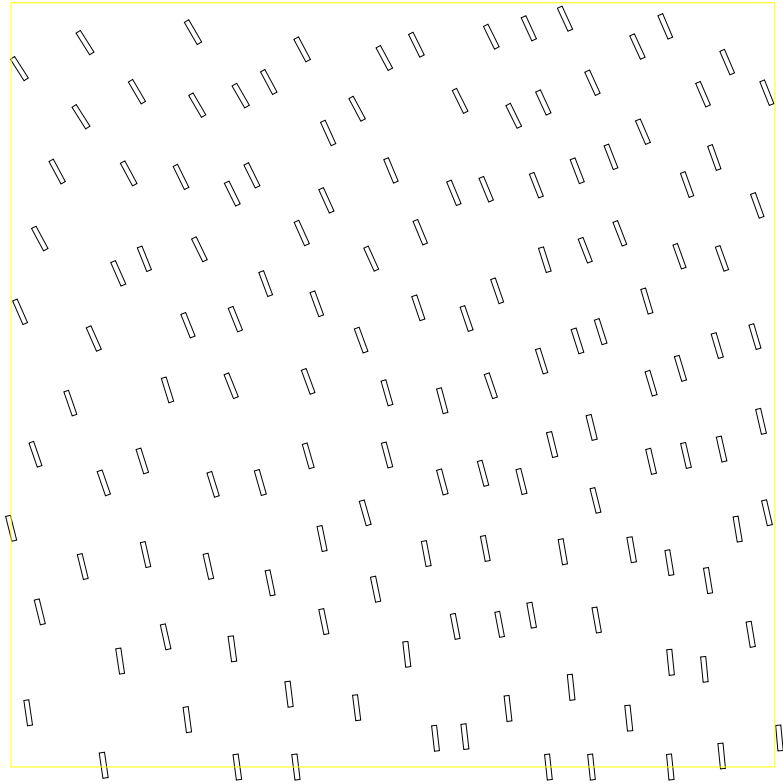
A



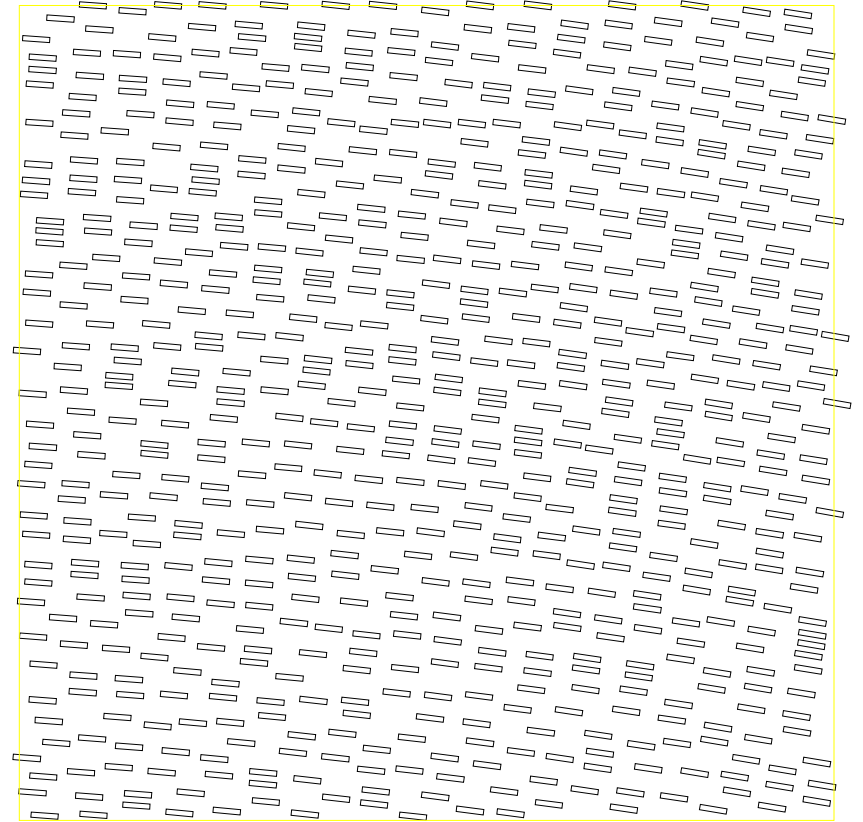
B



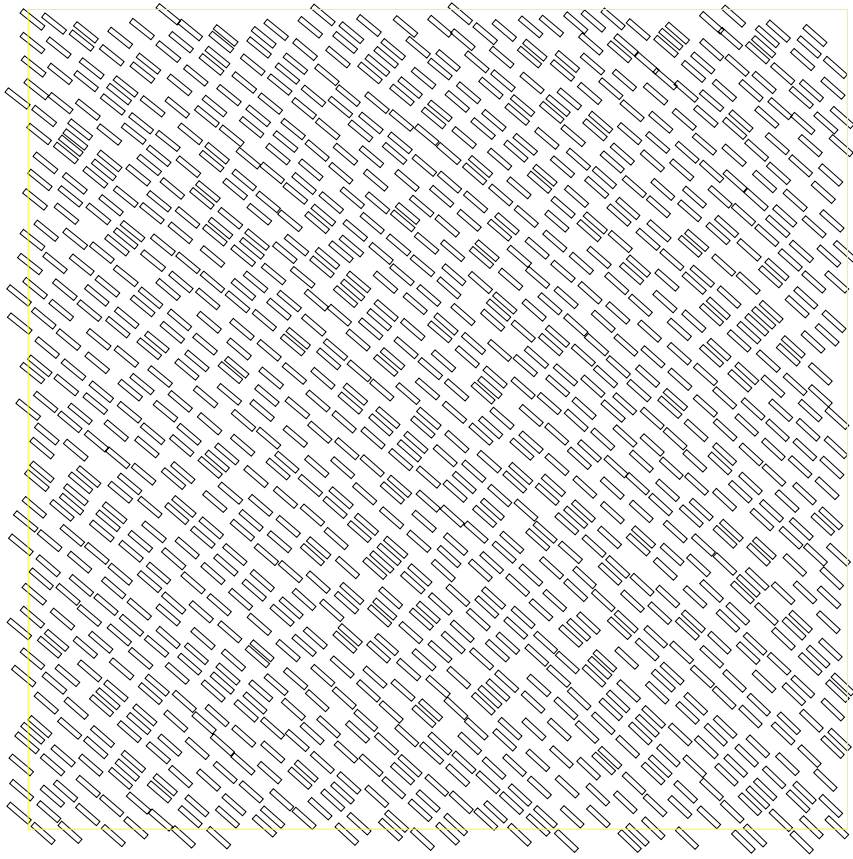
C



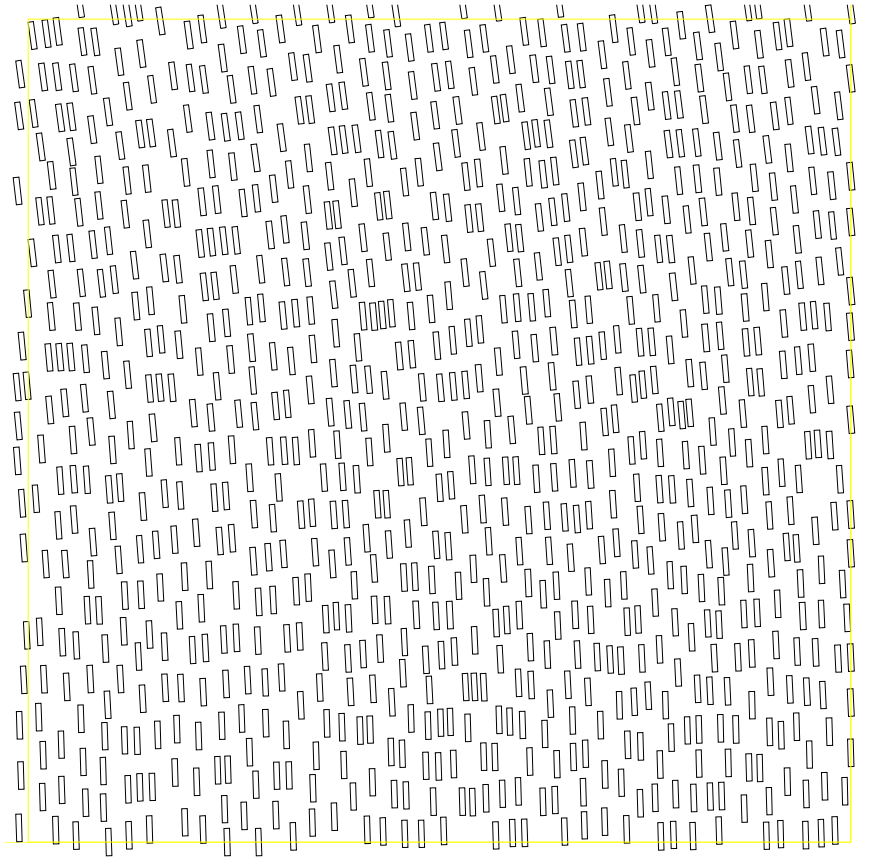
D



E

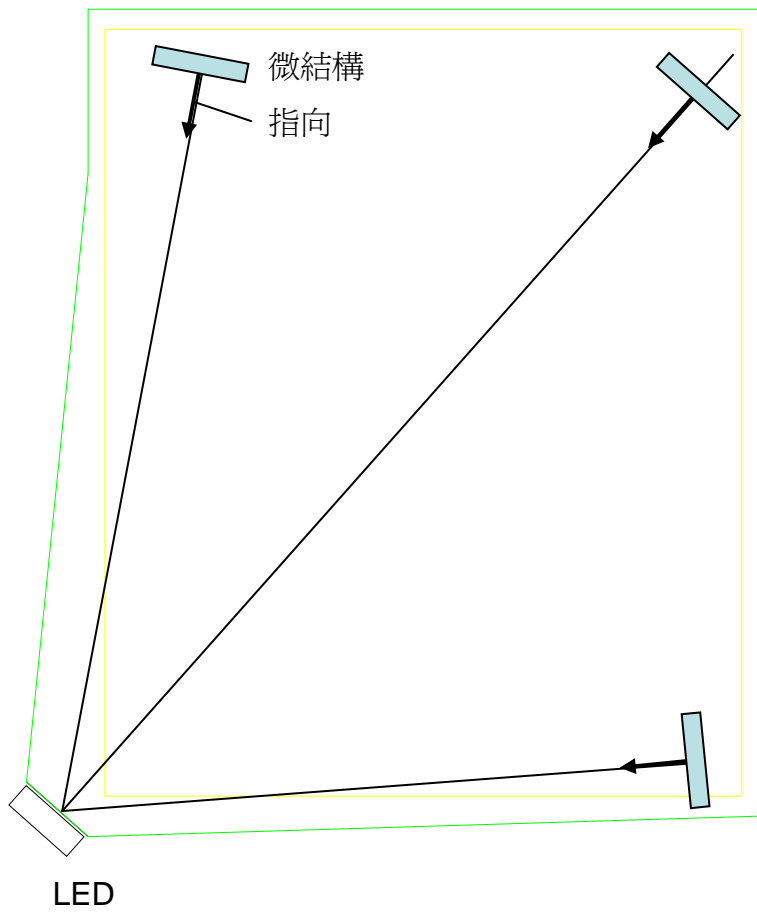


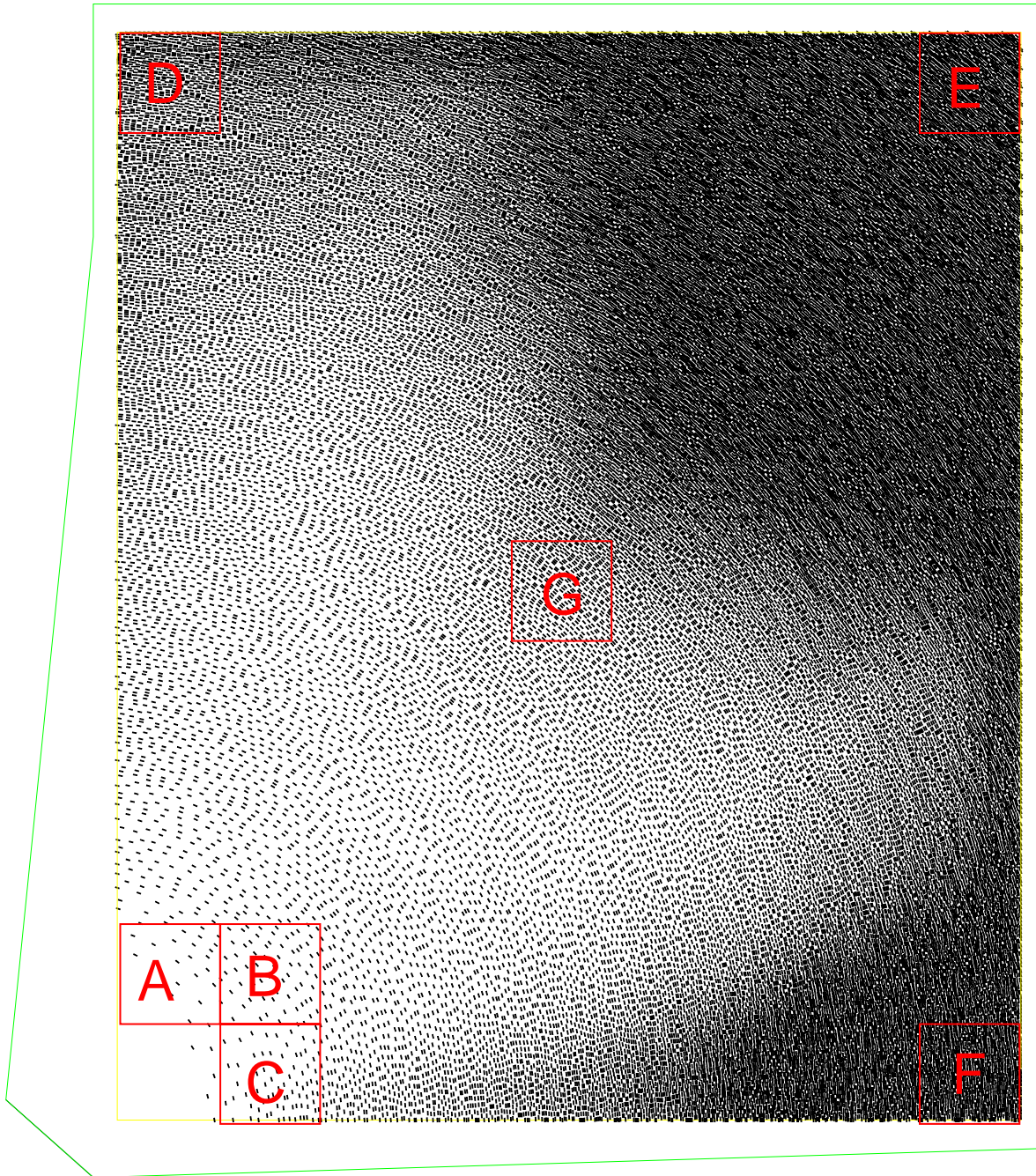
F



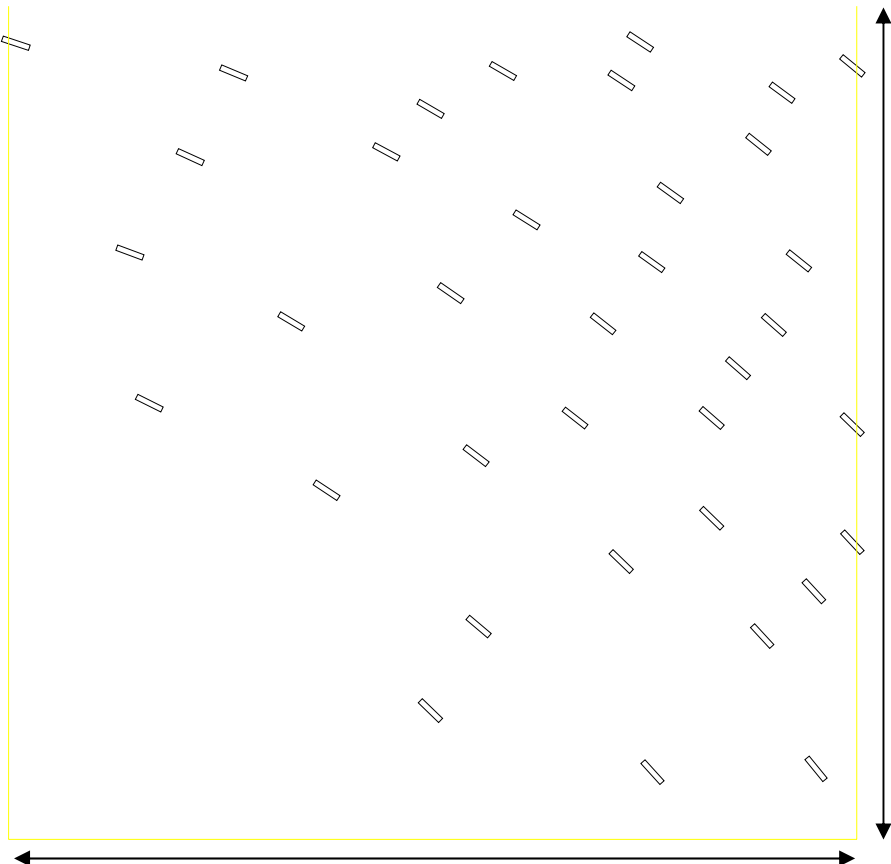
G



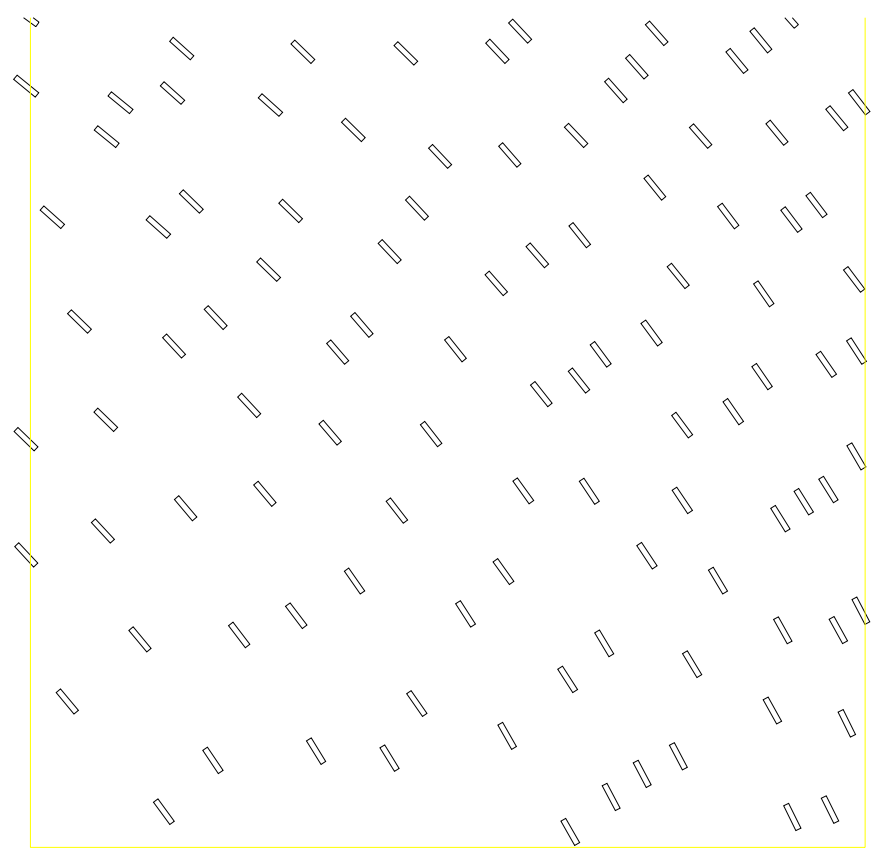




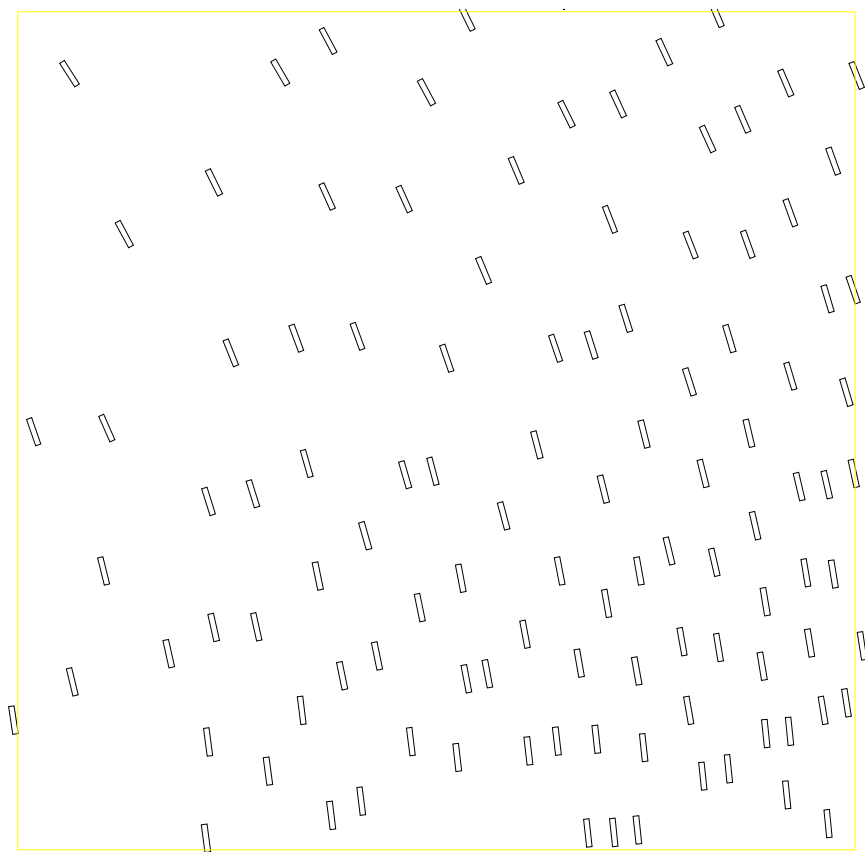
A



B



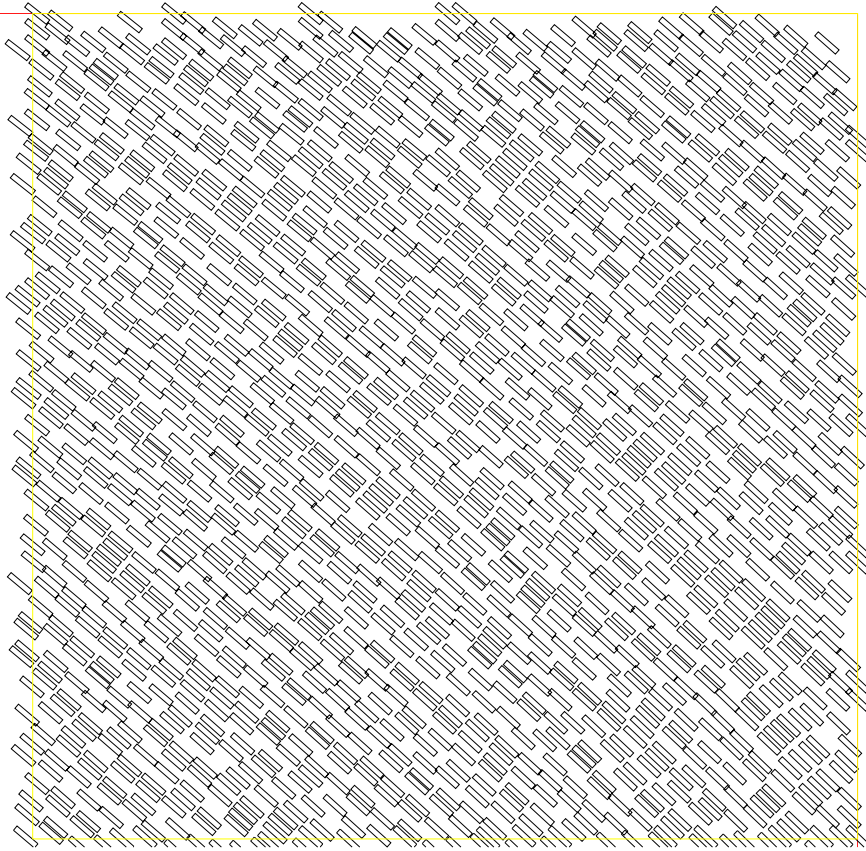
C



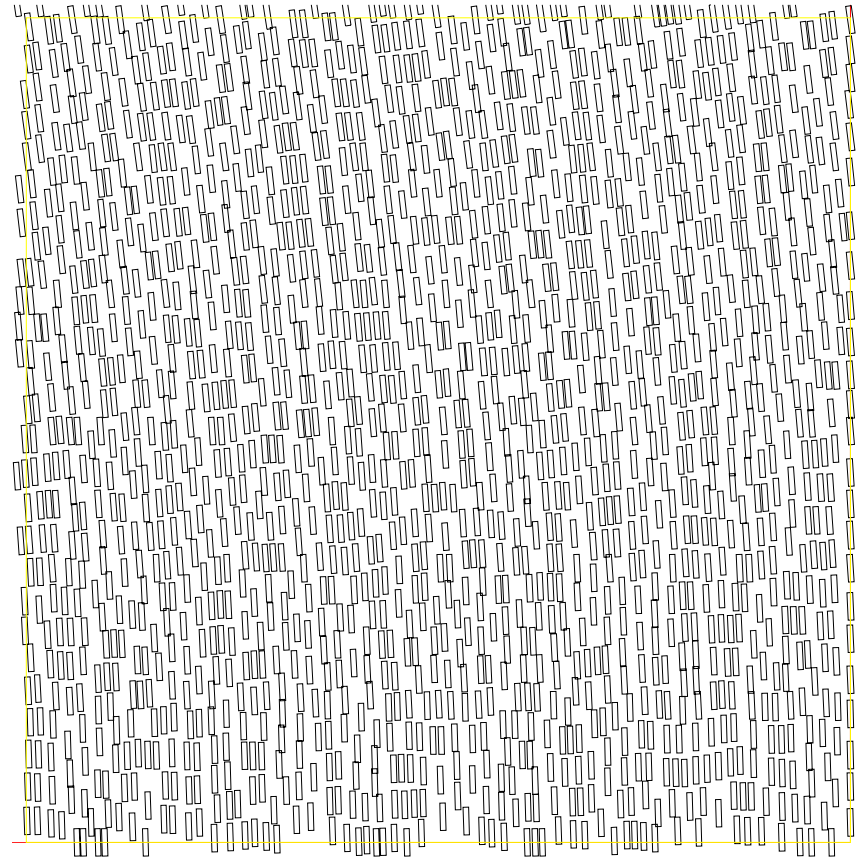
D



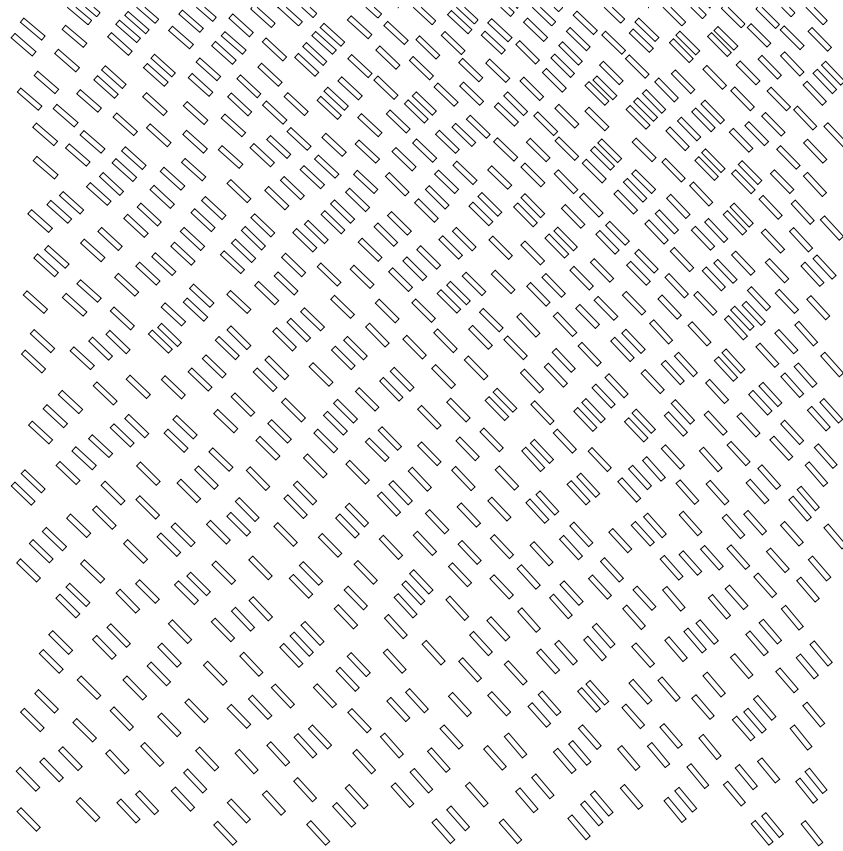
E



F



G



- 實質效應
 - 縮短開發時程
 - 減少試誤法及後製所浪費之時間
 - 簡省金錢
 - 時間就是金錢(無法接單更是一大損失)



Thank you!