

+

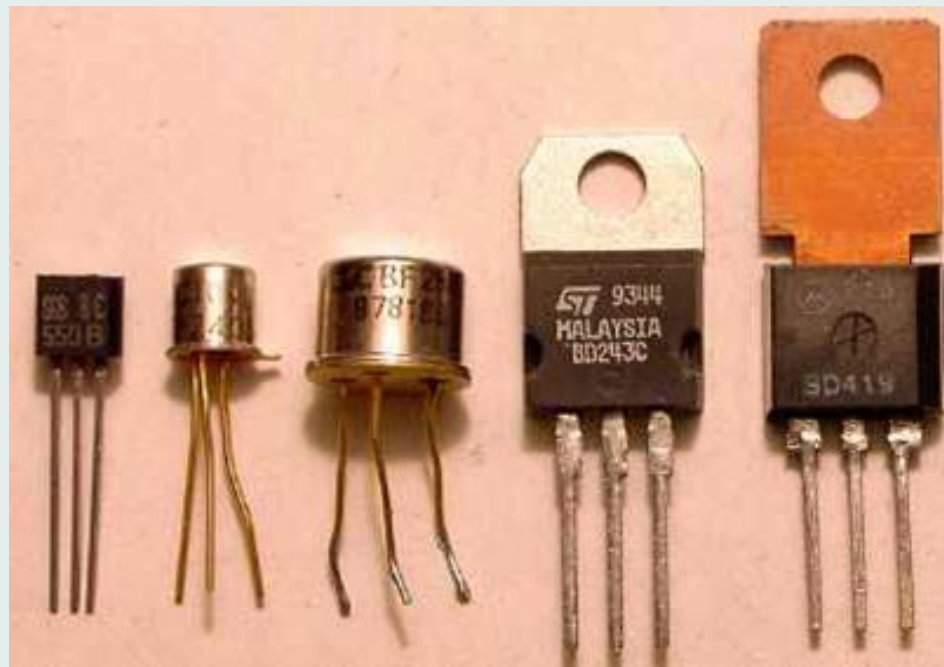
沙子到黃金 ——一個電晶體的誕生

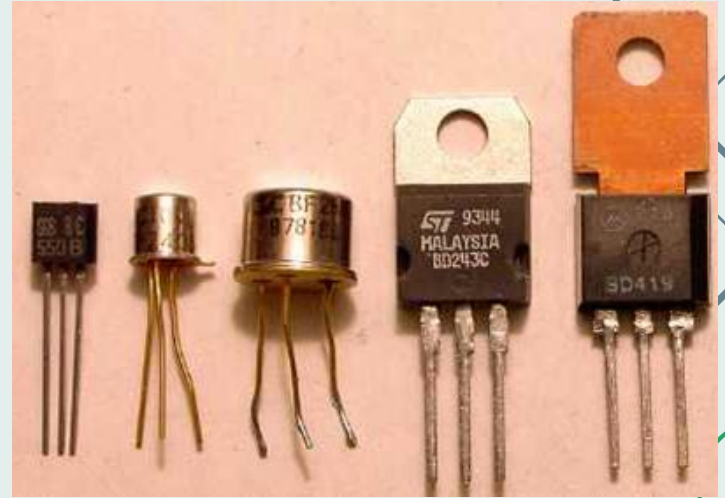
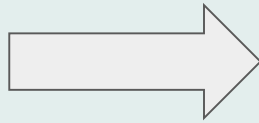
鍊金術師：翁宥縈、郭芯妤、張丞希

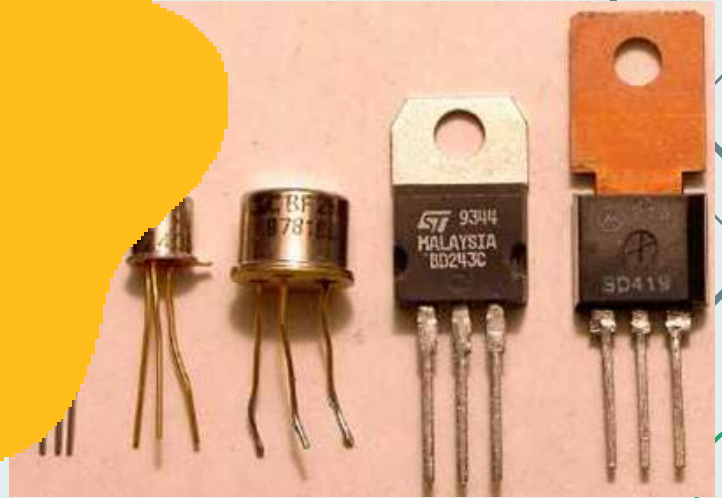
你看過沙子嗎？



你看過電晶體嗎？







半導體

(semiconductor)



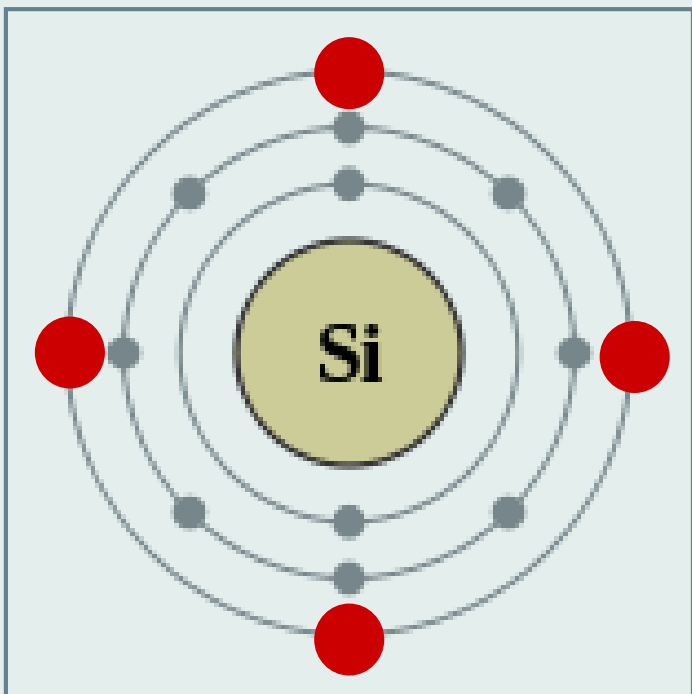


常見的半導體材料:矽 (Si)、鍺 (Ge)、...

族 →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1 週期	1 H 氫																		2 He 氦
2	3 Li 鋰	4 Be 鈹											5 B 硼	6 C 碳	7 N 氮	8 O 氧	9 F 氟	10 Ne 氖	
3	11 Na 鈉	12 Mg 鎂											13 Al 鋁	14 Si 矽	15 P 磷	16 S 硫	17 Cl 氯	18 Ar 氬	
4	19 K 鉀	20 Ca 鈣	21 Sc 鈦	22 Ti 鈦	23 V 釩	24 Cr 鉻	25 Mn 錳	26 Fe 鐵	27 Co 鈷	28 Ni 鎳	29 Cu 銅	30 Zn 鋅	31 Ga 鎵	32 Ge 鍺	33 As 砷	34 Se 硒	35 Br 溴	36 Kr 氪	
5	37 Rb 銣	38 Sr 銻	39 Y 釷	40 Zr 鈷	41 Nb 鈮	42 Mo 鉬	43 Tc 錳	44 Ru 鈷	45 Rh 銲	46 Pd 鈀	47 Ag 銀	48 Cd 鎘	49 In 銦	50 Sn 錫	51 Sb 銻	52 Te 碲	53 I 碘	54 Xe 氙	
6	55 Cs 銫	56 Ba 鋇	銅系	72 Hf 鈷	73 Ta 鉭	74 W 鎢	75 Re 錳	76 Os 銱	77 Ir 銲	78 Pt 鉑	79 Au 金	80 Hg 汞	81 Tl 鉍	82 Pb 鉛	83 Bi 鉍	84 Po 釷	85 At 砒	86 Rn 氡	
7	87 Fr 銣	88 Ra 釷	銅系	104 Rf 鈷	105 Db 鉭	106 Sg 錳	107 Bh 錳	108 Hs 銱	109 Mt 銲	110 Ds 鉑	111 Rg 銲	112 Cn 鉍	113 Nh 鉍	114 Fl 鉍	115 Mc 鉍	116 Lv 鉍	117 Ts 鉍	118 Og 鉍	

銅系元素	57 La 釷	58 Ce 釷	59 Pr 釷	60 Nd 釷	61 Pm 釷	62 Sm 釷	63 Eu 釷	64 Gd 釷	65 Tb 釷	66 Dy 釷	67 Ho 釷	68 Er 釷	69 Tm 釷	70 Yb 釷	71 Lu 釷
銻系元素	89 Ac 釷	90 Th 釷	91 Pa 釷	92 U 釷	93 Np 釷	94 Pu 釷	95 Am 釷	96 Cm 釷	97 Bk 釷	98 Cf 釷	99 Es 釷	100 Fm 釷	101 Md 釷	102 No 釷	103 Lr 釷





每個矽原子有4個價電子

在常溫情況下，各原子之間會形成共價鍵



一、矽的純化

將砂土放入高溫爐進行反應

目的: 去除砂土雜質, 讓他們變乾淨

最終產物: 高純度多晶矽 (乾淨的沙)



二、矽晶柱長晶

目的:使矽原子整齊排列

過程:將高純度的多晶矽(乾淨的矽)放入高溫爐中長晶

最終產物:高純度單晶矽晶柱(減重又長高)



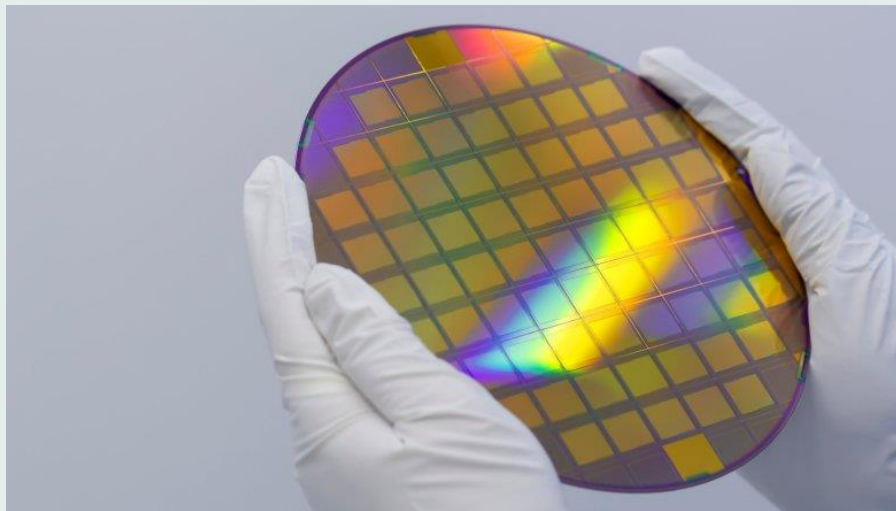
× ×





+

三、矽晶柱->晶圓



× ×
× ×

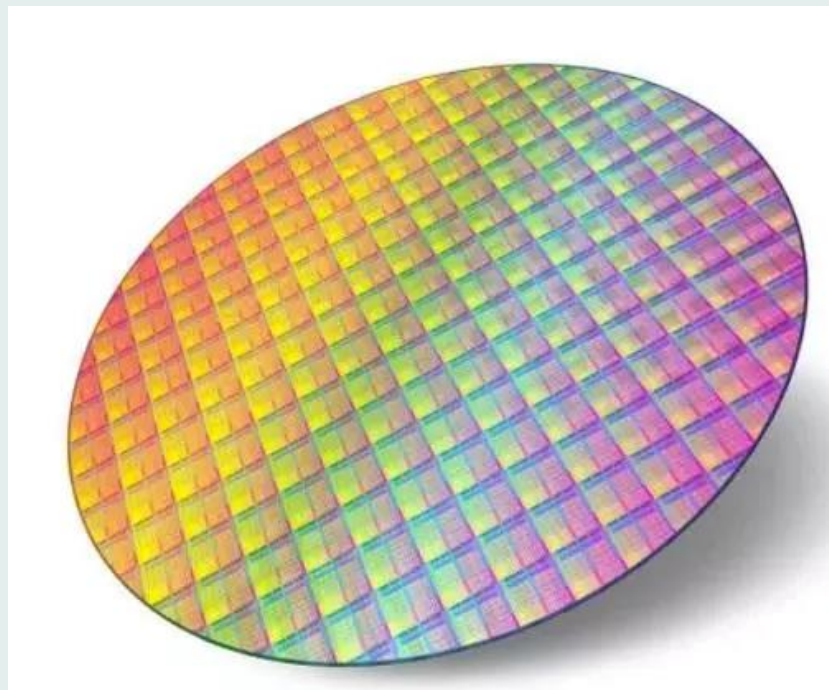


三、矽晶柱->晶圓



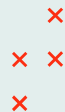
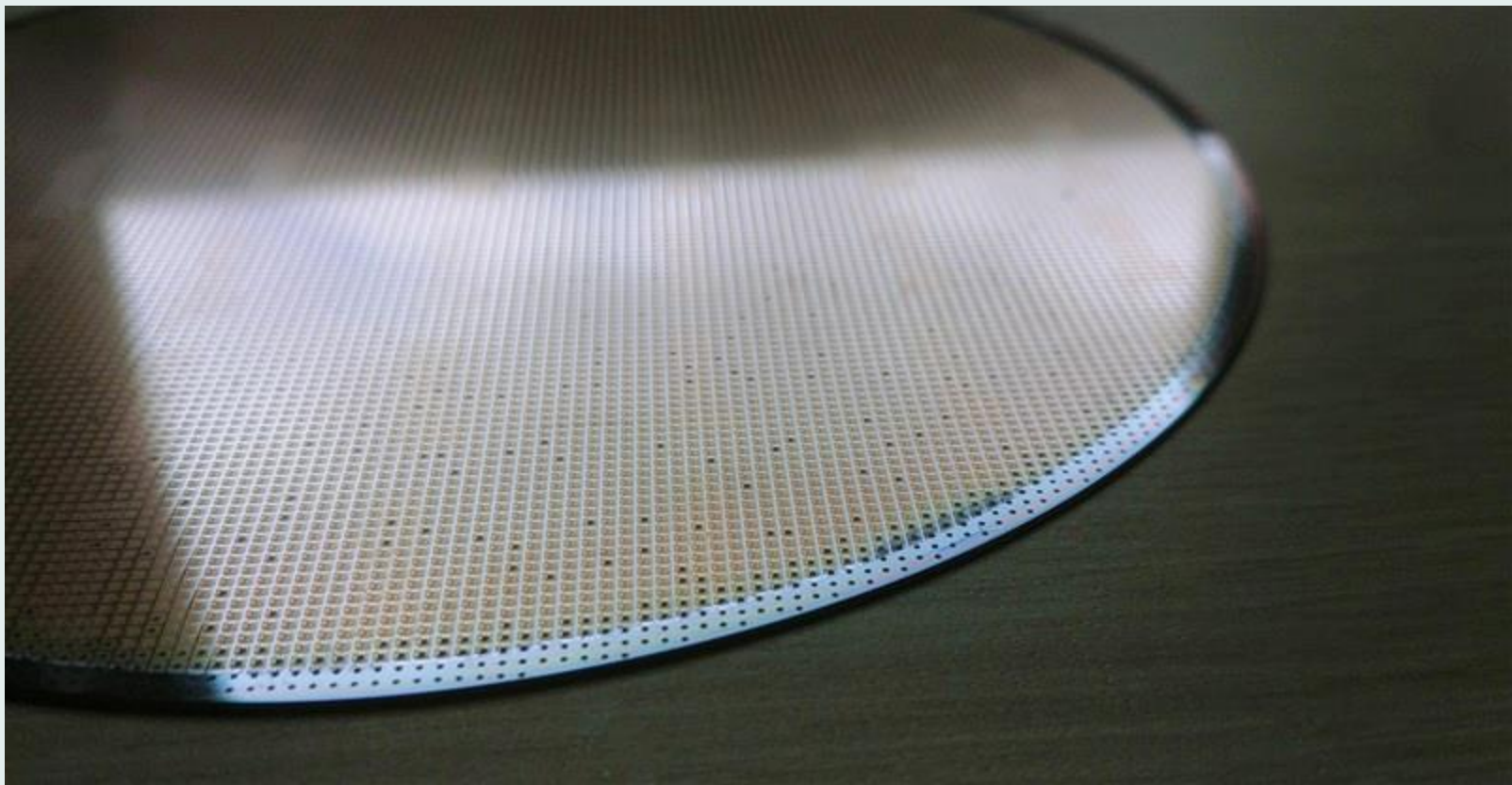
x x
x x

晶圓完成了！





晶圓做好了，下一步是什麼？





x
x x
x



電晶體



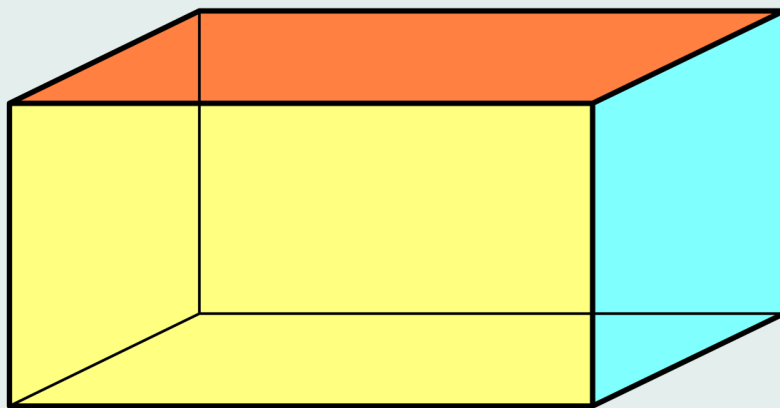
×
× ×
×



分層



分層

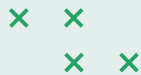
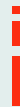


分層

×
× :
:
○



微影

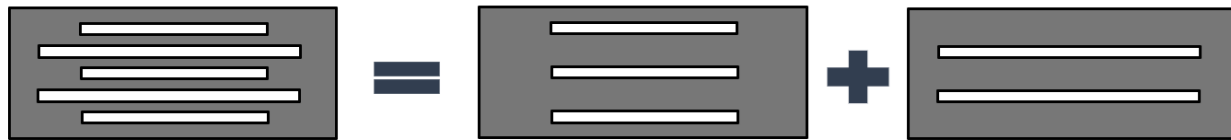




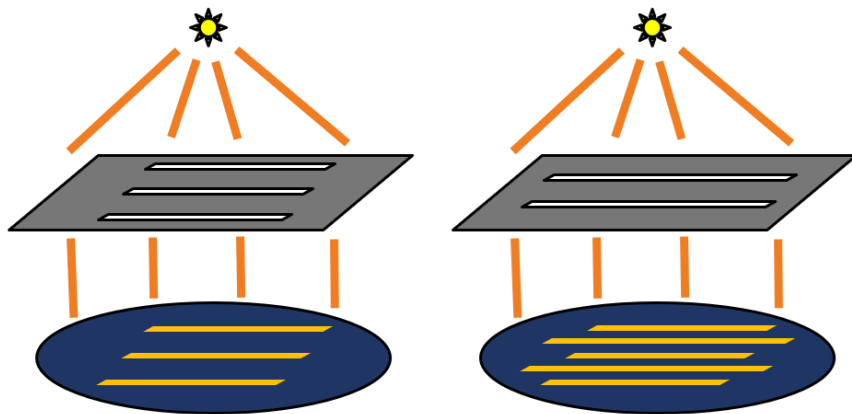
x
x x
x



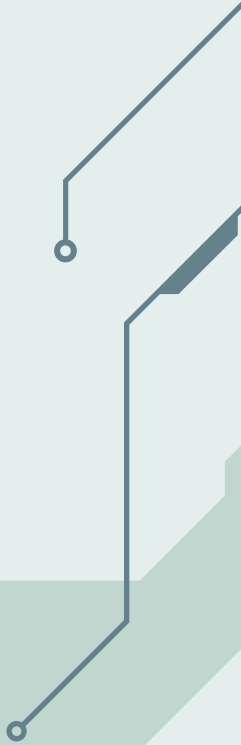
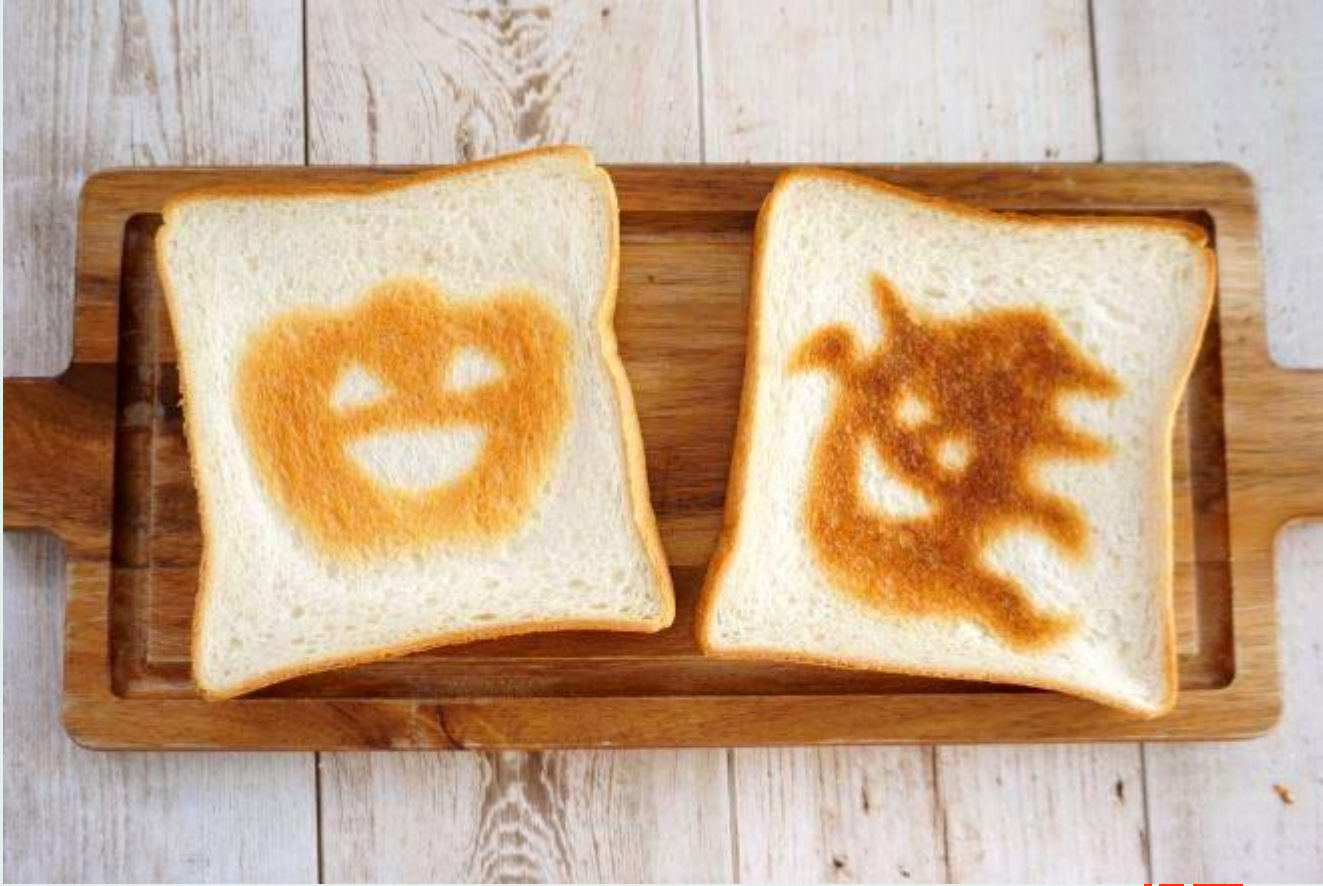
光罩



光照



×
× ×
×



蝕刻



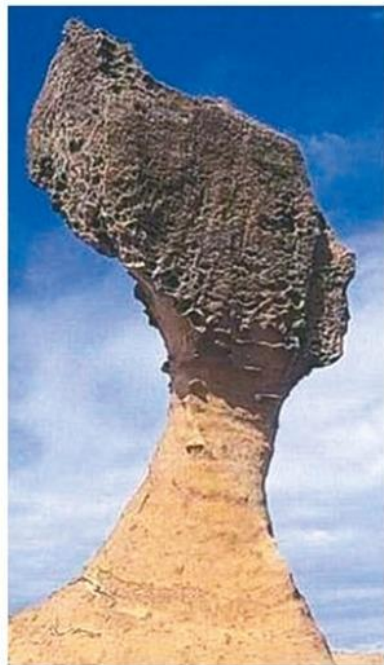
女王頭風化過程



1969 年



1980 年

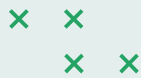


1990 年



2010 年

彳 亍 摻 雜

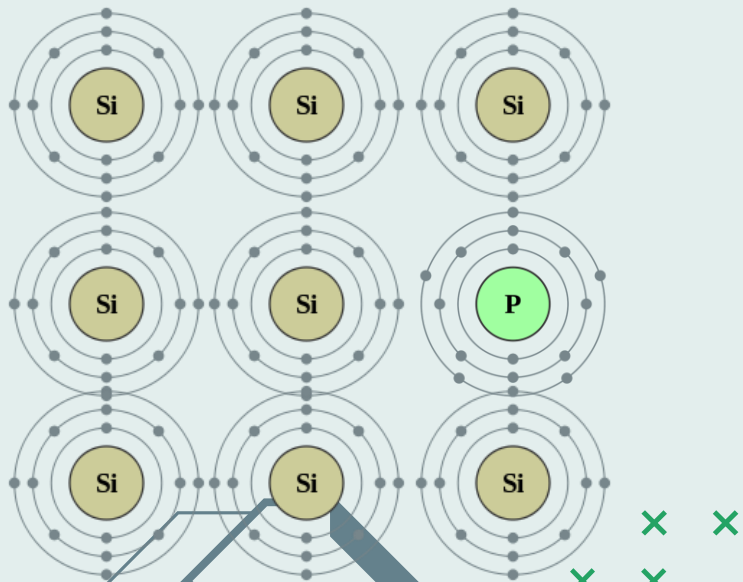


摻雜

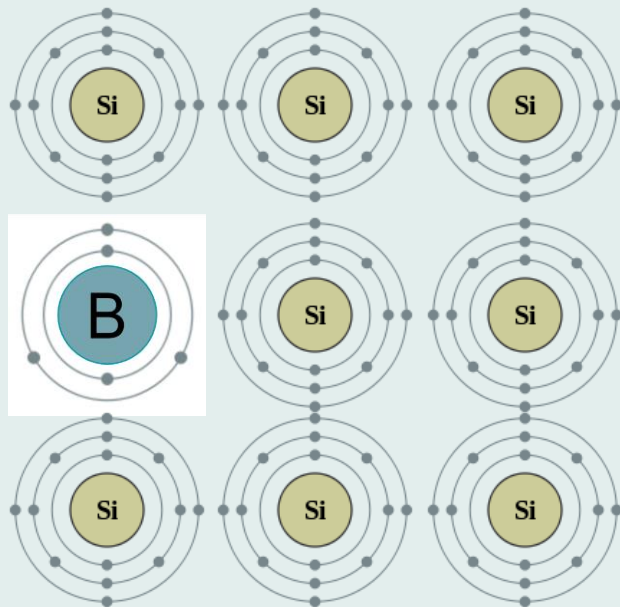
+

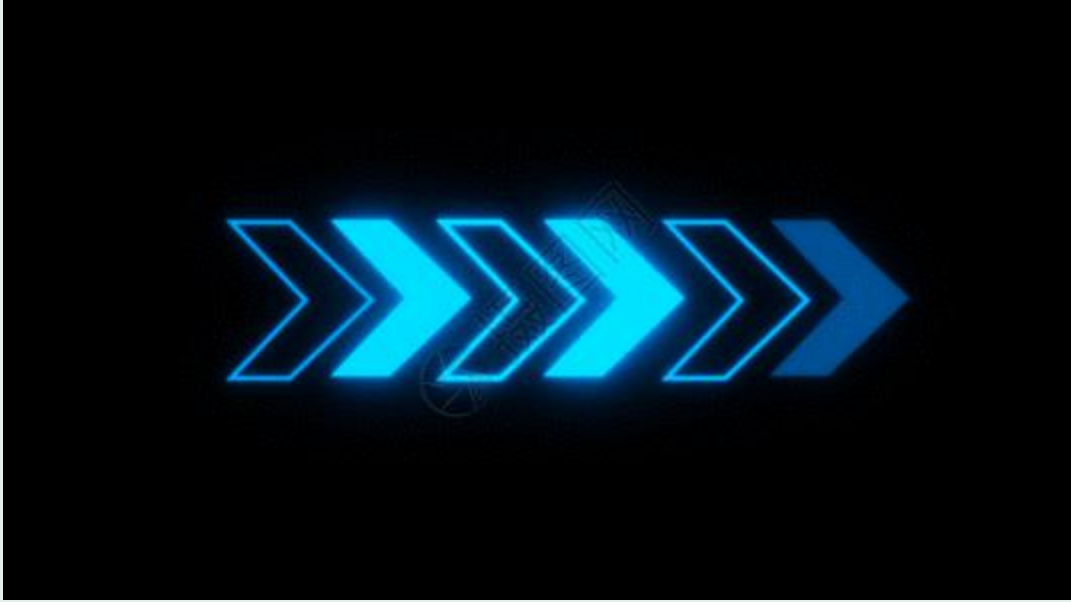
為了讓矽原子有導電和不導電的兩種特性，需在其中摻雜少量元素

電子(加入5A族)



電洞(加入3A族)





+



+ 先拚好塔基底【非實際長晶過程】



× ×

表面氧化



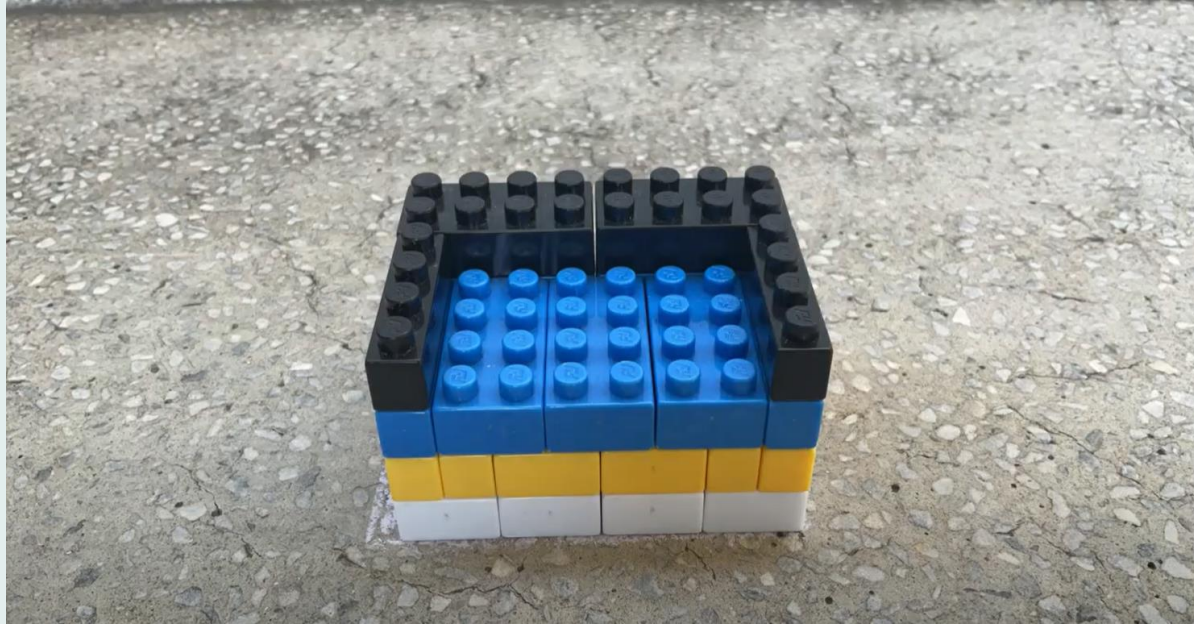
× ×

塗抹光阻

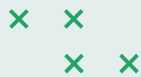


x x
x x

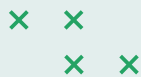
放光罩&曝光



顯影



蝕刻 & 去除剩餘光阻

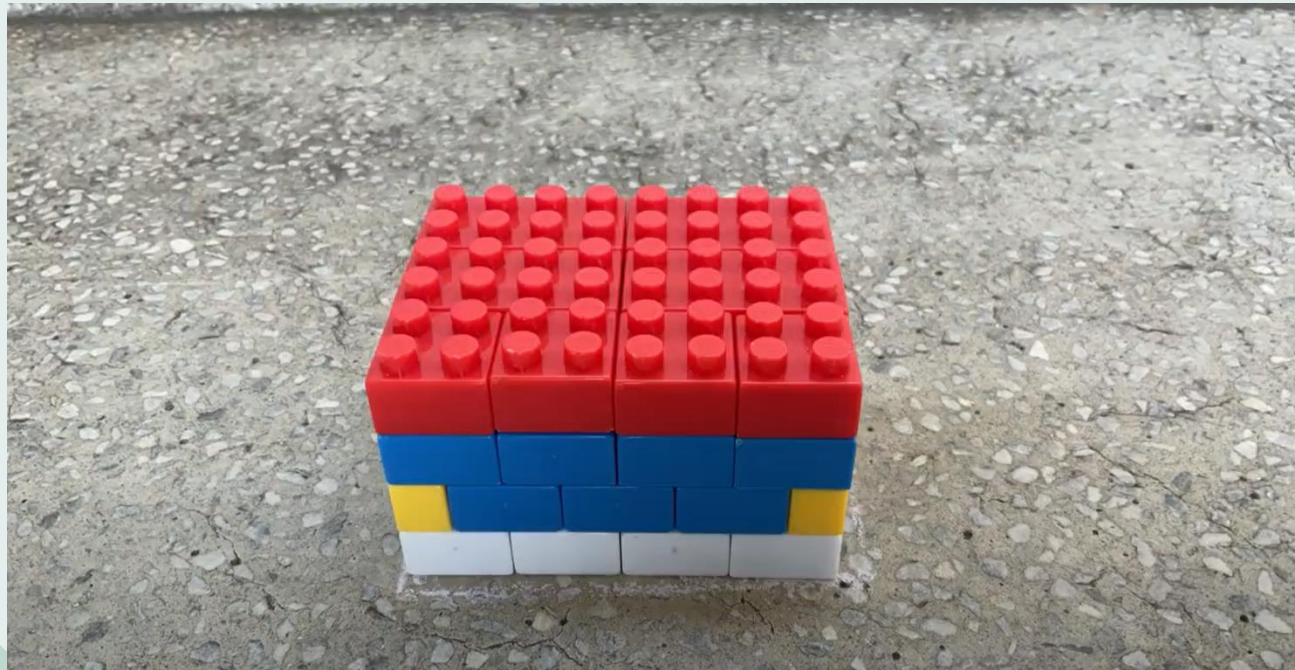


多晶矽沉積



× ×

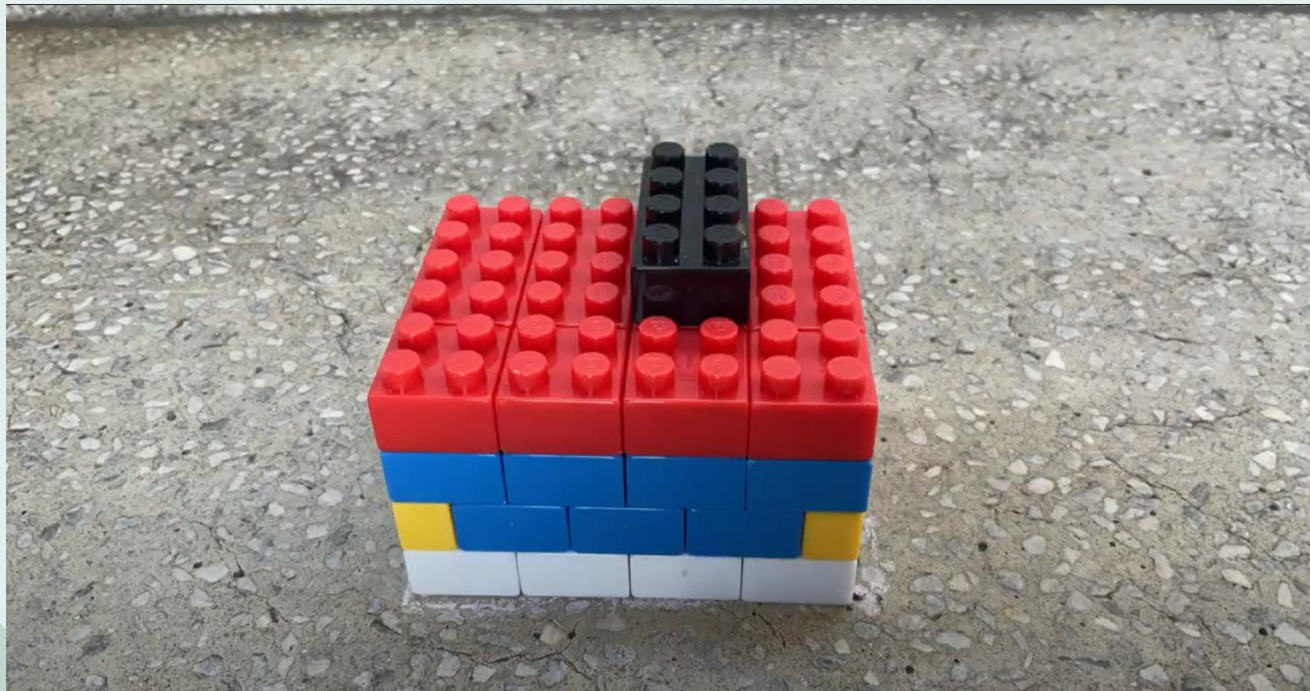
塗抹光阻



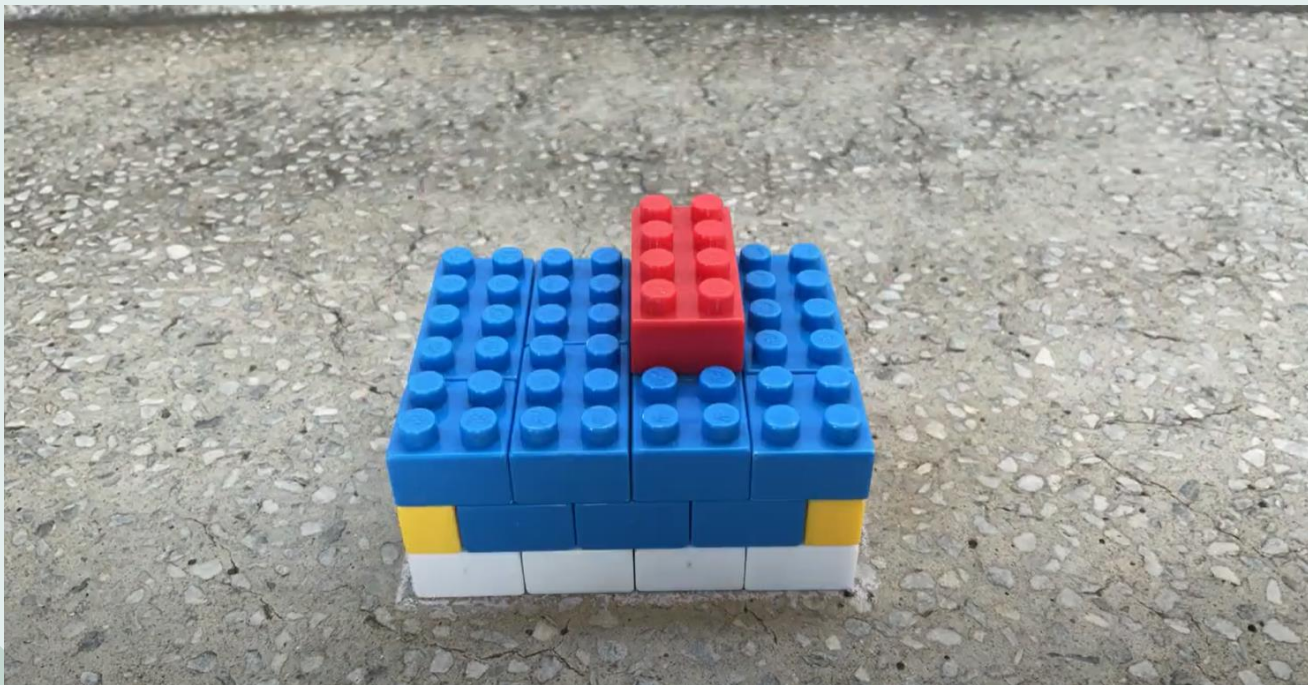
x x



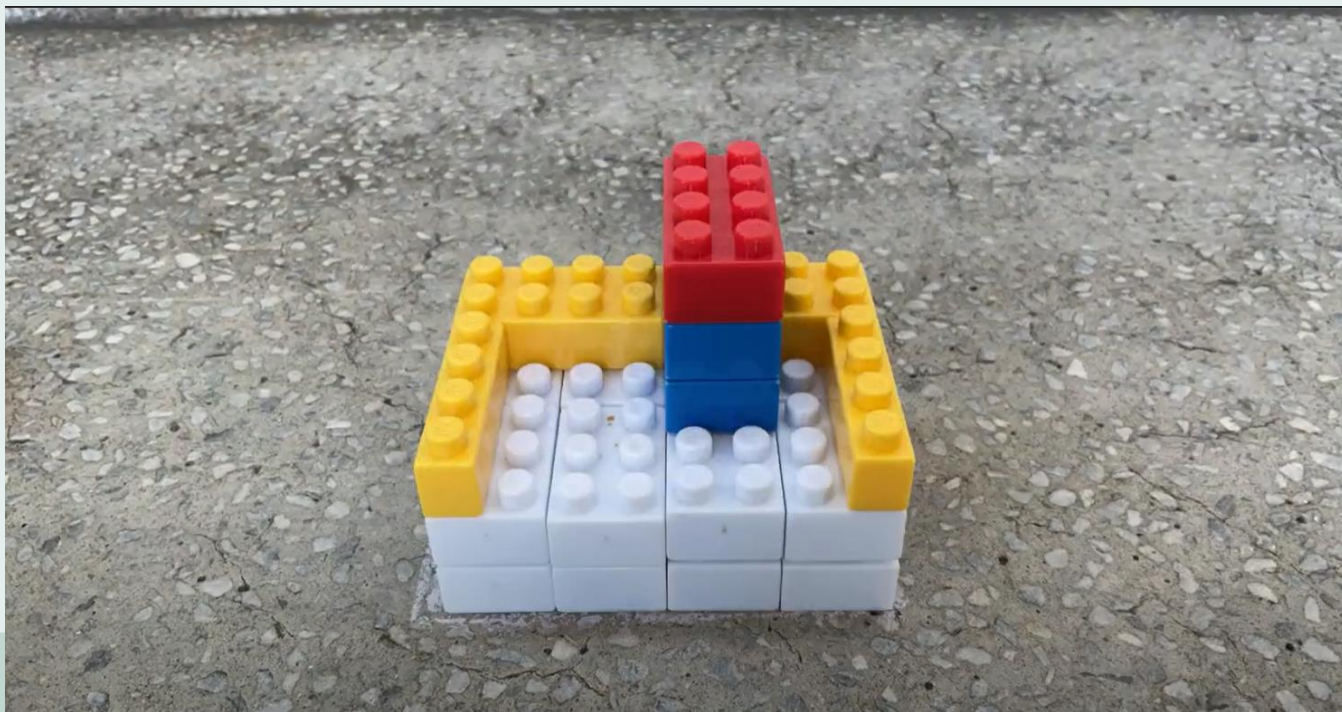
放光罩&曝光



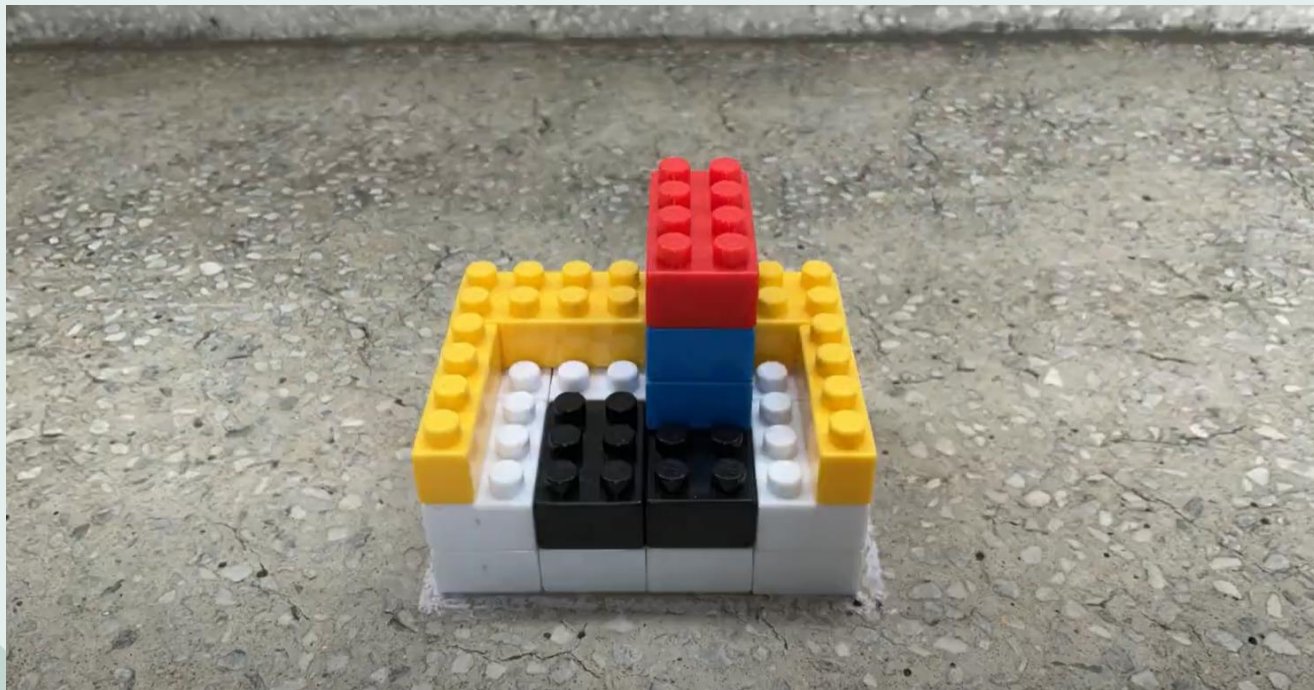
顯影



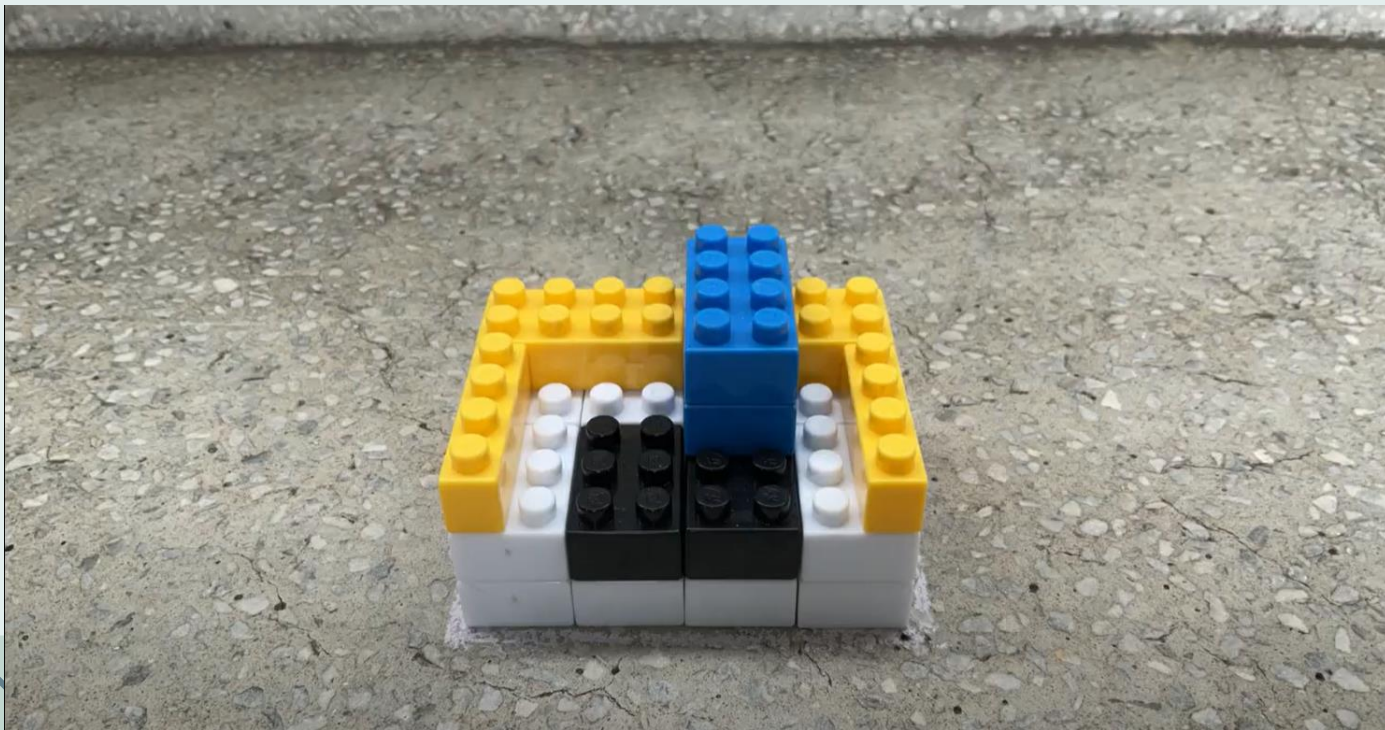
蝕刻



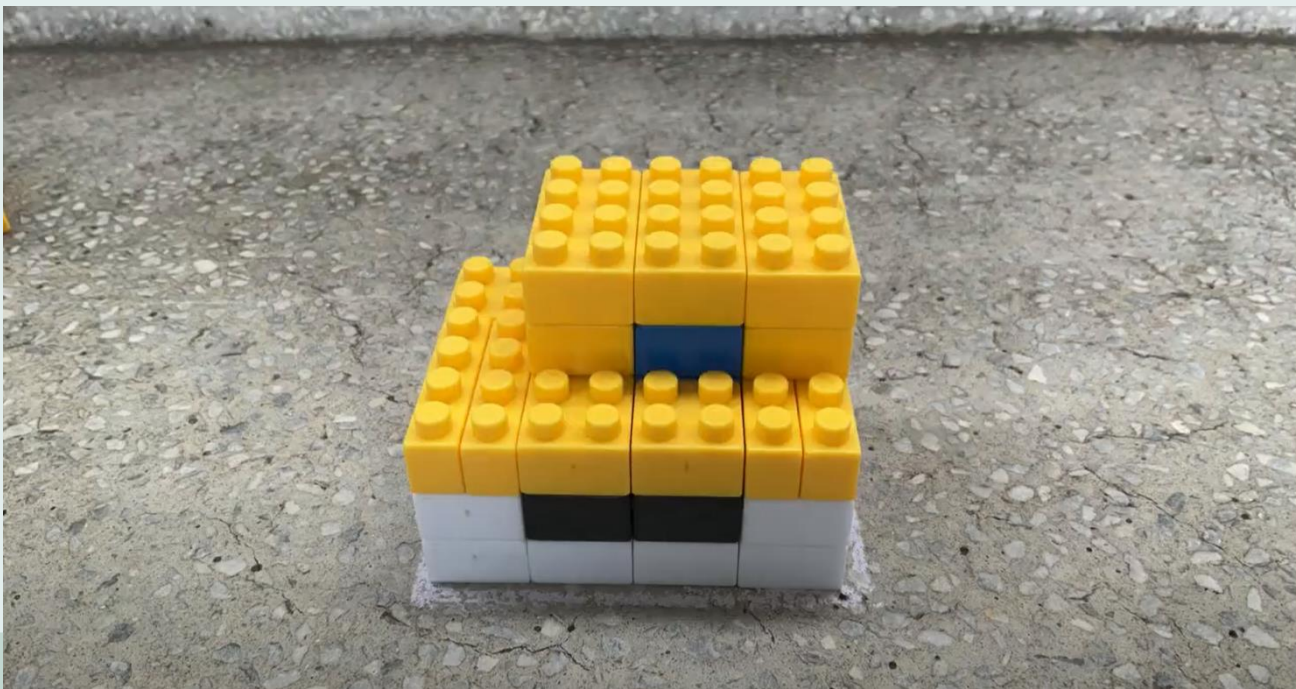
摻雜



去除剩餘光阻

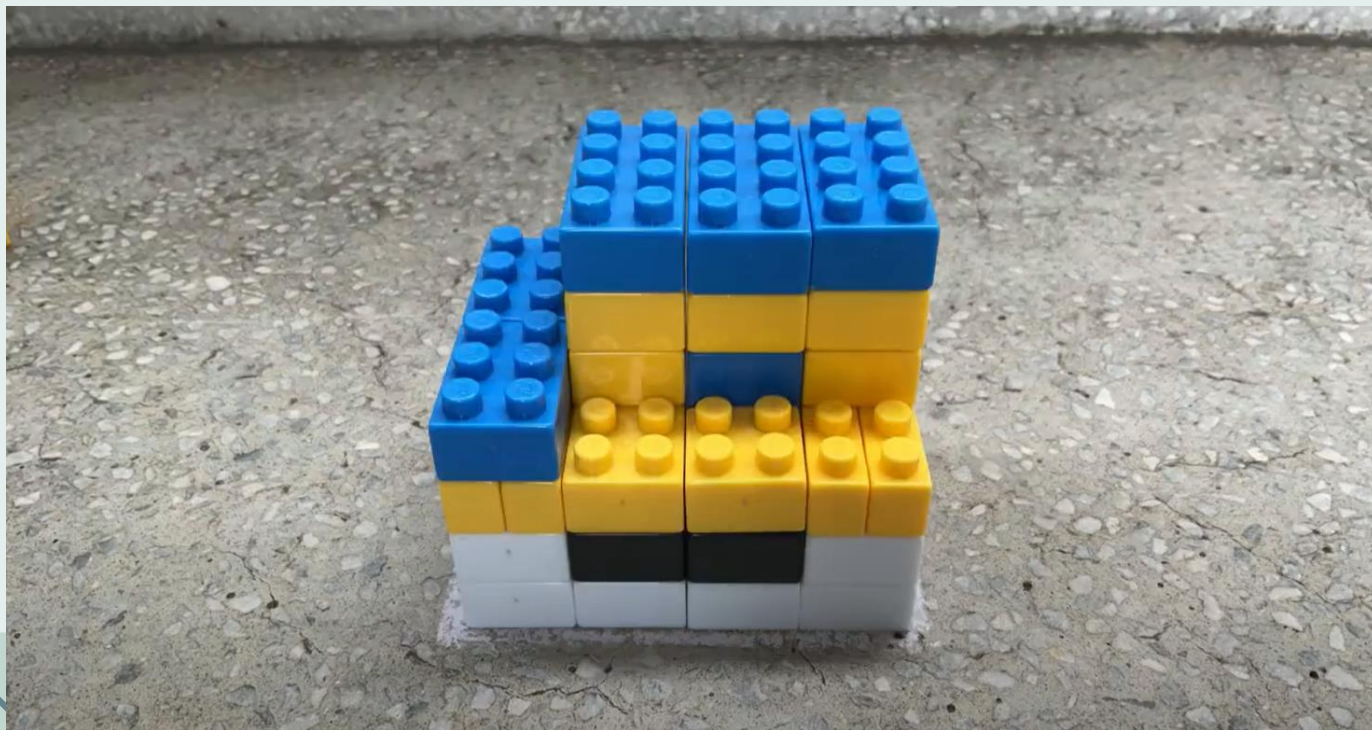


表面氧化

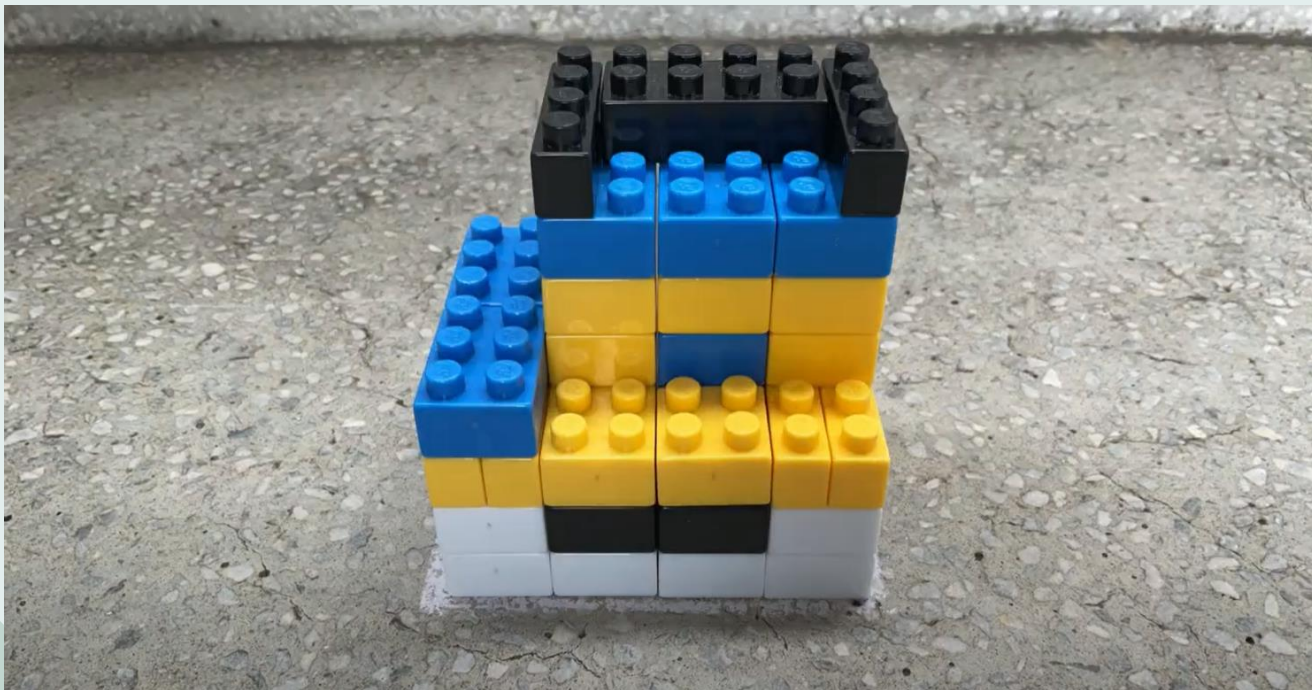


x x

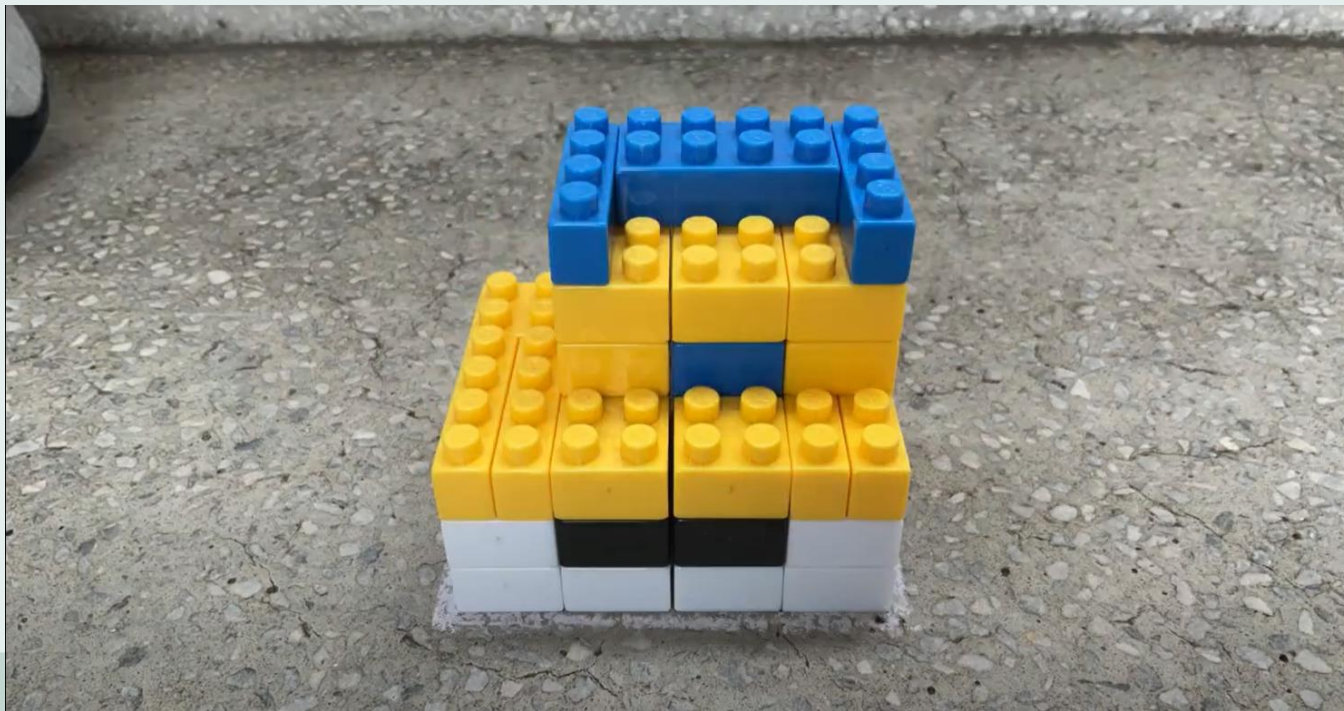
塗抹光阻



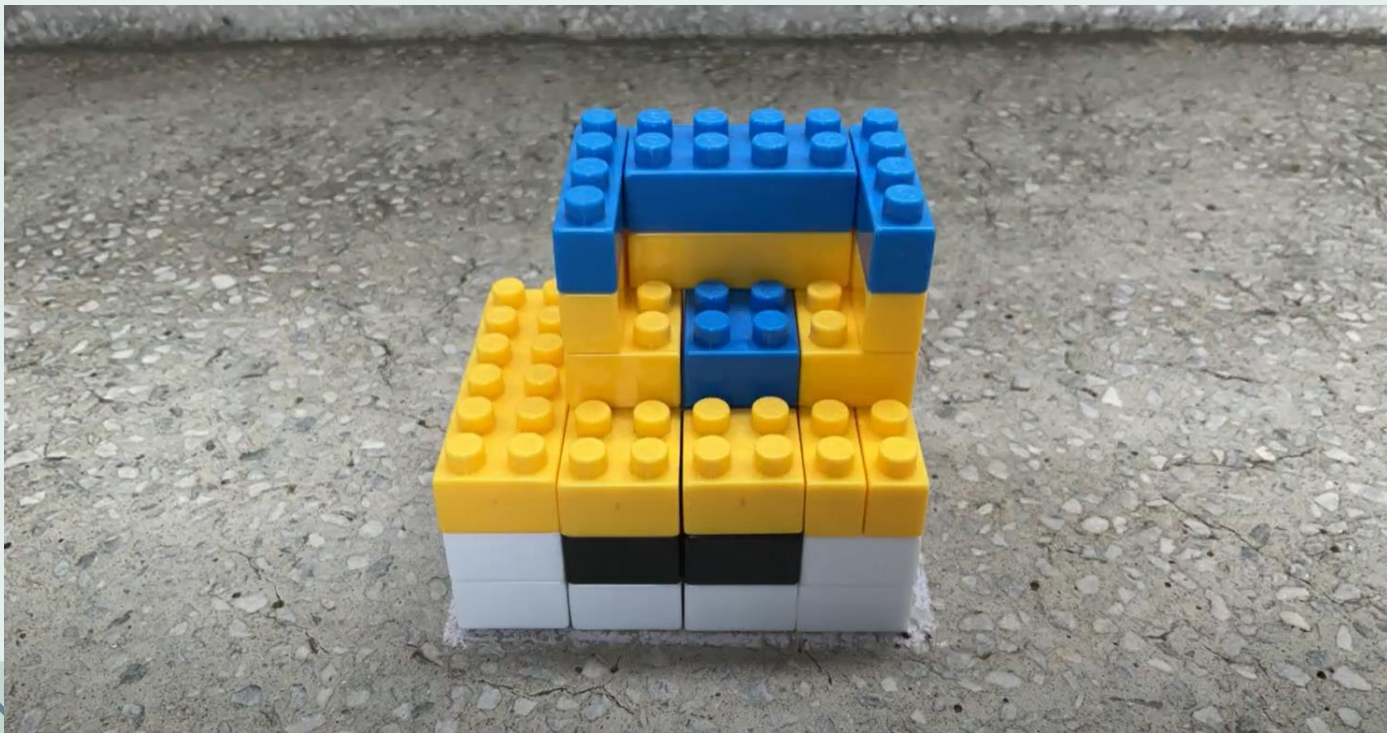
放光罩&曝光



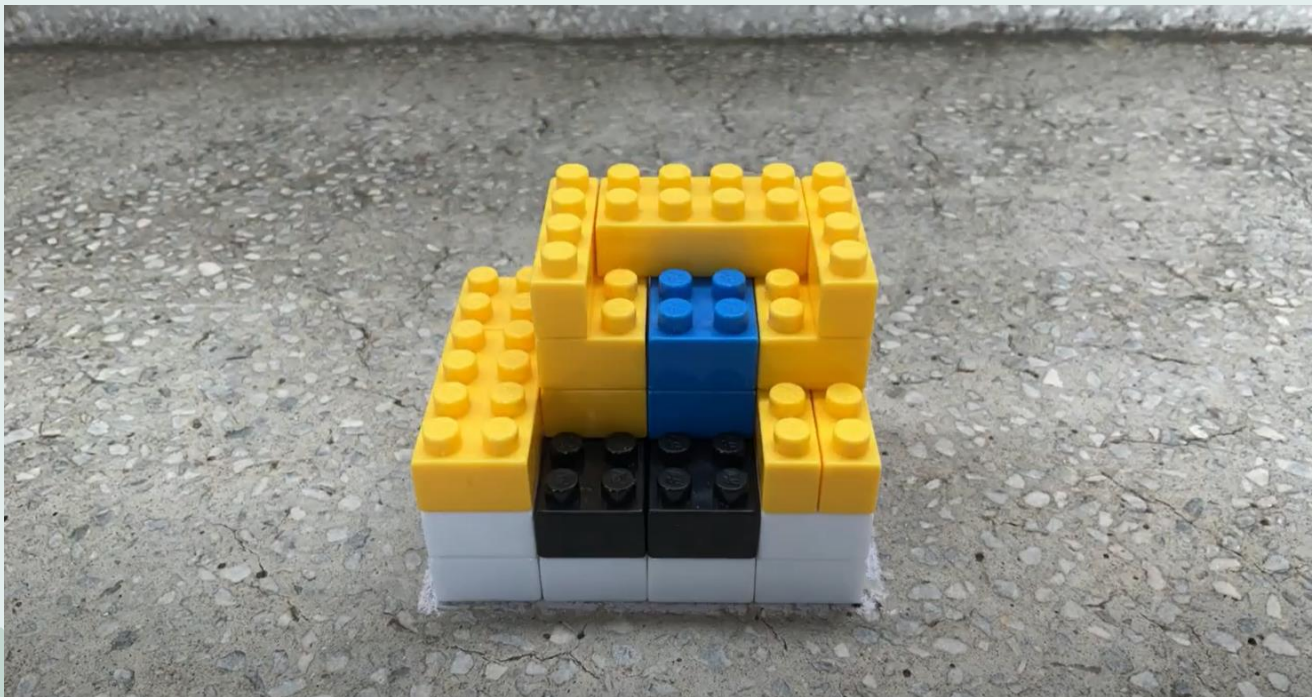
顯影



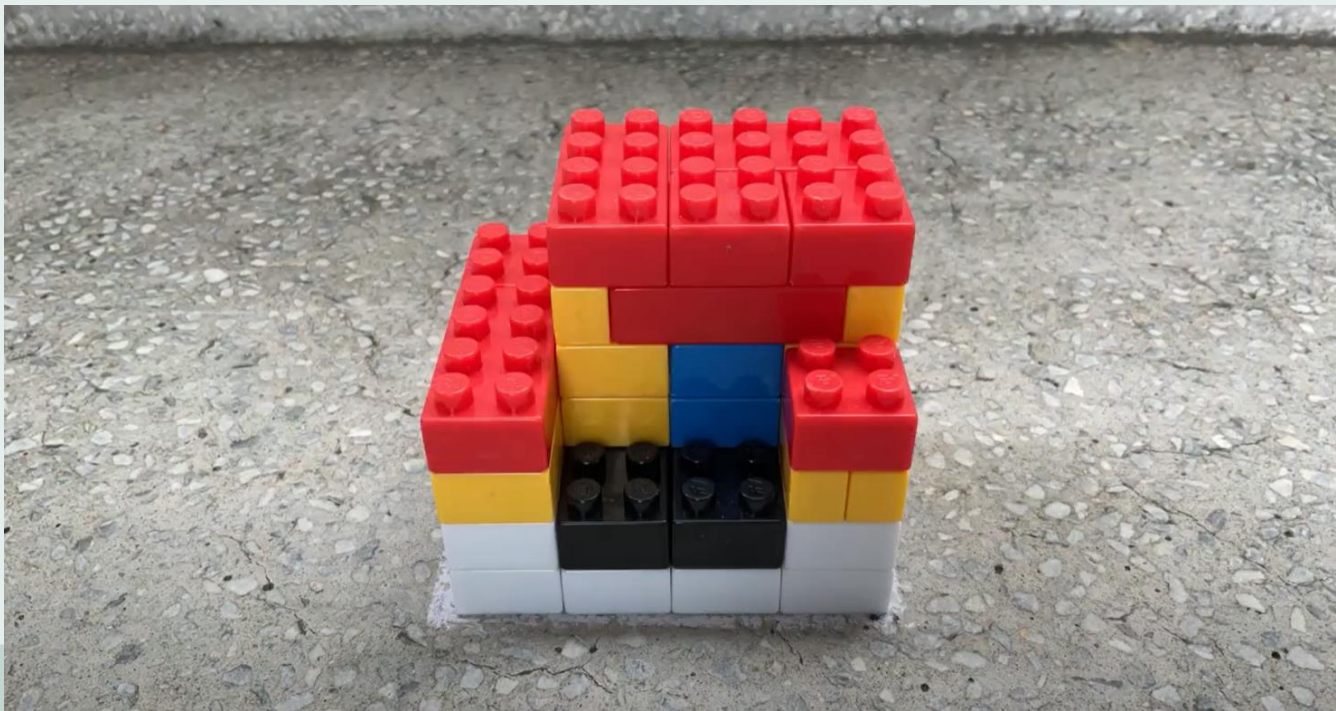
蝕刻



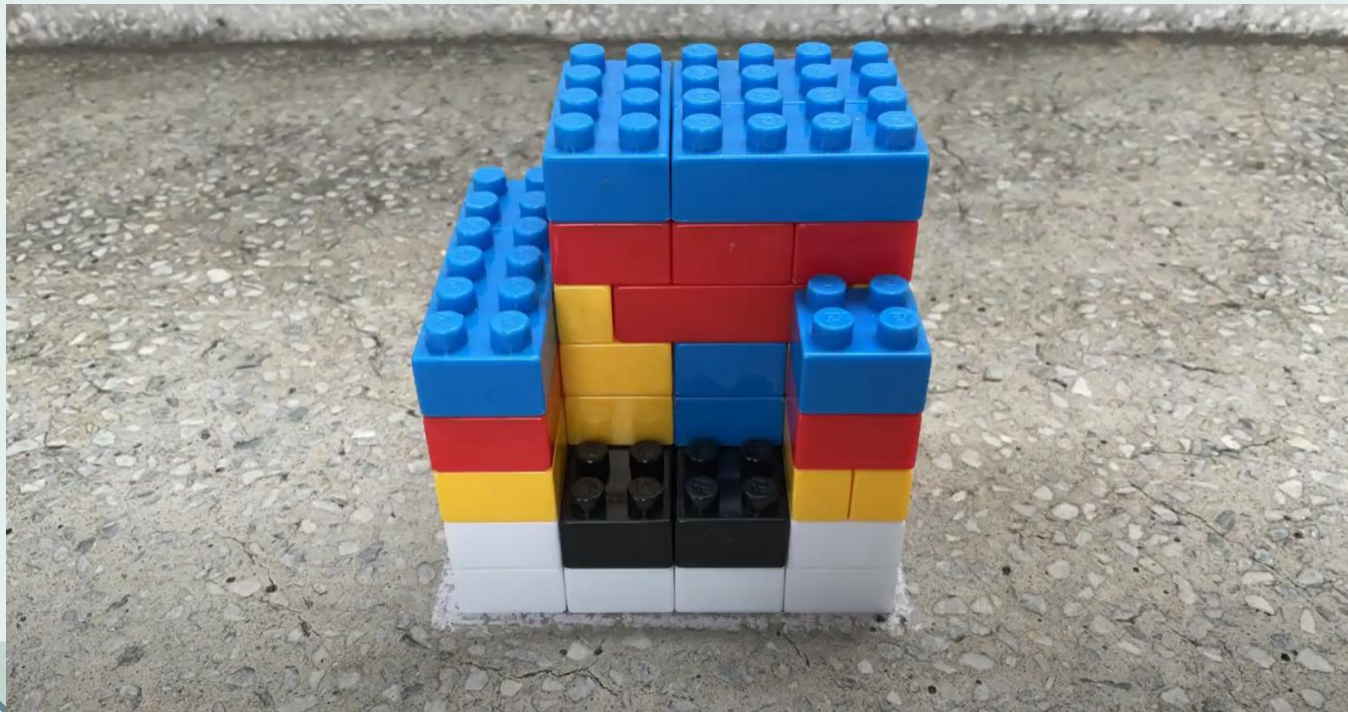
去除剩餘光阻



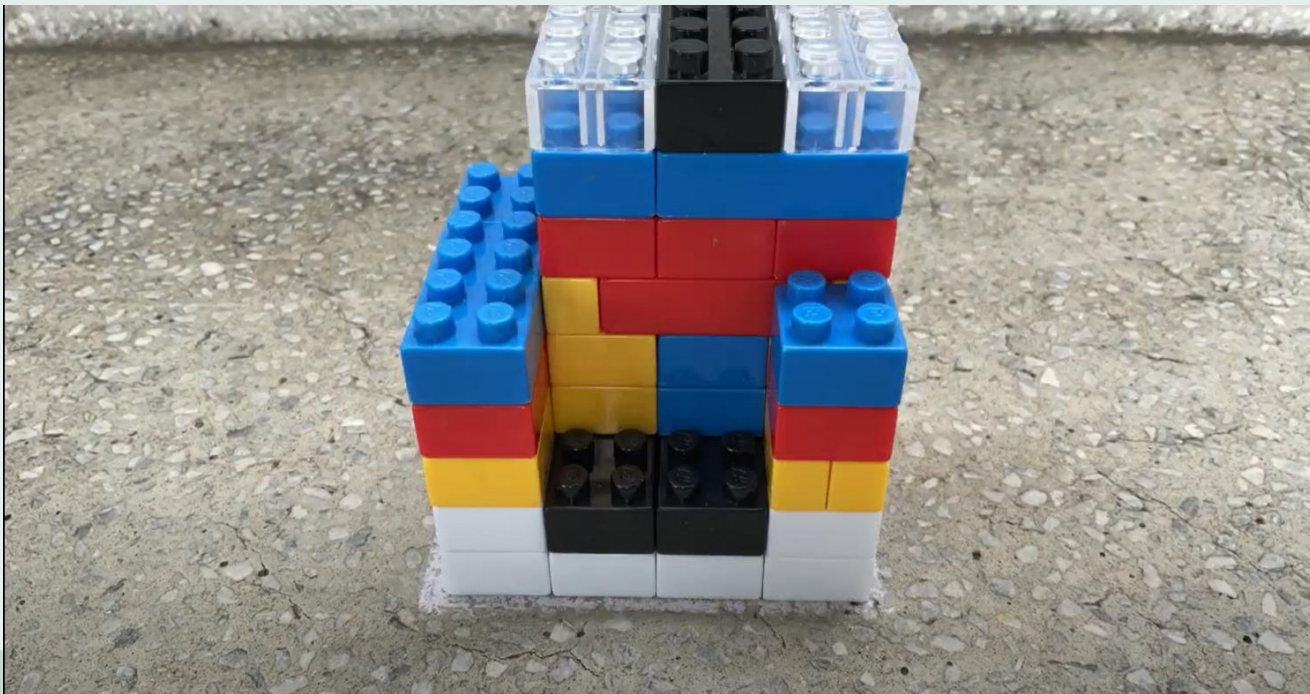
金屬薄膜沉積



塗抹光阻

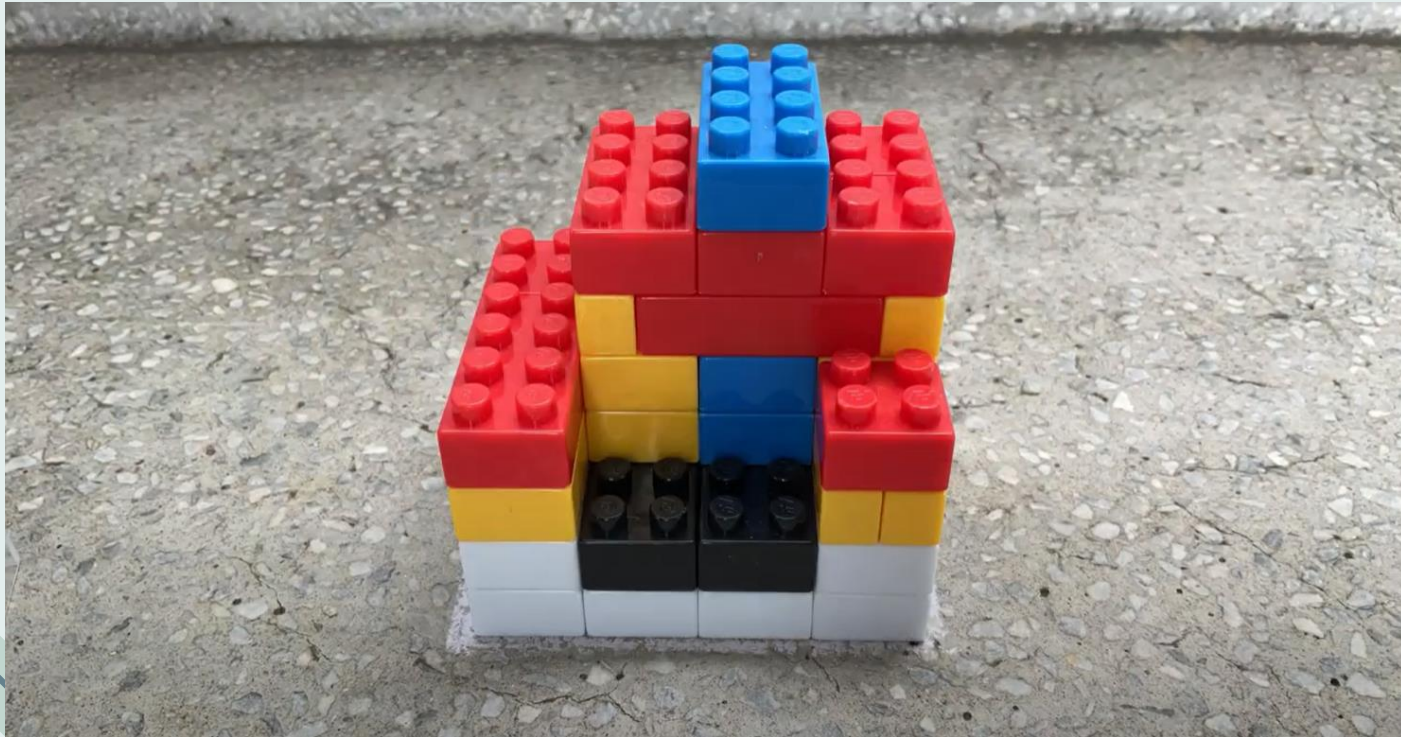


放光罩&曝光

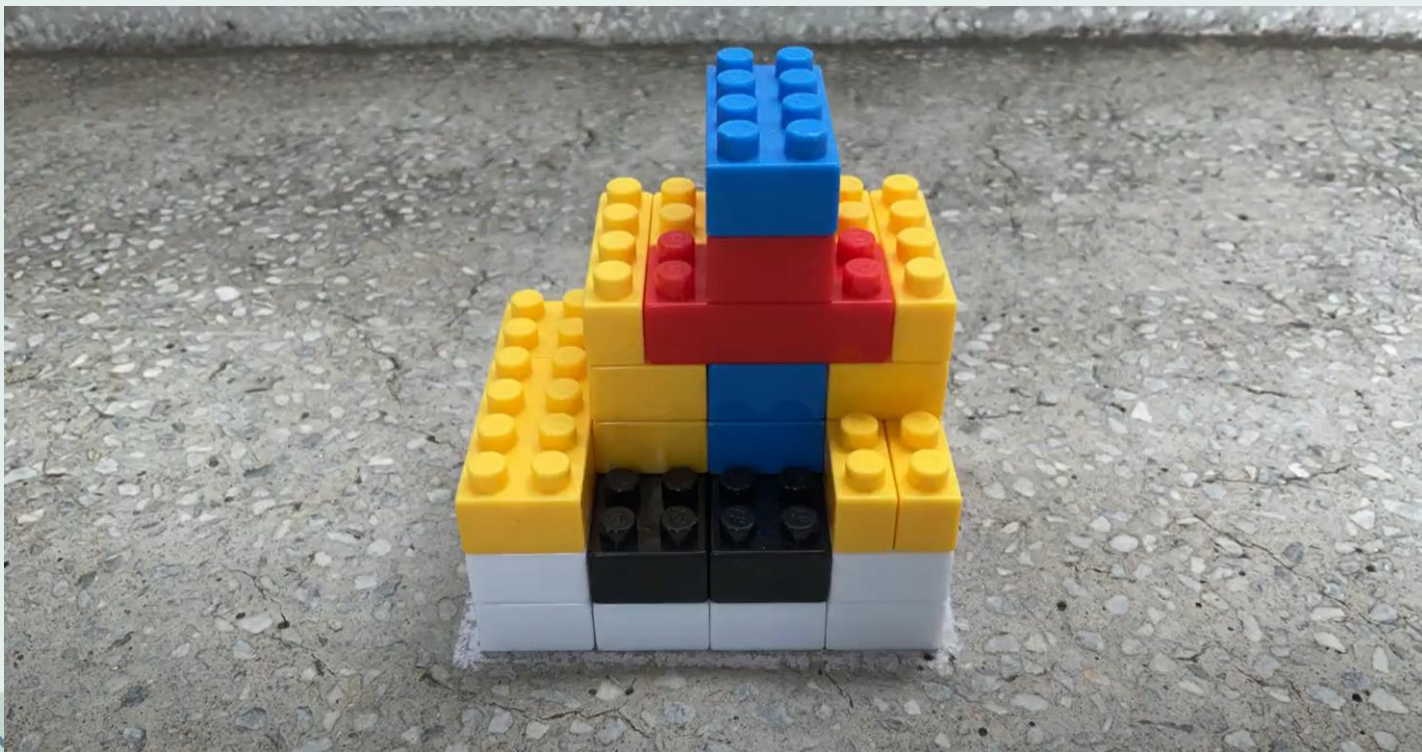


x x

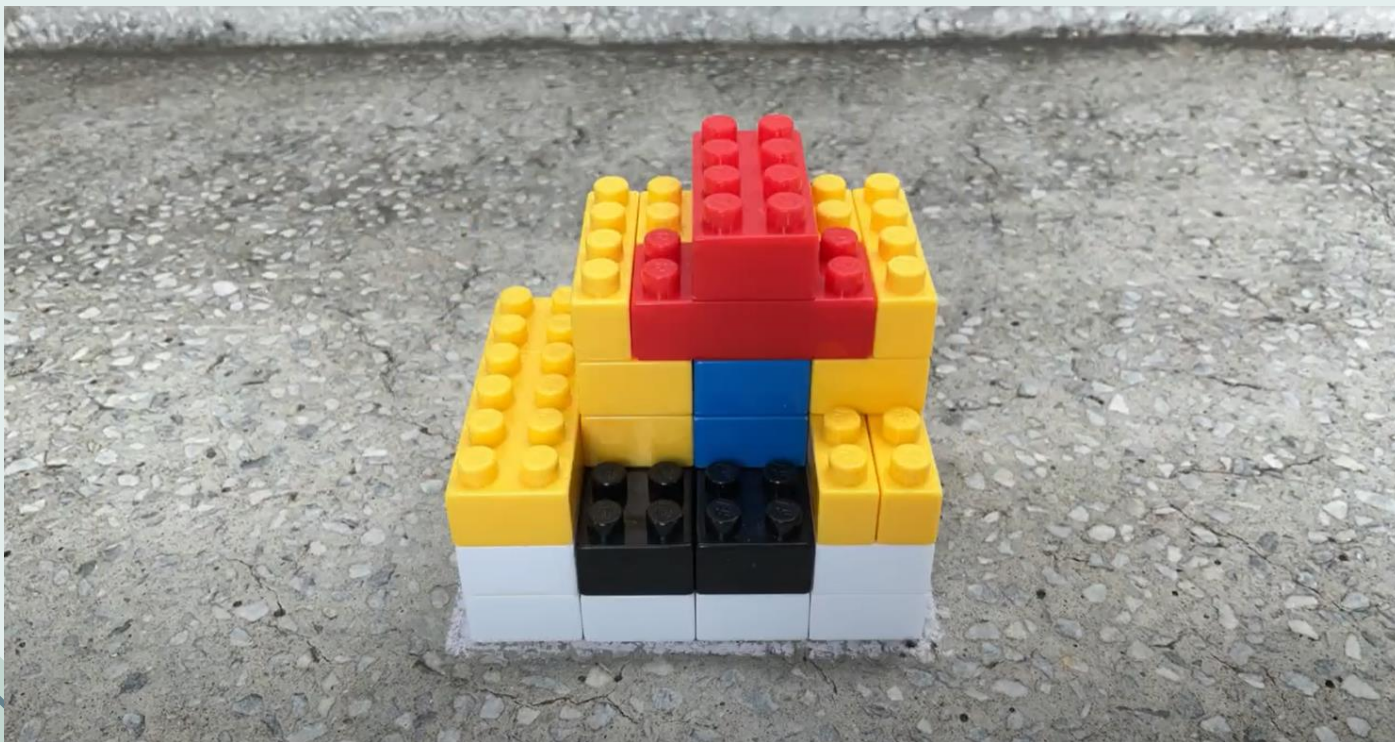
顯影



蝕刻



去除剩餘光阻





透過這些半導體製程就完成一個場效
的電晶體了

