



南京大學

2010.10.14





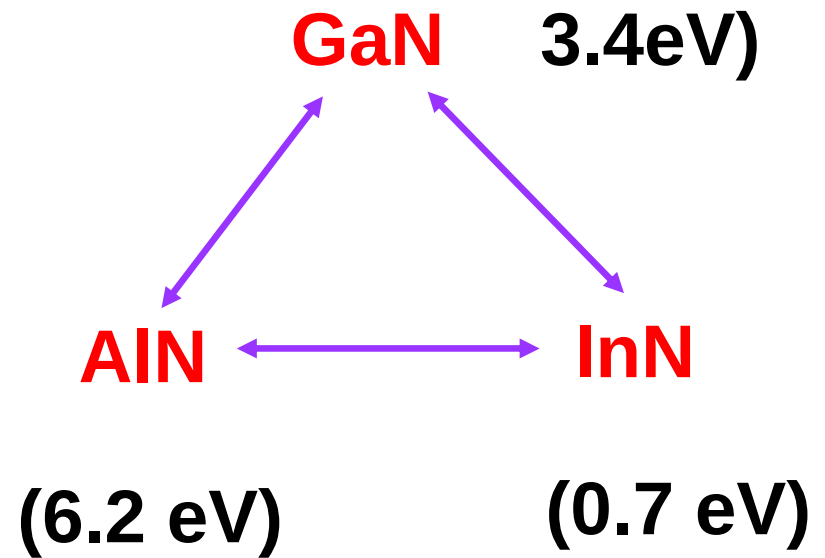
(AlN)

(InN)

(GaN)



$0 \leq x \leq 1$ $0 \leq y \leq 1$





1

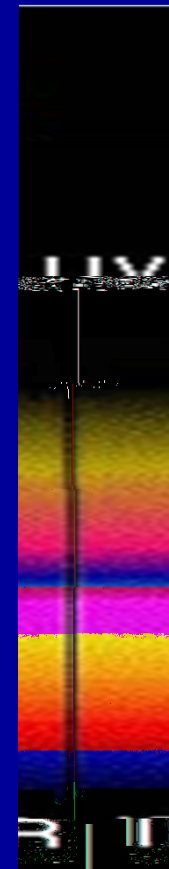
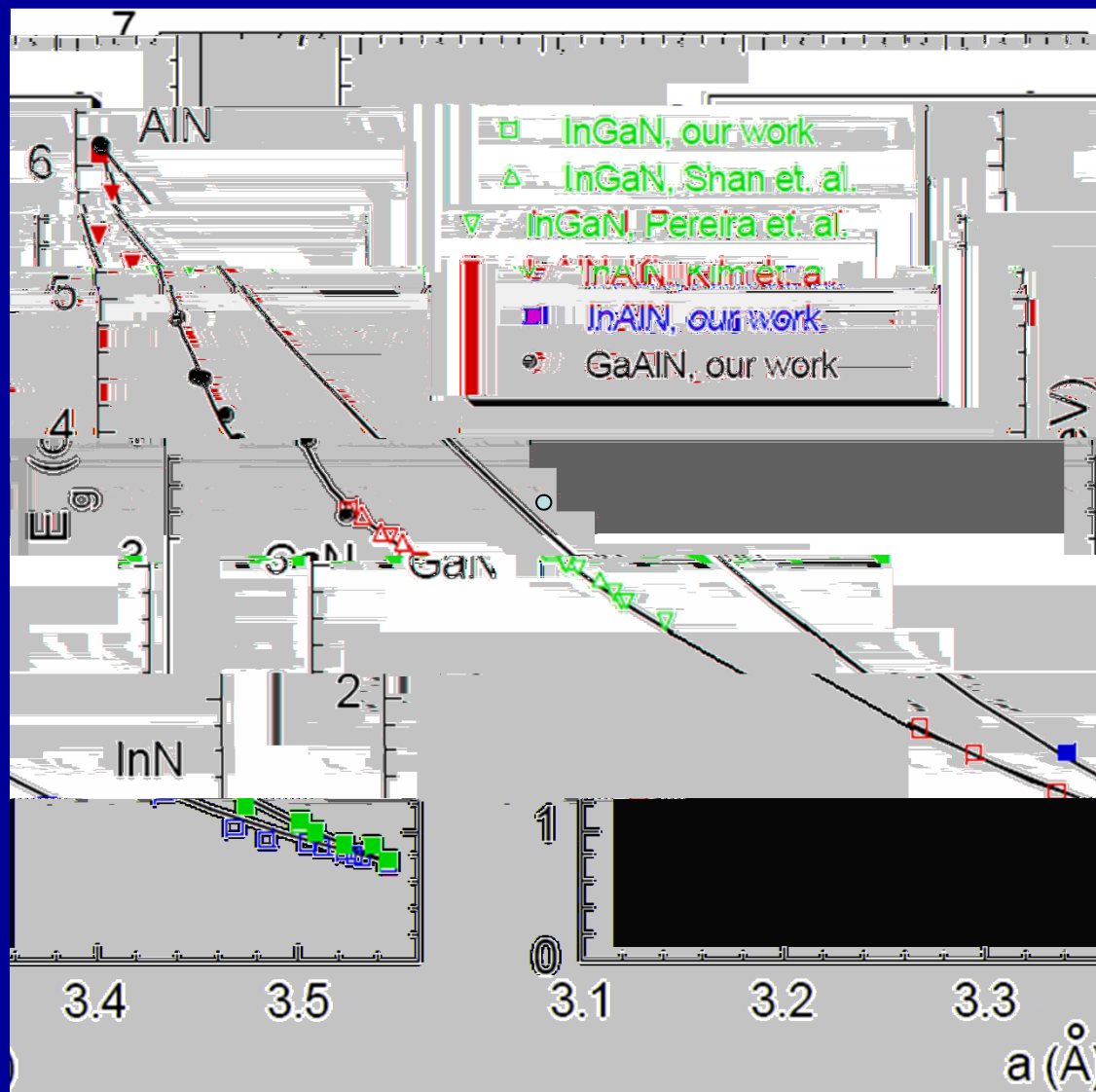


0.7- 6.2 eV

Ge Si GaAs InP



1.77 μm — 0.36 μm – 0.20 μm





2

GaN

AlN

InN



3

N

In Ga Al



$$c_0/a_0=1.633$$

GaN(1.627), InN(1.623)
AlN(1.601)

(C/cm²)

GaN (- 0.029) InN (- 0.032)
AlN (- 0.081)

AlN

3-5



4

2500

4.5 GPa

GaN

16%



5

[0001]

(0001)



P_{PE}

e

0

$$P_{PE} = 21 \quad R \frac{a - a_0}{a_0} \cdot e_{31} \cdot e_{33} \frac{C_{13}}{C_{33}}$$

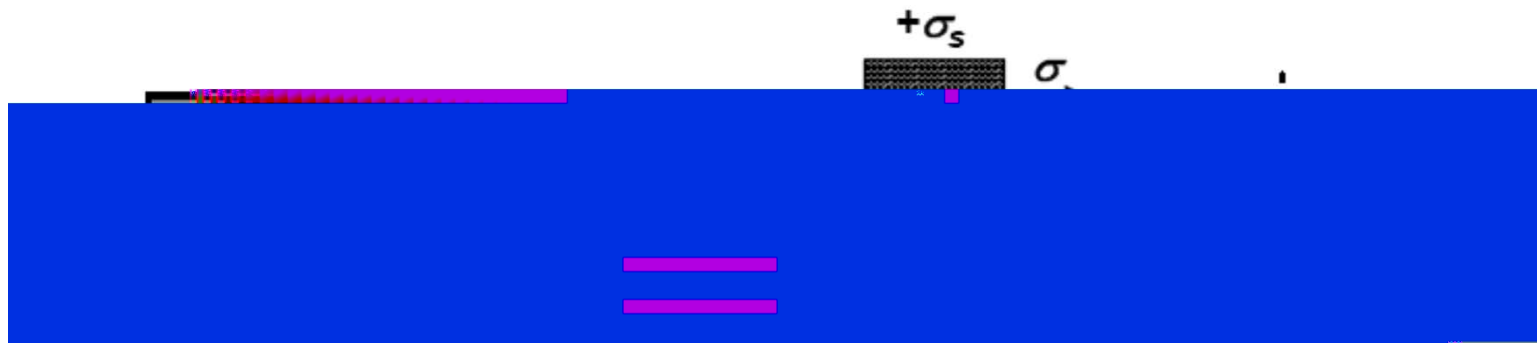
$(a > a_0)$

$(a < a_0)$



6

2DEG)



2DEG

4 5

10^{13}cm^{-2} , AlGaAs/GaAs



7

p



1

2

3







LED,LD)

LED

//

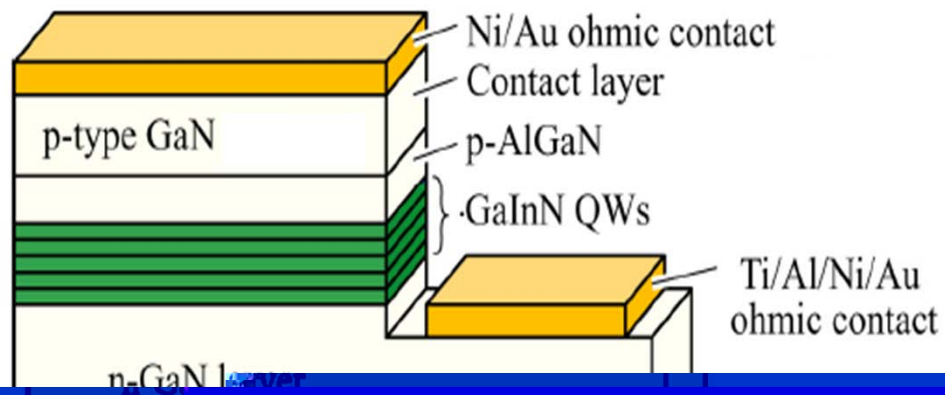
// 230-280nm

HEMT)

HEMT



LED

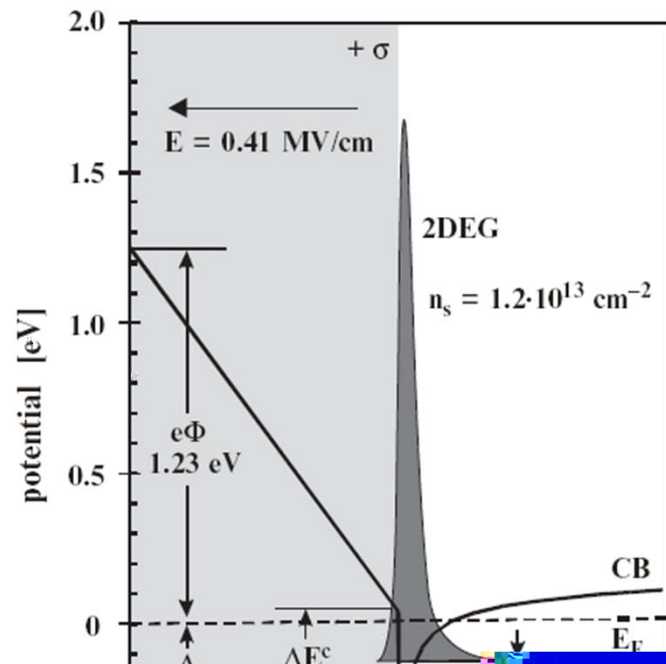


InGaN/GaN

LED



HEMT



AlGaIn/GaN

(HEMT



10

LED HEMT



LED

LED

2009

600

LED

//

//





C
LED

HEMT
ᄒ

GaN

ᄒ



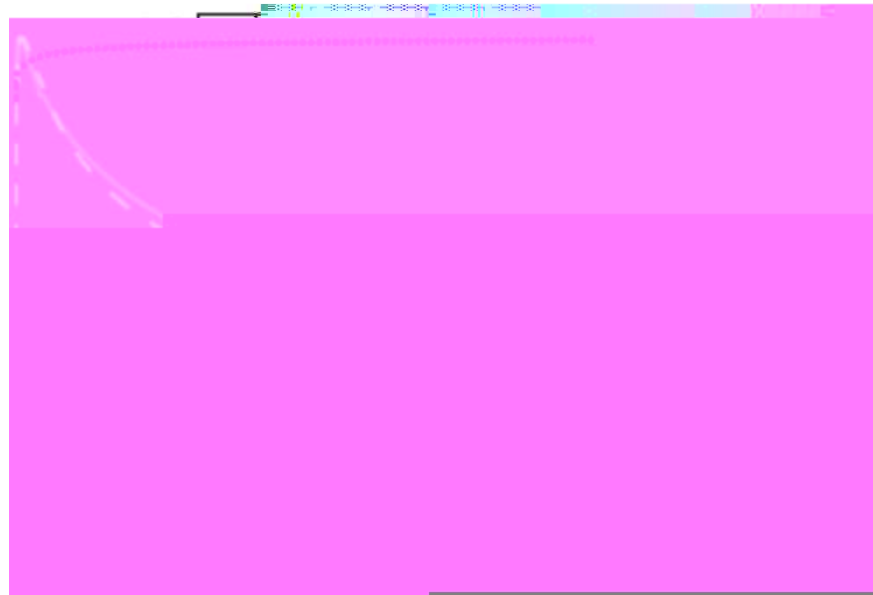
LED

Efficiency Droop

InGaN LED

10-70A/cm²

“ Efficiency Droop”



—Chichibu SF at al



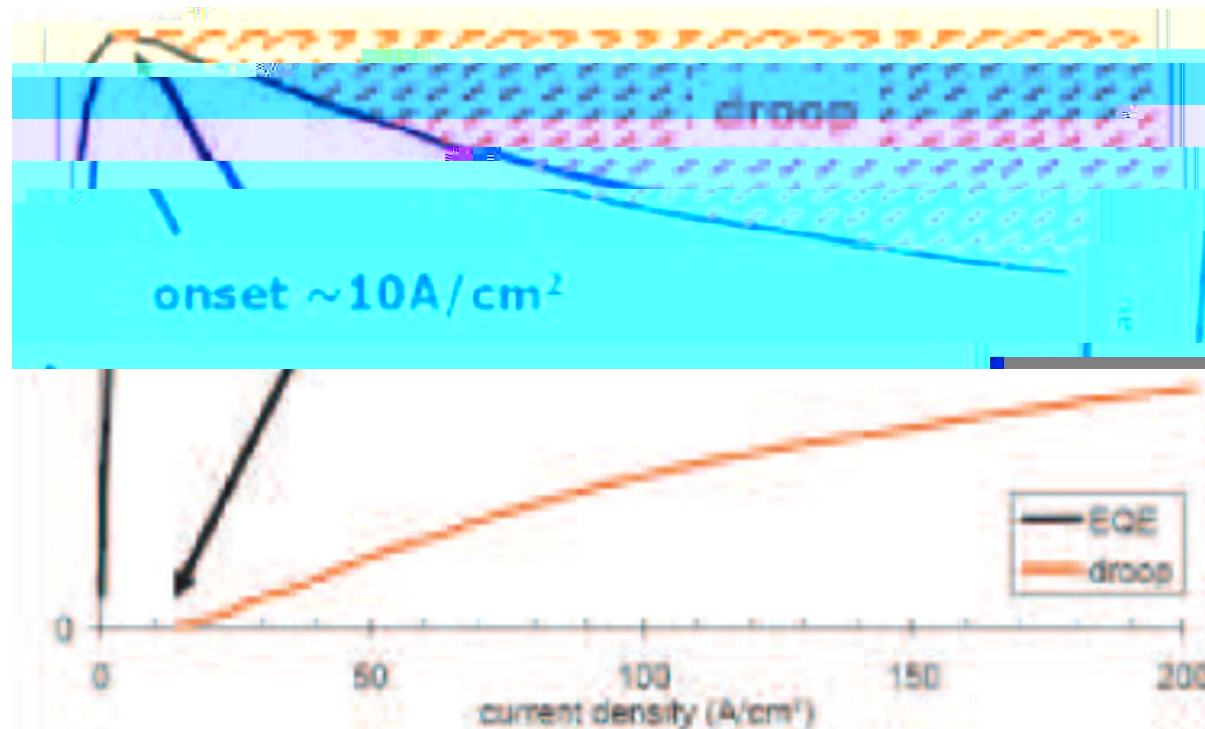
“Efficiency Droop”

LED

// //

LED Efficiency Droop

LED





0
150lm/W,



300 lm/W



Km = 683 lm/W

1W

683

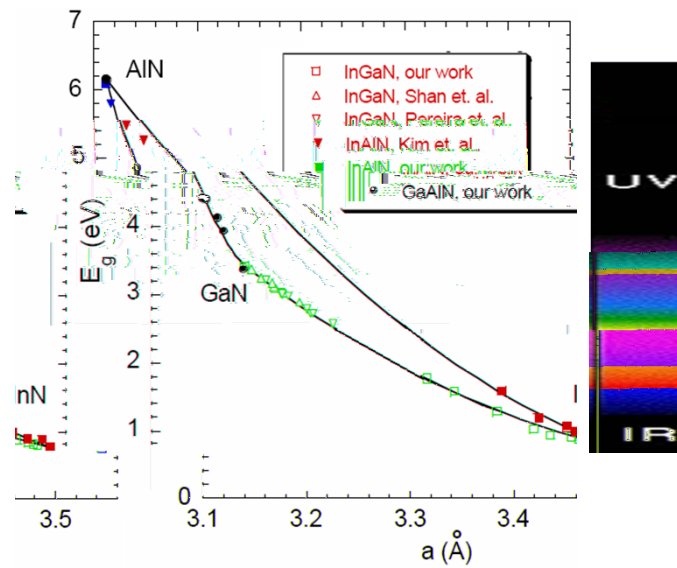
lm/W

LED

140-



LED

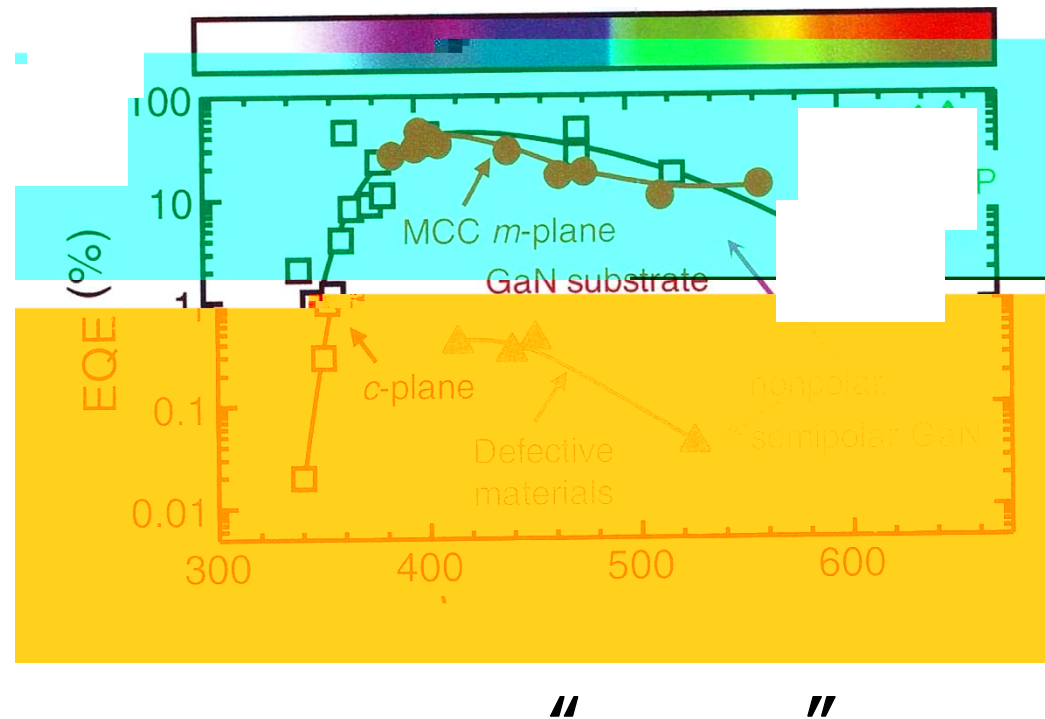


(0.7eV-6.2eV)

LED



LED



LED



HEMT

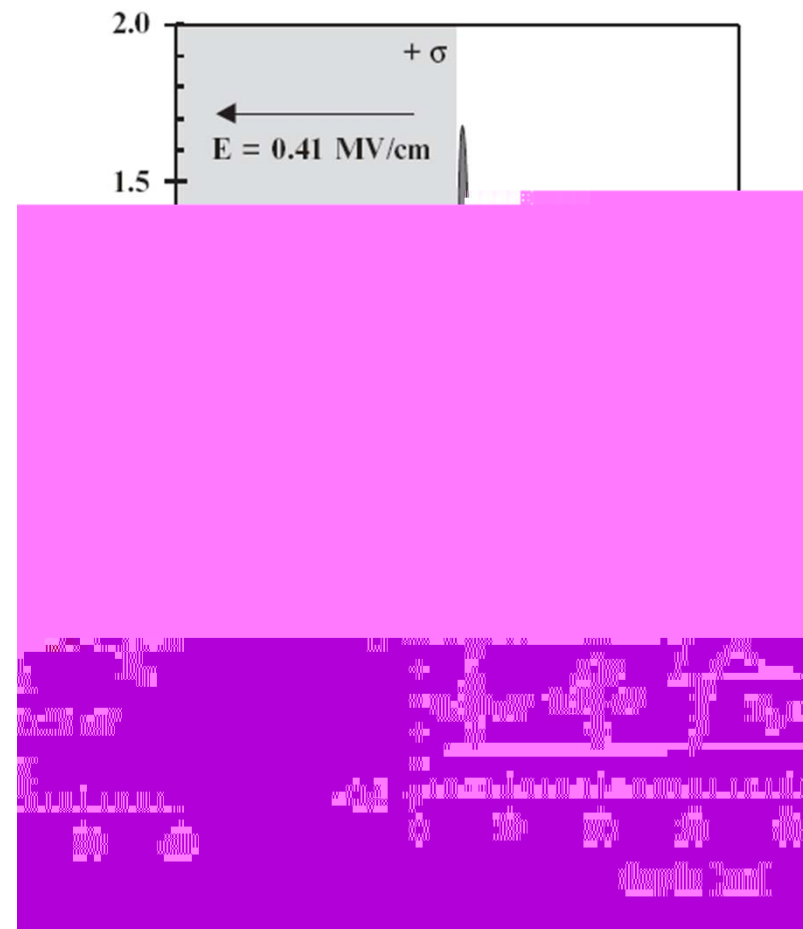
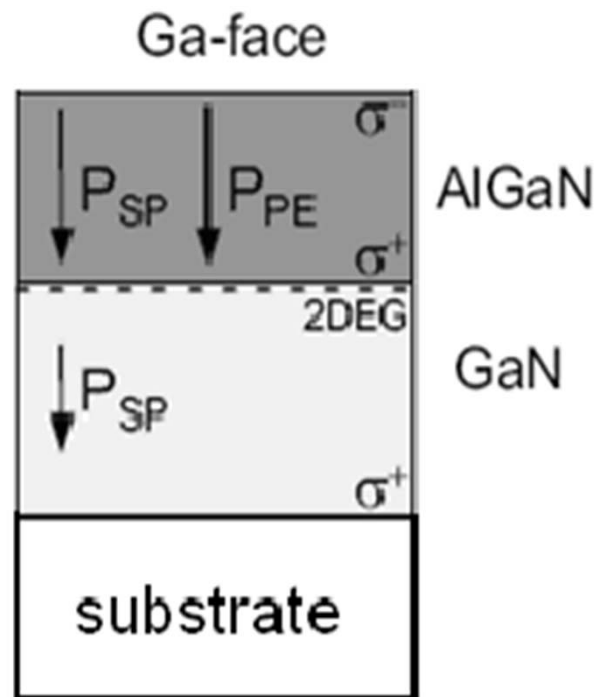
Current collapse)

RF





1







GaAs

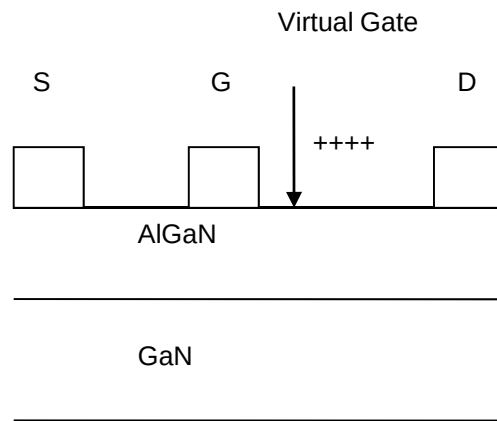
GaN

HEMT

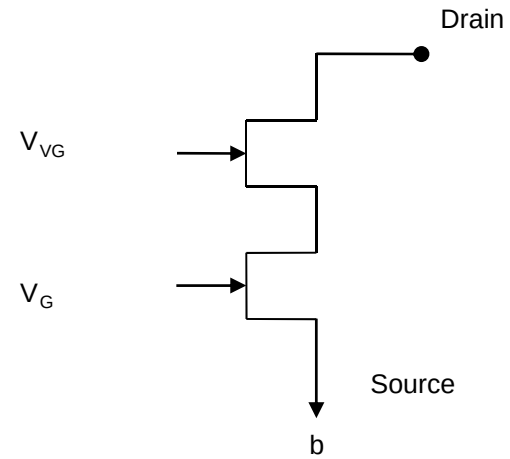
2DEG



Current collapse)



a





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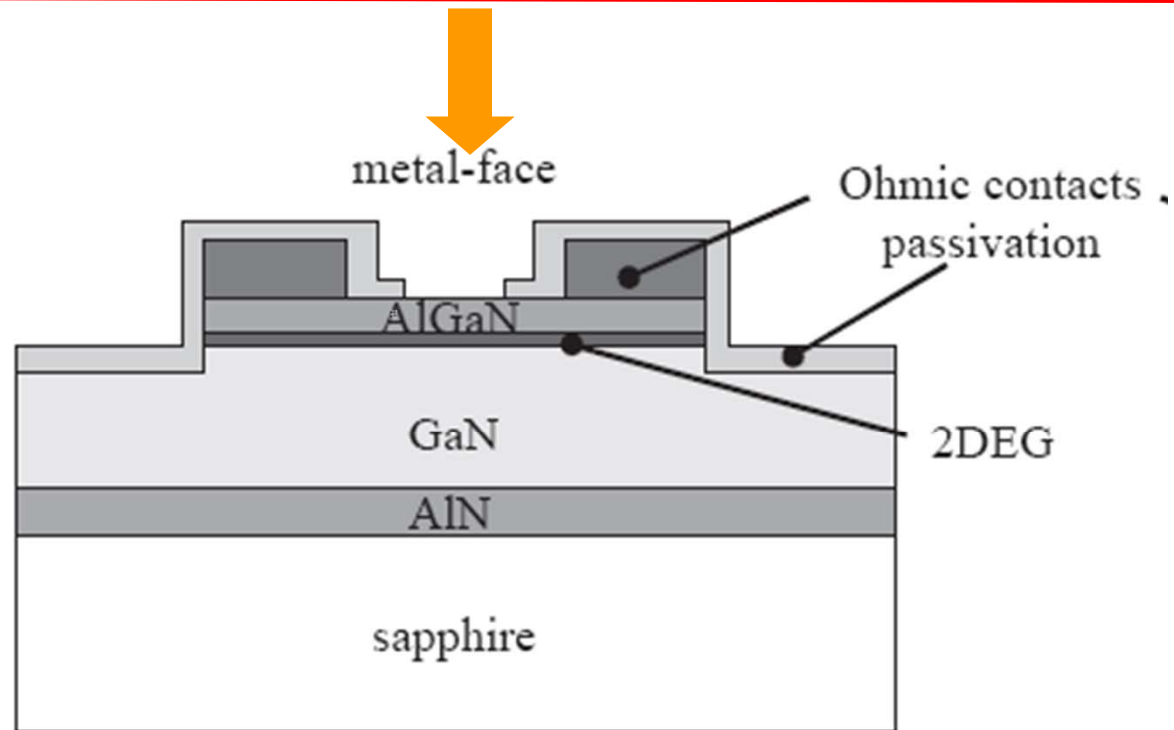
HEM

2DEG

2DEG



HEMT - 2DEG



2DEG

Open-gate M



HEMT 2DEG

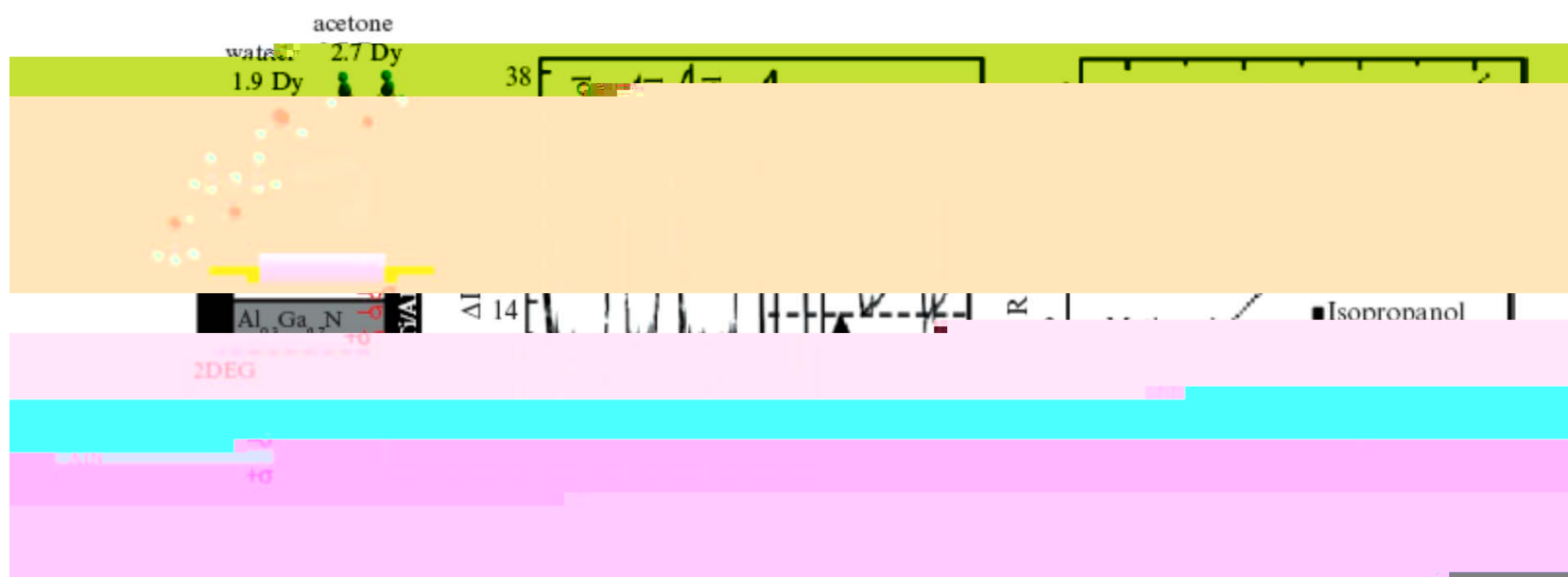
HEMT 2DEG

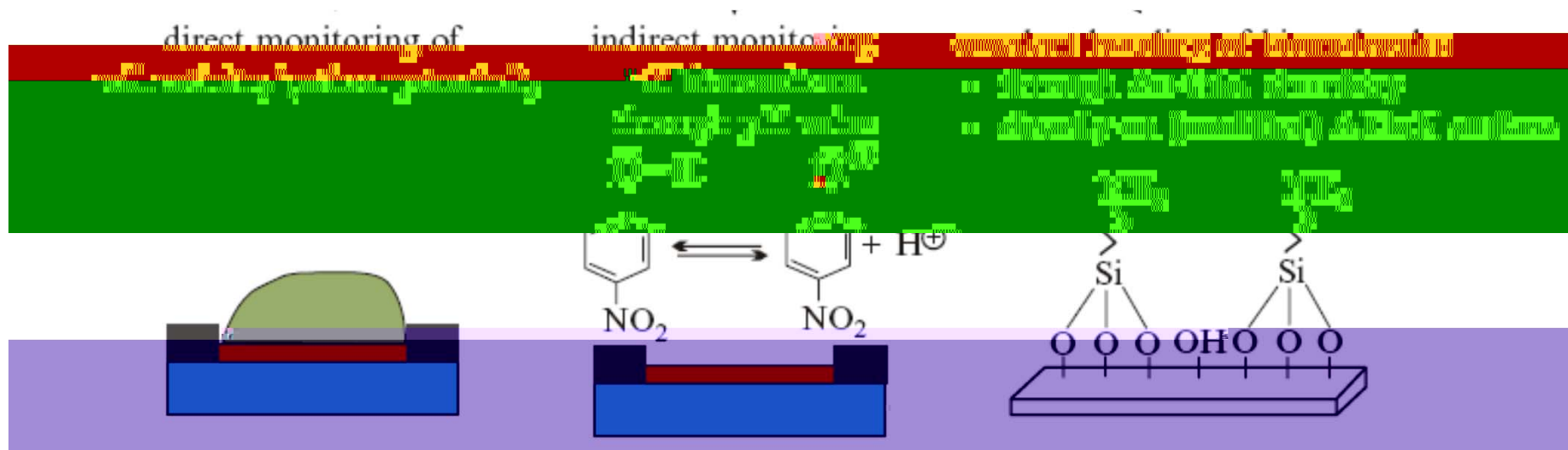
M

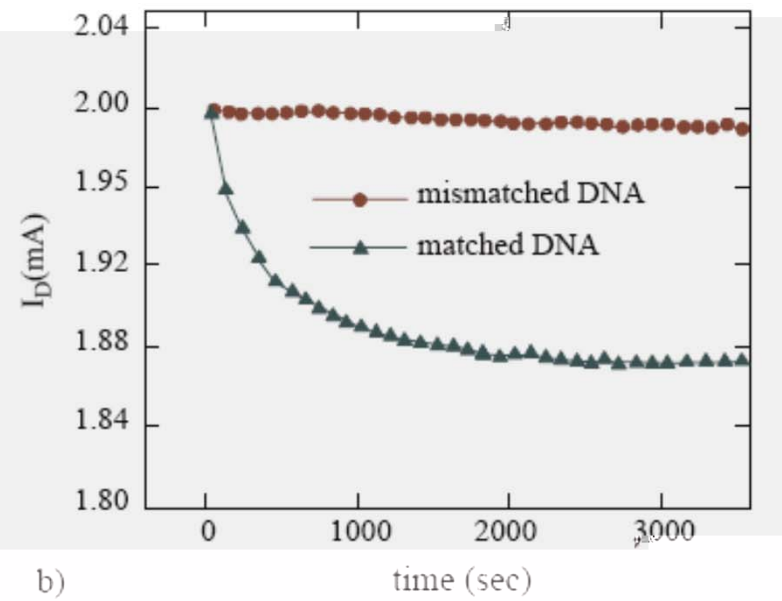
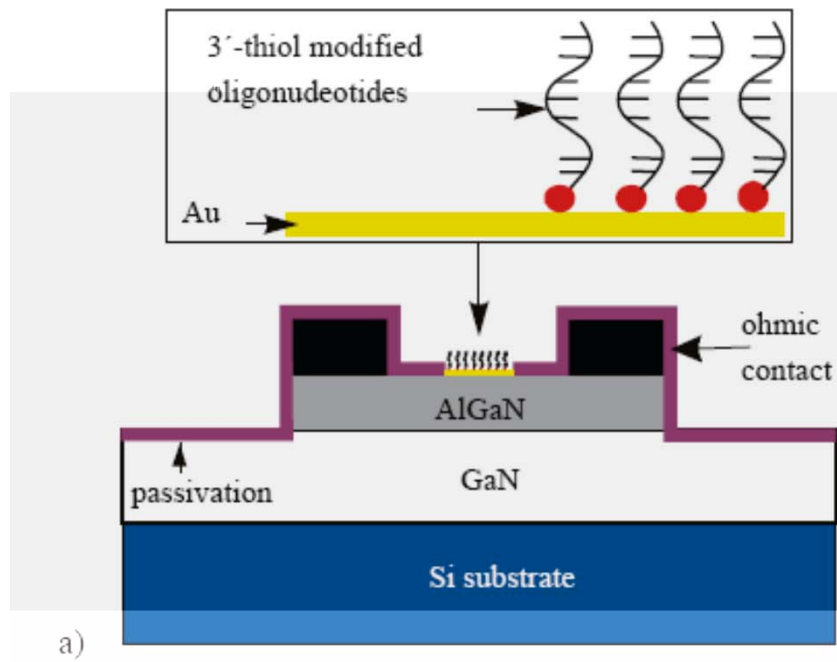
AlGaIn

2DEG

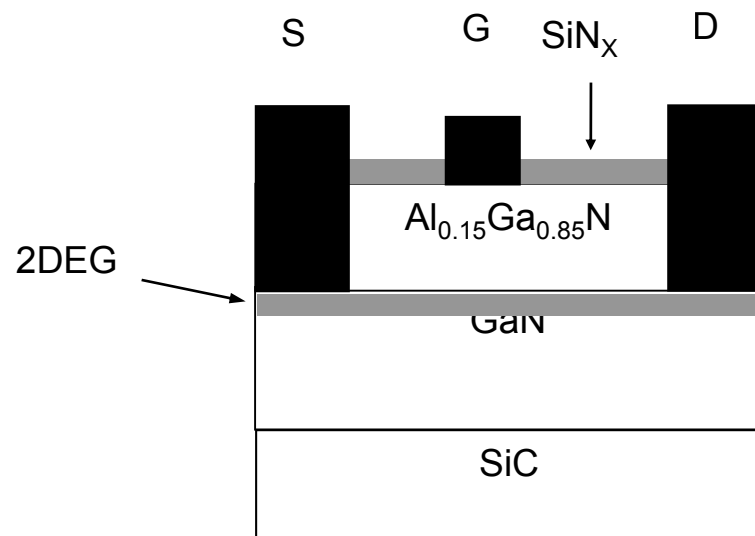
PH



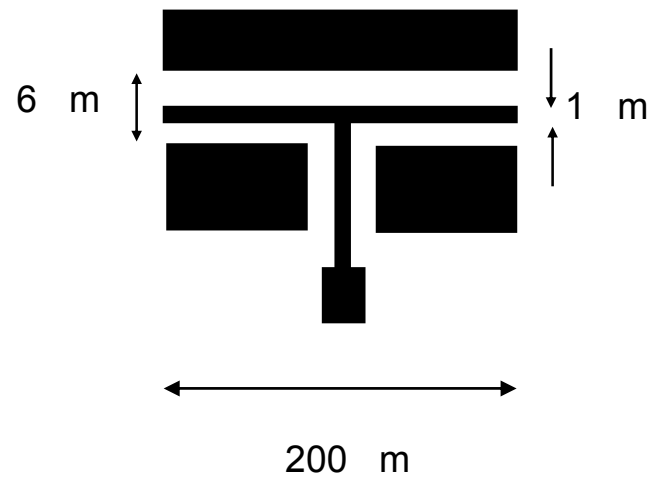




AlGaN/GaN HEMT



(a)

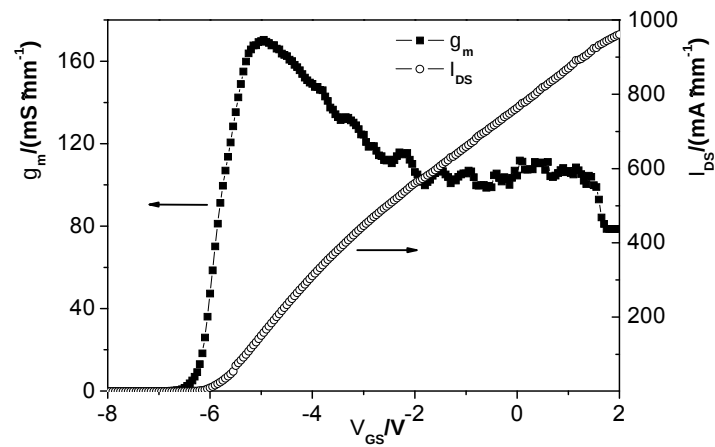
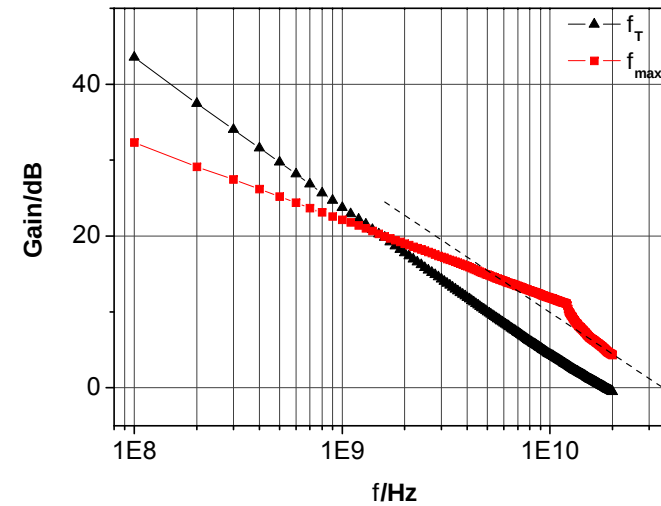
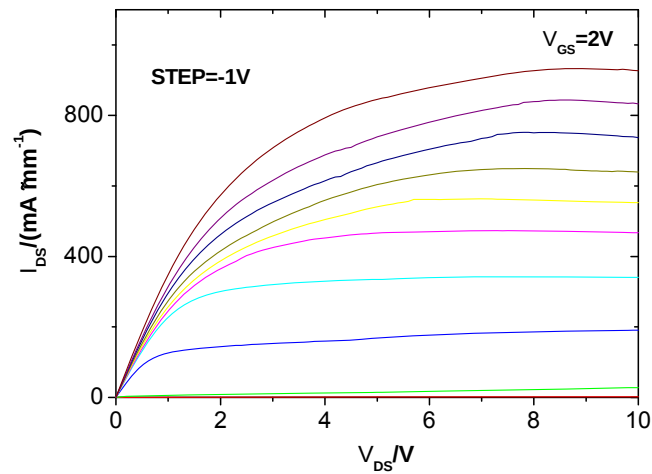


(b)

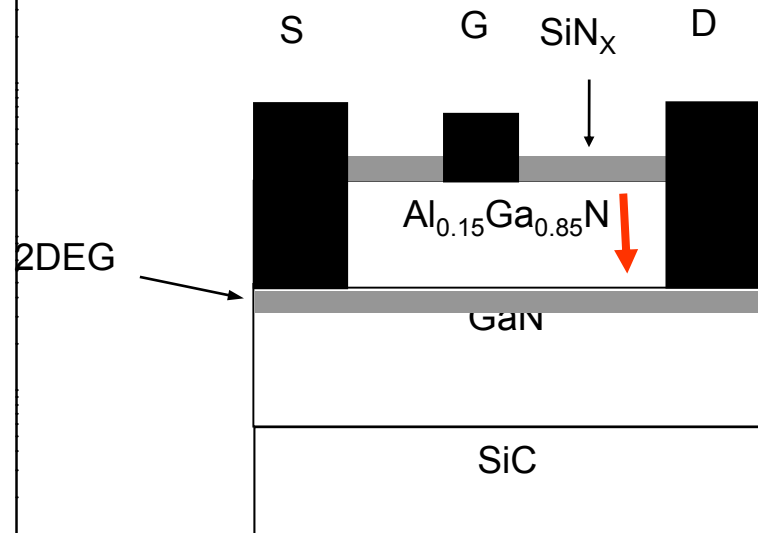
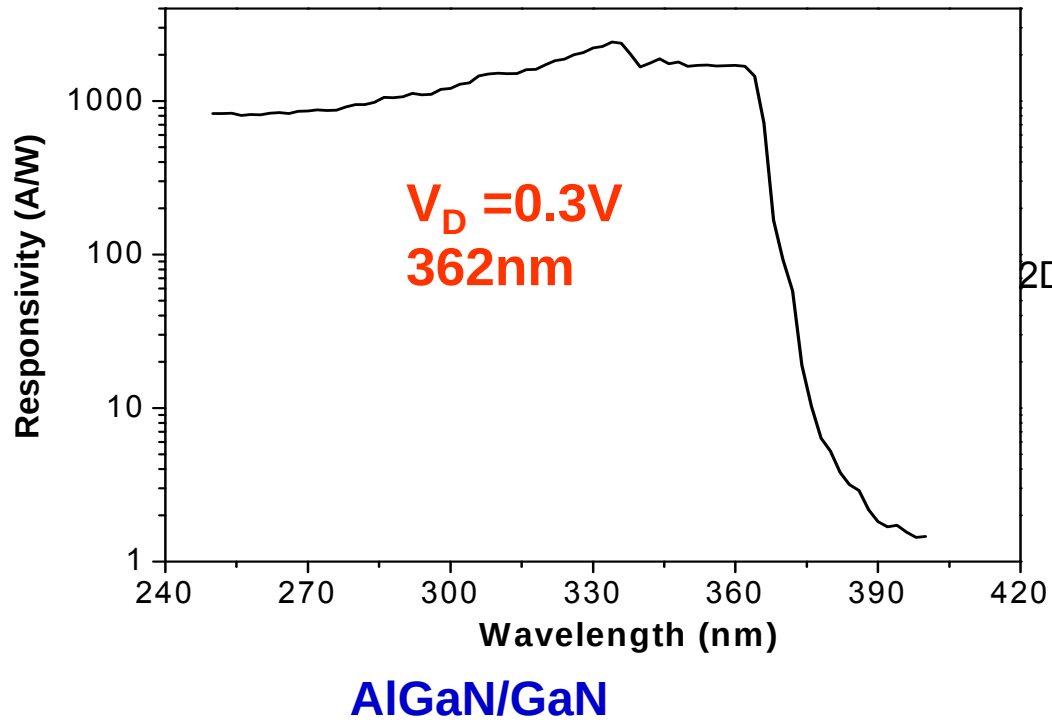
(a)



HEMT



19GHz
35GHz



- 362nm 1700A/W 3 0.8
- g 279
- 333nm Al_{0.15}Ga_{0.85}N



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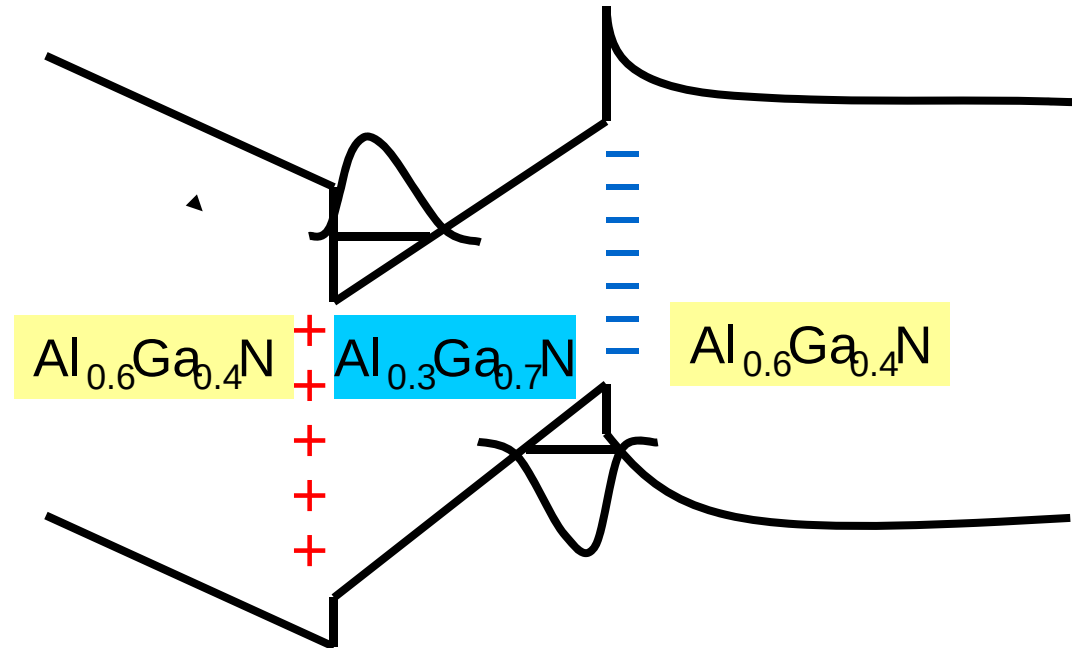


2



//

(QCSE)



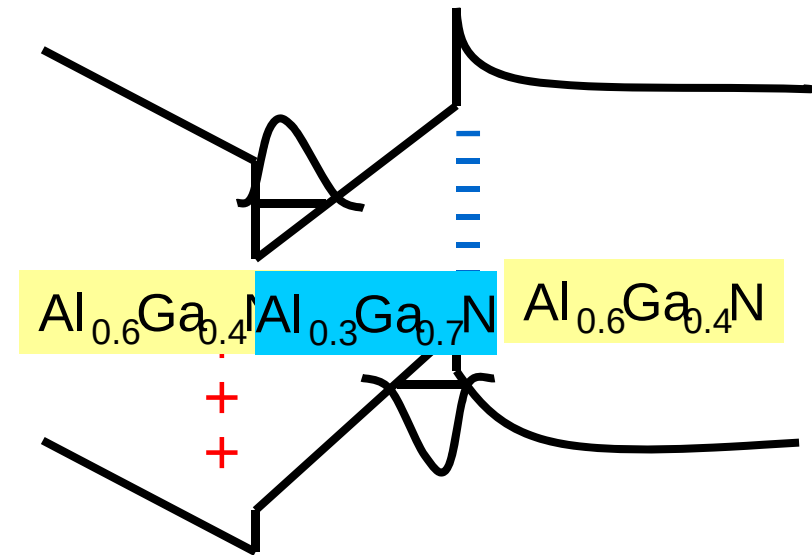


LED LD

1,

LED LD
LD

2,

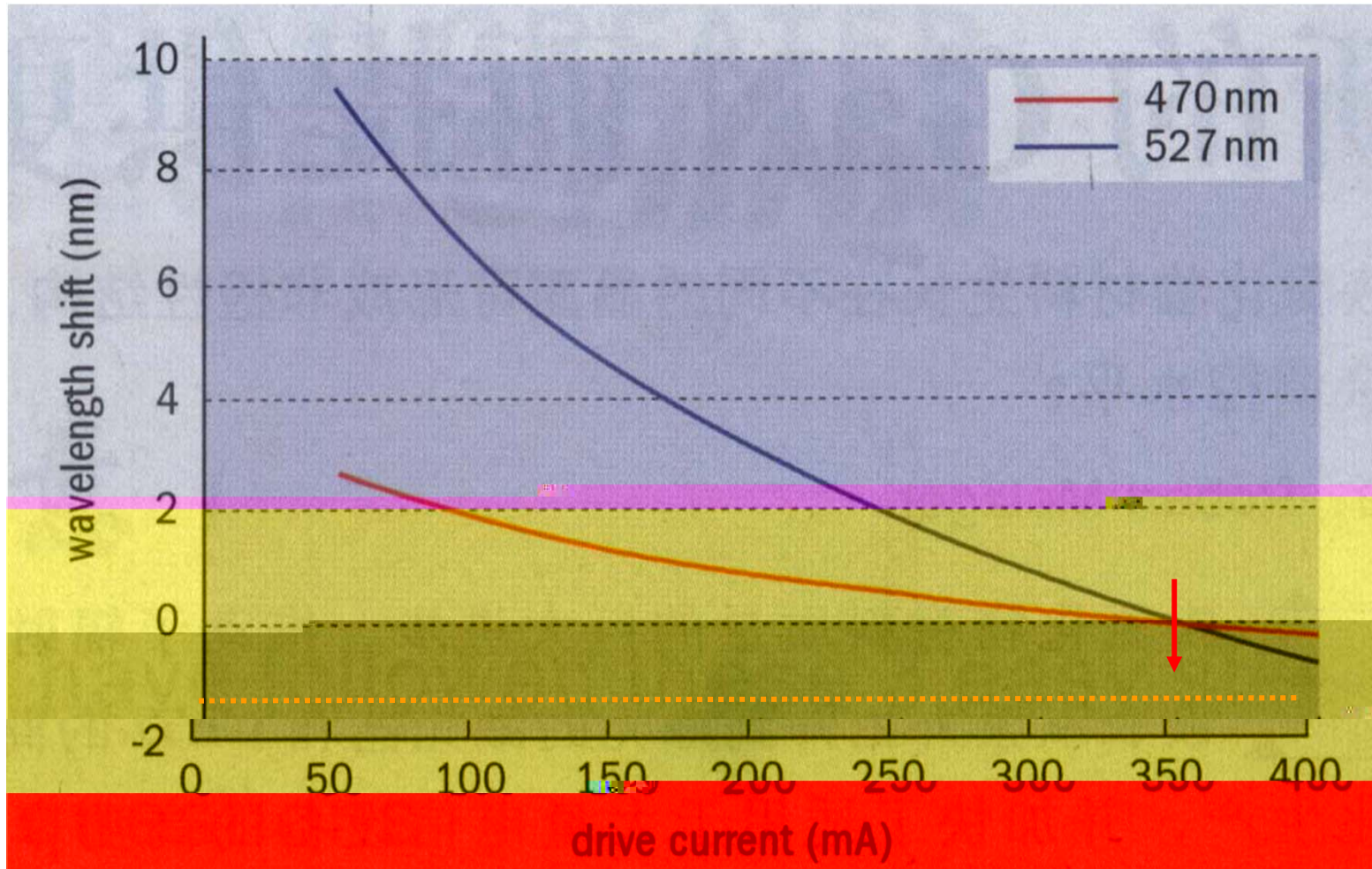


3,

QCSE



LED





LED

InGaN/GaN

$$, P_{sp} \approx 0$$
$$, P_{PE}$$

QCSE

QCSE

LED



LED

InGaN/GaN

$$, P_{sp} \approx 0$$
$$, P_{PE}$$

QCSE

QCSE

LED



LED

Al AlGaIn/GaN

3 , P_{sp}
, P_{PE}

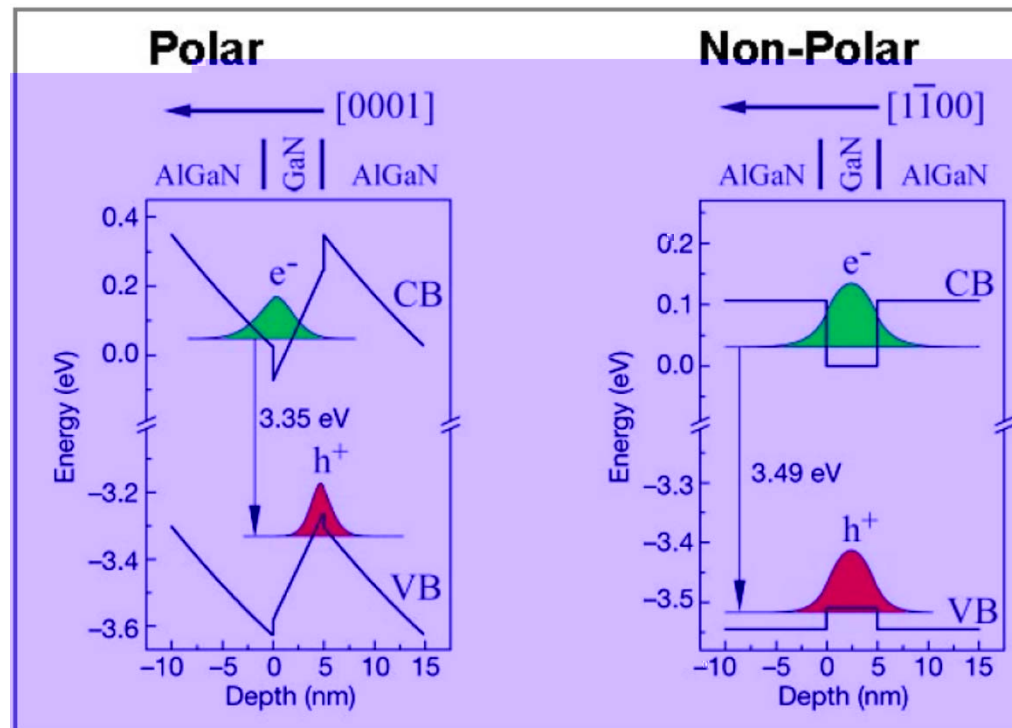
QCSE

QCSE

LED

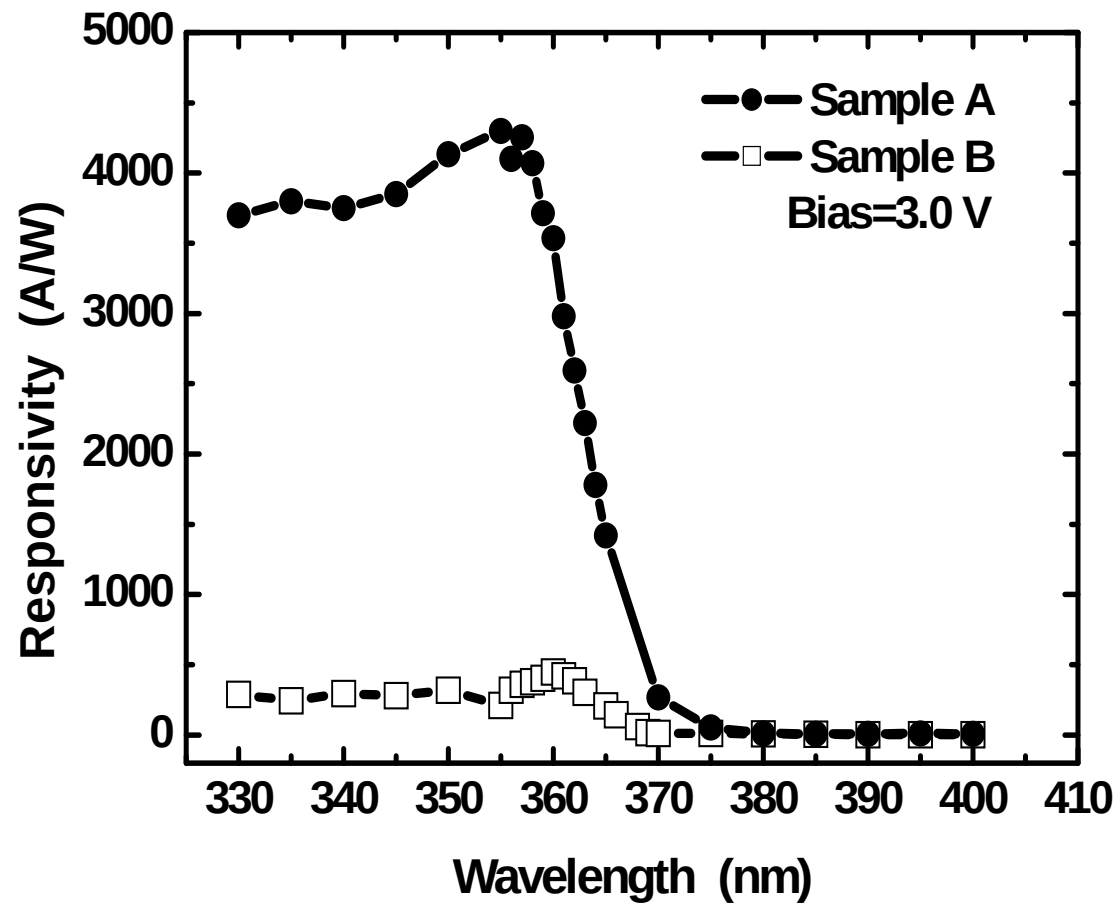


//

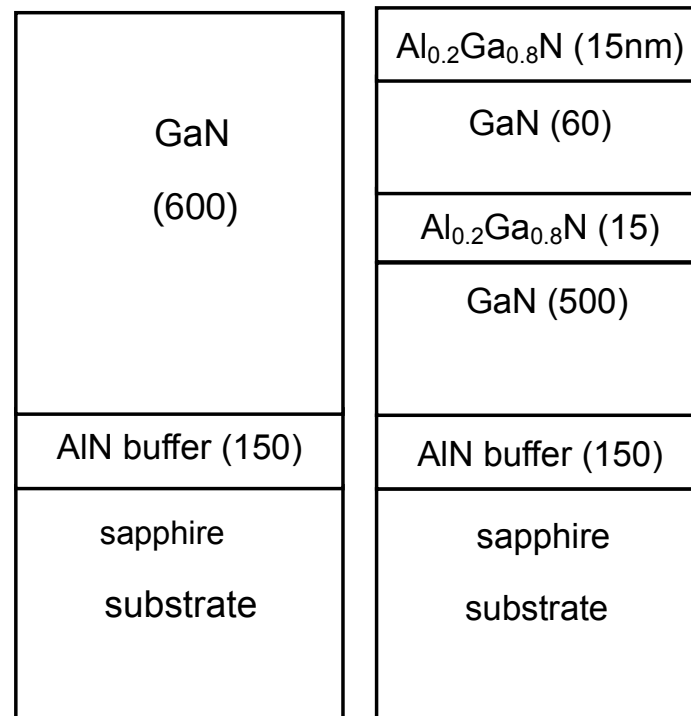




8 AlGaN/GaN DH



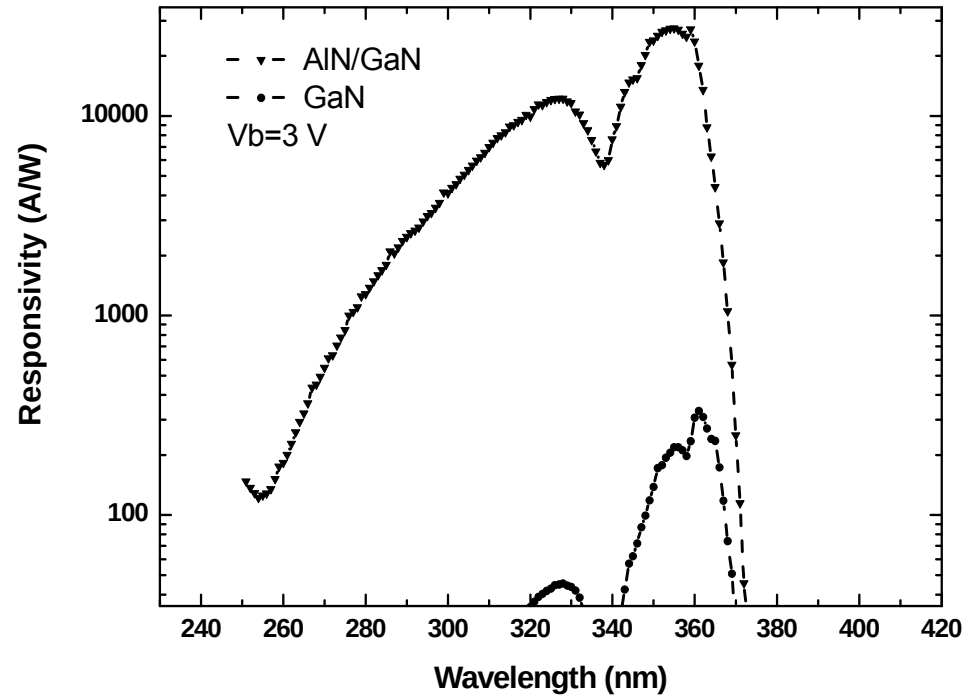
A: $\text{Al}_{0.22}\text{Ga}_{0.78}\text{N}/\text{GaN}/\text{Al}_{0.22}\text{Ga}_{0.78}\text{N}/\text{Sapphire}$
B: $\text{GaN}/\text{Sapphire}$



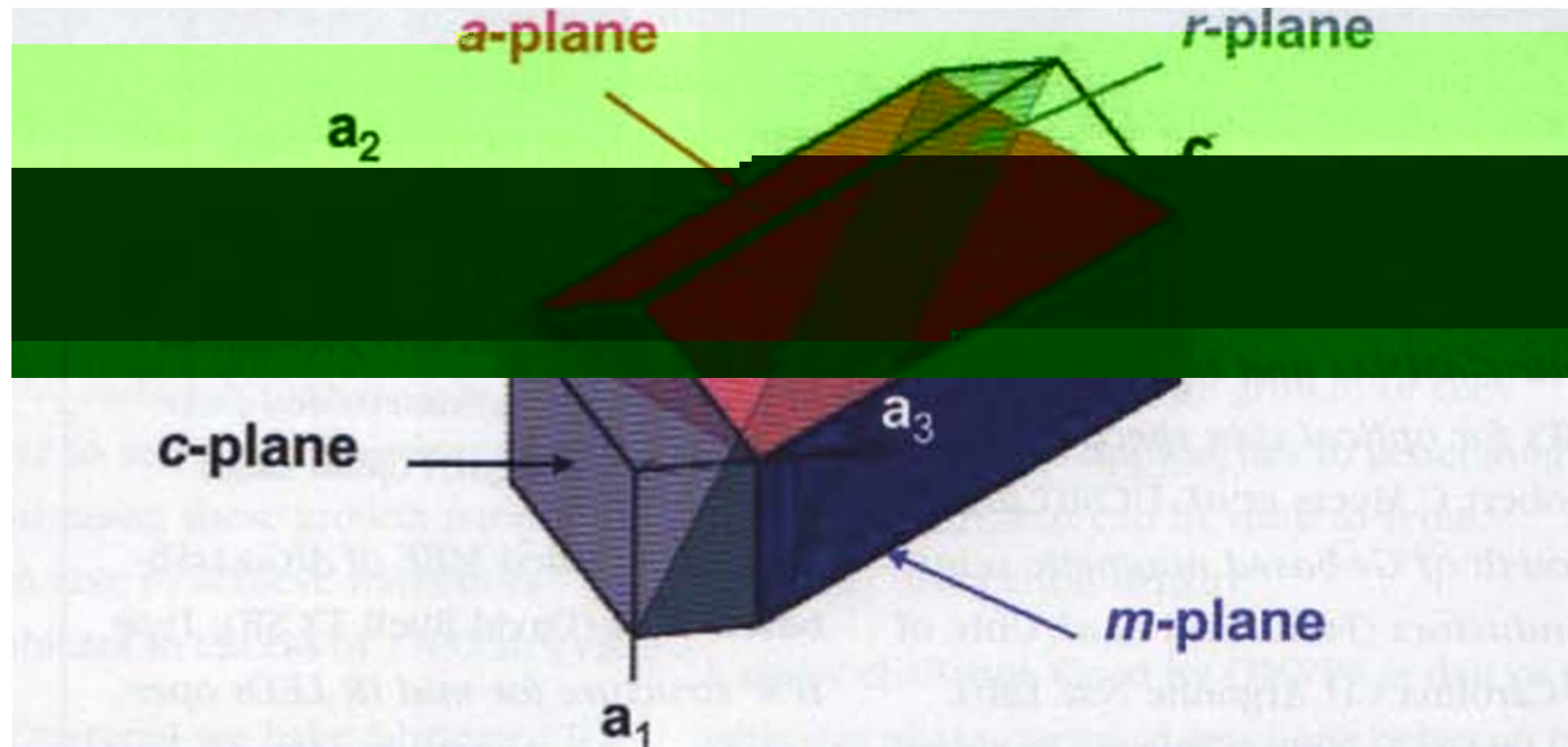
(a)(a)



AlN/GaN



AlN/GaN	I'	27500A/W	3V	358nm	
GaN	I'	330A/W	3V	360nm)	83

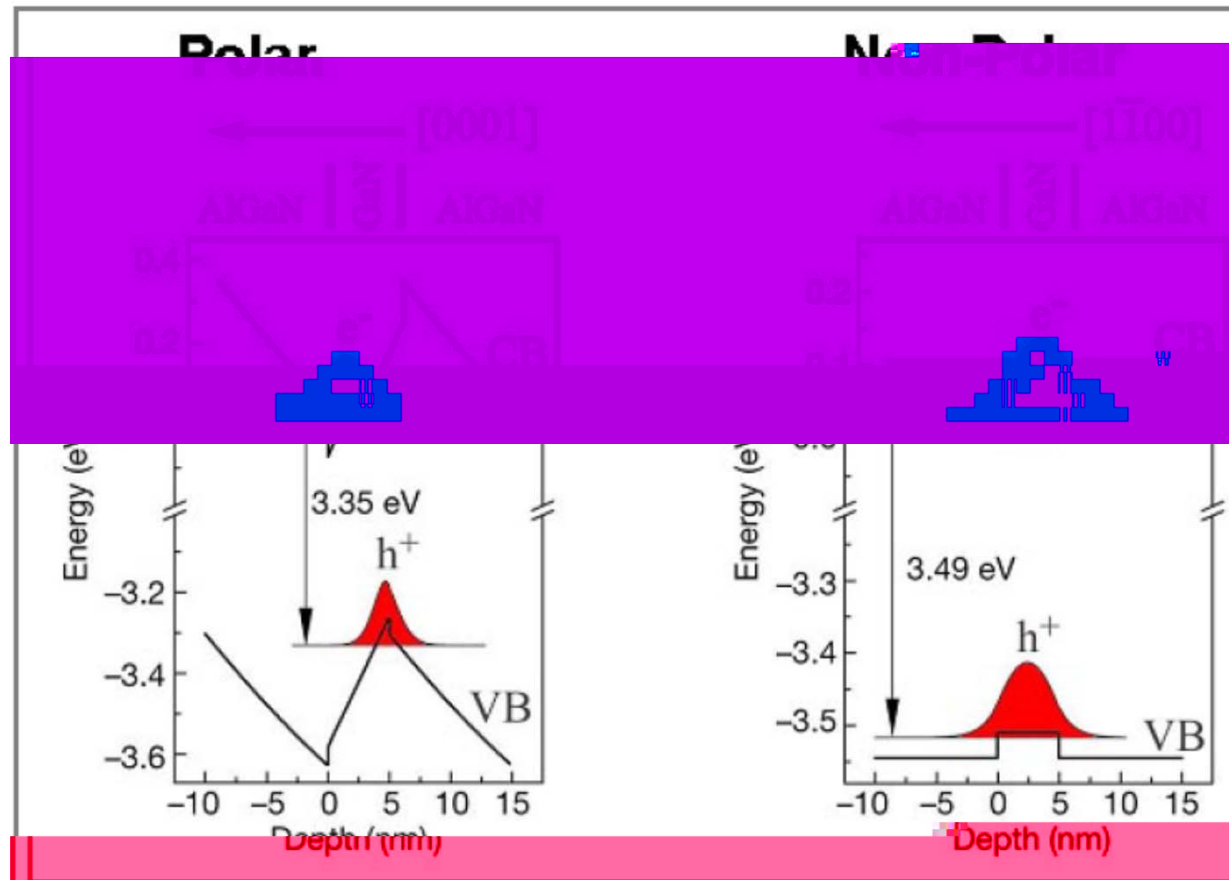


Xc

Xa

Xr

m

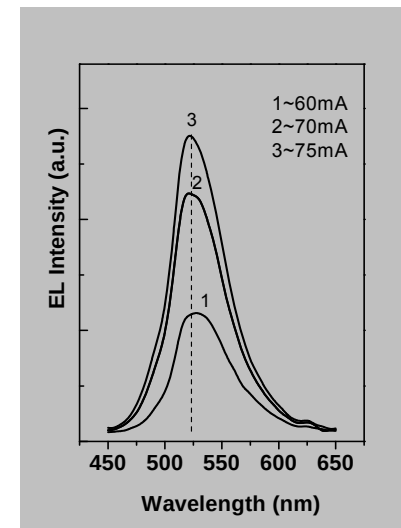
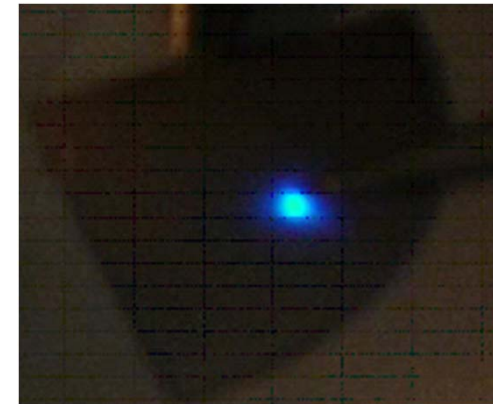
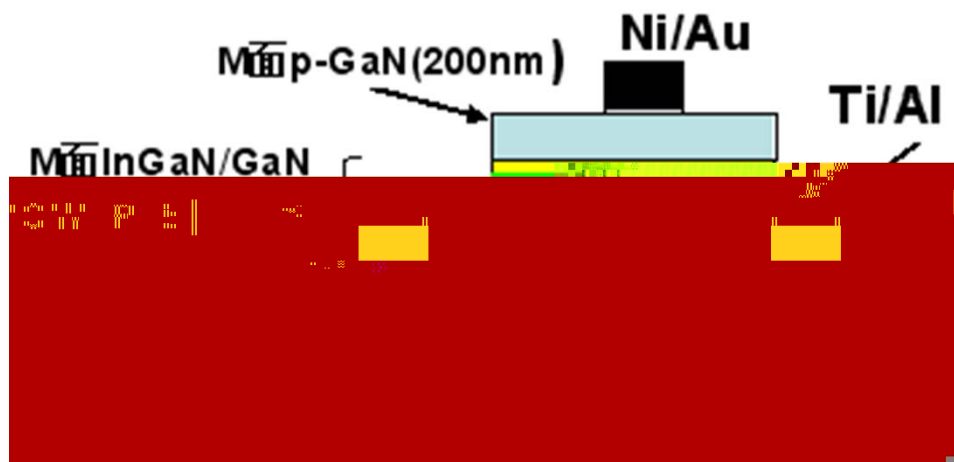




LiAlO_2

M InGaN/GaN

LED





3

GaN

16%

10^8 - $10^{11}/\text{cm}^2$



III InGaN/GaN LED

$10^8 - 10^9 / \text{cm}^2$,

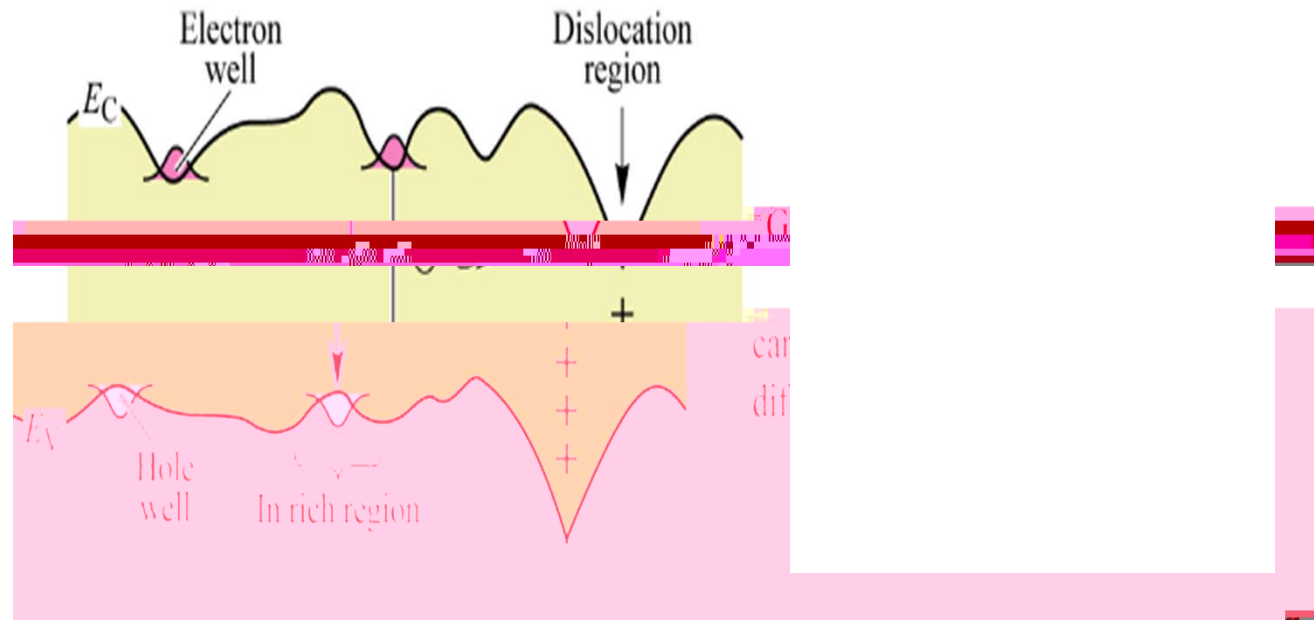
III

III

III



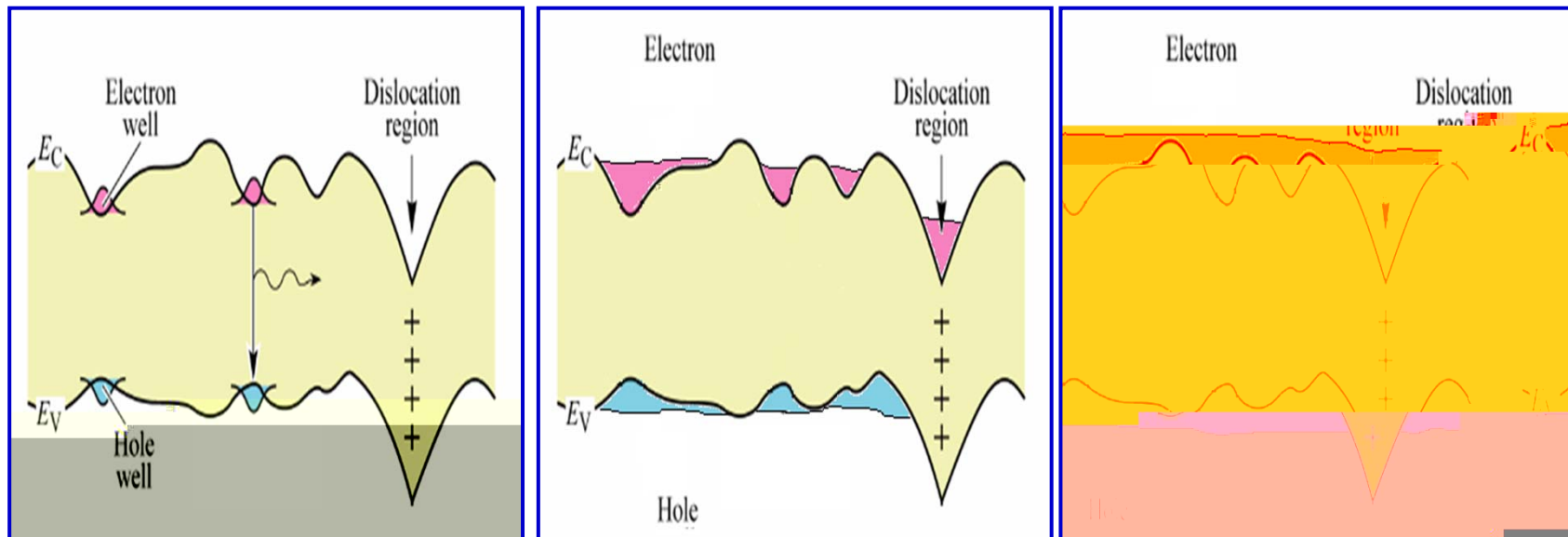
In



LED



$\text{In}_x\text{Ga}_{1-x}\text{N}/\text{GaN}$

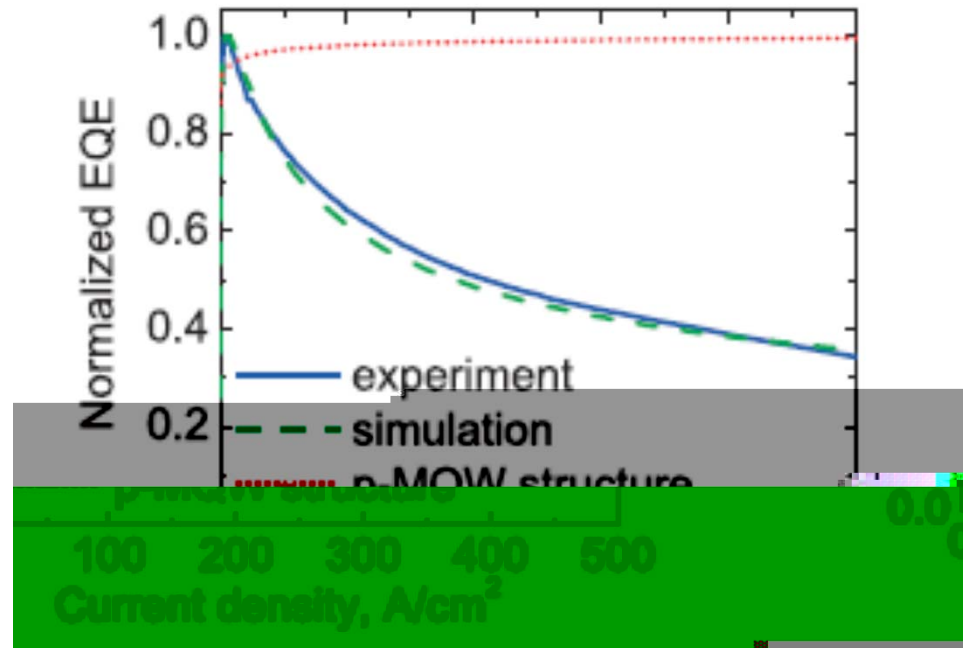


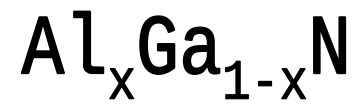


LED“

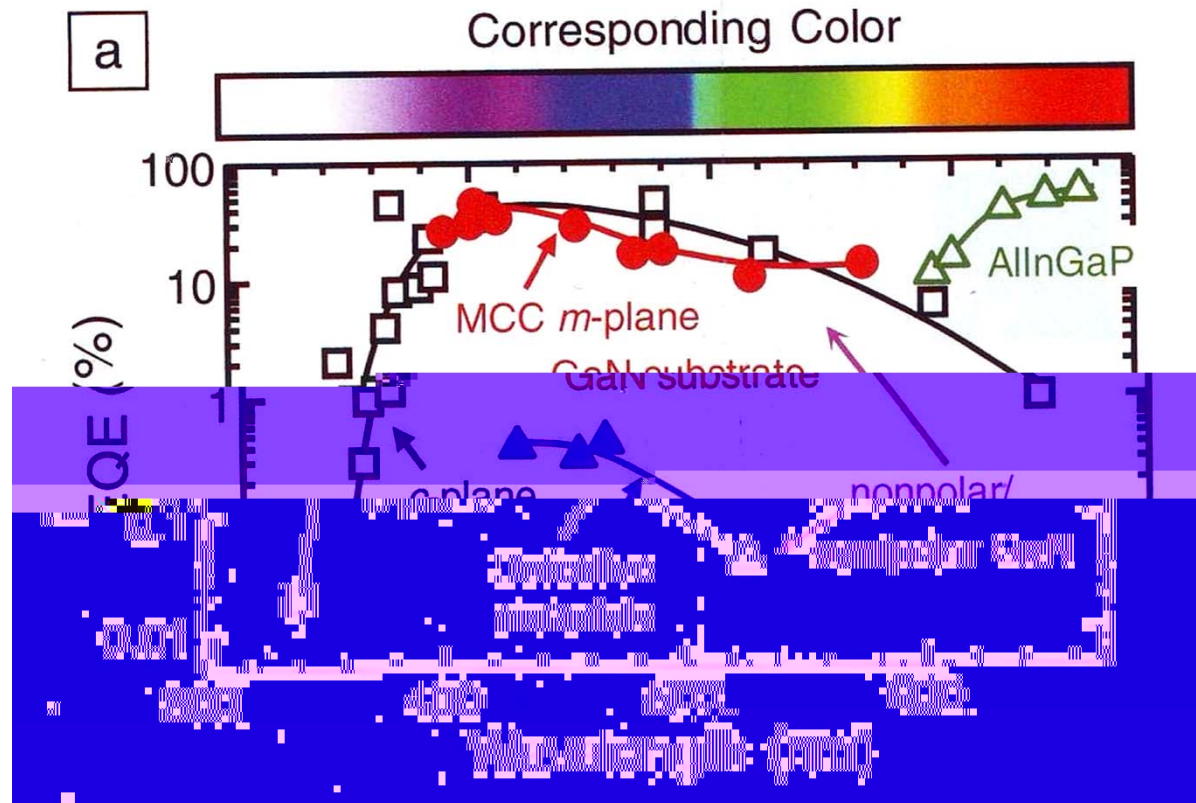
”

Efficiency Droop



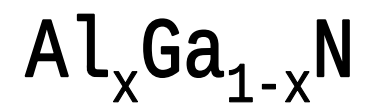


UV





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Al



LED



Al AlGaN

Al V_{Al} AlGaN

Al AlGaN Al

Al

Al

0

$0 - V_{Al}$



Al

AlGa_N

0 V_{AL}

Al

$Al_xGa_{1-x}N$

eg.

AlN



Al	1%,	(Mg)
3meV	(Si)	5.23meV
eg. $\text{Al}_{0.7}\text{Ga}_{0.3}\text{N}$	23meV;	AlN 180meV

Al	8%,	1	,
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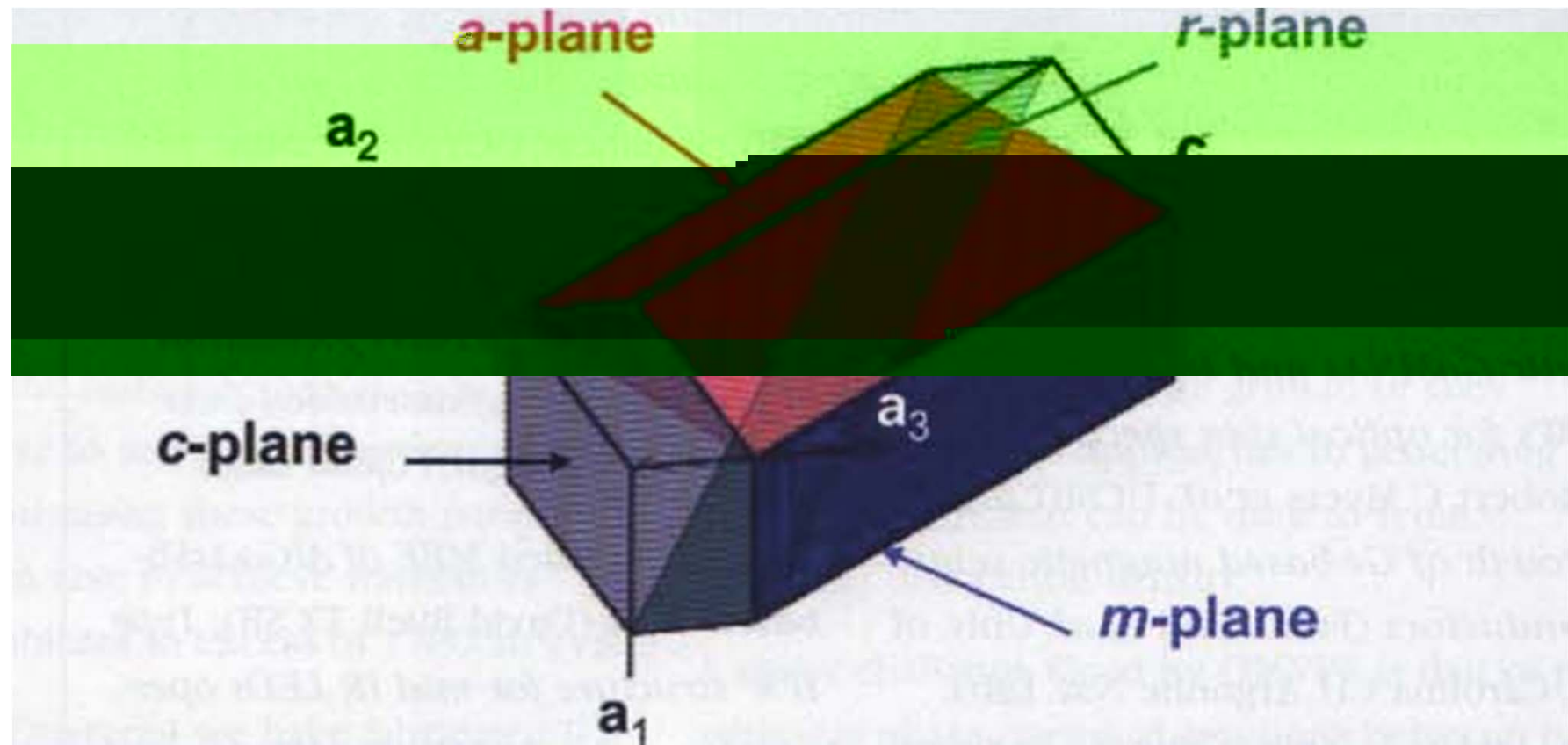


—









Xc

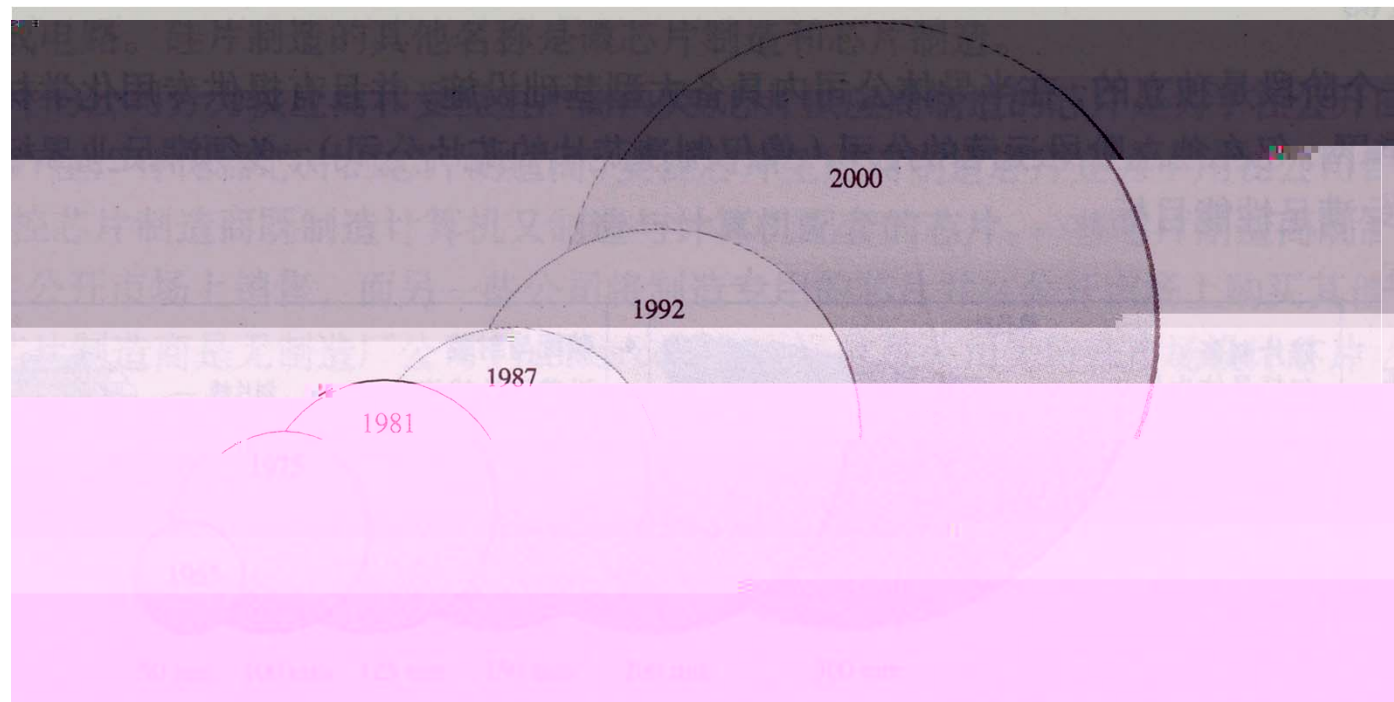
Xa

Xr

m



LED





LED

//

//

AIXTRON

**1 42x2"/ ,
662cm²**

**2 6x6"/ ,
1009cm² 1**

AIX G5 MOCVD

851cm²,

**1094cm²,
52.63%**



LED



MOCVD



MOCVD

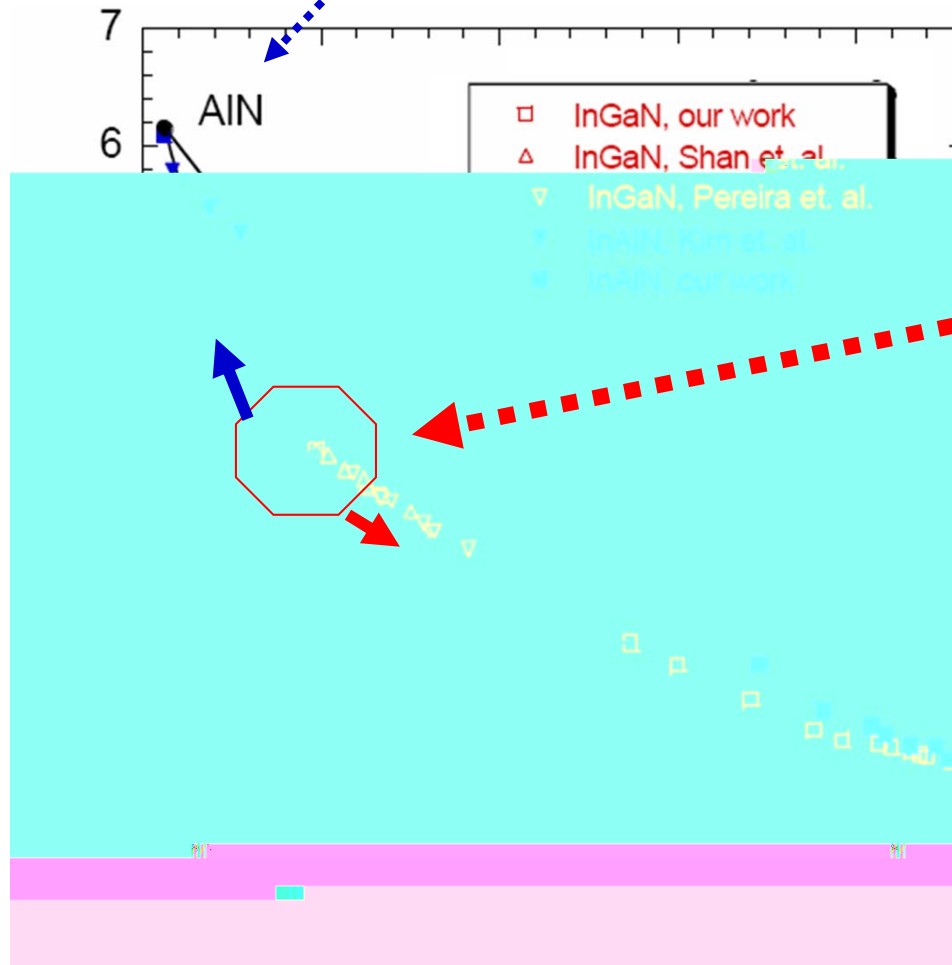


LED



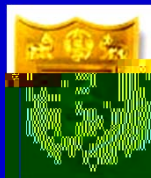


AlN-based ?



GaN-based

InN-based ?



AQAAQ



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