



# Light Emitting Transistor

---

電機所甲組

施力勝      N26944012

呂俊賢      N26941048



# Outline

---

## **Introduction**

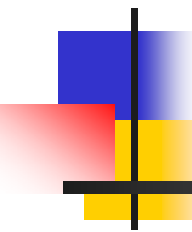
- **Heterojunction bipolar transistor (HBT)**
  - Heterojunction
  - Result and Discussion
  - Conclusion
- **Visible spectrum light-emitting transistor**
  - Result and Discussion
  - Conclusion
- **Organic light emitting transistor(OLED)**
  - Result and Discussion
  - Conclusion
- **References**



# Introduction

---

- 具有電輸出輸入埠和紅外光輸出埠.
- 以磷化銦鎵(InGaP)及砷化鎵 (GaAs)的異質結構所構成.



Light-emitting transistor:  
Light emission from InGaP/GaAs  
heterojunction bipolar transistor  
(HBT)

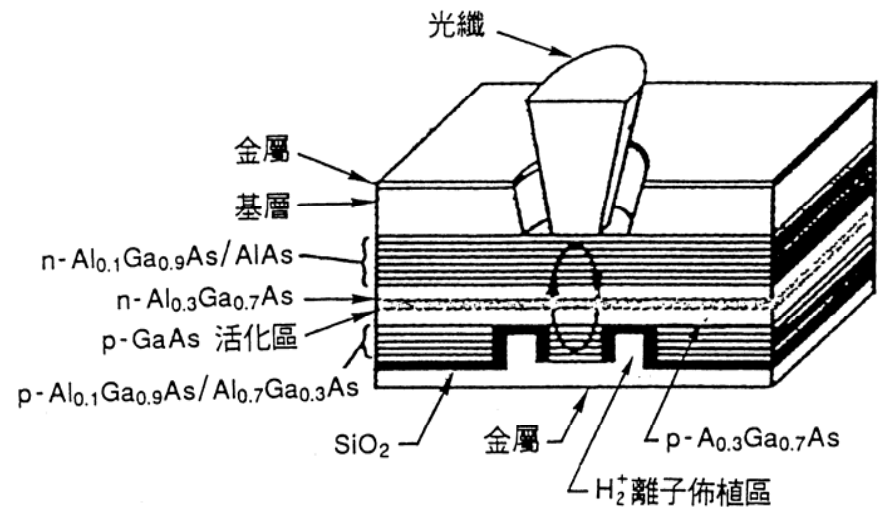
M. Feng, N. Holonyak, Jr., and W. Hafez

*Department of Electrical and Computer Engineering, University of Illinois at  
Urbana-Champaign, 208 North Wright Street, Urbana, Illinois 61801*

APPLIED PHYSICS LETTERS (2004)

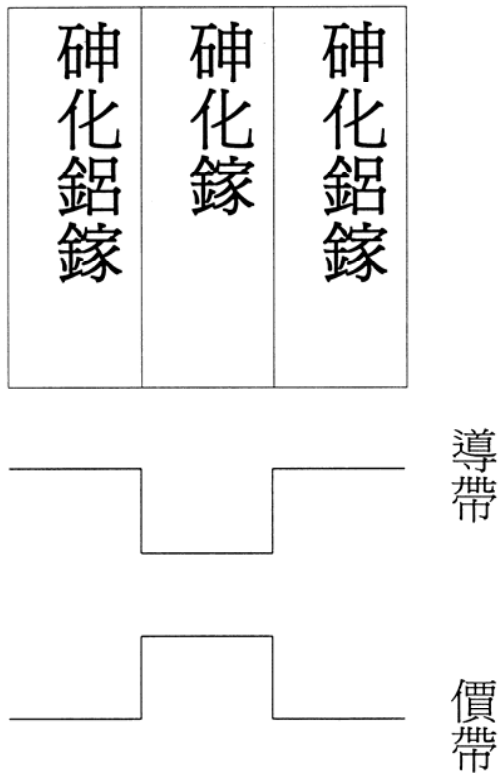
# hetero junction (1)

所謂半導體異質結構，就是將不同材料的半導體薄膜，依先後次序沈積在同一基座上。



半導體異質結構

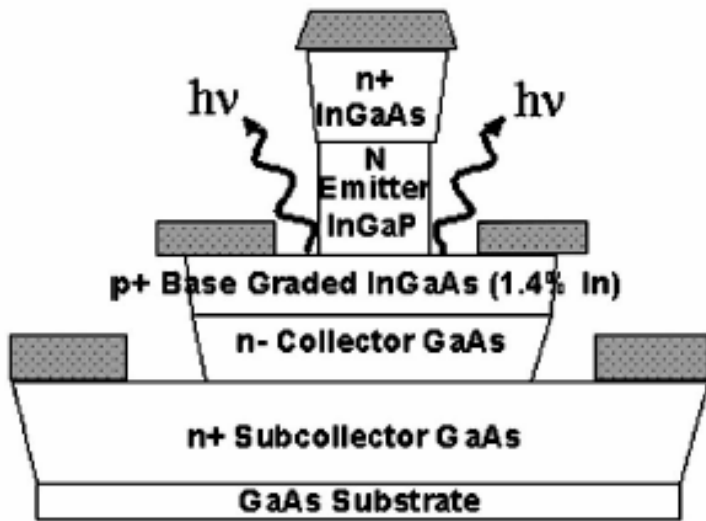
# heterojunction (2)



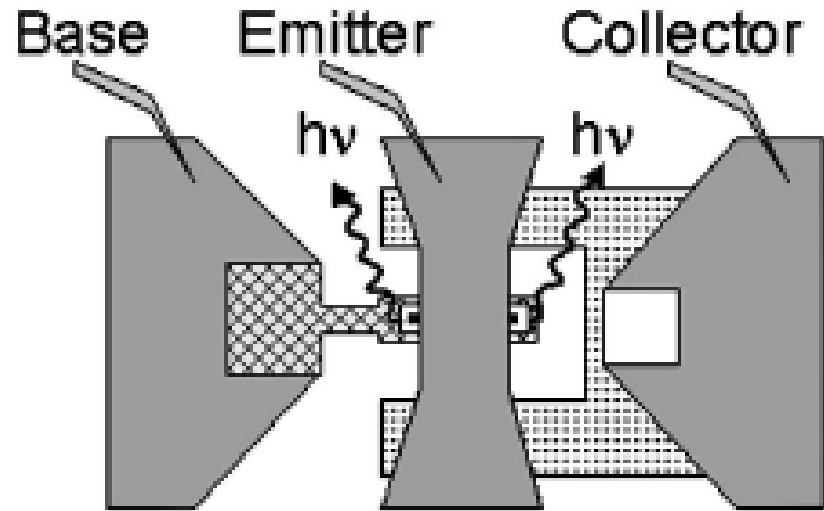
- 異質結構特性：
  - (1) 量子效應
  - (2) 遷移率 (Mobility) 變大
  - (3) 奇異的二度空間特性
  - (4) 人造材料工程學

砷化鎵與砷化鋁鎵異質結構量子井的簡圖

# HBT structure



structure of InGaP/GaAs HBT



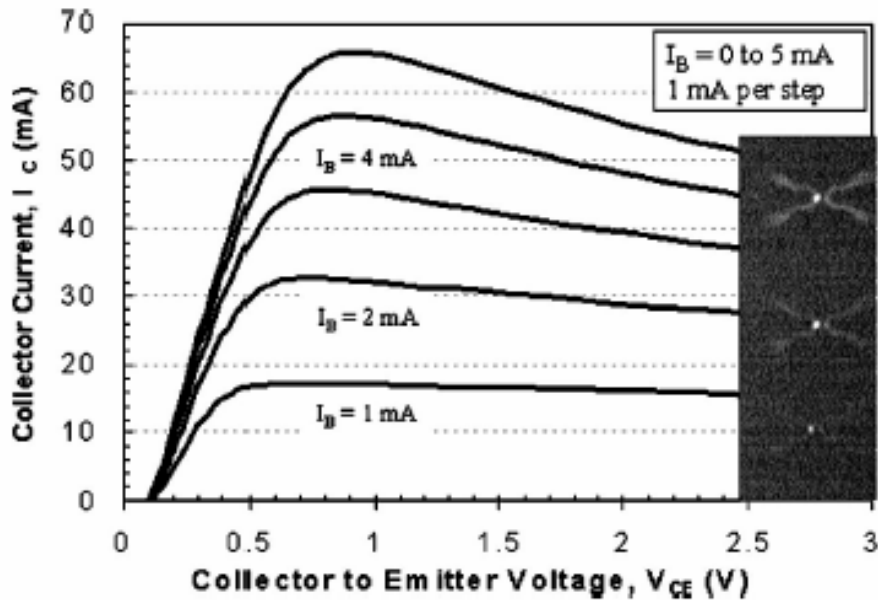
top view layout of InGaP/GaAs HBT

radiative recombination (light emission) from the base layer of direct-gap InGaP/GaAs

# Result and Discussion (1)

$I-V$  curve for common emitter

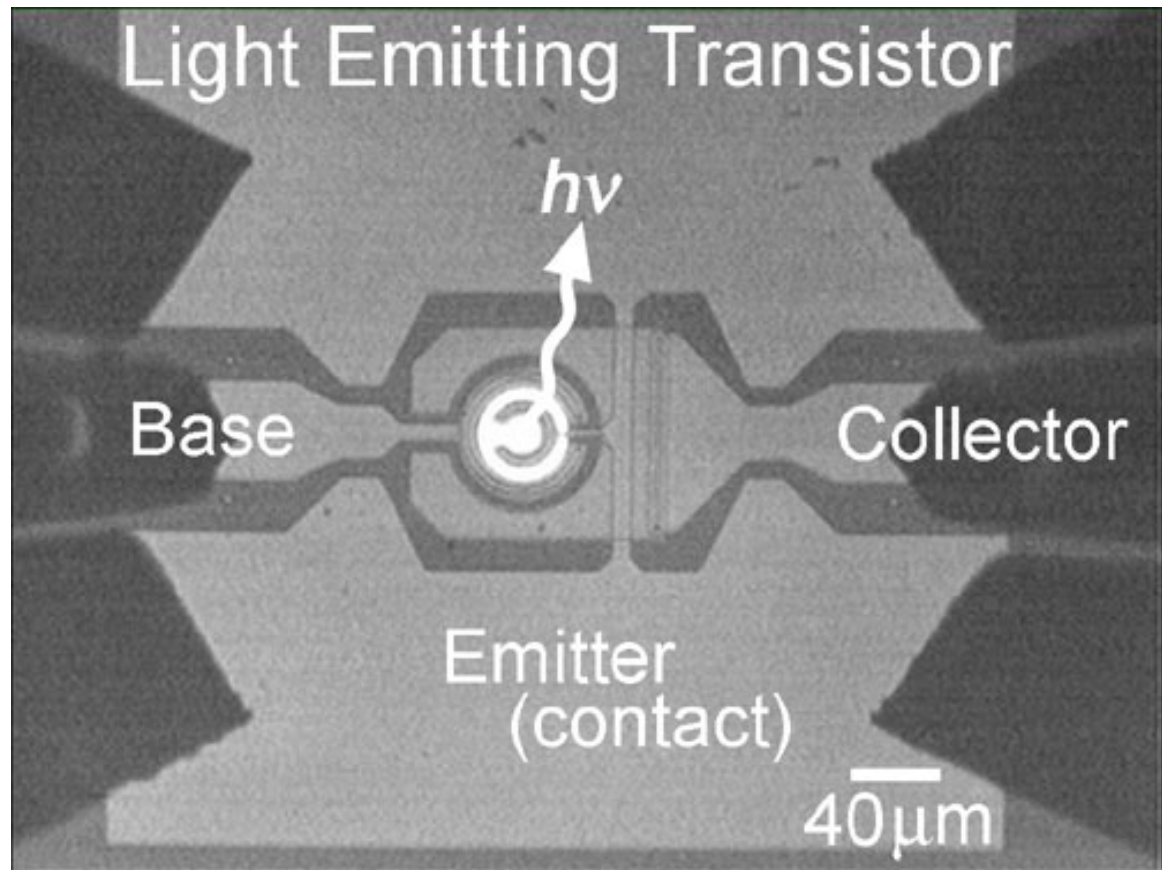
dc beta gain ( $\beta = \Delta i_c / \Delta i_b$ )



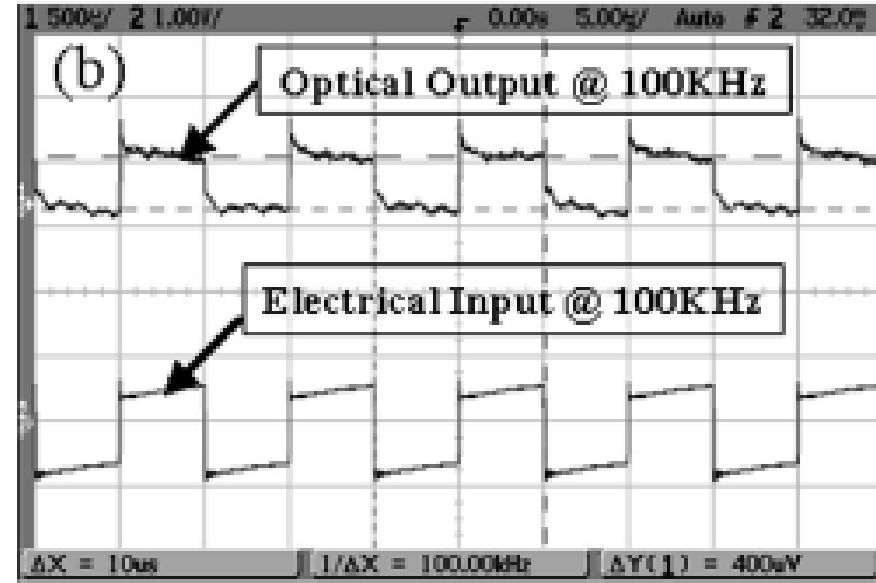
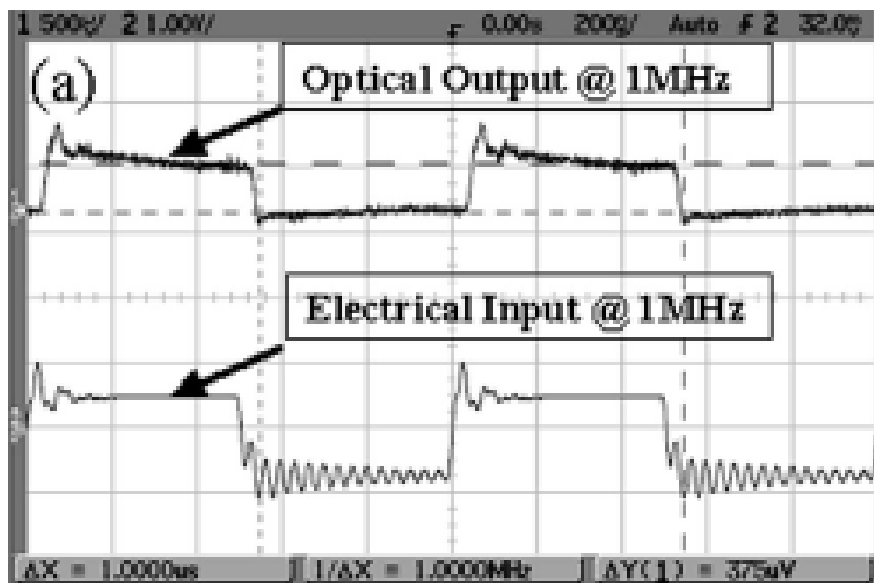
different base current for  $i_b = 1, 2,$  and  $4$  mA

# Result and Discussion(2)

light emission

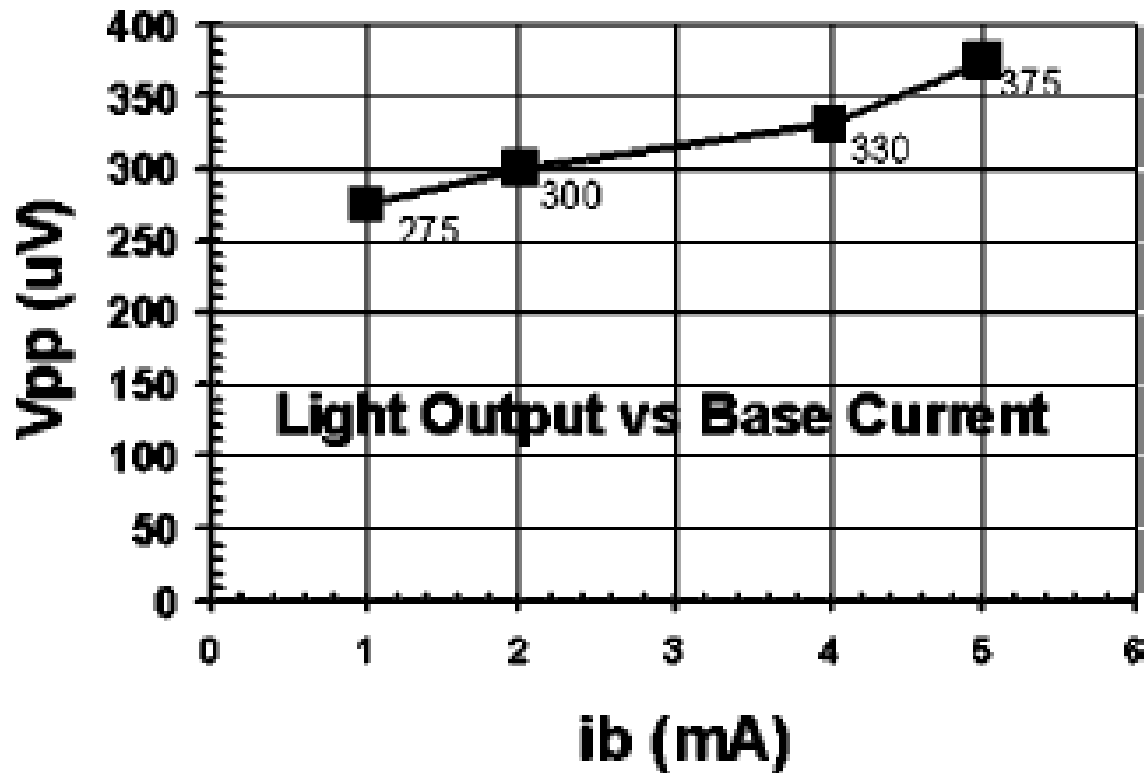


# Result and Discussion(3)



optical output modulation from the base layer for input signal emitter to base junction at (a) 1 MHz and (b) 100 kHz.

# Result and Discussion(4)



HBT peak-to-peak output voltage



# Conclusion

---

- light emission intensity as a function of base current.
- HBT is a light-emitting transistor (LET) that operates at transistor speed.



# Visible spectrum light-emitting transistors

---

F. Dixon, R. Chan, G. Walter, N. Holonyak, Jr., and M. Feng

*Department of Electrical and Computer Engineering, University of Illinois at Urbana—Champaign, 1406 West Green Street, Urbana, Illinois 61801*

X. B. Zhang, J. H. Ryou, and R. D. Dupuis *School of Electrical and Computer Engineering and Center for Compound Semiconductors, Georgia Institute of Technology, 777 Atlantic Drive NW, Atlanta, Georgia 30332-0250*

Received 21 September 2005; accepted 3 November 2005; published online 5 January 2006

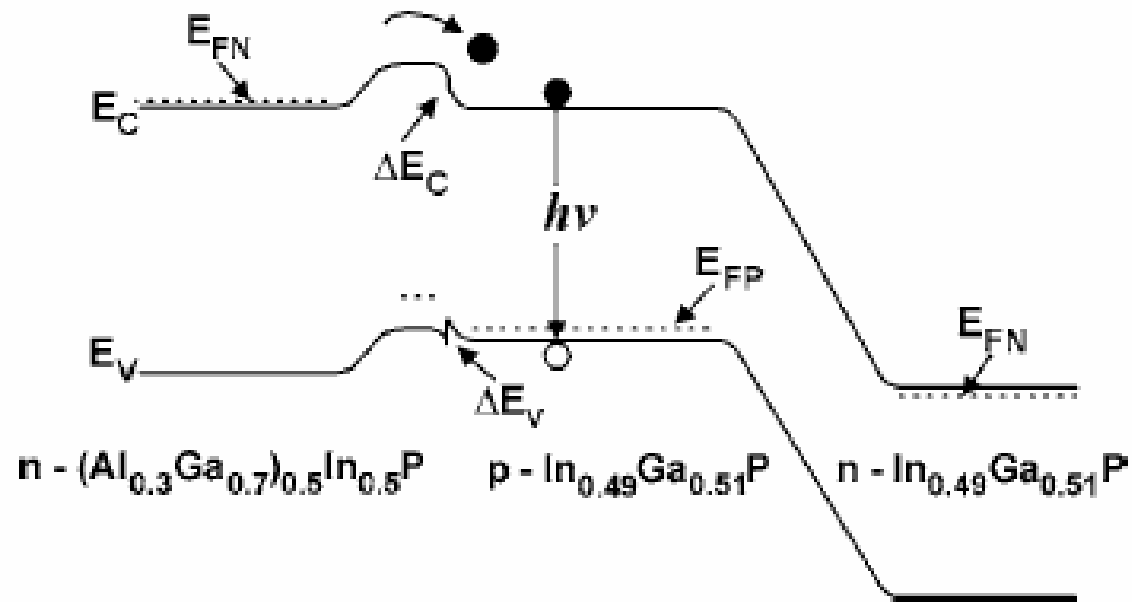


# Structure

<b>Emitter Contact</b>	<b>0.15 <math>\mu\text{m}</math>, GaAs (<math>n = 7.0 \times 10^{18} \text{ cm}^{-3}</math>)</b>
<b>Emitter</b>	<b>0.10 <math>\mu\text{m}</math>, <math>(\text{Al}_{0.3}\text{Ga}_{0.7})_{0.5}\text{In}_{0.5}\text{P}</math> (<math>n = 1.7 \times 10^{18} \text{ cm}^{-3}</math>)</b>
<b>Base</b>	<b>0.30 <math>\mu\text{m}</math>, <math>\text{In}_{0.49}\text{Ga}_{0.51}\text{P}</math> (<math>p = 1.0 \times 10^{18} \text{ cm}^{-3}</math>)</b>
<b>Collector</b>	<b>0.15 <math>\mu\text{m}</math>, <math>\text{In}_{0.49}\text{Ga}_{0.51}\text{P}</math> (<math>n = 1.3 \times 10^{17} \text{ cm}^{-3}</math>)</b>
<b>Sub-collector</b>	<b>0.20 <math>\mu\text{m}</math>, GaAs (<math>n = 6.0 \times 10^{18} \text{ cm}^{-3}</math>)</b>
	<b>GaAs Substrate (<math>n = 1.0 \times 10^{18} \text{ cm}^{-3}</math>)</b>

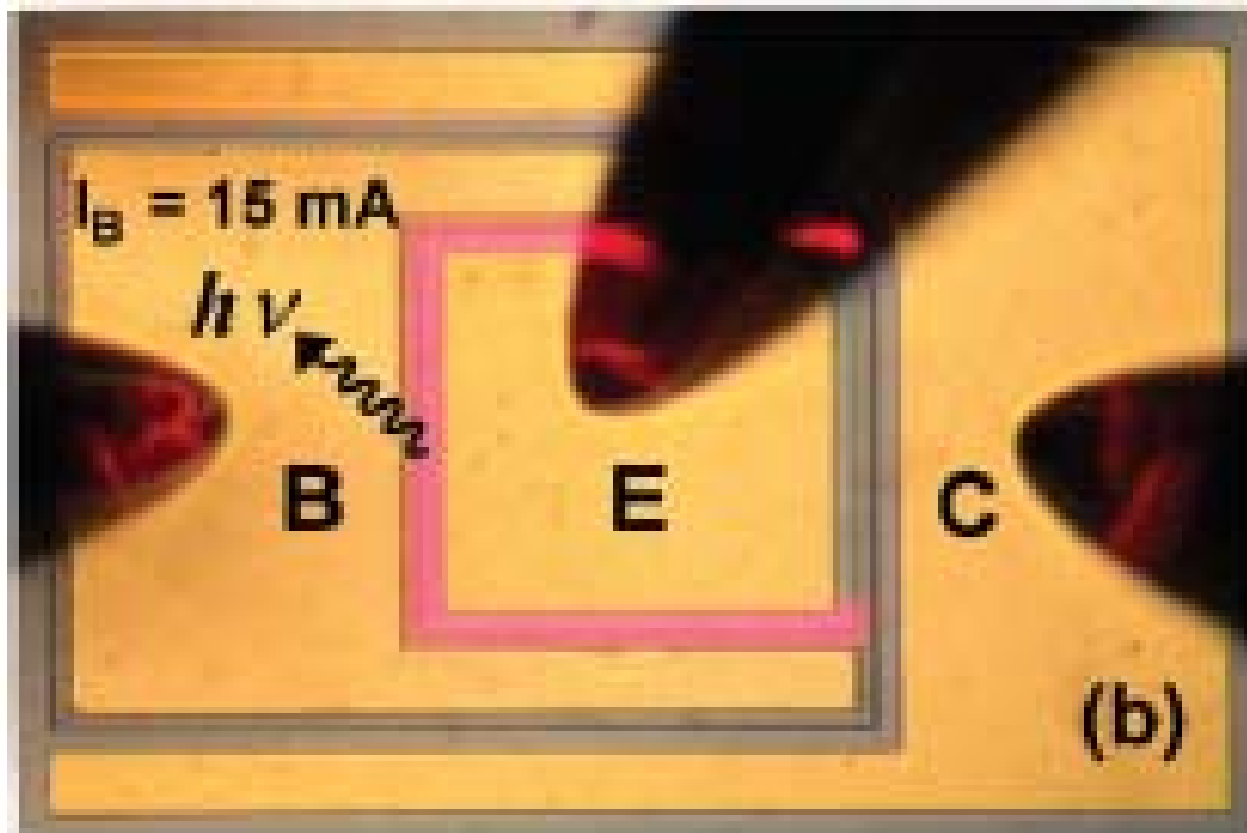
Diagram of the epitaxial layers of an AlGaInP/InGaP crystal used for a LET employing a *p*-type InGaP base.

# Energy-band diagram

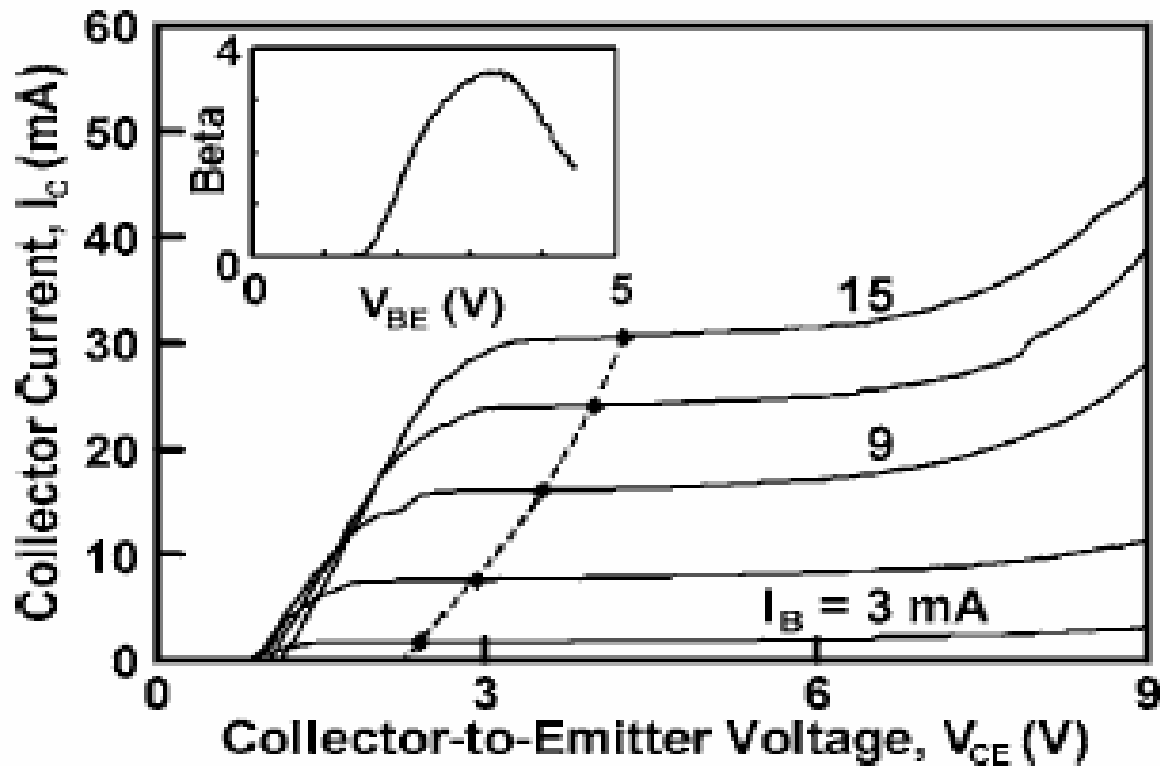


The conduction- and valence-band discontinuities,  $\Delta E_C$  and  $\Delta E_V$ , are indicated at the P-p E-B heterojunction.

# Light emission diagram

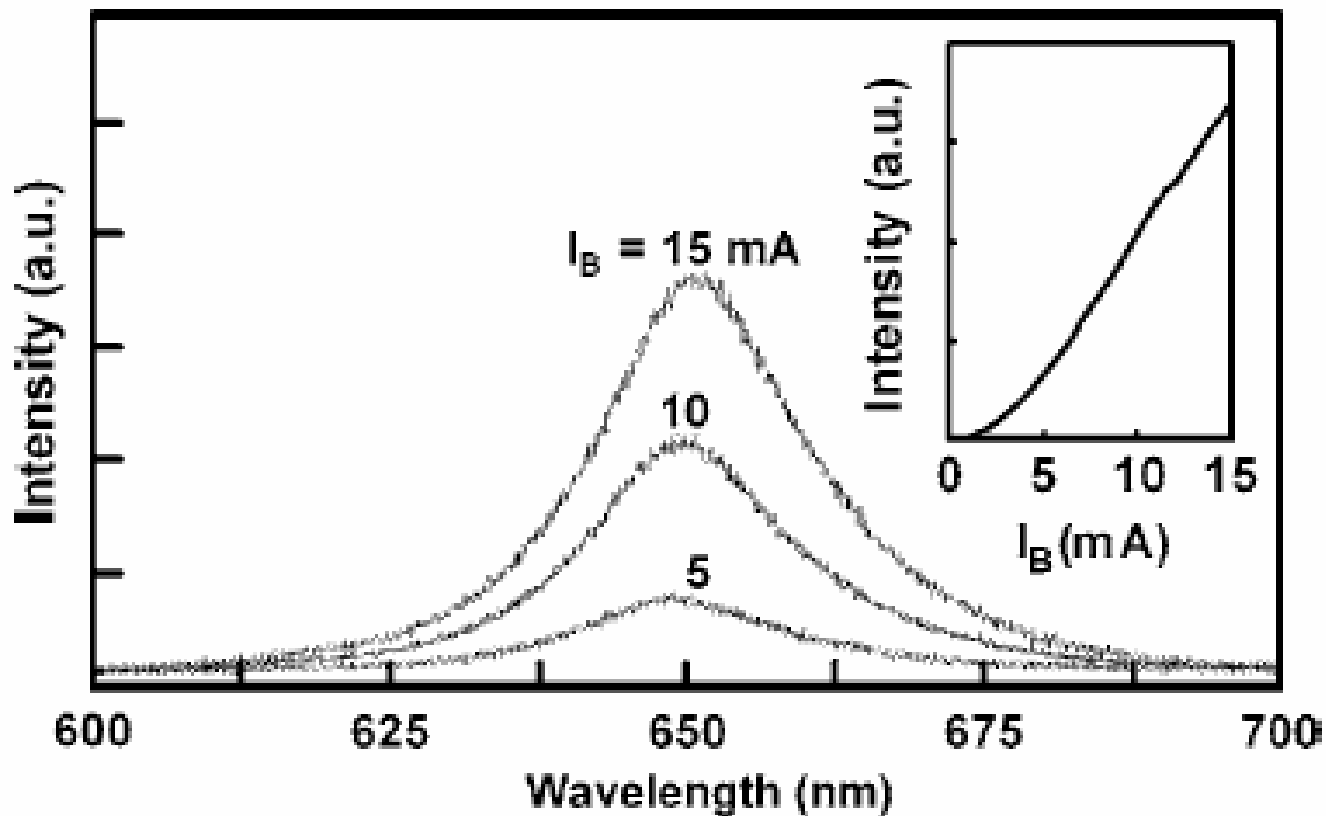


# Result and Discussion



The common-emitter output characteristics, collector current vs collector-to-emitter voltage  $I$ - $V$  curve

# Result and Discussion



Optical emission wavelength



# Conclusion

---

- Visible radiative recombination in the base layer of AlGaInP/InGaP light-emitting transistors LETs is reported.
- The LET  $\text{In}_{0.49}\text{Ga}_{0.51}\text{P}$  base recombination radiation is centered in the visible at =650 nm red emission.



---

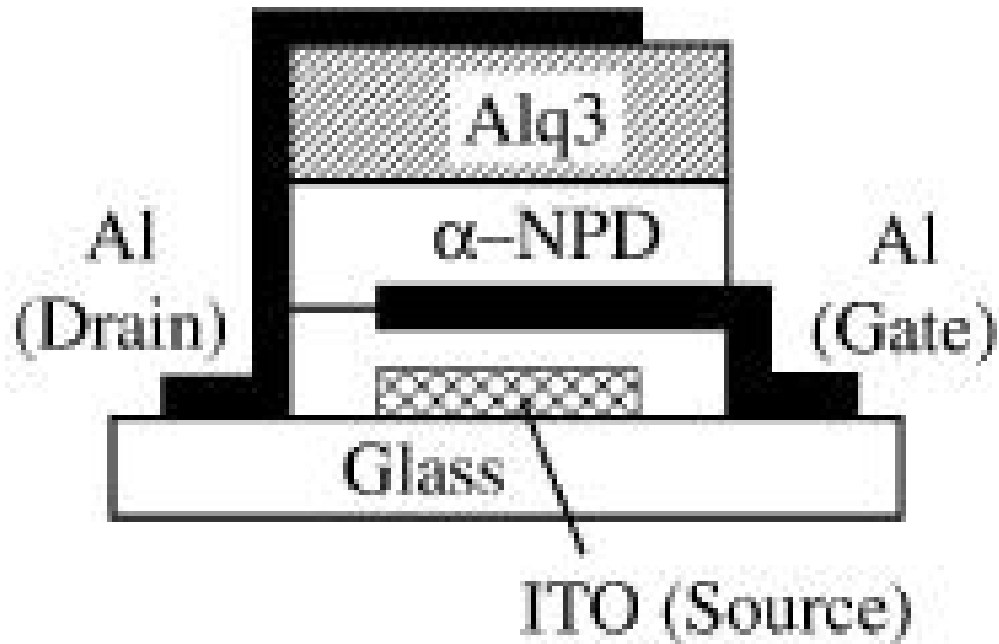
# Organic light emitting transistor

Kazuhiro Kudo

Faculty of Engineering, Chiba University, 1-33 Yayoi-cho, Chiba 263-8522, Japan Received 30 August 2003; accepted 7 November 2003

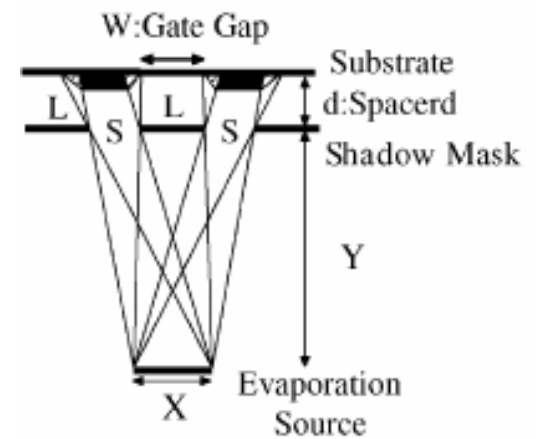
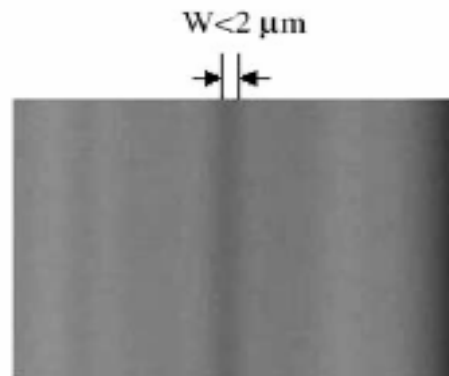
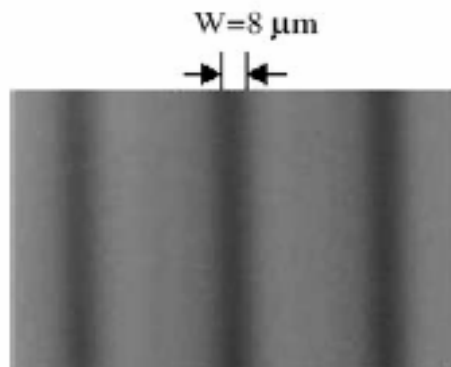
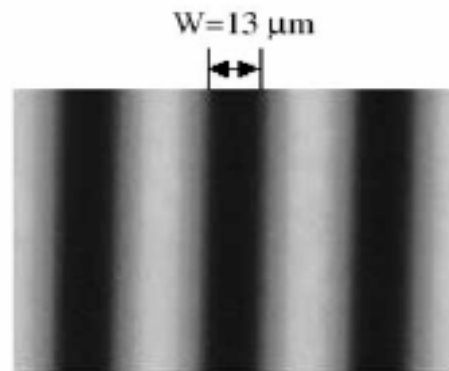
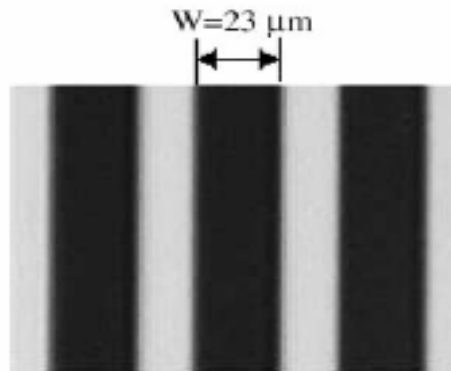
Available online 7 June 2004

# OLET Structure



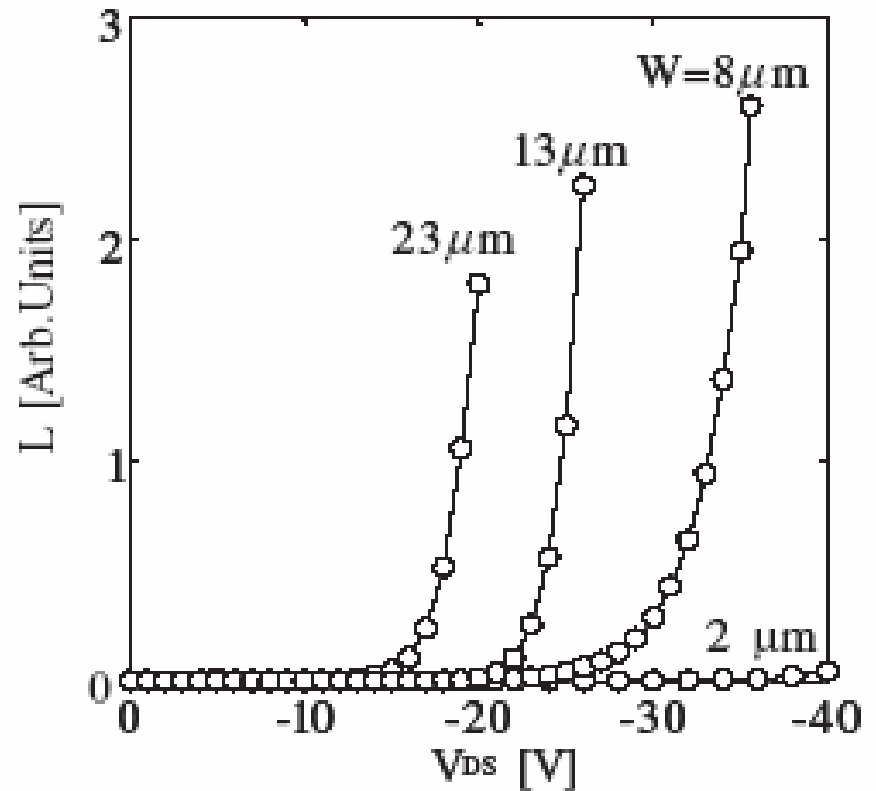
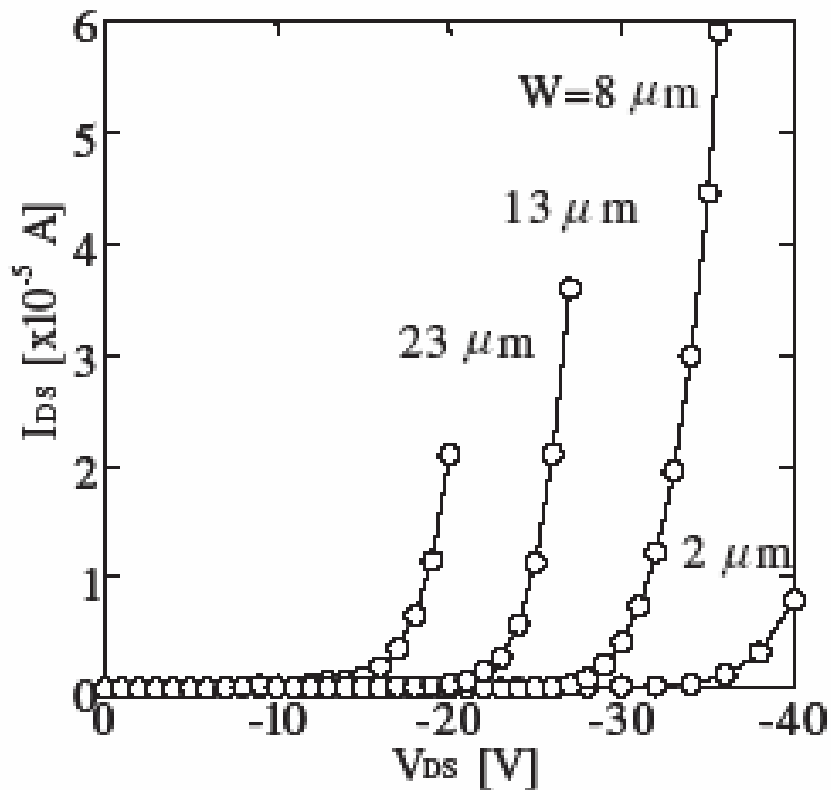
Cross-sectional structures of OLET

# Optical microscope



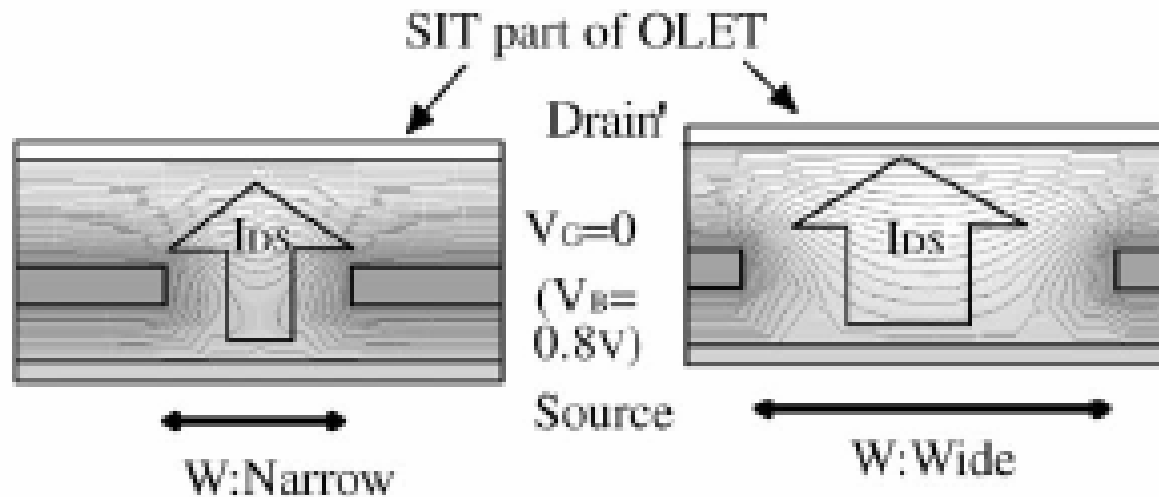
shadow evaporation

# Result and Discussion



I-V and L-V characteristics of the OLET

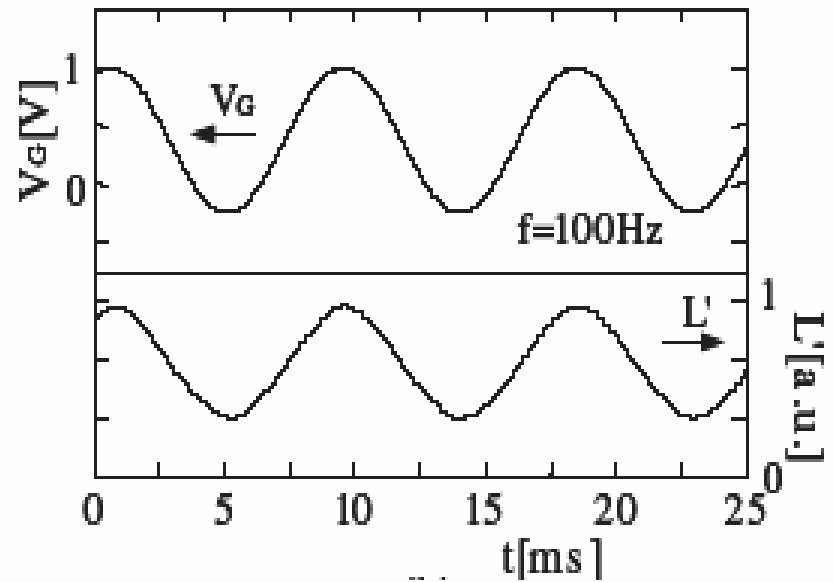
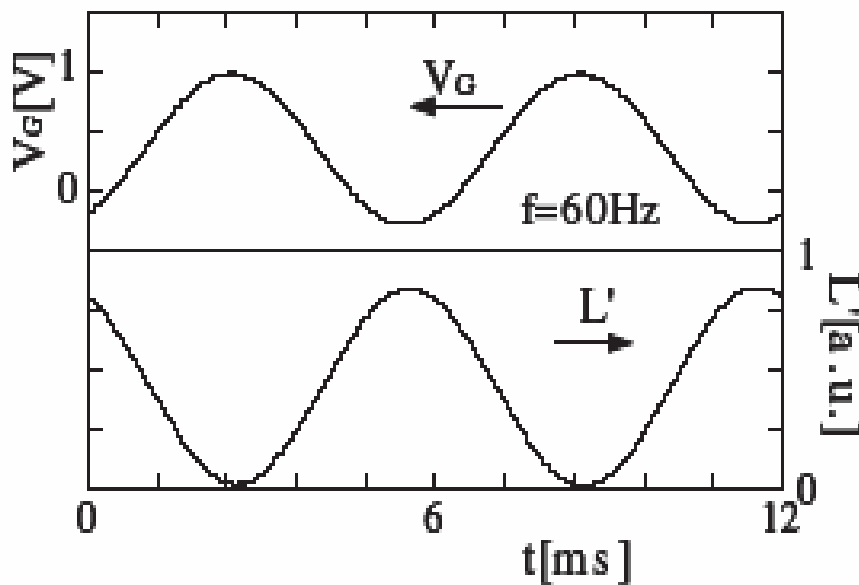
# Result and Discussion



	W: Narrow	W: Wide
$V_{th}$	High	Low
Modulation	High	Low

Potential profile

# Result and Discussion



Dynamic characteristics



# Conclusion

---

- High luminance modulation by low gate voltage was observed in the OLET by optimizing the gate electrode and layer thicknesses.



# References

---

- Light-emitting transistor: Light emission from InGaP/GaAs heterojunction bipolar transistor M. Feng, N. Holonyak, Jr., and W. Hafez APPLIED PHYSICS LETTERS (2004)
- Visible spectrum light-emitting transistors F. Dixon, R. Chan, G. Walter, N. Holonyak, Jr., and M. Feng APPLIED PHYSICS LETTERS (2006)
- Organic light emitting transistors Kazuhiro Kudo Current Applied Physics 5 (2005)
- 異質界面雙載子電晶體表面溫度之研究 李宜慶