ผลของระยะเบี่ยงเบนและความกว้างการฉีดพาหะต่อความไวของแมกนีโตทรานซิสเตอร์

The Deflection Length and Injection Width on the Sensitivity of Magnetotransistor

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ชนะ ลีภัทรพงศ์พันธ์, พุทธพล เพ็งพัด, นริชพันธ์ เป็นผลดี, อาคม ศรีหาเพท, ชาญเดช หรูอนันต์ และอัมพร โพธิ์ใย

ศูนย์เทคโนโลยีไมโครอิเล็กทรอนิกส์ ศูนย์เทคโนโลยีอิเล็กทรอนิกส์และคอมพิวเตอร์แห่งชาติ

OUTLINE

- Introduction
- Structure and principle
- Fabrication
- Experimental and result
- Conclusion

1. Introduction

- ## Sensor and Measurement

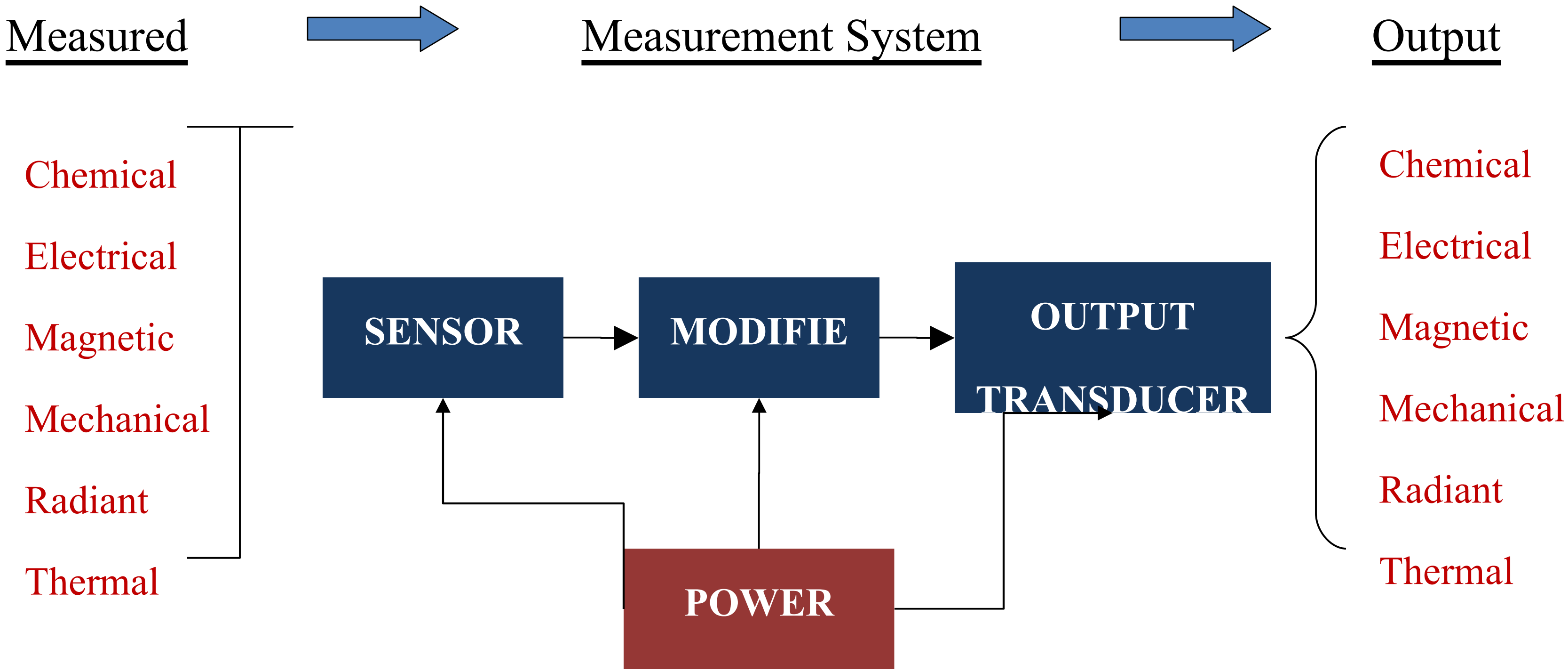
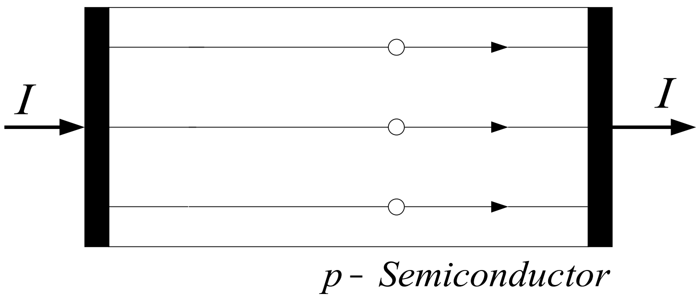


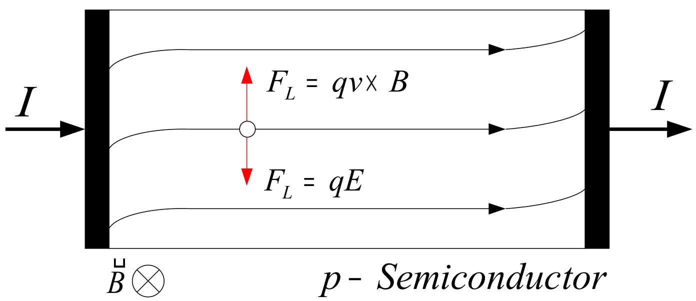
Fig. 1 A general measurement system[1]

1. Introduction

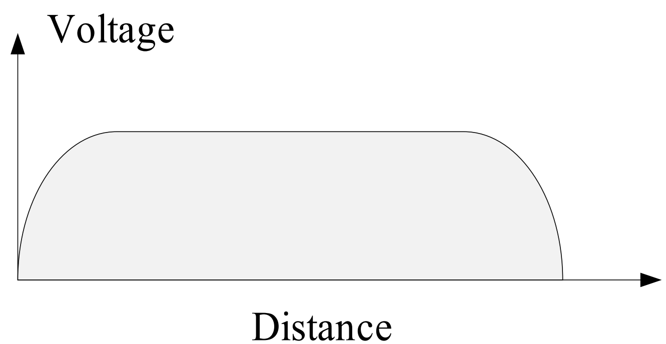
- ## Hall Effect



(a). B = 0



(b). B ≠ 0



(c). Voltage Hall to distance

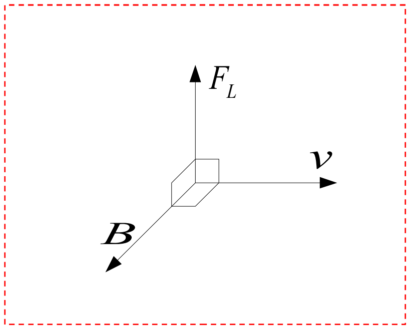


Fig. 2 Hall Effect theory

1. Introduction

- **Magnetic sensor**

**Majority carrier response to magnetic field

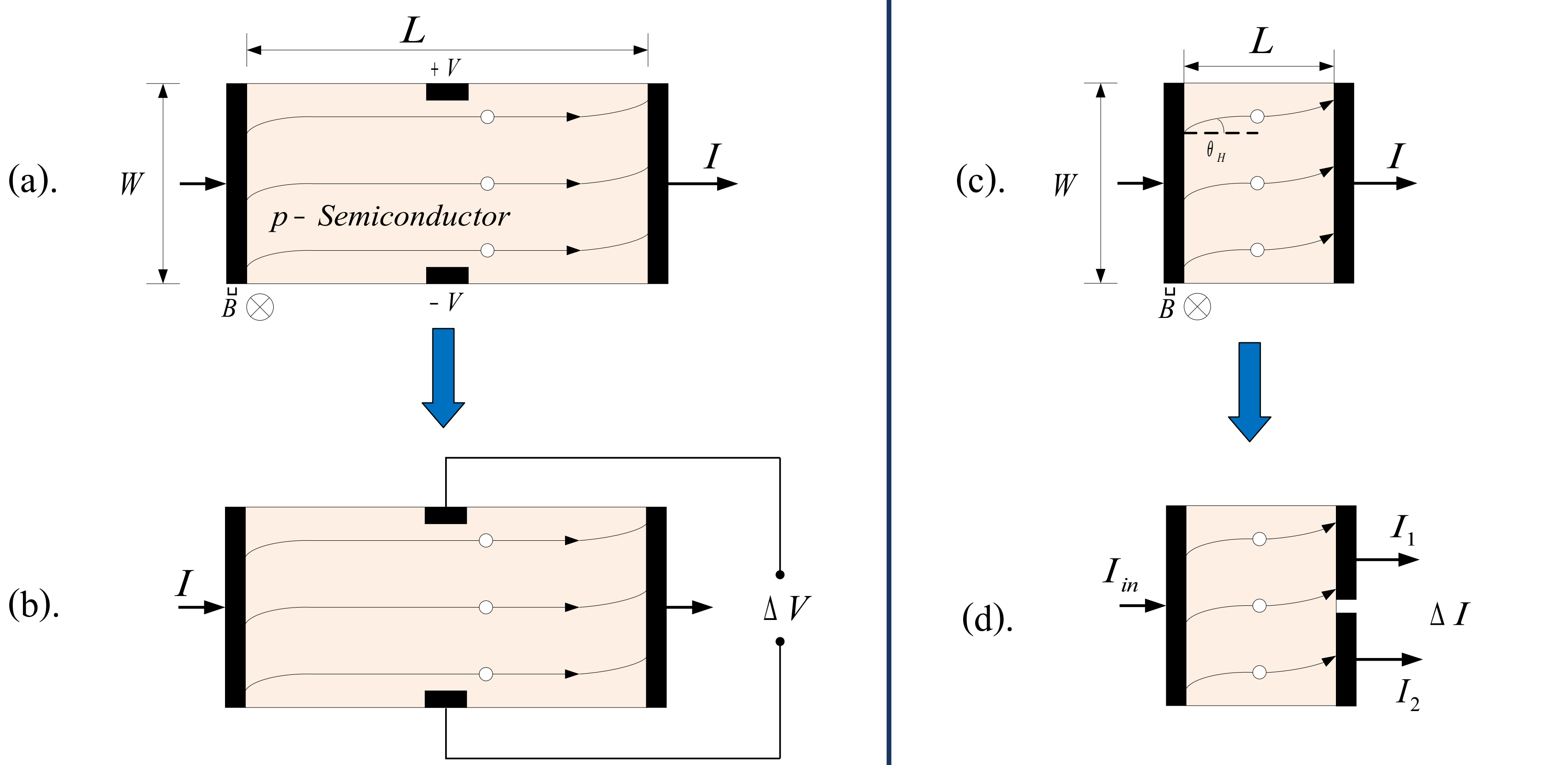


Fig. 3 Hall plate (a). Hall effect in a long sample (b). Magnetic sensor that used voltage different (c). Hall effect in a narrow sample and (d). Magnetic sensor is used current different[2]

1. Introduction

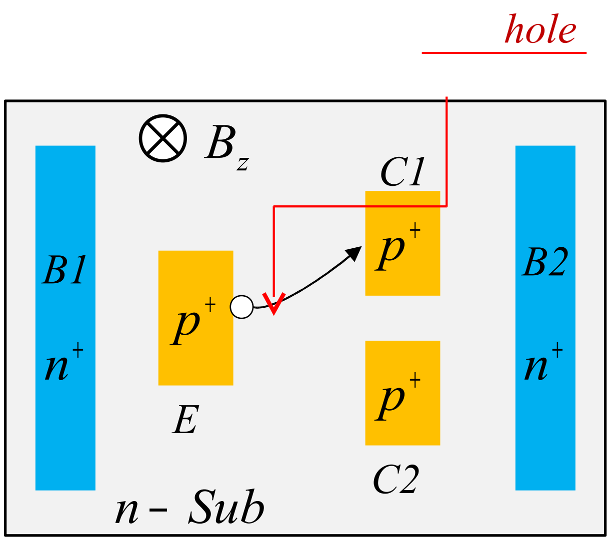
- **Magnetotransistor**

**Minority carrier response to magnetic field

Magnetotransistor = Magnetic + Bipolar transistor

Type of magnetotransistor

(1). Lateral magnetotransistor (2). Vertical magnetotransistor



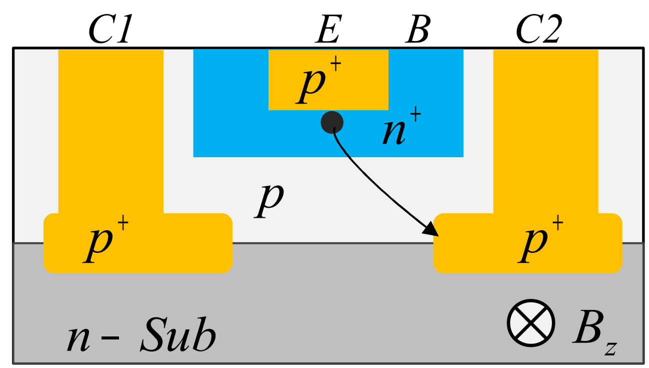


Fig. 4 Lateral magnetotransistor (top view) **Fig. 5** Vertical magnetotransistor (cross section)

- **Development and Approve**

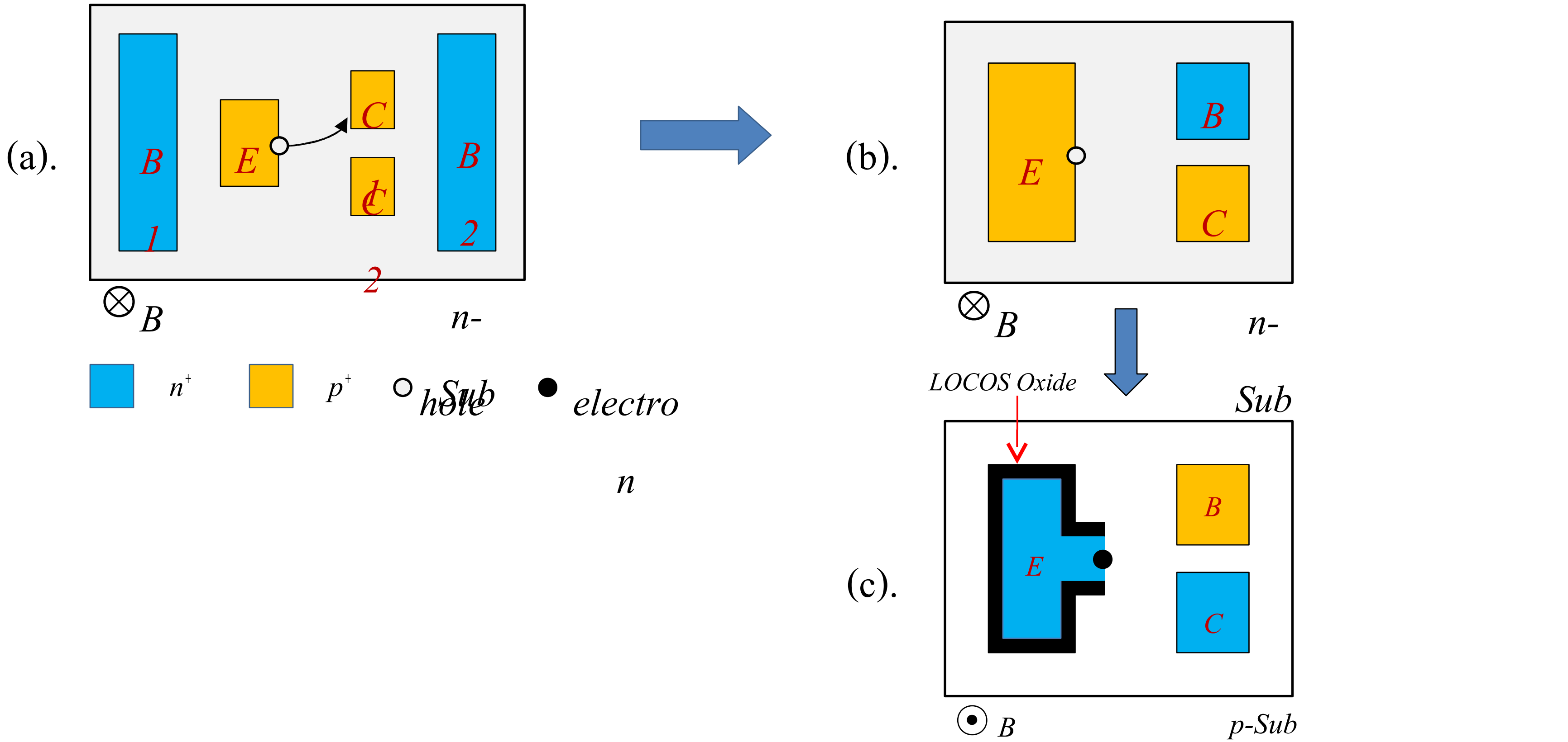


Fig. 6 Structure of magnetotransistor (a). Classical structure (b). Developed structure by reduce base and collector And (c). Currently structure that used n-type substrate

2. Structure and principle

- **Structure**

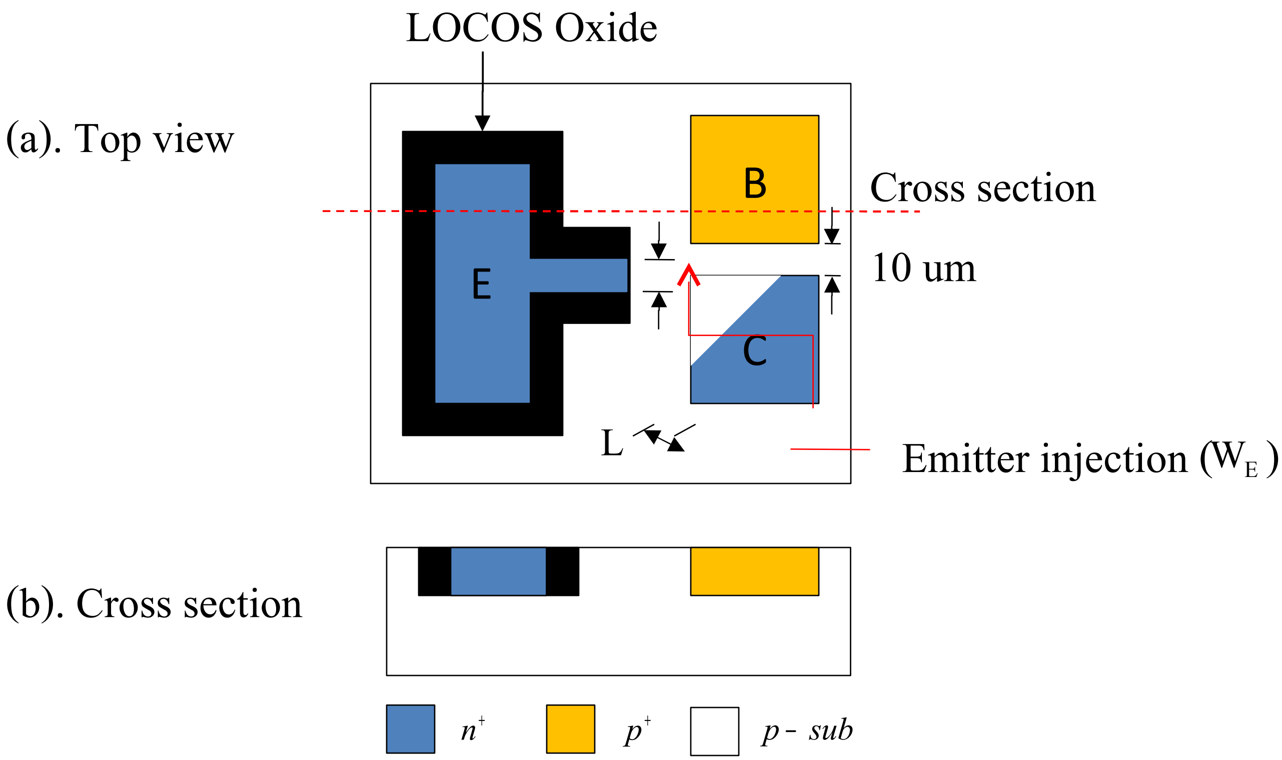
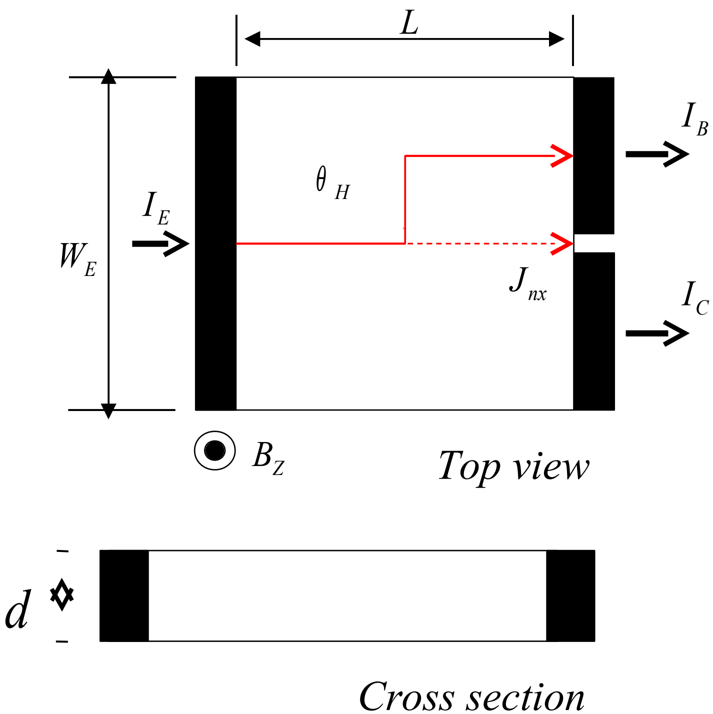


Fig. 7 Structure of magnetotransistor (NPN) (a). Top view And (b). Cross section

- **Principle** ***(hole injection)***



$$I_E = I_C + I_B \qquad \text{.......(1)}$$

$$I_E = J_{nx} \cdot W_E \cdot d \qquad \text{.......(2)}$$

$$\tan\theta_H = \mu_n \cdot B_Z \qquad \text{.......(3)}$$

$$\Delta I_{CB} = J_{nx} \cdot W_E \cdot L \cdot \tan\theta_H \qquad \text{.......(4)}$$

$$S_R = \frac{\Delta I_{CB}}{I_E \cdot \Delta B_Z} \qquad \text{.......(5)}$$

$$\boxed{S_A = \frac{\Delta V}{\Delta B_Z}} \qquad \text{.......(6)}$$

Fig. 8 Carrier deflection area of electron

▪ Fabrication

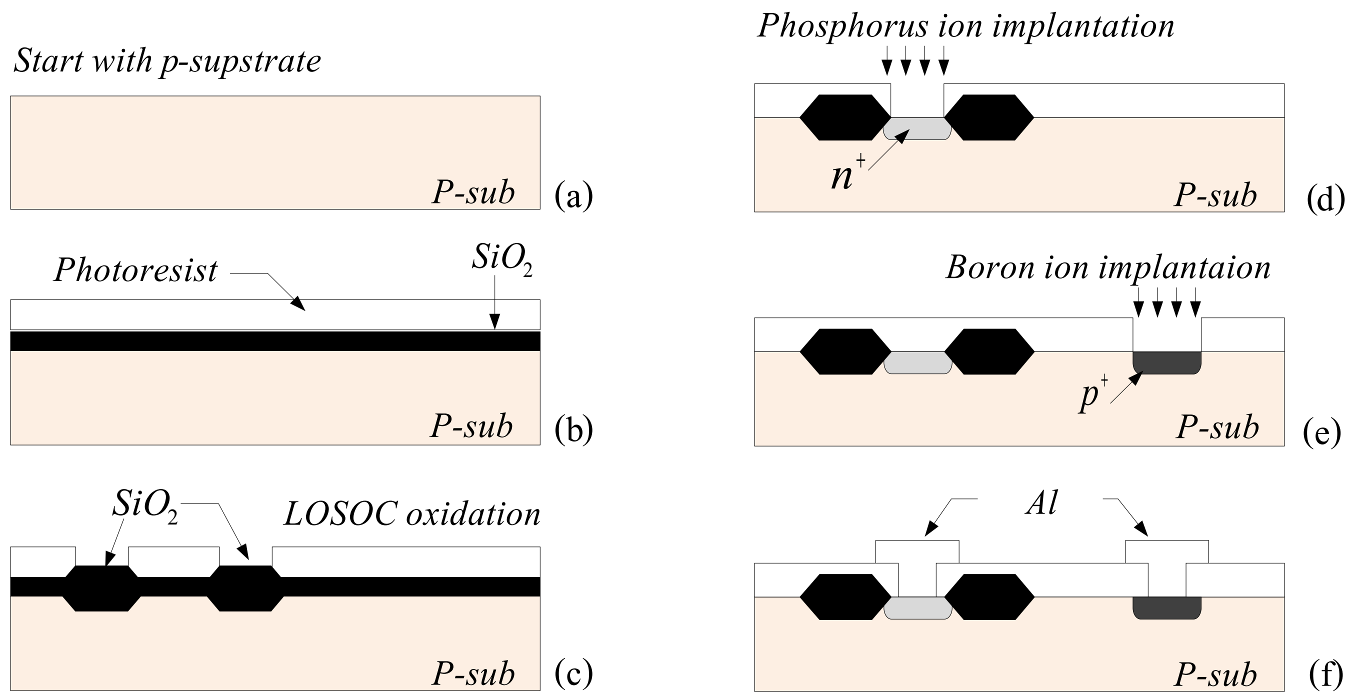
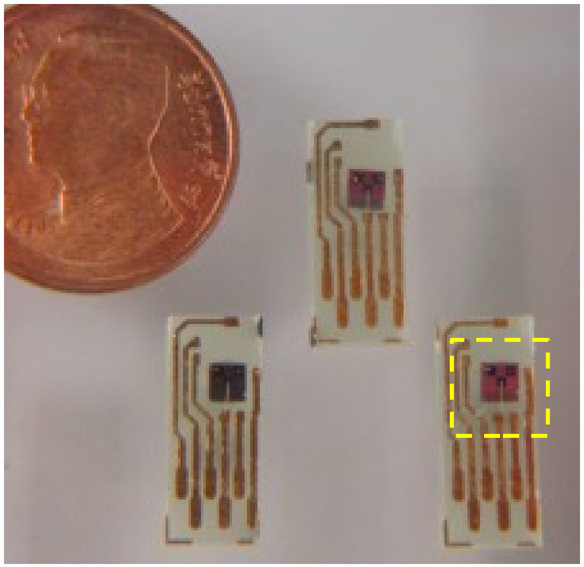


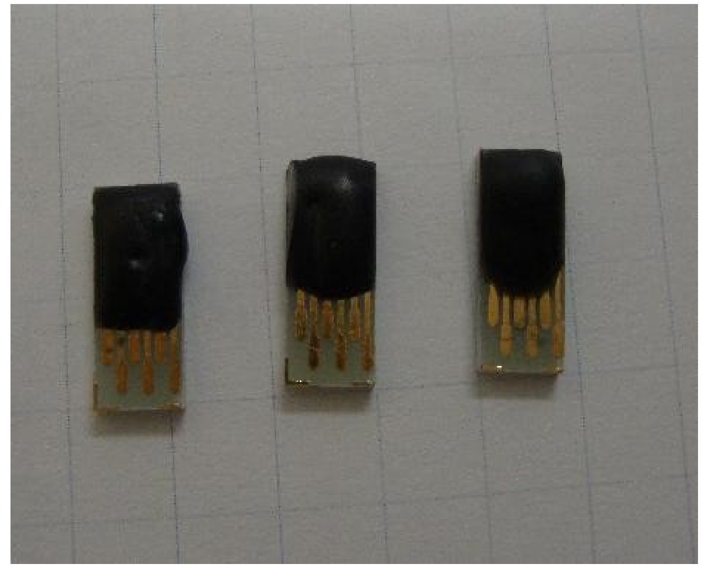
Fig. 9 Fabrication processes of magnetotransistor (a).Start with p-supstrate (b). Growth oxide and apply photoresist on wafer (c). Use oxidation process for built LOSOC oxide (d). Ion implant Phosphorus (n-type) for emitter and collector region (e). Ion implant for base region and (f). Form Al contact over region

3. Fabrication

- **Fabrication**



(a)

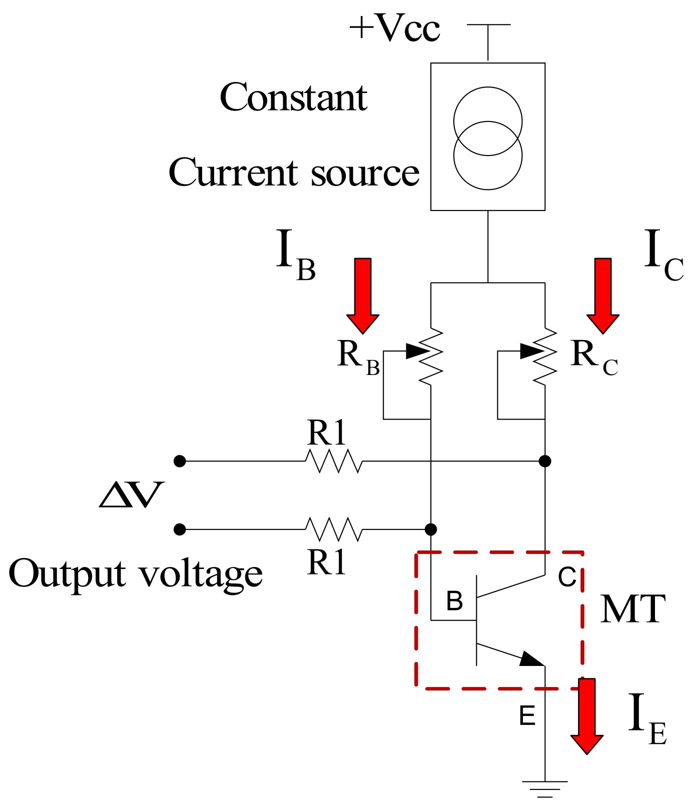


(b)

Fig. 10 This picture show device structure (a). Magnetotransistor bounding on PCB And (b). Magnetotransistor in packaging.

4. Experimental and result

- **Interface circuit**



$$I_E = I_C + I_B$$

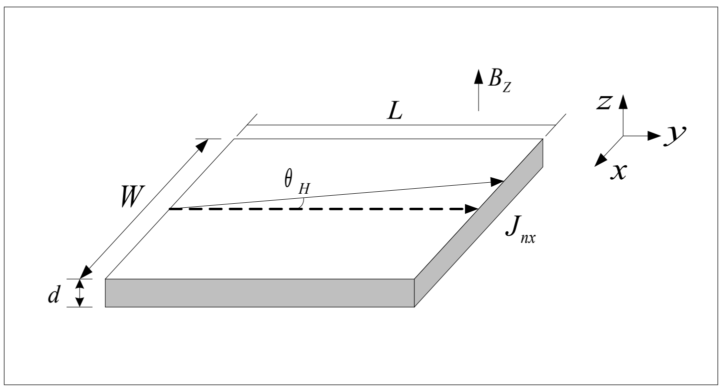
$$\Delta V = I_B R_B - I_C R_C$$

$$S_A = \frac{\Delta V}{\Delta B_Z}$$

Fig. 11 Sensor interface circuit

- ## Responding to vertical magnetic field

Vertical magnetic field response



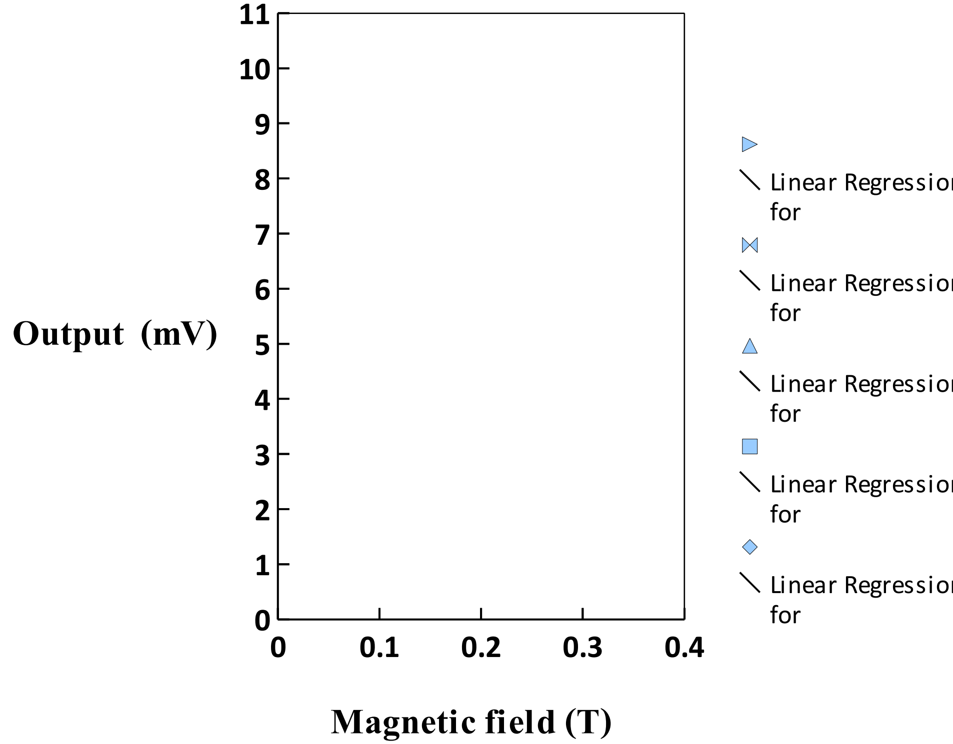


Fig. 12 Vertical magnetic field response as a function of emitter current

4. Experimental and result

- ## Responding to vertical magnetic field

Table I Show the sensitivity of magnetotransistor as function of emitter current at the deflection length 10 µm and 20 µm

I (mA)	Sensitivity (mV/T)		
	4 um	5 um	10 um
0.5	1.41	1.27	1.13
1.0	4.04	3.83	3.51
1.5	5.92	5.61	5.12
2.0	7.52	7.08	6.29
3.0	10.75	10.04	9.18

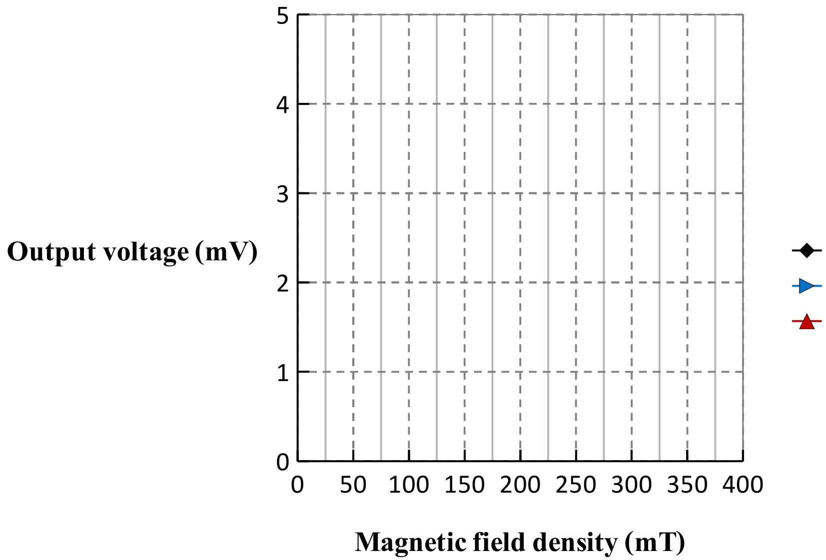
(a). Deflection length 10 µm

I (mA)	Sensitivity (mV/T)		
	4 um	5 um	10 um
0.5	1.85	1.65	1.47
1.0	4.49	4.36	3.83
1.5	6.49	6.23	5.21
2.0	8.34	7.72	6.57
3.0	11.77	11.05	9.28

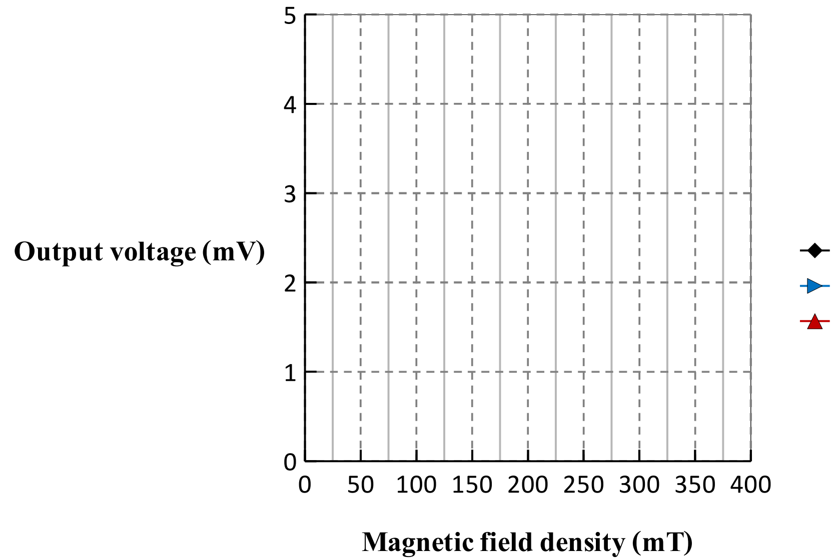
(b). Deflection length 20 µm

4. Experimental and result

- **Responding to vertical magnetic field**



(a). L = 10 μm

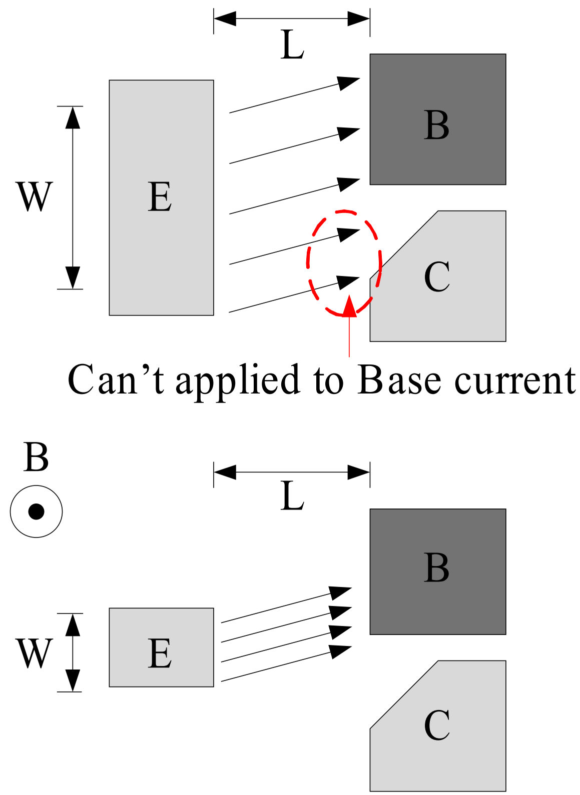


(b). L = 20 μm

Fig. 13 Vertical magnetic field response as different deflection length and injection width

4. Experimental and result

- **Responding to vertical magnetic field**



(a). Emitter wide

(b). Emitter narrow

Fig. 14 Deflection area of carrier (electron)

5. Conclusions

1. The magnetotransistor can detect vertical magnetic field by Hall Effect theory and carrier deflection cause to different between base and emitter current (ΔICB).
2. From experiment compare different deflection length are 10 and 20 um. The result at the deflection length 20 um is best sensitivity.
3. When compare emitter width 4, 5 and 10 um. The result is sensitivity decrease while increase emitter width.

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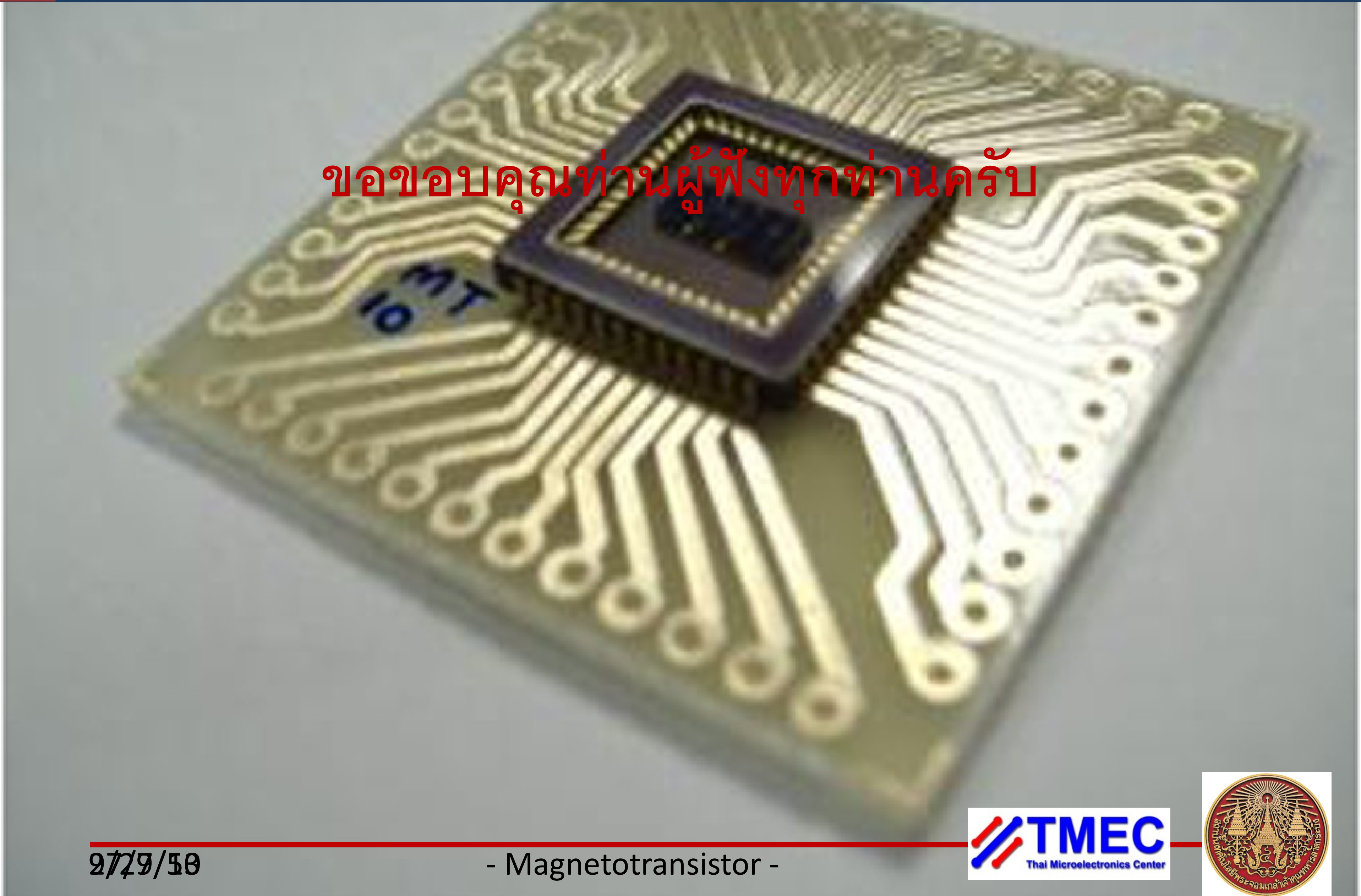

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