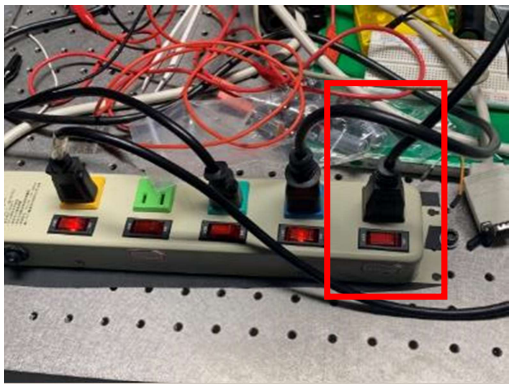
The process of set up PL measurement system

Student: Jordan Cheng Advisor: Prof. Hao-Chung Kuo, Senior. James
Place: National Chiao Tung University Department of Photonics

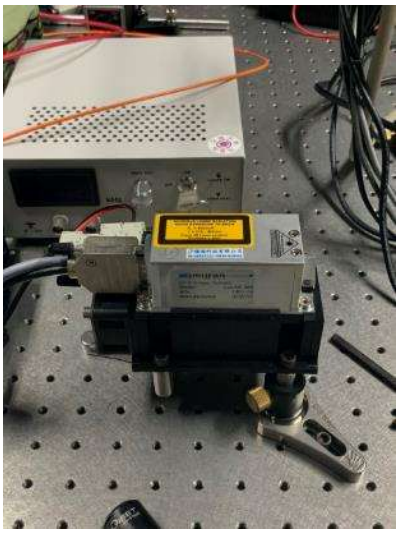
1. Set up device to correct position

2. Put the sample on the glass and put it in correct position

3. Open the power of laser

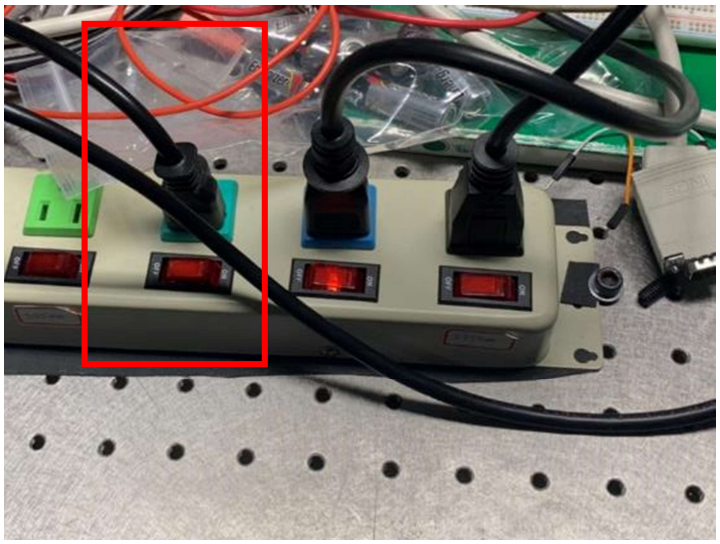


4. Open the key of laser and wait it light is out

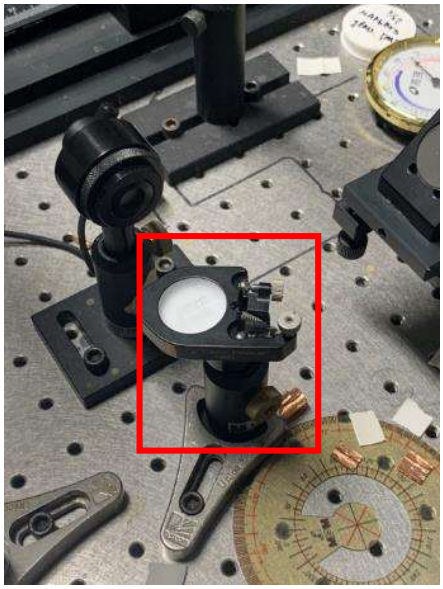


5. Open the PL cooling machine

6. Open the power of PL system

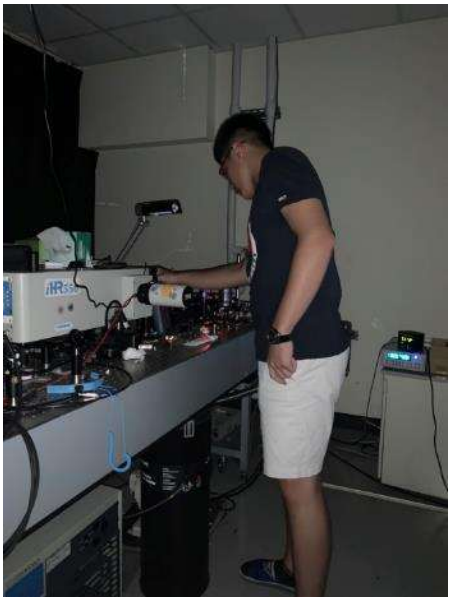


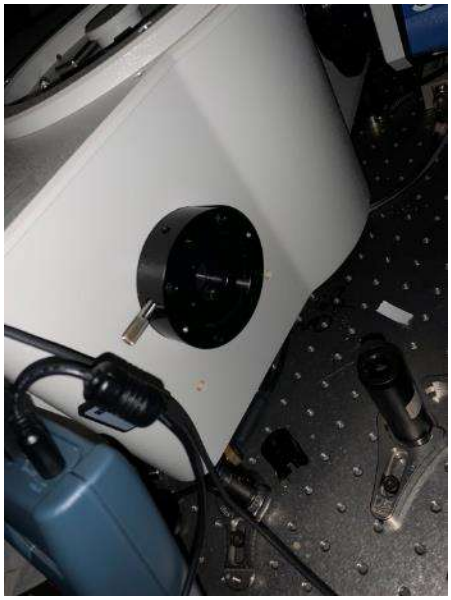
7. Put up this mirror and open it to check the value of laser power



8. Close the light

9. Open the slit of the device

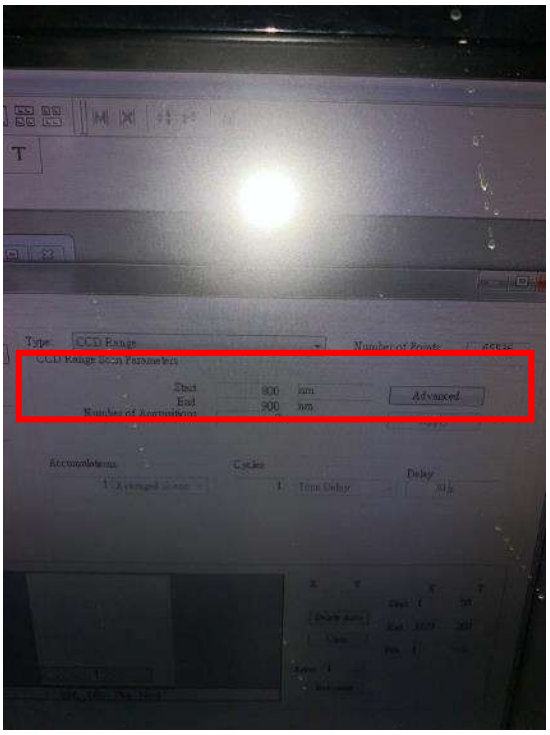




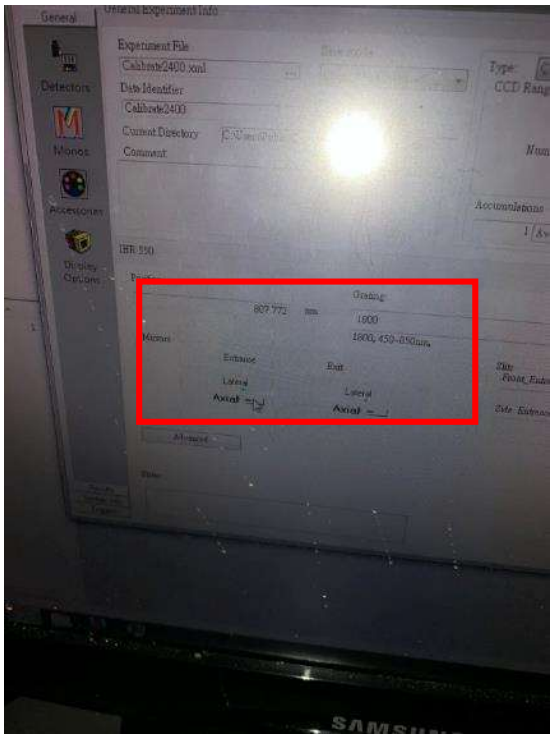
10. Check the light color of the sample reflect

11. Open the application (SynerJY V3.5)

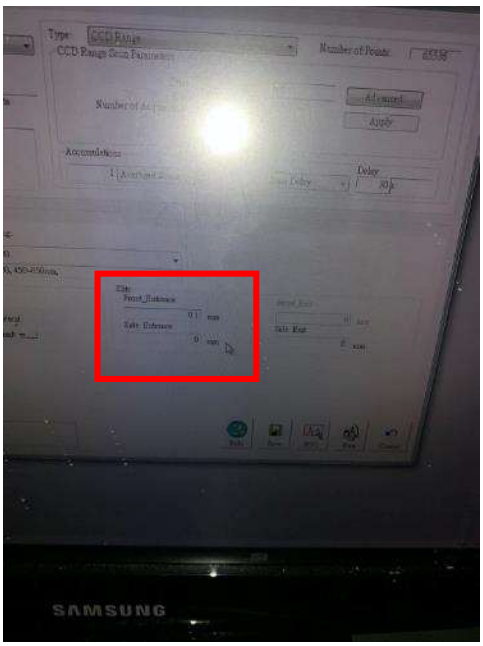
12. Set up the wavelength



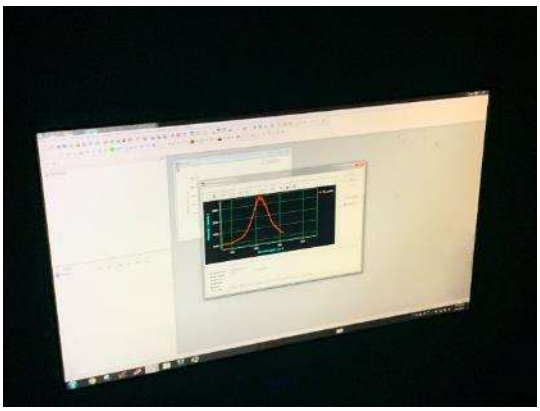
13. Set up the direction of the light come from



14. Set up the Slits of front entrance or side entrance



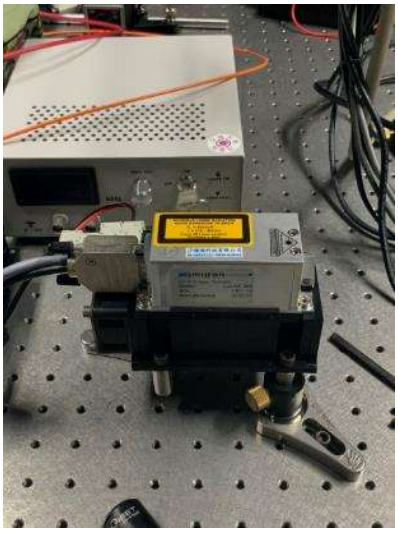
14. Get the result



15. Save the result

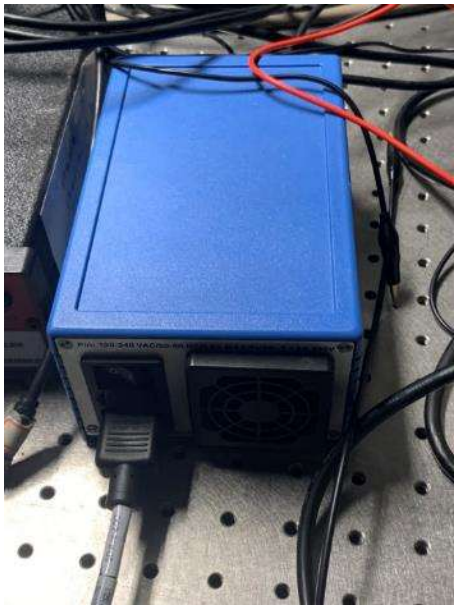
16. Close the slit of the device

17. Turn off the laser

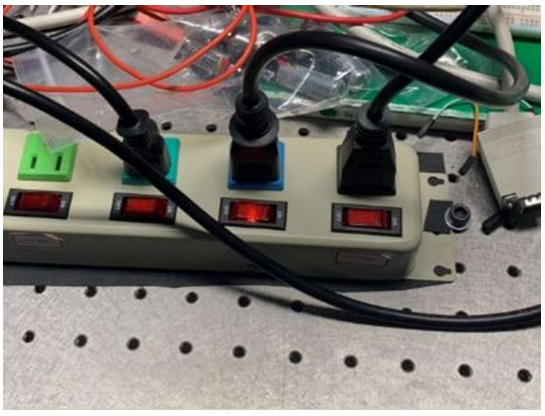


18. Turn on the light

19. Turn off the PL cooling machine



20. Turn off the power of PL cooling machine



Light-Emitting Diodes Report

The LED is an element in which an N (negative) type semiconductor with many electrons and a P (positive) type semiconductor with many holes are joined together. After adding voltage to the semiconductor, electrons and holes will move and recombine at the junction.

This recombined energy becomes light and is released. Compared with the traditional light source which converts electric energy into heat energy and then into light energy, because it directly converts electric energy into light energy, it can obtain the light source more efficiently without wasting electric energy.

Photoluminescence abbreviation is PL. The principle of PL is using the laser light to irradiate on the sample, which exciting the electrons in the valence band to the conductive band and leaving a hole in the valence band. Since electrons are conducting, the electric belt is in a high-energy unstable state, so it will recombine with the hole and release photons to jump back to the valence

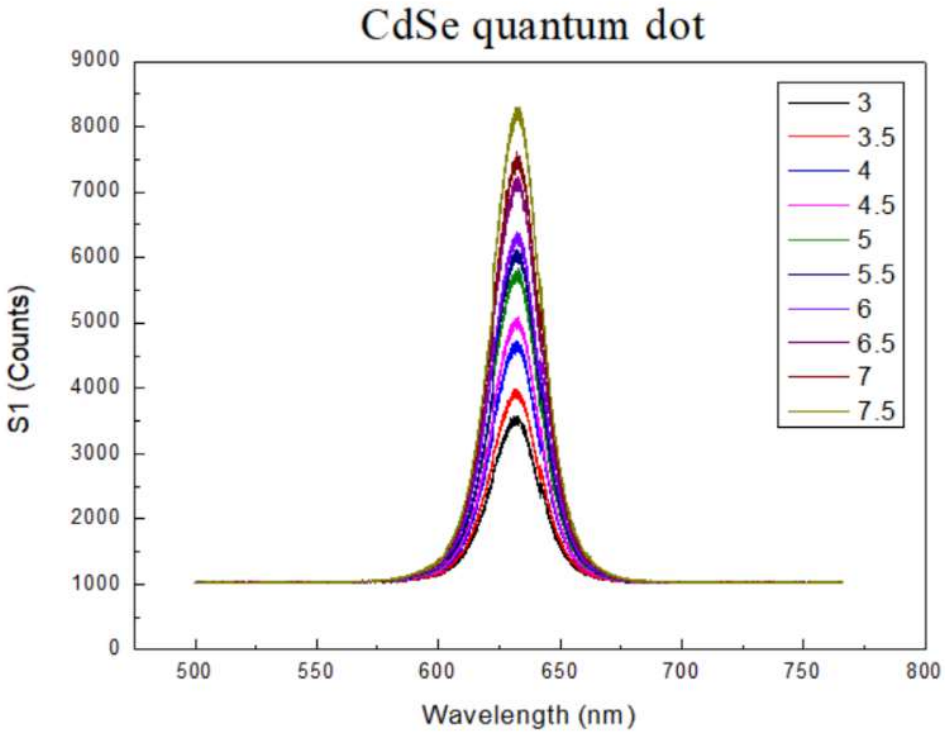
belt, and the released photon energy will be varies with the size of the energy gap. Therefore, PL is often used to detect the energy gap of materials.

Luminous efficacy is a parameter of a light source. It is the ratio of luminous flux to power. Its unit is lm(lumen)/W. The higher value of luminous efficiency, the higher efficiency of converting electrical energy into light, that is the less electrical energy is consumed to emit the same luminous flux.

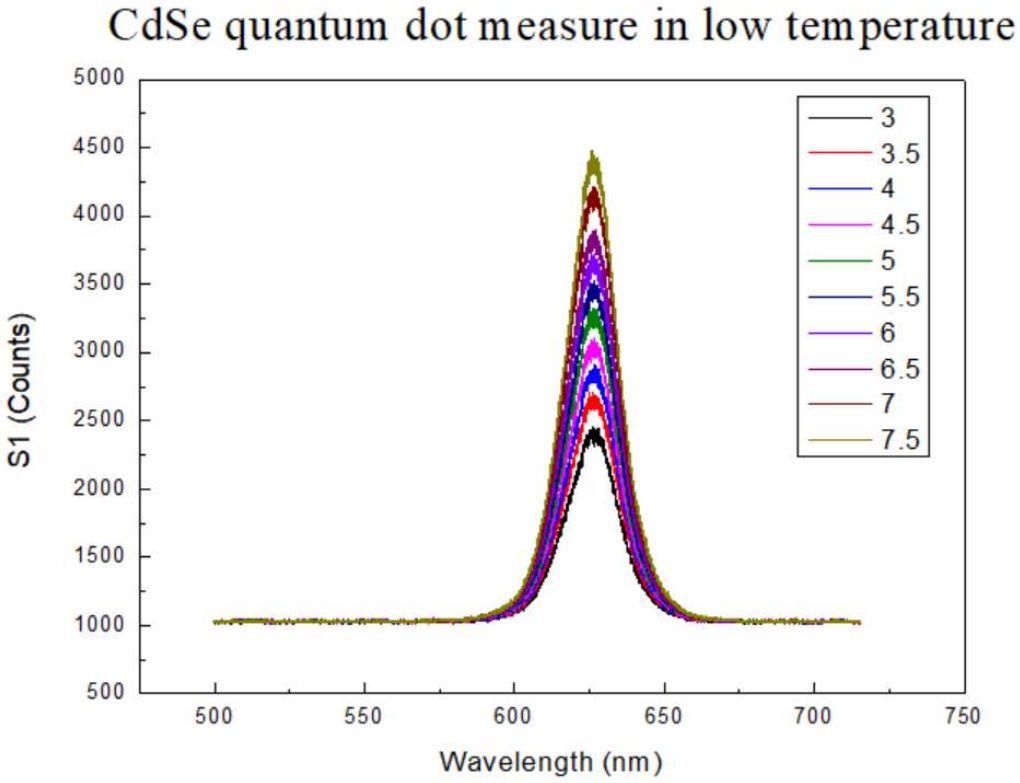
Internal Quantum Efficiency (IQE) is also an indicator used to measure the efficiency of LEDs. Its definition is simply the probability that a unit electron is converted into a photon. In practice, there is almost no way to directly obtain the internal quantum efficiency of the LED. Because the analytical instrument is set up outside LED, when photons are generated inside the LED, they generally do not emit light in a specific direction, and the photons may affect the absorption rate of other materials during the process of generating to the receiving end of

the analytical instrument. The photon probability that can be successfully separated from the LED due to factors such as transmittance and light exit angle is called Light Extraction Efficiency (LEE). Therefore, the general analysis of LED quantum efficiency will directly use External Quantum Efficiency (EQE) as an indicator. The EQE is that when photons are incident on the surface of the photosensitive device, some of the photons will excite the photosensitive material to generate electron-hole pairs to form a current. The ratio of the collected electrons (through internal electron-hole recombination processes) to the number of all incident photons.

The data of PL



- Independent Variables: The power value of laser(3mW to 7.5mW)



- Independent Variables: The power value of laser(3mW to 7.5mW)

- Temperature: 15K

The overview of GaN-Based High Electron Mobility Transistor

Author: Jordan Cheng 鄭仲恩

指導教授 國立交通大學光電工程學系 郭浩中 教授

I. Introduction

With the continuous progress of society and the rapid development of science and technology, whether it is energy loss or data volume, etc., it is much more than in the past. Therefore, major manufacturers are now developing faster transmission tools, including chargers. In the past, there was mini Different chargers such as USB and micro USB are used in society. As people use 3C for longer and longer periods of time, how to effectively improve charging efficiency and enhance the battery life of mobile phones has become a major issue for mobile phone manufacturers in recent years. To increase the charging speed is to increase the electric power of the power supply. There are currently three ways to increase the "voltage" within a safe load range to increase the charging power in the

"high voltage constant current mode"; increase the "current" to increase the charging power "Low voltage and high current mode", or "high voltage and high current mode" that increases the voltage and current at the same time. When the power supply is greater than 5V2A, This can be called "quick charger" technology. Because of the demand for fast charging technology and the vigorous development of the current society, from the first generation of semiconductor materials germanium and silicon to the later widely used gallium arsenide and indium phosphide, it has become The most concerned materials are gallium nitride, gallium arsenide, silicon carbide and other wide-bandgap semiconductor materials. Among them, AUKEY has proposed many gallium nitride chip chargers, or companies such as RAVPower have launched them. So the GaN wafer charger is a very developmental application.

2. Gallium nitride material characteristics and manufacturing process

GaN is an extremely stable and hard high melting point material with a melting point of about 1700°C. GaN is a wide

energy gap material with an energy gap of 3.4ev. Its crystal structure is generally hexagonal wurtzite structure, while wide energy gap materials have A very good advantage is that they have a higher electron mobility so that they can achieve faster switching, because the charge accumulated at the junction can usually be released faster. Among the GaN components, because of its high temperature resistance, it can operate in a higher temperature environment, and because its low resistance, low loss during output and so on... characteristics make GaN more suitable for high-frequency applications. Nowadays, GaN-Based High Electron Mobility Transistors have been developed. The biggest advantage of HEMT is the two-dimensional electron cloud with high charge density and high speed electron mobility. This performance is quite suitable It is applied in the fields of fast charging technology, 5G communication, wireless transmission, satellite communication, fully automatic driving vehicles, etc., which are mainly developed in today's society. GaN HEMT is quite forward-looking, and there are many different methods in its manufacturing process. After all, GaN

HEMT is a fairly novel material, so everyone's understanding of it and the maturity of the technology are still under development. As GaN grows It is impossible to use a crystalline method like silicon to produce a large area crystal as a substrate, so GaN is mostly made by using a crystalline method. This method is to find other crystals with similar lattice constants and thermal expansion coefficients. Materials are used as substrates. At present, the more widely used materials are sapphire substrates, aluminum gallium nitride (AlGaN), silicon carbide, gallium arsenide, etc.... And because they are made of different materials, they are likely to be due to the lattice constant Or the impact of different coefficients of thermal expansion leads to material cracking, which is still a problem that GaN HEMTs need to solve in the future.

Next I want to focus on the AlGaN / GaN heterostructure. The device of this material itself is a normally-on device (Normally-On), but it needs to be normally-off in high-speed switching, RF integrated circuits, digital circuits, etc... (Normally-Off) HEMT devices, so some technologies have been developed to convert

AIGaN/GaN to Normally-Off, such as cascode, p-GaN gate and hidden Type gate hybrid MISHEMT (recessed gate hybrid MISHEMT) and other methods.

3. Why GaN is very important to use in LED?

- High conversion efficiency:

The band gap of GaN is 3 times that of Si, and the breakdown electric field is 10 times that of Si. Therefore, the on-resistance of the GaN switching power device with the same rated voltage is 3 orders of magnitude lower than that of the Si device, which greatly reduces the conduction loss of the switch.

- GaN switching speed is faster than Silicon, which can greatly improve efficiency
- High operating frequency:

  GaN switching devices have low parasitic capacitance, and their operating efficiency can be increased by at least 20 times compared with silicon devices, greatly reducing the volume of energy storage components in the circuit such as capacitors and inductors

- The power density of GaN devices is ten times that of

gallium arsenide (GaAs) devices. The higher power density of GaN devices enables them to provide wider bandwidth, higher amplifier gain and higher efficiency. This is due to the peripheral smaller.

- With cost reduction, GaN market space is huge:

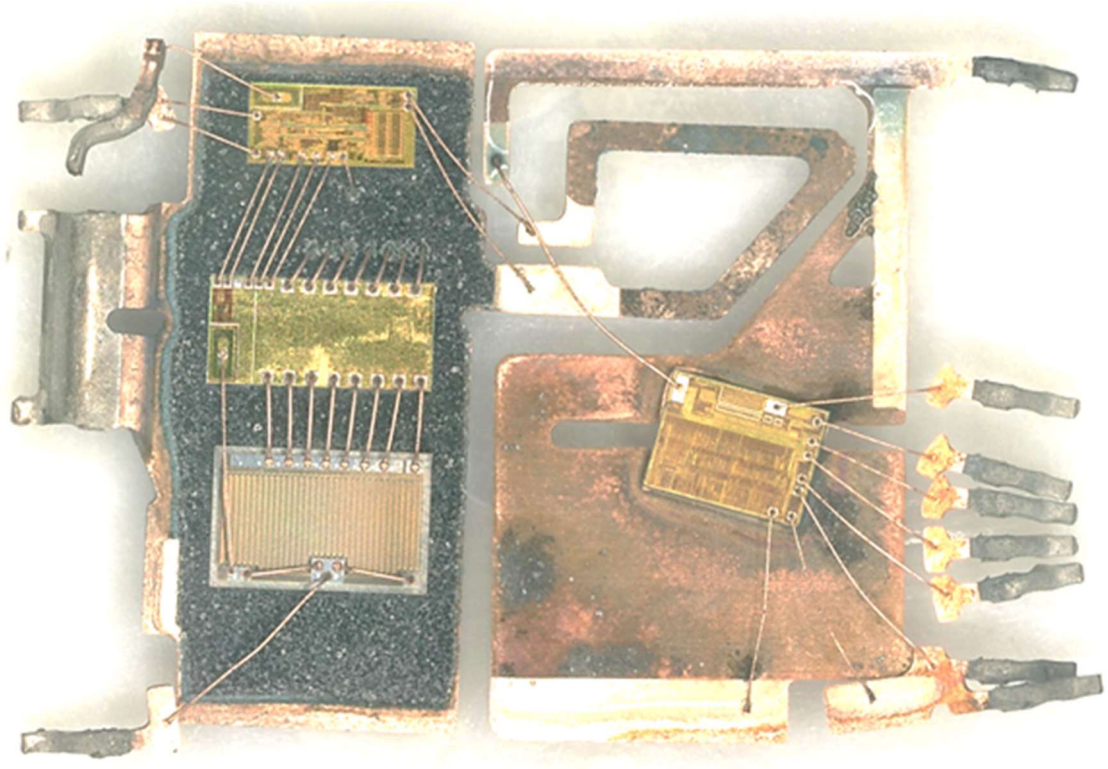
  With the cost reduction, the GaN market has a huge space. GaN and SiC and Si materials each have their own advantages, but there are also overlaps. GaN material has the highest electronic saturation drift rate and is suitable for high-frequency application scenarios, but it is not as good as SiC in high-voltage and high-power scenarios. With the decrease in cost, GaN is expected to replace silicon-based power devices such as diodes, IGBTs, and MOSFETs in the low- and medium-power fields. In terms of voltage, 0~300V is the advantage of Si materials, above 600V is the advantage of SiC, and between 300V and 600V is the advantage of GaN materials.

- The optical penetration band of sapphire is very wide, from near ultraviolet light (190nm) to mid-infrared light has good

light transmittance, and has high sound velocity, high temperature resistance, corrosion resistance, high hardness, high melting point (20452 degrees C), etc. Features, often used as optoelectronic component materials. The lattice constant mismatch rate between the sapphire (single crystal $A1_2O_3$) C-plane and the GaN deposited films is small, and it meets the high temperature resistance requirements of the GaN epitaxy process. Therefore, the sapphire substrate has become the key of a white/blue/green LED.

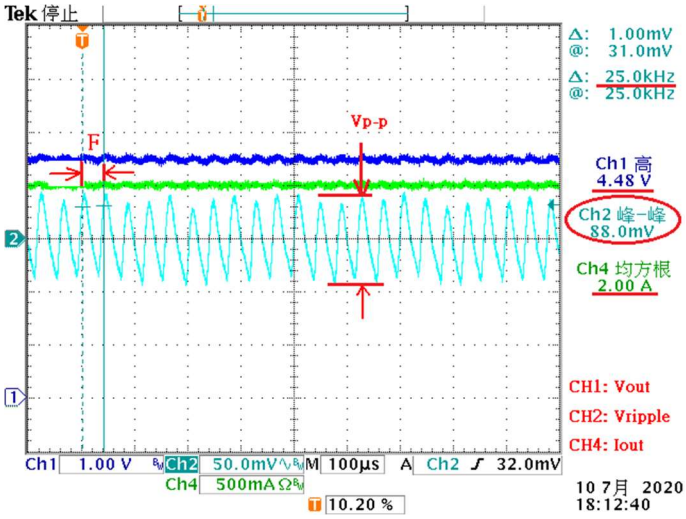
Disassembly of RAVPOWER 61W Gallium Nitride USB PD Charger

- RAVPOWER 61W　PD 型號: RP-PC112

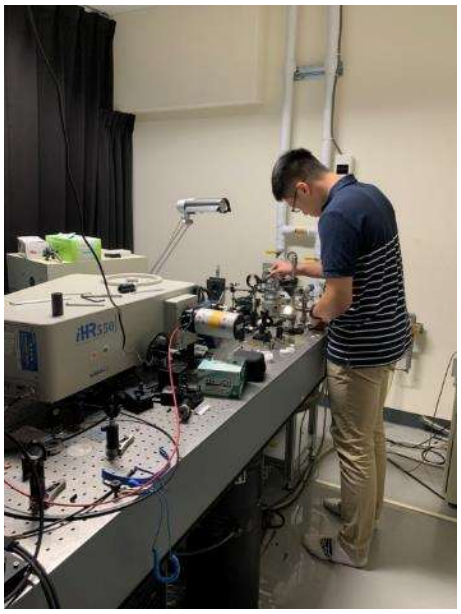


- The inside of RAVPOWER 61W GaN USB PD

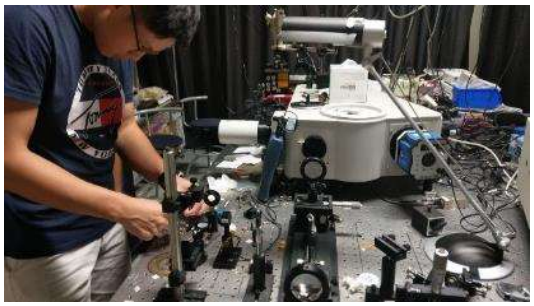
3. Performance measurement of RAVPOWER 61W GaN USB PD charger

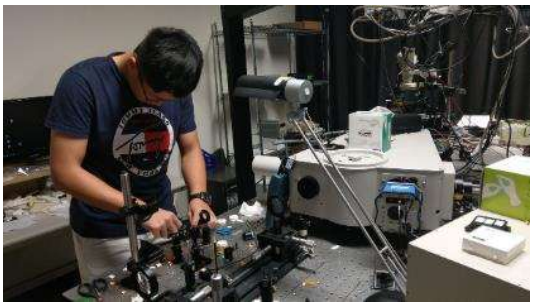


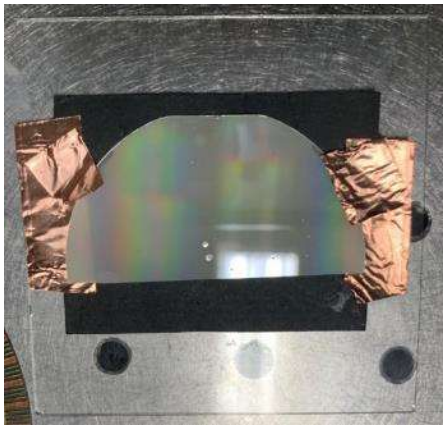
- In 5V / 2A




iHR550








- Take photos with Prof. Hao-Chung Kuo

交通大學光電工程學系實習

茲證明鄭仲恩同學於 109 年暑假期間至交通大學光電工程學系由郭浩中教授帶領至半導體雷射技術實驗室學習，。特由此狀，以茲證明。

國立交通大學
光電工程學系 教授 UIUC 電機 博士
郭 浩 中
OSA, SPIE, IEEE Fellow

國立交通大學 光電工程學系
NATIONAL CHIAO TUNG UNIVERSITY Department of Photonics

教授：郭浩中

中 華 民 國 109 年 8 月 27 日

- 實習證明