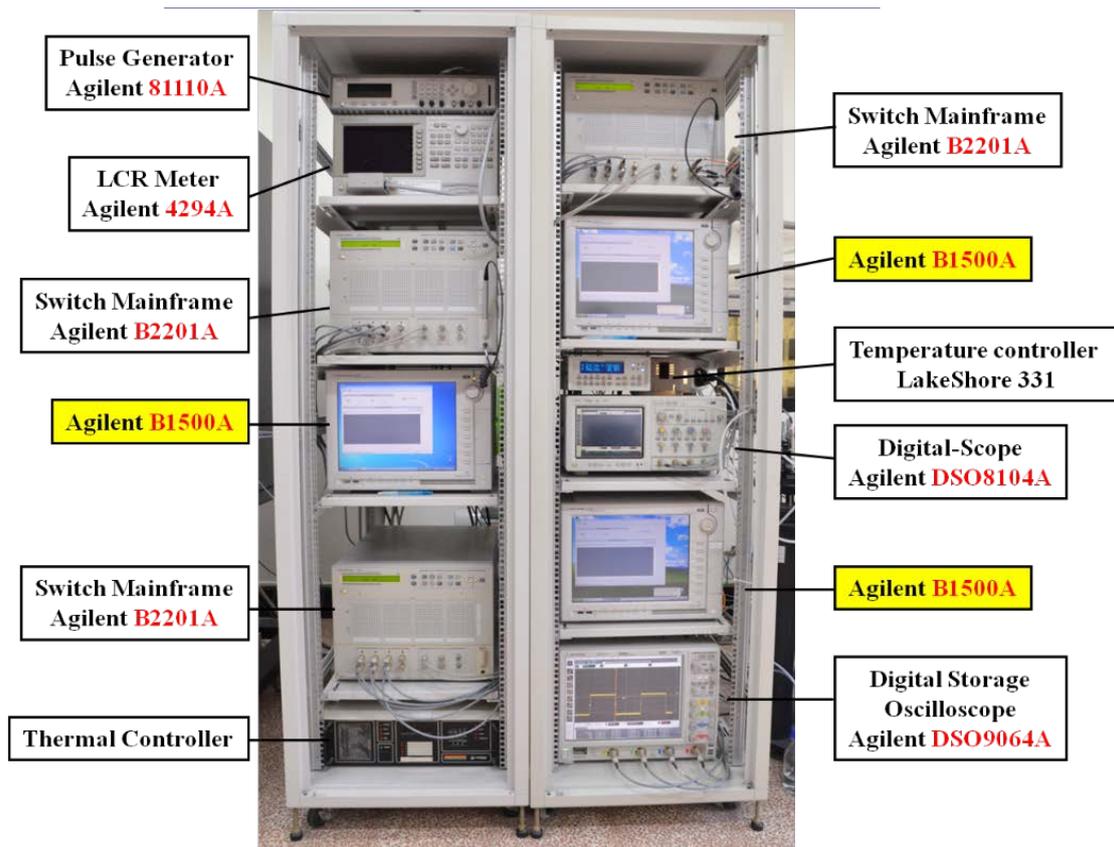


# 多功能高頻半導體量測分析系統



本量測系統適用於半導體電子材料、奈米元件之電性量測 (I-V、C-V)，並且附加溫控系統做溫度調變，可用來分析電子元件之可靠度和電性機制。本平台提供 RT~473K 之變溫量測環境及 1kHz~5MHz 之變頻量測，及提供照光 (紅、綠、藍、UV)下量測，且最多 4 端點元件之量測。並可由 Agilent B1500A 半導體參數分析儀，量測在不同溫度和照光下的元件特性及可靠度，更能釐清其中的物理機制，是研究分析電性不可或缺的利器。整個系統利用 Agilent Desktop EasyExpert 量測軟體進行自動控制，提供方便且迅速的量測功能。



量測儀器型號：Agilent B1500 半導體參數分析儀(With Pulse Generator)

## 服務項目

(1) 精準電性量測分析 (2) 升溫量測

## 收費標準

儀器使用每小時收費 1500 元整

## 試片準備

Sample 大小須 12 吋以內

## 聯絡方式

指導教授：張鼎張 教授 中山大學物理系

TEL：(07)5252000 轉 3708

儀器負責人：廖日謙、林建佑 同學

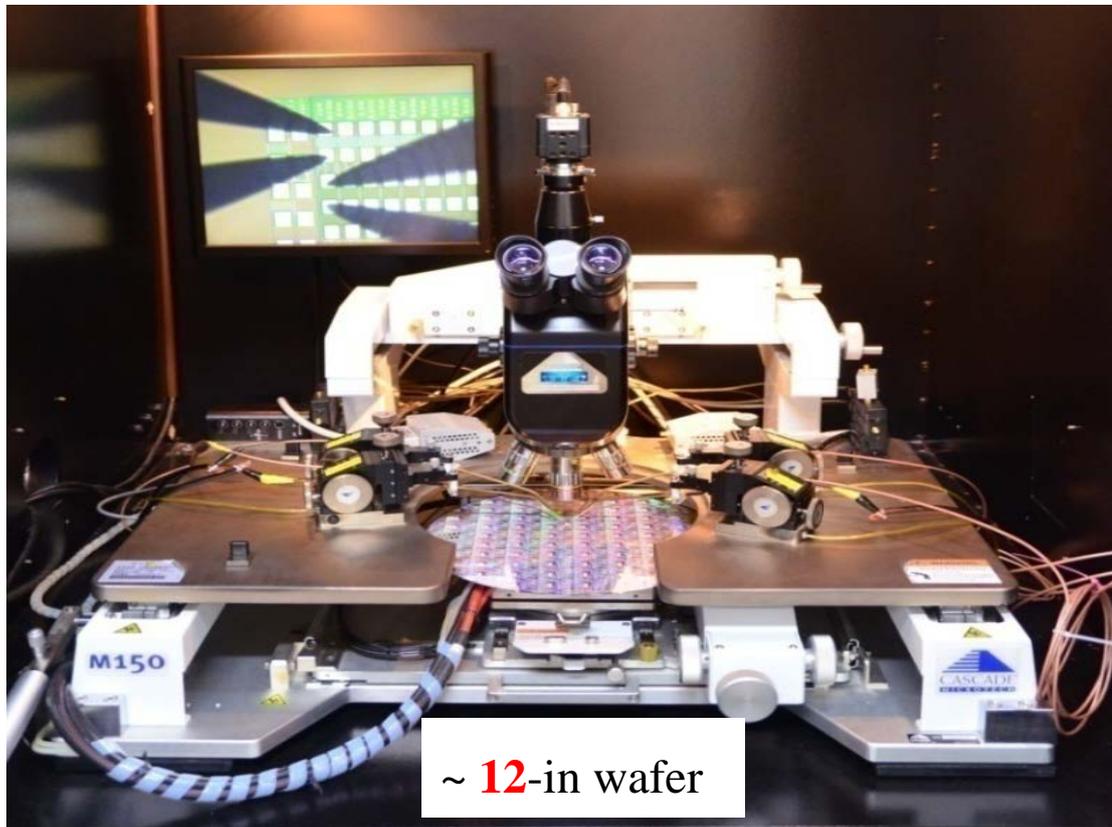
TEL：(07)5252000 轉 3708

儀器地點：中山大學物理館七樓 D7009 室

## 儀器設備說明

量測平台型號：

Cascade M150 probe station



規格： 4 具低漏電探針座(Cascade DCM210)

6 吋可變溫氣浮式平台

RT~473K 變溫量測範圍

功能及用途：放置並固定待測元件供探針座下針

量測儀器型號：  
Agilent B1500A 半導體參數分析儀



規格:

HRSMU(High Resolution SMU) × 4

Resolution : 1fA/25 $\mu$ V to 100mA/100V

HPSMU(High Power SMU) × 1

Resolution : 10fA/2 $\mu$ V to 1A/200V

PGU(Pulse Generator Unit) × 2

Amplitude : 40Vp-p

Pulse width : 500 $\mu$ s to 2s (100 $\mu$ s res.)

Pulse period : 5ms to 5s (100 $\mu$ s res.)

Transition time : 8ns to 400ms (2ns to 8ns res.)

註 : Source Monitor Unit(SMU)

MFCMU(Multi-Frequency capacitance measurement unit)

Frequency

Range : 1kHz to 5MHz

Resolution : 1mHz

Amplitude : 100 V DC bias with SMU and SCUU (SMU CMU Unify Unit)

Output signal level :

Range : 10mV to 250mV

Resolution : 1mV

## HV-SPGU(High voltage semiconductor pulse generator unit)

Resolution : 10ns

Amplitude : -40V to 40V

Pulse width : 10ns to period-10ns (2.5ns to 10ns res.)

Pulse period : 20ns to 10s (10ns res.)

Transition time : 8ns to 400ms (2ns to 8ns res.)

功能及用途：提供高解析度 I-V 量測、C-V 量測及可靠度測試，如：

MOSFETs 與 TFTs 之  $I_D-V_D$  &  $I_D-V_G$  & C-V 特性

Solar cell、Diode、BJT 與 MOS 之 I-V & C-V 特性&元件缺陷萃取

RRAM 的 I-V 量測

Hot Carrier Stress 與 AC Stress

### Current range, resolution, and accuracy (high speed ADC)

Current range	Force resolution	Measure resolution <sup>1</sup>	Force accuracy <sup>2</sup>	Measure accuracy <sup>2</sup>	Maximum voltage
±1 nA	50 fA	50 fA	±(0.1%+300 fA+1 fA x Vo)	±(0.25%+300 fA+1 fA x Vo)	200 V
±10 nA	500 fA	500 fA	±(0.1%+3 pA+10 fA x Vo)	±(0.25%+2 pA+10 fA x Vo)	200 V
±100 nA	5 pA	5 pA	±(0.05%+30 pA+100 fA x Vo)	±(0.1%+20 pA+100 fA x Vo)	200 V
±1 μA	50 pA	50 pA	±(0.05%+300 pA+1 pA x Vo)	±(0.1%+200 pA+1 pA x Vo)	200 V
±10 μA	500 pA	500 pA	±(0.05%+3 nA+10 pA x Vo)	±(0.05%+2 nA+10 pA x Vo)	200 V
±100 μA	5 nA	5 nA	±(0.035%+15 nA+100 pA x Vo)	±(0.05%+20 nA+100 pA x Vo)	200 V
±1 mA	50 nA	50 nA	±(0.04%+150 nA+1 nA x Vo)	±(0.04%+200 nA+1 nA x Vo)	200 V
±10 mA	500 nA	500 nA	±(0.04%+1.5 μA+10 nA x Vo)	±(0.04%+2 μA+10 nA x Vo)	200 V
±100 mA	5 μA	5 μA	±(0.045%+15 μA+100 nA x Vo)	±(0.1%+20 μA+100 nA x Vo)	<sup>3</sup>
±1 A	50 μA	50 μA	±(0.4%+300 μA+1 μA x Vo)	±(0.5%+300 μA+1 μA x Vo)	<sup>3</sup>

1. Specified measurement resolution is limited by fundamental noise limits.

2. ± (% of read value + offset current (fixed part determined by the output/measurement range + proportional part that is multiplied by Vo))

3. 200 V (Io ≤ 50 mA), 100 V (50 mA < Io ≤ 125 mA), 40 V (125 mA < Io ≤ 500 mA), 20 V (500 mA < Io ≤ 1 A), Io is the output current in Amps.

### Power consumption

#### Voltage source mode

Voltage range	Power
2 V	20 x Ic (W)
20 V	20 x Ic (W)
40 V	40 x Ic (W)
100 V	100 x Ic (W)
200 V	200 x Ic (W)

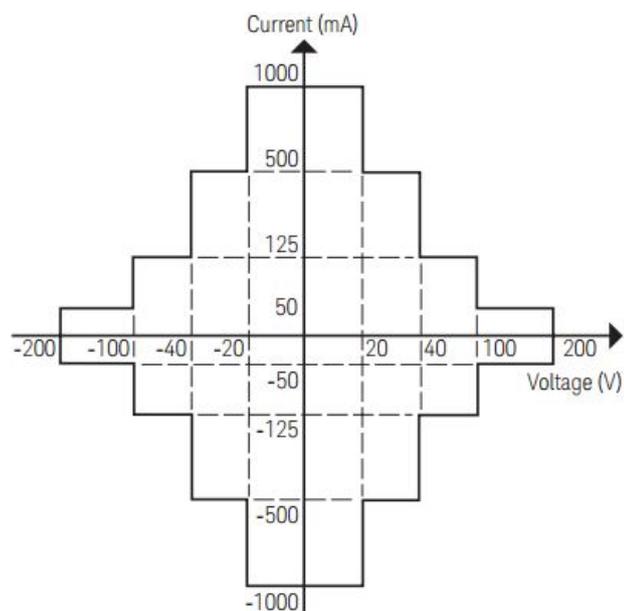
Where Ic is the current compliance setting.

#### Current source mode

Voltage compliance	Power
$V_c \leq 20$	20 x Io (W)
$20 < V_c \leq 40$	40 x Io (W)
$40 < V_c \leq 100$	100 x Io (W)
$100 < V_c \leq 200$	200 x Io (W)

Where Vc is the voltage compliance setting and Io is output current.

### HPSMU measurement and output range



## MPSMU and HRSMU Module Specifications

### Voltage range, resolution, and accuracy (high resolution ADC)

Voltage range	Force resolution	Measure resolution	Force accuracy <sup>1</sup>	Measure accuracy <sup>1</sup>	Maximum current
±0.5 V	25 µV	0.5 µV	±(0.018% + 150 µV)	±(0.01% + 120 µV)	100 mA
±2 V	100 µV	2 µV	±(0.018% + 400 µV)	±(0.01% + 140 µV)	100 mA
±5 V	250 µV	5 µV	±(0.018% + 750 µV)	±(0.009% + 250 µV)	100 mA
±20 V	1 mV	20 µV	±(0.018% + 3 mV)	±(0.009% + 900 µV)	100 mA
±40 V	2 mV	40 µV	±(0.018% + 6 mV)	±(0.01% + 1 mV)	<sup>2</sup>
±100 V	5 mV	100 µV	±(0.018% + 15 mV)	±(0.012% + 2.5 mV)	<sup>2</sup>

1. ± (% of read value + offset voltage V)

2. 100 mA (Vo ≤ 20 V), 50 mA (20 V < Vo ≤ 40 V), 20 mA (40 V < Vo ≤ 100 V), Vo is the output voltage in Volts.

### Current range, resolution, and accuracy (high resolution ADC)

SMU type	Current range	Force resolution	Measure resolution <sup>1,2</sup>	Force accuracy <sup>3</sup>	Measure accuracy <sup>3</sup>	Maximum voltage
MPSMU w/ ASU	±1 pA	1 fA	100 aA	±(0.9%+15 fA)	±(0.9%+12 fA)	100 V
HRSMU	±10 pA	5 fA	400 aA (with ASU) 1 fA (HRSMU)	±(0.46%+30 fA+10 aA x Vo)	±(0.46%+15 fA+10 aA x Vo)	100 V
	±100 pA	5 fA	500 aA (with ASU) 2 fA (HRSMU)	±(0.3%+100 fA+100 aA x Vo)	±(0.3%+30 fA+100 aA x Vo)	100 V
MPSMU	±1 nA	50 fA	10 fA	±(0.1%+300 fA+1 fA x Vo)	±(0.1%+200 fA+1 fA x Vo)	100 V
	±10 nA	500 fA	10 fA	±(0.1%+3 pA+10 fA x Vo)	±(0.1%+1 pA+10 fA x Vo)	100 V
	±100 nA	5 pA	100 fA	±(0.05%+30 pA+100 fA x Vo)	±(0.05%+20 pA+100 fA x Vo)	100 V
	±1 µA	50 pA	1 pA	±(0.05%+300 pA+1 pA x Vo)	±(0.05%+100 pA+1 pA x Vo)	100 V
	±10 µA	500 pA	10 pA	±(0.05%+3 nA+10 pA x Vo)	±(0.04%+2 nA+10 pA x Vo)	100 V
	±100 µA	5 nA	100 pA	±(0.035%+15 nA+100 pA x Vo)	±(0.03%+3 nA+100 pA x Vo)	100 V
	±1 mA	50 nA	1 nA	±(0.04%+150 nA+1 nA x Vo)	±(0.03%+60 nA+1 nA x Vo)	100 V
	±10 mA	500 nA	10 nA	±(0.04%+1.5 µA+10 nA x Vo)	±(0.03%+200 nA+10 nA x Vo)	100 V
	±100 mA	5 µA	100 nA	±(0.045%+15 µA+100 nA x Vo)	±(0.04%+6 µA+100 nA x Vo)	<sup>4</sup>

1. Specified measurement resolution is limited by fundamental noise limits. Minimum displayed resolution is 1 aA at 1 pA range by 6 digits.

2. Measurements made in the lower ranges can be greatly impacted by vibrations and shocks. These specifications assume an environment free of these factors.

3. ± (% of read value + offset current (fixed part determined by the output/measurement range + proportional part that is multiplied by Vo))

4. 100 V (Io ≤ 20 mA), 40 V (20 mA < Io ≤ 50 mA), 20 V (50 mA < Io ≤ 100 mA), Io is the output current in Amps.

## Voltage range, resolution, and accuracy (high speed ADC)

Voltage range	Force resolution	Measure resolution	Force accuracy <sup>1</sup>	Measure accuracy <sup>1</sup>	Maximum current
±0.5 V	25 µV	25 µV	±(0.018% + 150 µV)	±(0.01% + 250 µV)	100 mA
±2 V	100 µV	100 µV	±(0.018% + 400 µV)	±(0.01% + 700 µV)	100 mA
±5 V	250 µV	250 µV	±(0.018% + 750 µV)	±(0.01% + 2 mV)	100 mA
±20 V	1 mV	1 mV	±(0.018% + 3 mV)	±(0.01% + 4 mV)	100 mA
±40 V	2 mV	2 mV	±(0.018% + 6 mV)	±(0.015% + 8 mV)	2
±100 V	5 mV	5 mV	±(0.018% + 15 mV)	±(0.02% + 20 mV)	2

1. ± (% of read value + offset voltage V)

2. 100 mA (Vo ≤ 20 V), 50 mA (20 V < Vo ≤ 40 V), 20 mA (40 V < Vo ≤ 100 V), Vo is the output voltage in Volts.

## Current range, resolution, and accuracy (high speed ADC)

SMU type	Current range	Force resolution	Measure resolution <sup>1,2</sup>	Force accuracy <sup>3</sup>	Measure accuracy <sup>3</sup>	Maximum voltage	
MPSMU	HRSMU	±1 pA	1 fA	100 aA	±(0.9%+15 fA)	±(1.8%+12 fA)	100 V
	w/ASU						
	HRSMU	±10 pA	5 fA	1 fA	±(0.46%+30 fA+10 aA x Vo)	±(0.5%+15 fA+10 aA x Vo)	100 V
		±100 pA	5 fA	5 fA	±(0.3%+100 fA+100 aA x Vo)	±(0.5%+40 fA+100 aA x Vo)	100 V
MPSMU		±1 nA	50 fA	50 fA	±(0.1%+300 fA+1 fA x Vo)	±(0.25%+300 fA+1 fA x Vo)	100 V
		±10 nA	500 fA	500 fA	±(0.1%+3 pA+10 fA x Vo)	±(0.25%+2 pA+10 fA x Vo)	100 V
		±100 nA	5 pA	5 pA	±(0.05%+30 pA+100 fA x Vo)	±(0.1%+20 pA+100 fA x Vo)	100 V
		±1 µA	50 pA	50 pA	±(0.05%+300 pA+1 pA x Vo)	±(0.1%+200 pA+1 pA x Vo)	100 V
		±10 µA	500 pA	500 pA	±(0.05%+3 nA+10 pA x Vo)	±(0.05%+2 nA+10 pA x Vo)	100 V
		±100 µA	5 nA	5 nA	±(0.035%+15 nA+100 pA x Vo)	±(0.05%+20 nA+100 pA x Vo)	100 V
		±1 mA	50 nA	50 nA	±(0.04%+150 nA+1 nA x Vo)	±(0.04%+200 nA+1 nA x Vo)	100 V
		±10 mA	500 nA	500 nA	±(0.04%+1.5 µA+10 nA x Vo)	±(0.04%+2 µA+10 nA x Vo)	100 V
		±100 mA	5 µA	5 µA	±(0.045%+15 µA+100 nA x Vo)	±(0.1%+20 µA+100 nA x Vo)	4

1. Specified measurement resolution is limited by fundamental noise limits. Minimum displayed resolution is 1 aA at 1 pA range by 6 digits.

2. Measurements made in the lower ranges can be greatly impacted by vibrations and shocks. These specifications assume an environment free of these factors.

3. ± (% of read value + offset current (fixed part determined by the output/measurement range + proportional part that is multiplied by Vo))

4. 100 V (Io ≤ 20 mA), 40 V (20 mA < Io ≤ 50 mA), 20 V (50 mA < Io ≤ 100 mA), Io is the output current in Amps.

## Power consumption

### Voltage source mode

Voltage range	Power
0.5 V	20 x Ic (W)
2 V	20 x Ic (W)
5 V	20 x Ic (W)
20 V	20 x Ic (W)
40 V	40 x Ic (W)
100 V	100 x Ic (W)

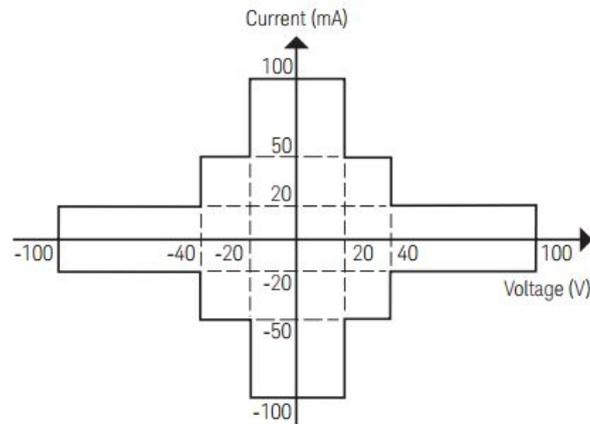
Where Ic is the current compliance setting.

### Current source mode

Voltage compliance	Power
Vc ≤ 20	20 x Io (W)
20 < Vc ≤ 40	40 x Io (W)
40 < Vc ≤ 100	100 x Io (W)

Where Vc is the voltage compliance setting and Io is output current.

## MPSMU and HRSMU measurement and output range



## B1500A Mainframe Specifications

### Supported plug-in modules

The B1500A supports ten slots for plug-in modules.

Module Name	Slots occupied	Key Features
B1510A High power source/monitor unit (HPSMU)	2	<ul style="list-style-type: none"> <li>– Range up to 200 V/1 A with 4-quadrant operation</li> <li>– Minimum measurement resolution 10 fA/2 <math>\mu</math>V</li> </ul>
B1511B Medium power source/monitor unit (MPSMU)	1	<ul style="list-style-type: none"> <li>– Range up to 100 V/0.1 A with 4-quadrant operation</li> <li>– Minimum measurement resolution 10 fA/0.5 <math>\mu</math>V</li> <li>– Optional ASU (atto-sense and switch unit) for 100</li> <li>– aResolution and IV/CV switching capability</li> </ul>
B1517A High resolution source/monitor unit (HRSMU)	1	<ul style="list-style-type: none"> <li>– Range up to 100 V/0.1 A with 4-quadrant operation</li> <li>– Minimum measurement resolution 1 fA/0.5 <math>\mu</math>V</li> <li>– Optional ASU (atto-sense and switch unit) for 100</li> <li>– aResolution and IV/CV switching capability</li> </ul>
B1514A 50 $\mu$ s Pulse medium current source/monitor unit (50 $\mu$ s Pulse MCSMU)	1	<ul style="list-style-type: none"> <li>– Range up to 30 V/1 A pulsed (0.1 A DC) with 4-quadrant operation</li> <li>– Pulse measurement from 50 <math>\mu</math>s pulse width with 2 <math>\mu</math>s resolution</li> <li>– Oscilloscope view (voltage/current waveform viewer) is supported</li> <li>– Minimum measurement resolution 10 pA/0.2 <math>\mu</math>V</li> </ul>
B1520A Multi-frequency capacitance measurement unit (MFCMU)	1	<ul style="list-style-type: none"> <li>– AC impedance measurement (C-V, C-f, C-t)</li> <li>– 1 kHz to 5 MHz frequency range with minimum 1 MHz frequency resolution</li> <li>– 25 V built-in DC bias and 100 V DC bias with SMU and SCUU (SMU CMU Unify Unit)</li> <li>– Easy and fast yet accurate IV and CV automated connection change by SCUU</li> </ul>
B1525A High voltage semiconductor pulse generator unit (HV-SPGU)	1	<ul style="list-style-type: none"> <li>– High voltage output up to <math>\pm</math>40 V applicable for non-volatile memory testing</li> <li>– Two-level and three-level pulse capability by single channel</li> <li>– Flexible arbitrary waveform generation with 10 ns resolution (arbitrary linear waveform generation function)</li> <li>– Two channels per module</li> </ul>
B1530A Waveform generator/fast measurement unit (WGFMU)	1	<ul style="list-style-type: none"> <li>– Ultra-fast IV measurement capability for the pulsed IV and transient IV such as NBTI/PBTI, RTN, etc.</li> <li>– Waveform generation with 10 ns programmable resolution</li> <li>– Simultaneous high-speed IV measurement capability (200 MSa/s, 5 ns sampling rate) 10 V peak-to-peak output</li> <li>– No load line effect accurate pulsed IV measurement by dynamic SMU technology</li> </ul>

## HPSMU Module Specifications

### Voltage range, resolution, and accuracy (high resolution ADC)

Voltage range	Force resolution	Measure resolution	Force accuracy <sup>1</sup>	Measure accuracy <sup>1</sup>	Maximum current
±2 V	100 µV	2 µV	±(0.018% + 400 µV)	±(0.01% + 140 µV)	1 A
±20 V	1 mV	20 µV	±(0.018% + 3 mV)	±(0.009% + 900 µV)	1 A
±40 V	2 mV	40 µV	±(0.018% + 6 mV)	±(0.01% + 1 mV)	500 mA
±100 V	5 mV	100 µV	±(0.018% + 15 mV)	±(0.012% + 2.5 mV)	125 mA
±200 V	10 mV	200 µV	±(0.018% + 30 mV)	±(0.014% + 2.8 mV)	50 mA

1. ± (% of read value + offset voltage V)

### Current range, resolution, and accuracy (high resolution ADC)

Current range	Force resolution	Measure resolution <sup>1</sup>	Force accuracy <sup>2</sup>	Measure accuracy <sup>2</sup>	Maximum voltage
±1 nA	50 fA	10 fA	±(0.1%+300 fA+1 fA x Vo)	±(0.1%+200 fA+1 fA x Vo)	200 V
±10 nA	500 fA	10 fA	±(0.1%+3 pA+10 fA x Vo)	±(0.1%+1 pA+10 fA x Vo)	200 V
±100 nA	5 pA	100 fA	±(0.05%+30 pA+100 fA x Vo)	±(0.05%+20 pA+100 fA x Vo)	200 V
±1 µA	50 pA	1 pA	±(0.05%+300 pA+1 pA x Vo)	±(0.05%+100 pA+1 pA x Vo)	200 V
±10 µA	500 pA	10 pA	±(0.05%+3 nA+10 pA x Vo)	±(0.04%+2 nA+10 pA x Vo)	200 V
±100 µA	5 nA	100 pA	±(0.035%+15 nA+100 pA x Vo)	±(0.03%+3 nA+100 pA x Vo)	200 V
±1 mA	50 nA	1 nA	±(0.04%+150 nA+1 nA x Vo)	±(0.03%+60 nA+1 nA x Vo)	200 V
±10 mA	500 nA	10 nA	±(0.04%+1.5 µA+10 nA x Vo)	±(0.03%+200 nA+10 nA x Vo)	200 V
±100 mA	5 µA	100 nA	±(0.045%+15 µA+100 nA x Vo)	±(0.04%+6 µA+100 nA x Vo)	<sup>3</sup>
±1 A	50 µA	1 µA	±(0.4%+300 µA+1 µA x Vo)	±(0.4%+150 µA+1 µA x Vo)	<sup>3</sup>

1. Specified measurement resolution is limited by fundamental noise limits.

2. ± (% of read value + offset current (fixed part determined by the output/measurement range + proportional part that is multiplied by Vo))

3. 200 V (Io ≤ 50 mA), 100 V (50 mA < Io ≤ 125 mA), 40 V (125 mA < Io ≤ 500 mA), 20 V (500 mA < Io ≤ 1 A), Io is the output current in Amps.

### Voltage range, resolution, and accuracy (high speed ADC)

Voltage range	Force resolution	Measure resolution	Force accuracy <sup>1</sup>	Measure accuracy <sup>1</sup>	Maximum current
±2 V	100 µV	100 µV	±(0.018% + 400 µV)	±(0.01% + 700 µV)	1 A
±20 V	1 mV	1 mV	±(0.018% + 3 mV)	±(0.01% + 4 mV)	1 A
±40 V	2 mV	2 mV	±(0.018% + 6 mV)	±(0.015% + 8 mV)	500 mA
±100 V	5 mV	5 mV	±(0.018% + 15 mV)	±(0.02% + 20 mV)	125 mA
±200 V	10 mV	10 mV	±(0.018% + 30 mV)	±(0.035% + 40 mV)	50 mA

1. ± (% of read value + offset voltage V)

## Agilent B2201A 低漏電切換器



規格：Input Ports：8 Triaxial Ports(with guard), 6 BNC Ports (2 of CV port)

Output Ports：12 Triaxial Ports, Max 48 Ports

Leakage Current：50fA

功能及用途：提供 I-V 與 C-V 量測間的快速切換，去除更換線材的動作。

## Agilent DSO9254A 示波器



規格：Bandwidth：600MHz

功能及用途：提供確認脈衝產生器輸出的波形

## Temptronic TP03015A 變溫平台



規格：變溫範圍：RT~473K

功能及用途：提供變溫量測，分析元件於不同溫度下之電性。

## 服務項目

(1) 精準電性量測分析 (2) 升溫量測

## 收費標準

儀器使用每小時收費 1500 元整

## 試片準備

Sample 大小須 12 吋以內

## 聯絡方式

指導教授：張鼎張 教授 中山大學物理系

TEL：(07)5252000 轉 3708

儀器負責人：廖日謙、林建佑 同學

TEL：(07)5252000 轉 3708

儀器地點：中山大學物理館七樓 D7009 室