



吉时利经典测试测量和 行业解决方案

吉时利为精度和速度开发的解决方案

INSTRUMENT SOLUTIONS



CUSTOM CONFIGURED SOLUTIONS



TURN KEY SOLUTIONS

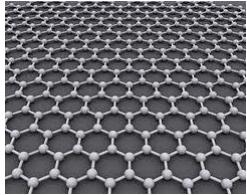


COMMON MEASUREMENT CAPABILITIES



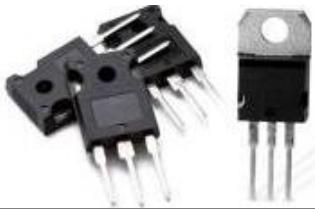
KEITHLEY
A Tektronix Company

主要应用方向



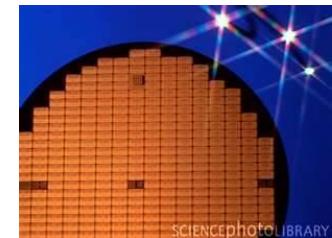
半导体

- 二极管/晶体管/场效应管
- DC-DC转换器
- IGBT等大功率器件



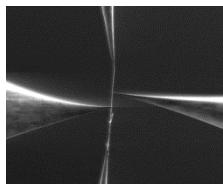
材料

- 光电材料
- 纳米材料
- 四探针，霍尔效应测试
- 电化学



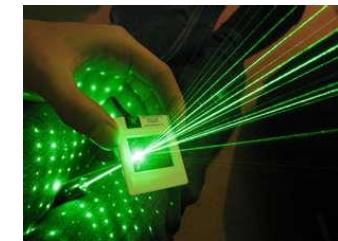
数据采集

- 连接器/电缆
- 老化测试
- IC芯片的LLCR



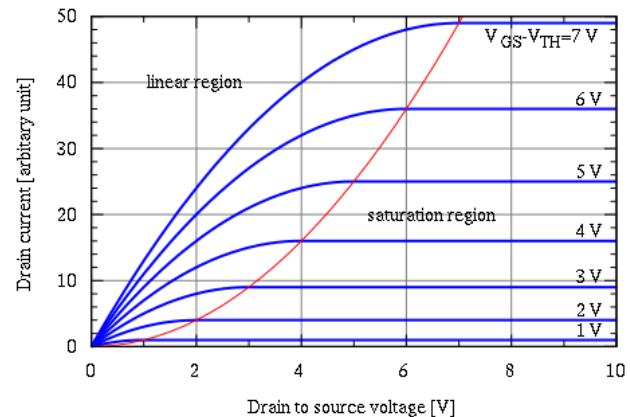
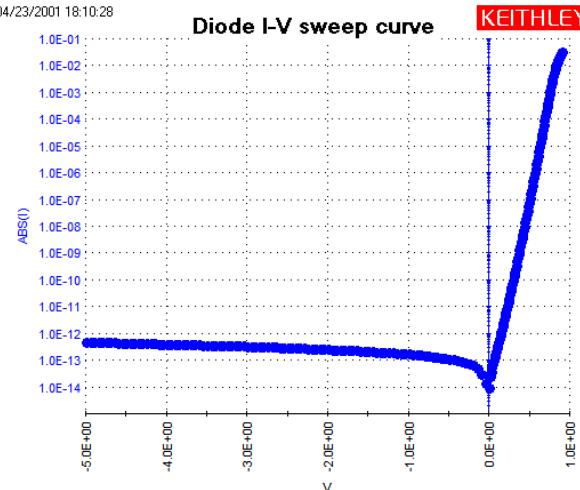
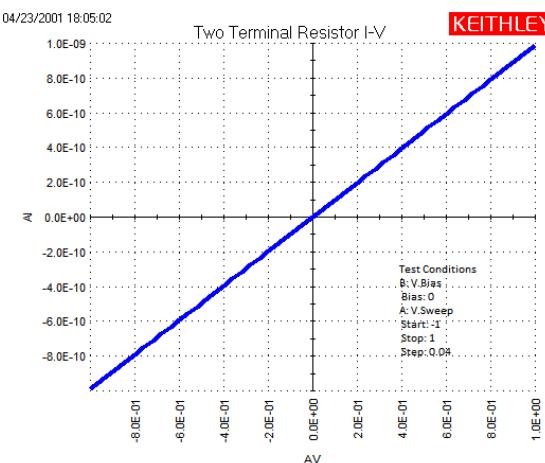
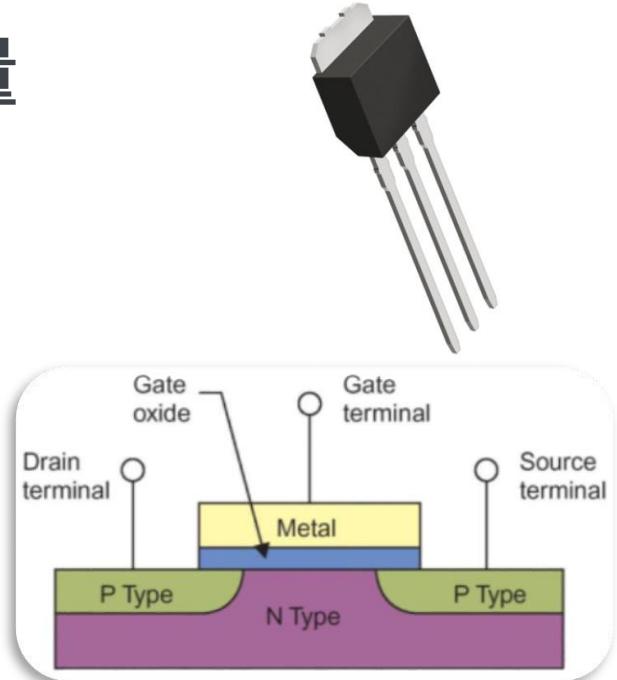
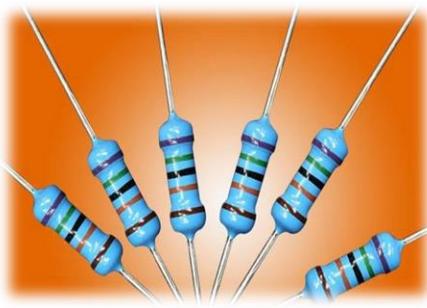
电源

- 可穿戴设备的低功耗测试
- 电源设计和系统集成



直流 (DC) I-V特性测量：精准测量

DC I-V 测量是器件及材料特性测量的最基本测试手段



*1(+9.00, +3.50e-2, 92)

元器件测量的好帮手: Source Measure Unit (SMU)

- Simultaneously source and measure voltage and/or current
- Perform resistance measurements



Precision DMM

Source Measure Unit (SMU)



True Current Source



Precision Power Supply



Electronic Load

半导体应用一

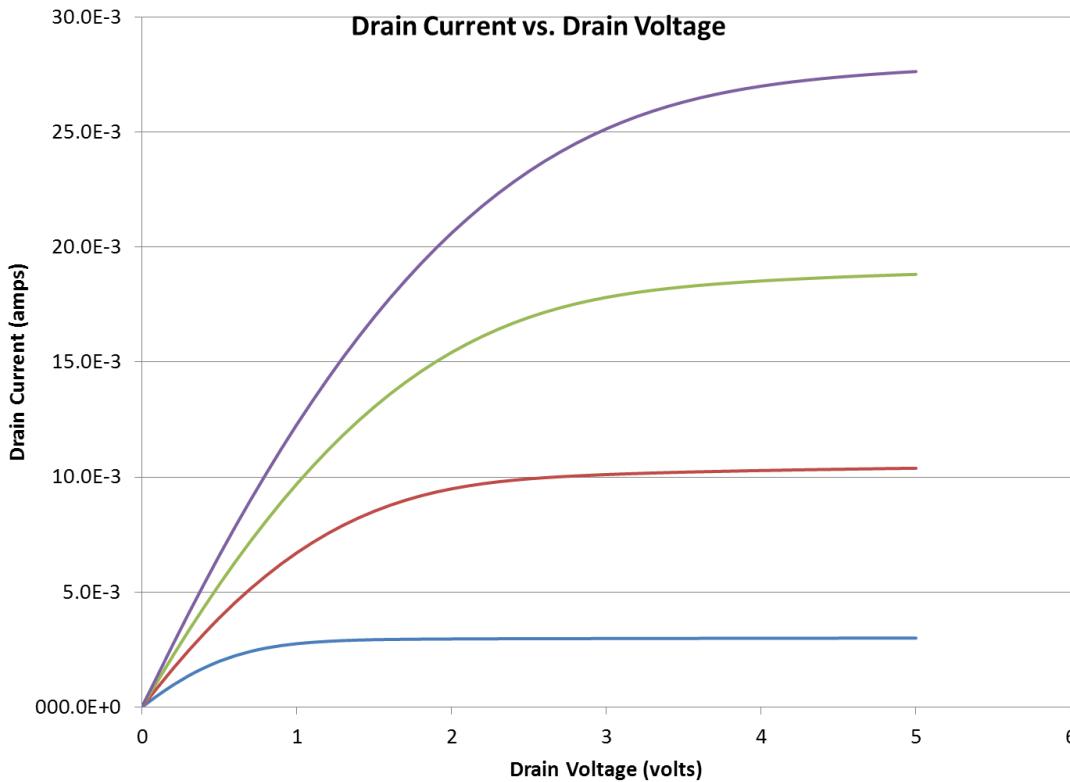
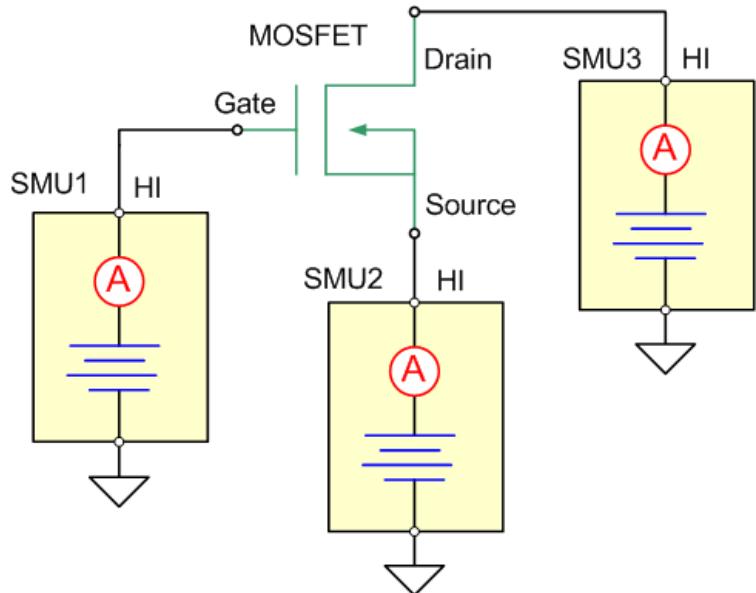
--二极管/晶体管/场效应管 IV曲线测试

半导体

材料

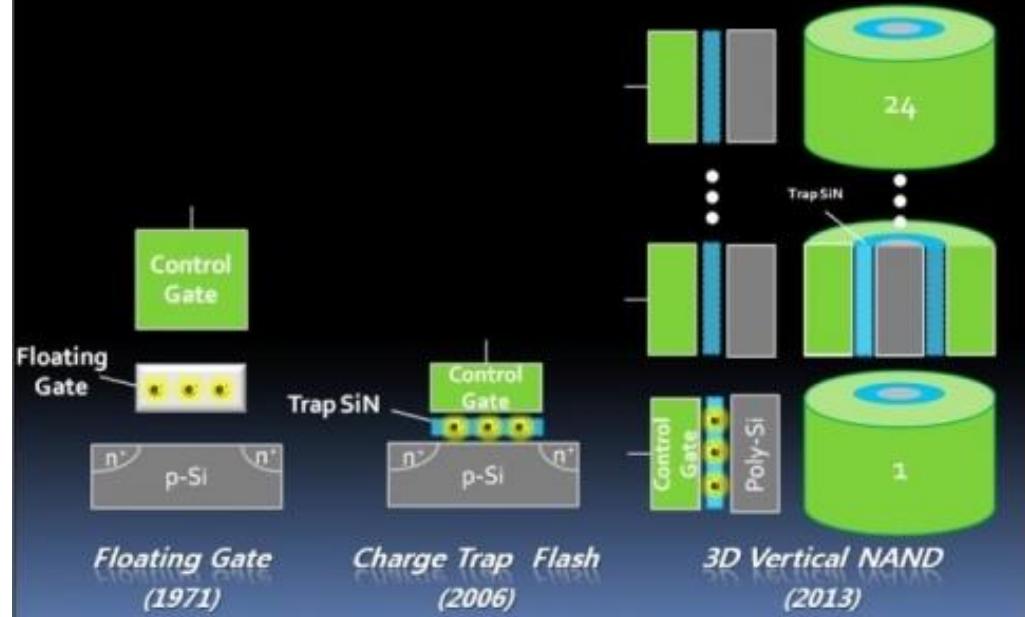
数据
采集

电源

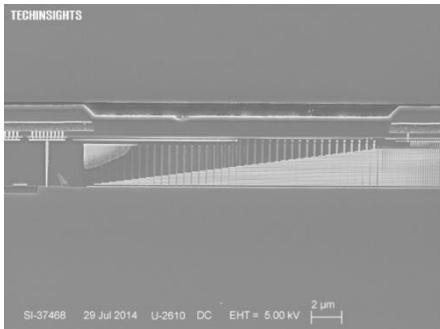


半导体应用二--NVM

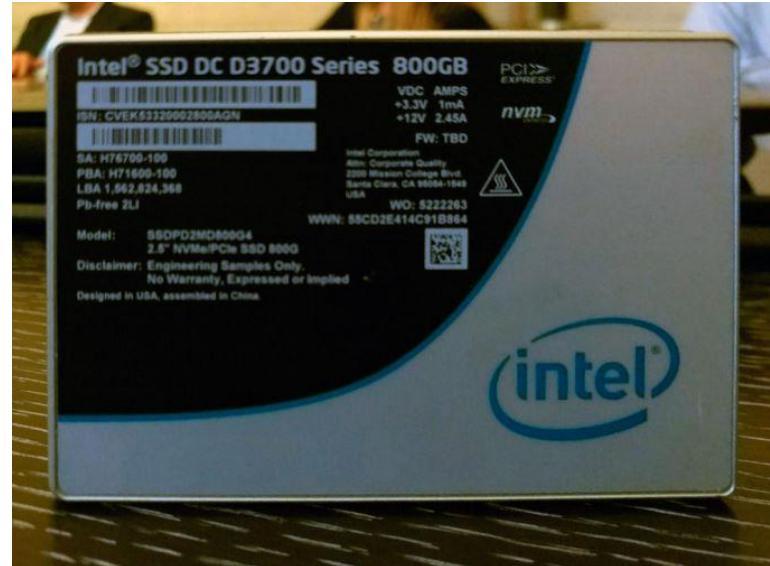
3D V-NAND Structure Innovation (Floating Gate → CTF → 3D V-NAND)



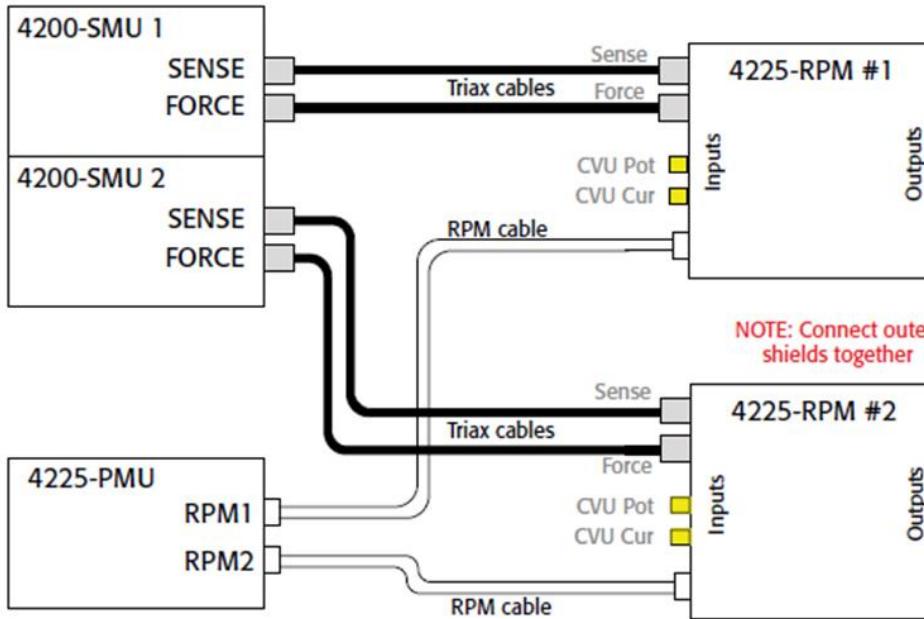
3D Nand Flash tech.
makes the massive data
store more easier and
faster.



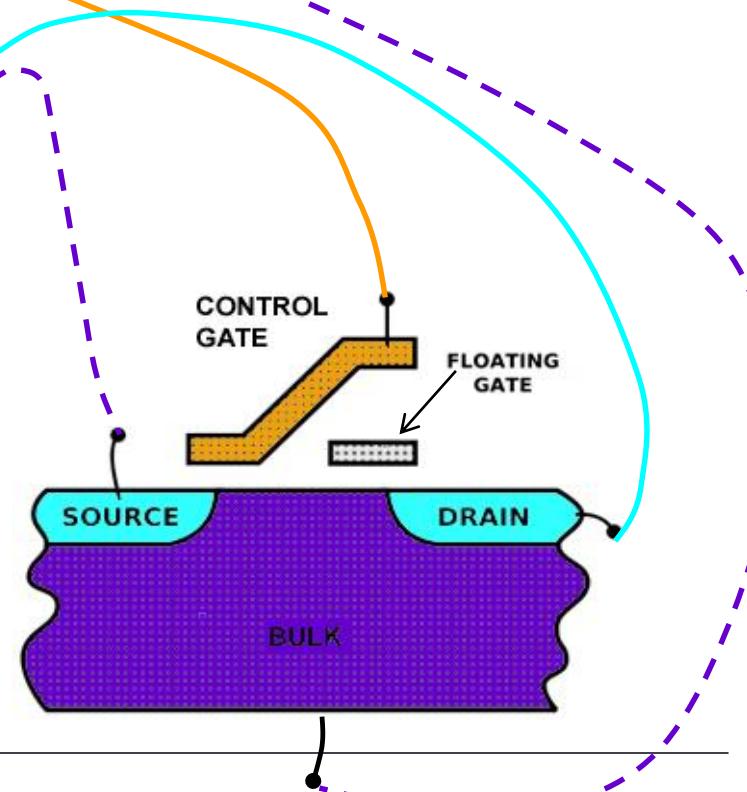
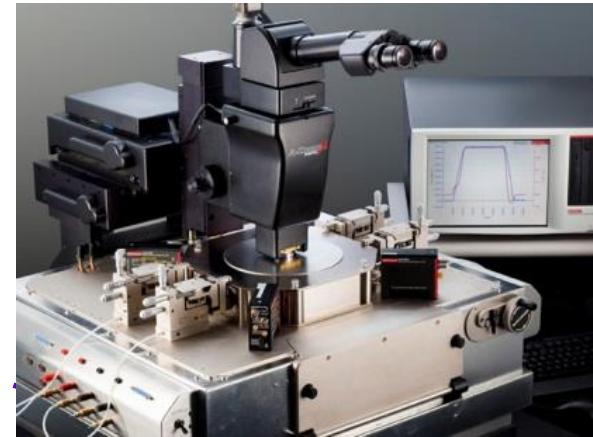
From How Samsung connects to
the wordlines in the array
(courtesy Techinsights)



Example of Flash Memory Cell Test Setup



*All connections
made via the
probe station*



- SMUs are used to accurately measure V_t and I_D
- PMU and RPM are used to generate program/erase segments

半导体应用三

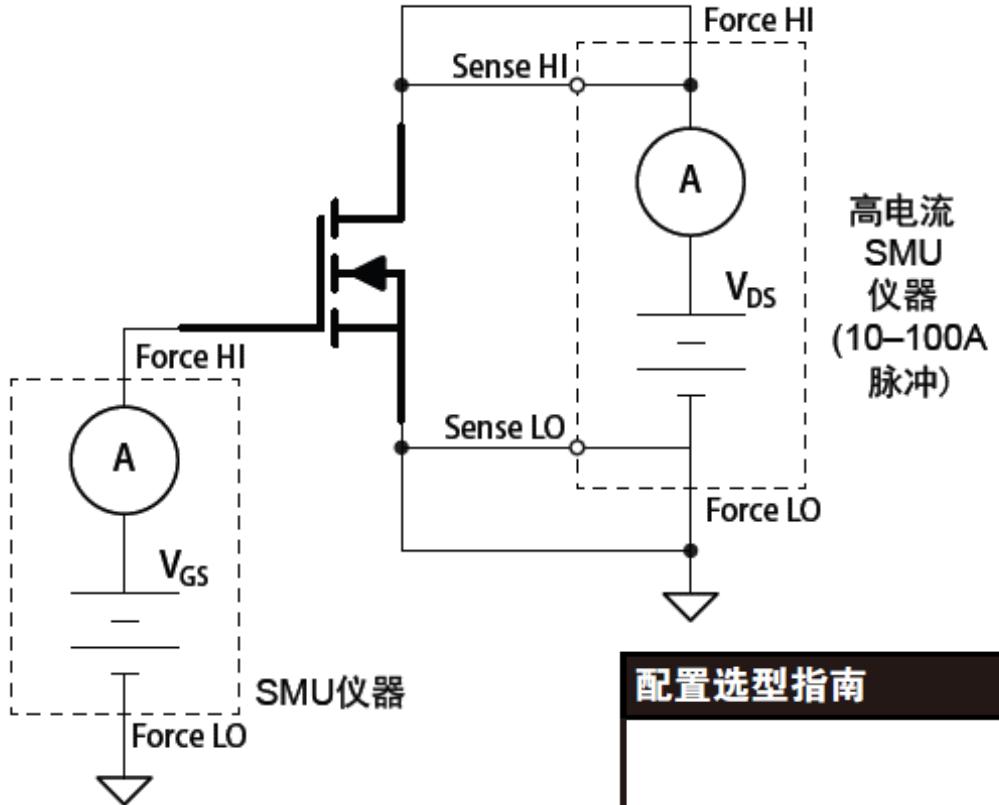
--IGBT/power nMOSFET等大功率器件测试

半导体

材料

数据
采集

电源



典型参数

击穿电压(V_{bdss} , V_{bceo})

开态电流(V_{dson} , V_{cesat} , V_f)

漏极/集电极泄漏(I_{dss} , I_r / I_{cbo} , I_{ceo})

阈值或截止电压(V_{th} , V_f , V_{beon})

基极泄漏(I_{gss} , I_b)

正向传输(y_{fs} , G_{fs} , H_{fe} , gain)

电容 (C_{iss} , C_{oss} , C_{rss})

配置选型指南

型号 ¹	集电极/漏极电源 ²		阶跃发生器 基极/栅极 电源	辅助 电源
	高压 模式	高流 模式		
低功率	2600-PCT-1B	200 V/10 A	200 V/10 A	200 V/10 A
高流	2600-PCT-2B	200 V/10 A	40 V/50 A	200 V/10 A
高压	2600-PCT-3B	3 kV/120 mA	200 V/10 A	200 V/10 A
高流和 高压	2600-PCT-4B	3 kV/120 mA	40 V/50 A	200 V/10 A



Keithley SMU Family - Instruments



2400 SourceMeter SMU Instruments

- Family of single-channel models with I-V capability from 1100V to 100nV and 10.5A pulse to 1pA
- Smart alternative to separate Power Supplies and Digital Multimeters (DMMs)
- Convenient DMM-like user interface



2450 & 2460 Touchscreen SourceMeter SMU Instruments

Industry-first 5" color capacitive touchscreen GUI

Test up to 200V and 1A (**2450**) or up to 100 V and 7A (**2460**)

Sub pA and sub μ V resolution



2600B System SourceMeter SMU Instruments

- Family of dual- or single-channel models with I-V capability from 10A pulse to 0.1fA and 200V to 100nV
- TSP® (Test Script Processor) technology for best-in-class throughput and lowest cost of test
- Browser-based GUI enables testing on any PC from anywhere in the world



2650A Hi-Power System SourceMeter SMU Instruments

- Source and measure up to 3kV or 50A pulse, with best-in-class low current resolution
- Up to 2000W pulse or 200W DC power
- Optimized for characterizing and testing high power semiconductors, electronics, and materials

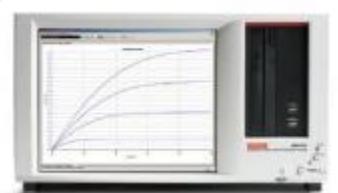


Keithley SMU Family - Systems



Parametric Curve Tracers

- Power device characterization up to 3kV and 100A including high quality instruments, cables, test fixturing, and software
- ACS Basic Edition software features real-time curve tracing and full parametric characterization modes
- Easily re-configurable to meet changing test needs



4200-SCS Semiconductor Parameter Analyzer

- An integrated analyzer for complete and precise characterization: I-V, C-V, Ultra-Fast I-V, and Pulse measurements
- Characterize devices, materials, and semiconductor processes with sub-fA resolution
- Easy-to-use Windows® GUI, modular architecture, and over 450 user-modifiable test applications simplify complex measurement



S530 Parametric Test Systems

- High-speed semiconductor parametric testing with low cost of ownership
- Designed for production and lab environments managing a broad range of devices and product wafers
- Proven SMU instrumentation technology ensures high measurement accuracy and repeatability



S500 Parametric Test Systems

- Highly configurable and scalable SMU instrument-based system
- Semiconductor device testing along with Automated Characterization Suite (ACS) at the device, wafer, or cassette level
- Ideal for SMU-per-pin Wafer Level Reliability (WLR) testing, high speed parallel test, die sort, and Process Control Monitoring (PCM)



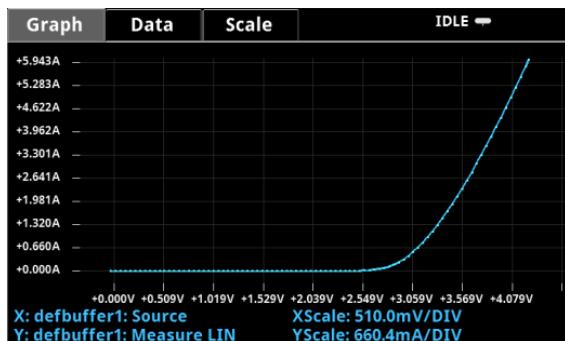
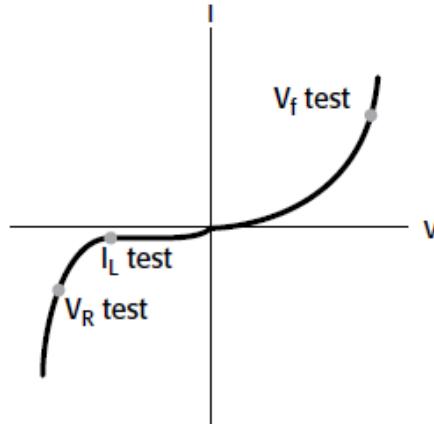
KEITHLEY

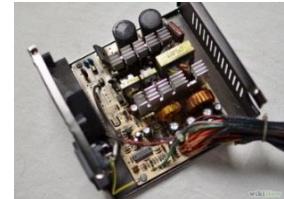
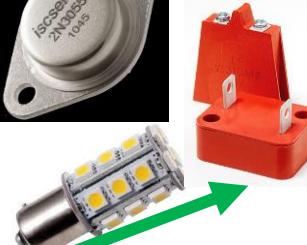
A Tektronix Company

材料应用一

--光电材料及器件测试(LED,高亮LED)

- 新型材料制做的二极管结构
 - InGaAlP, GaN(氮化镓) 等
- LED (高亮LED) 的测试
 - 需要正向和负向源 (I&V)
 - 研发：测量整条I-V曲线.
 - 量产：仅测量关键点.
 - 2个关键点测量：给电流测电压
 - Forward Voltage: Vf
 - Breakdown Voltage: VR
 - 1个关键点测量：给电压测电流





Source Measure Units Are Used in Many Places

Power Spectrum

For designers/researchers of lighting, power management, power conversion & control circuits and related devices

- Power transistor forward characteristics
- Battery Load Curves
- Charger simulation
- Dynamic load simulation
- 7A DC, 10A pulsed
- **2460/2461 SMU**



Model 2461 SourceMeter SMU

KEITHLEY CONTINUES TO INVEST IN ITS LINE OF
GRAPHICAL SOURCE MEASURE UNITS

new 10A @ 100V 1000W Pulse version of the
Model 2460

- 1000W Pulse Source/Sink, 100W DC Source/Sink
- Pulses as fast as 150µS. Dedicated pulse screen and commands



new Dual 18-Bit 1MS/s Digitizers for simultaneous I&V. Store up to 5 million rdgs.

new Contact Check

- Succeeds the Model 2430, 2420-C, 2425-C, 2430-C, 2440-C SourceMeter SMUs. Opportunity to upsell to the 2461.



材料应用一

--光电材料及器件测试(LED,高亮LED)

- LED LIV测试

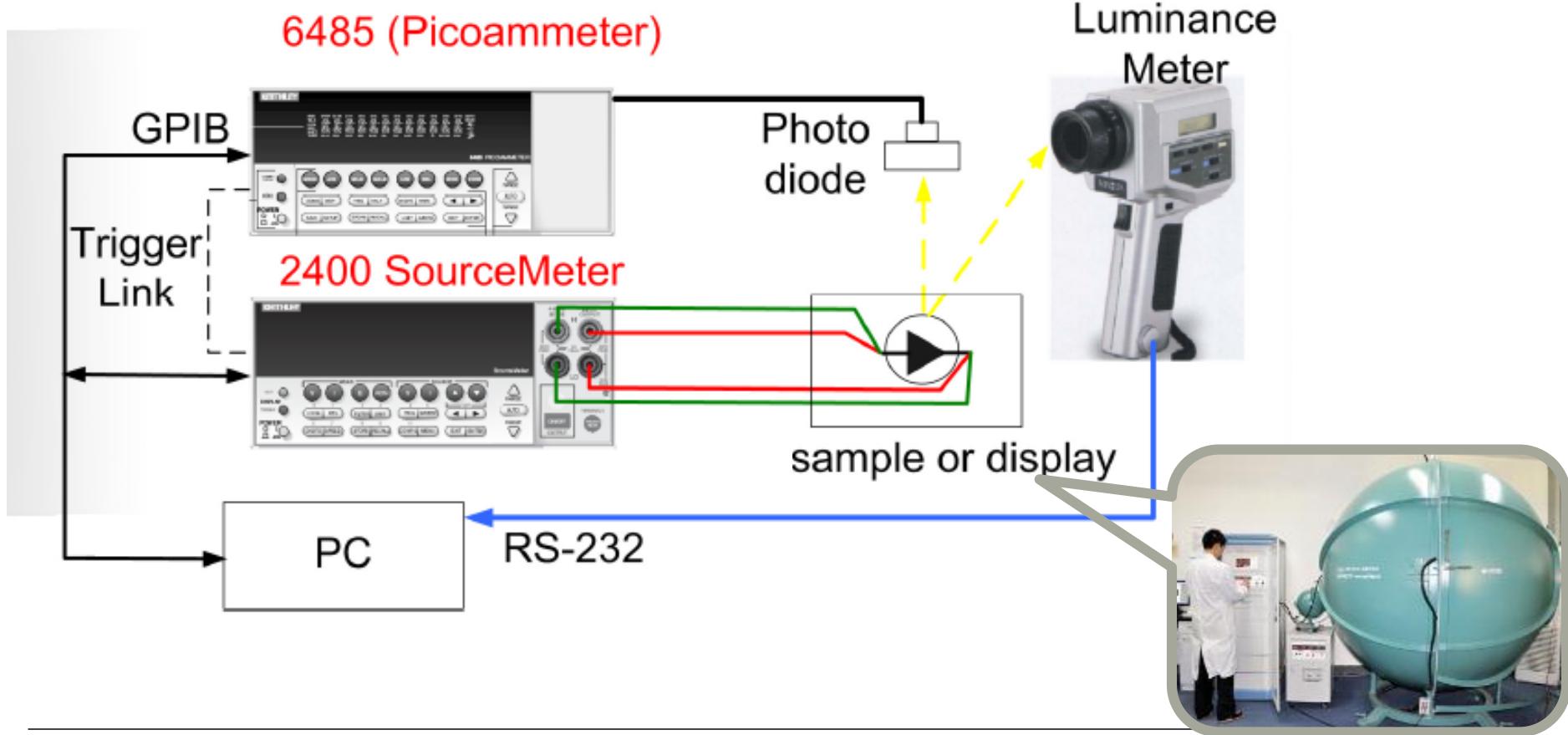
半导体

材料

数据
采集

电源

A Simple System for LIV Measurements



材料应用一

--光电材料及器件测试(Laser Diode)

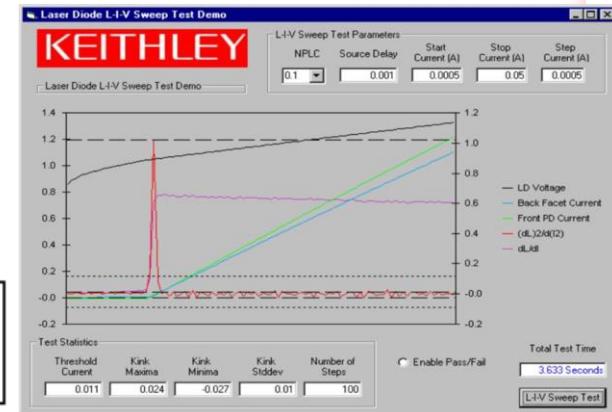
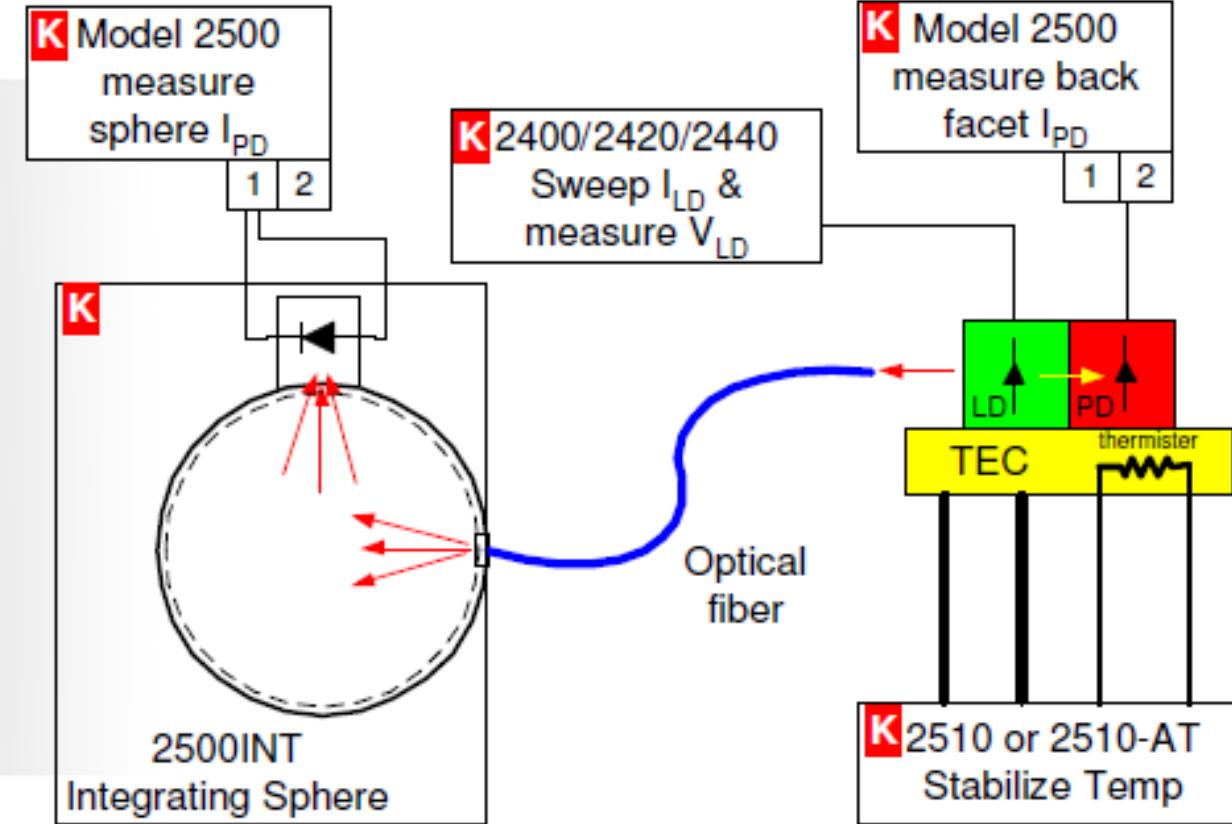
- LIV系统测LD的应用

半导体

材料

数据
采集

电源



材料应用一

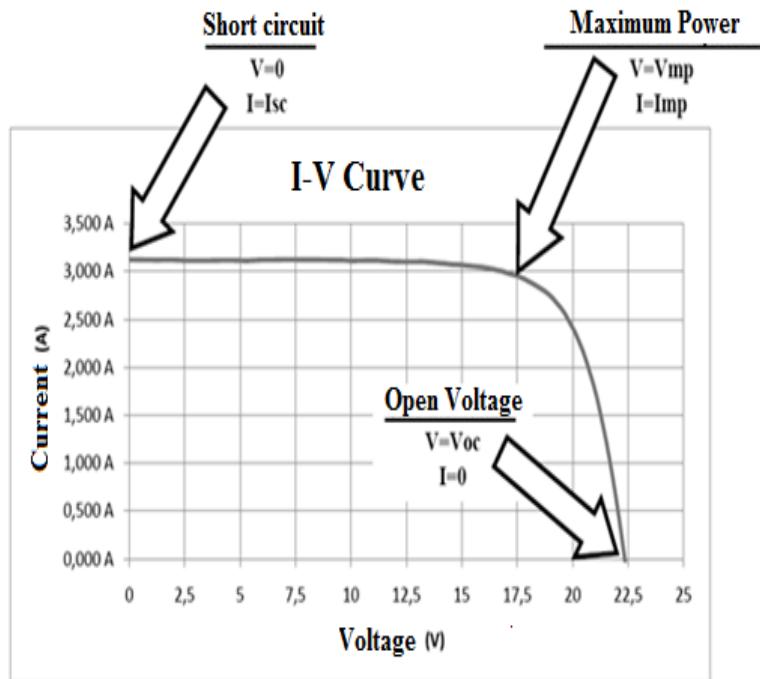
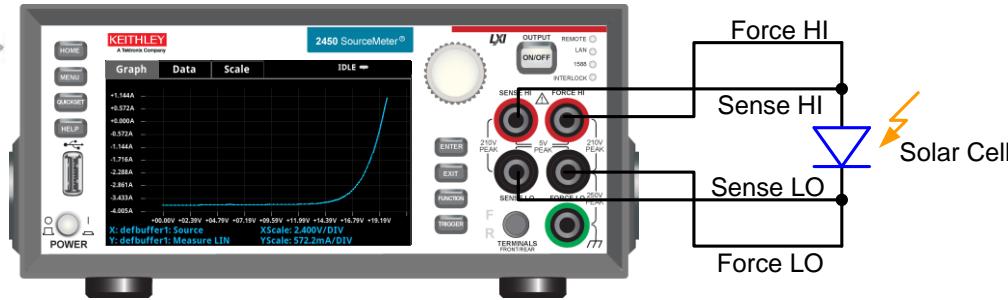
--光电材料及器件测试(太阳能电池)

半导体

材料

数据
采集

电源



GPIB ↑ defbuffer1 Script: None IDLE

MEASURE CURRENT 4-WIRE

-0.15197 A

PERF3 AZERO

Range 1A

USER DISPLAY

Pmax = 0.3036W

Isc = -0.864A, Voc = 0.53V

VRange: 2V VSource: 0.53V ILimit 1A

材料应用一

半导体

材料

数据
采集

电源

--光电材料及器件测试(太阳能电池)

- 面向太阳能电池从研发到制造多变的测试应用，吉时利推出了全新的太阳能电池测试解决方案。以四象限SMU源表为核心，加上ACS Basic专用软件，旨在帮助用户从复杂的编程中解脱出来，节约时间用于下一个科研突破。同时，套件中提供了不同的选型配置，满足用户不同功率和精度的测试需求

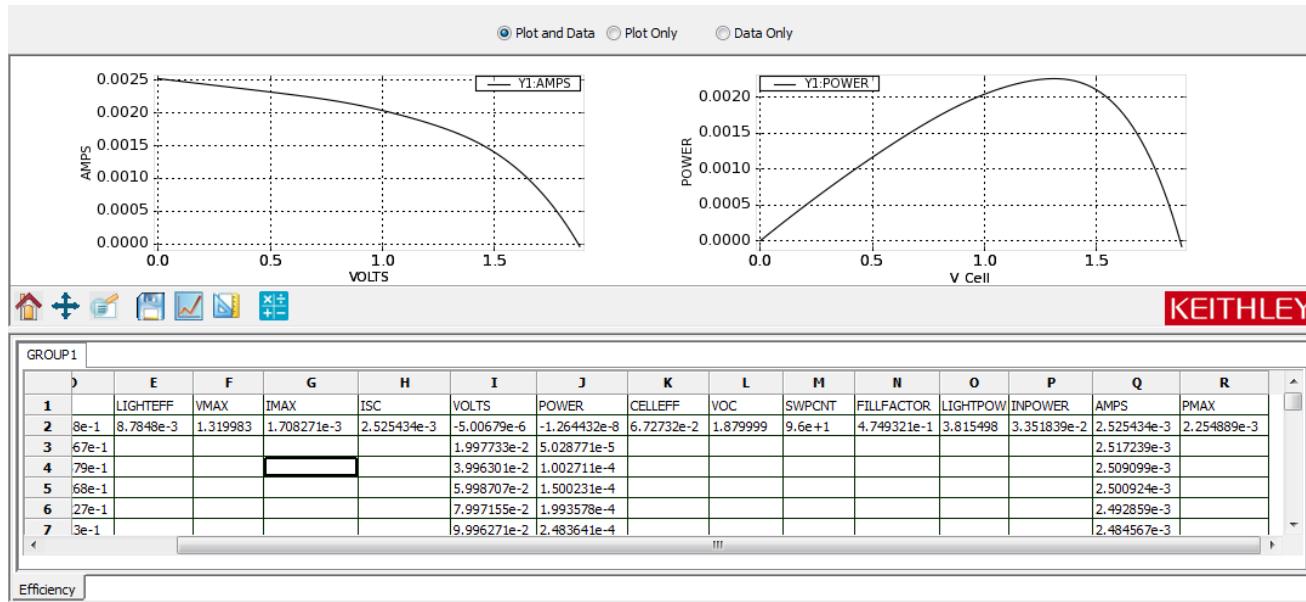
型号	最大电流	最大电压	最高分辨率	软件
SolarCell-24 	2450	±1.05A DC	±210V	10fA/10nV
	2460	±7A DC	±100V	10fA/10nV
SolarCell-26 	2601B	±3A DC/ ±10A Pulse	±40V	100fA/100nV
	2611B	±1.5A DC/ ±10A Pulse	±200V	100fA/100nV
	2635B	±1.5A DC/ ±10A Pulse	±200V	10fA/10nV
	2651A	±20A DC/ ±50A Pulse	±40V	0.1fA/100nV
				ACS Basic



材料应用一

--光电材料及器件测试(太阳能电池)

- ACS Basic软件包含太阳能电池测试专用模块，节省测量时间，提高测试效率。其内置的太阳能电池模块可自动计算出太阳能电池的典型参数，如Isc(短路电流)，Voc(开路电压)，Pmax(最大功率点)，FF(填充因子)等，用户无需编程直接获取参数结果，节约测量研发时间



半导体

材料

数据
采集

电源

符号	参数名称
Isc	短路电流
Voc	开路电压
Pmax	最大功率点
Imax	最大功率点处的电流
Vmax	最大功率点处的电压
FF	填充因子
η	转换效率
Rsh	并联电阻
Rs	串联电阻

太阳能电池测试参数

Finish standard Solar cell characterization test in **ONE MINUTE!**



KEITHLEY

A Tektronix Company

材料应用二

--纳米材料测试(CNT FET)

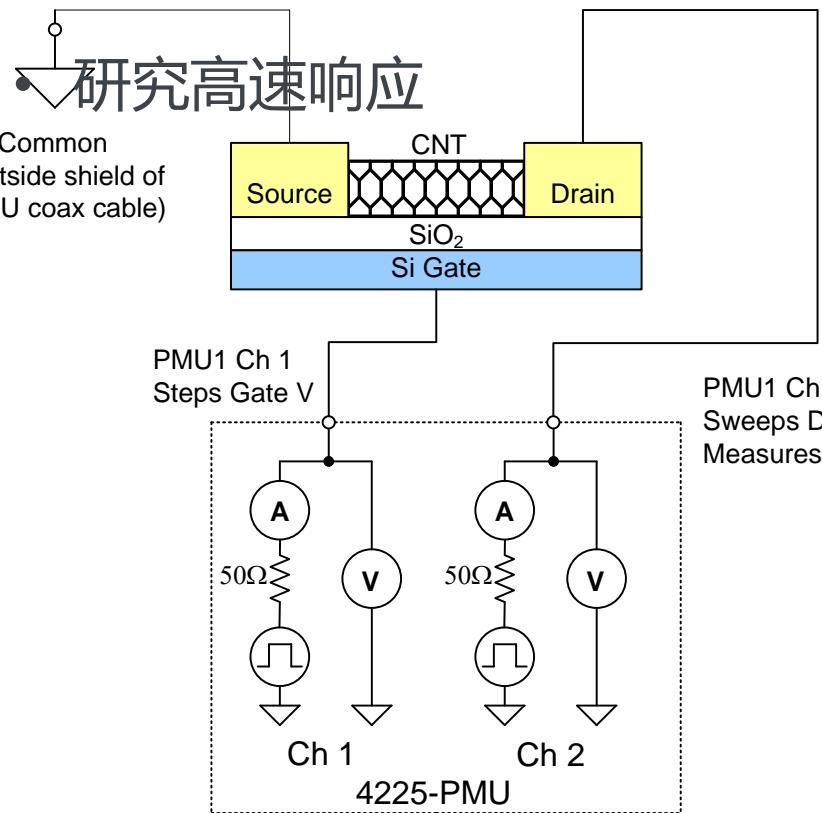
半导体

材料

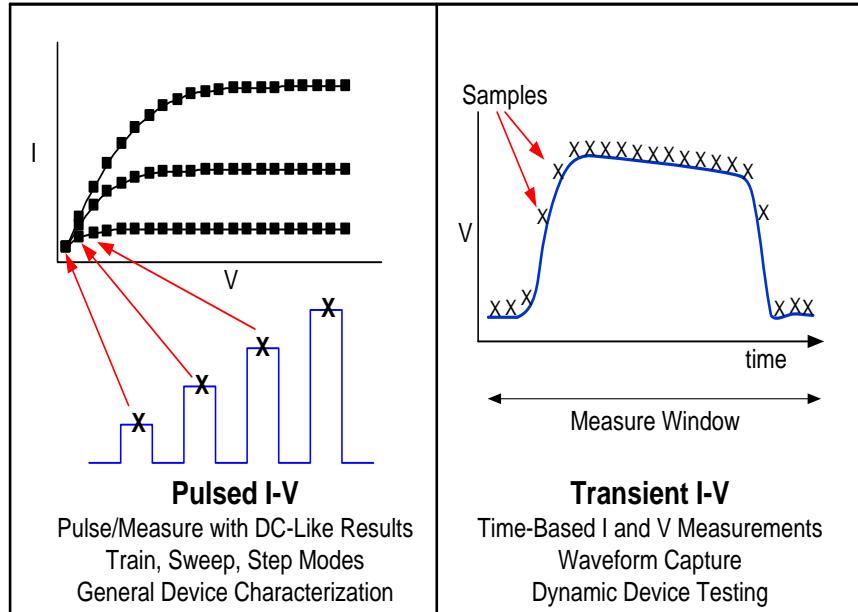
数据
采集

电源

- 减少能耗和电流漂移



双通道脉冲测量单元



$$P_{Dissipated} = V_{DC} * I_{DC} * \frac{PulseWidth}{PulsePeriod}$$



材料应用三 --四探针电阻率测试

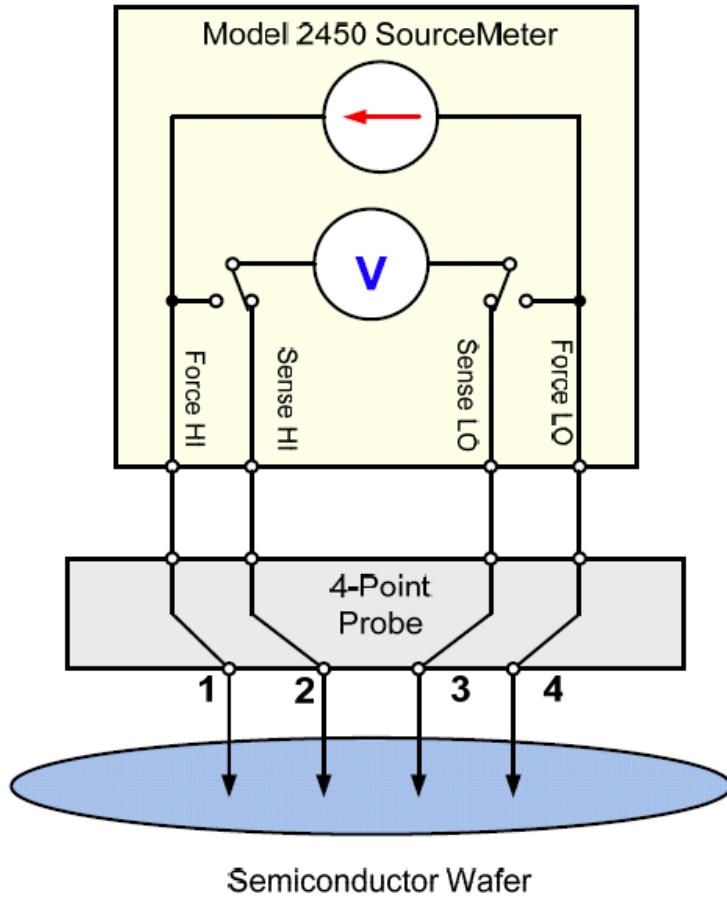
半导体

材料

数据
采集

电源

- The Model 2450 or 2460 can be used to measure the resistivity of a wide range of materials including conductive coatings, semiconductor wafers, solar cell materials, etc.



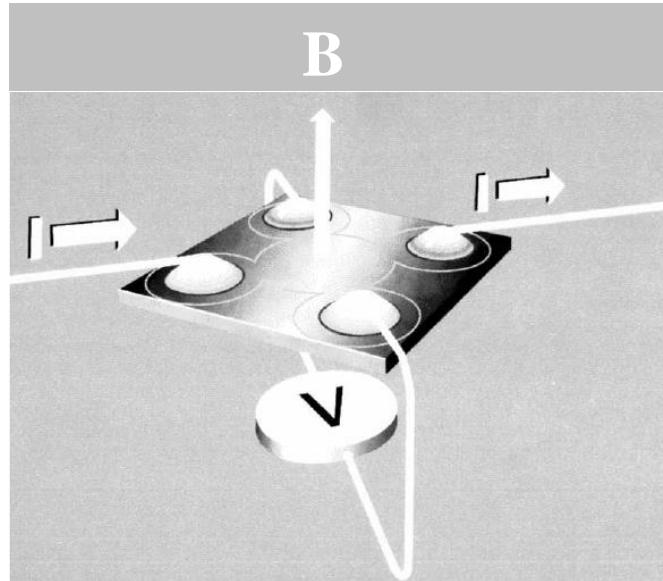
材料应用四

--霍尔效应测试



- 首先测量霍尔电压 V_H
 - 施加磁场 B
 - 提供电流 I
 - 测量 V_H
 - t 是样本厚度
- 然后测量电阻率 ρ
 - 使用范德堡技术
- 然后计算霍尔迁移率 μ_H :

$$\mu_H = \frac{|V_H t|}{BI\rho}$$



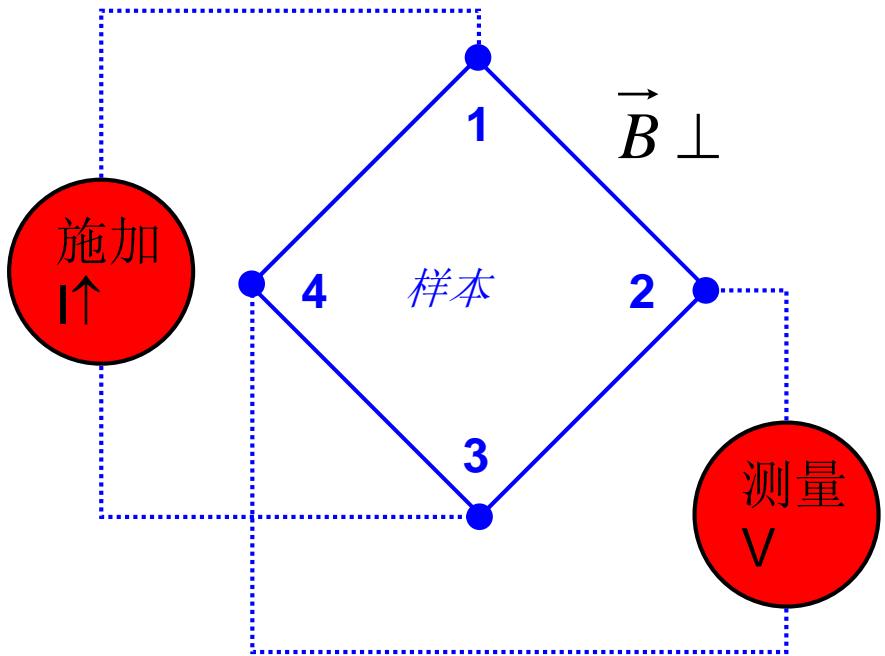
材料应用四

--霍尔效应测试



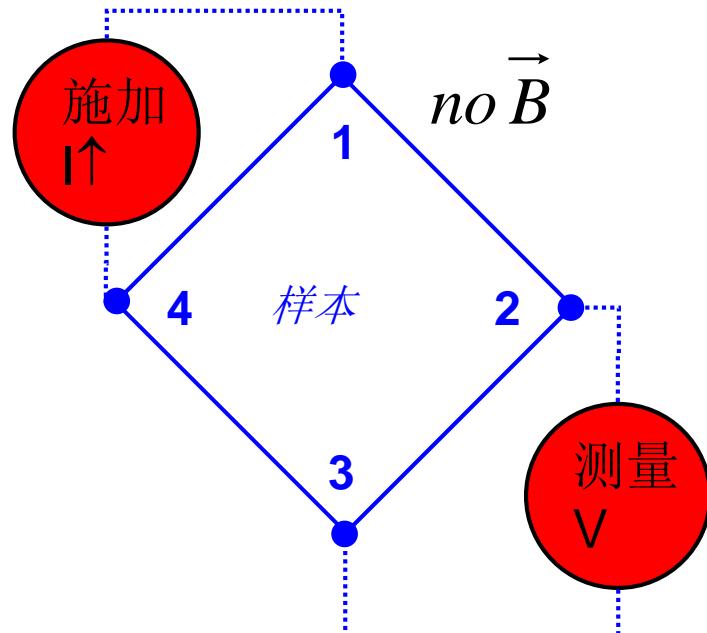
霍尔效应:

- 在相反节点上施加电流
- 在相反一端节点上测量电压
 - $V \sim nV - V$ (一般uV-mV)



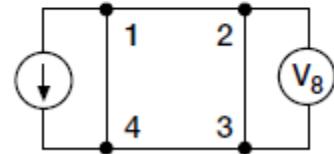
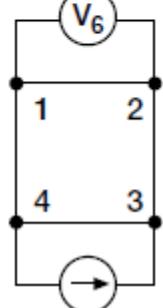
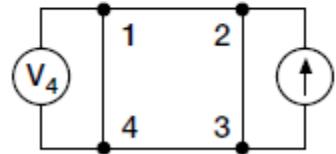
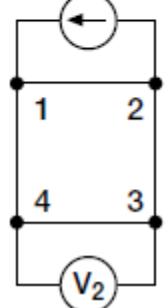
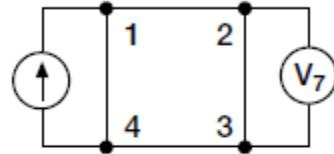
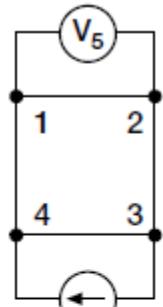
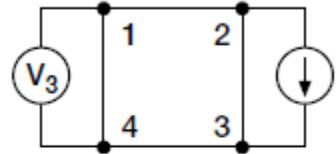
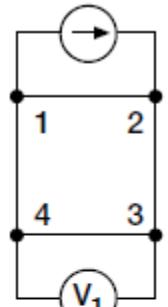
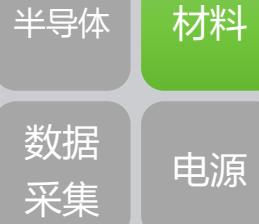
范德堡电阻率:

- 在相邻节点上施加电流
- 在相反的相邻节点上测量电压
 - 电压应该 $<5V$, 一般mV
- 给出 ρ , 从而可以计算 μ



材料应用三

--霍尔效应测试，范德堡法



$$\rho_A = \frac{\pi}{\ln 2} f_A t_s \frac{(V_1 - V_2 + V_3 - V_4)}{4I}$$

$$\rho_{AVG} = \frac{\rho_A + \rho_B}{2}$$

$$\rho_B = \frac{\pi}{\ln 2} f_B t_s \frac{(V_5 - V_6 + V_7 - V_8)}{4I}$$



材料应用四

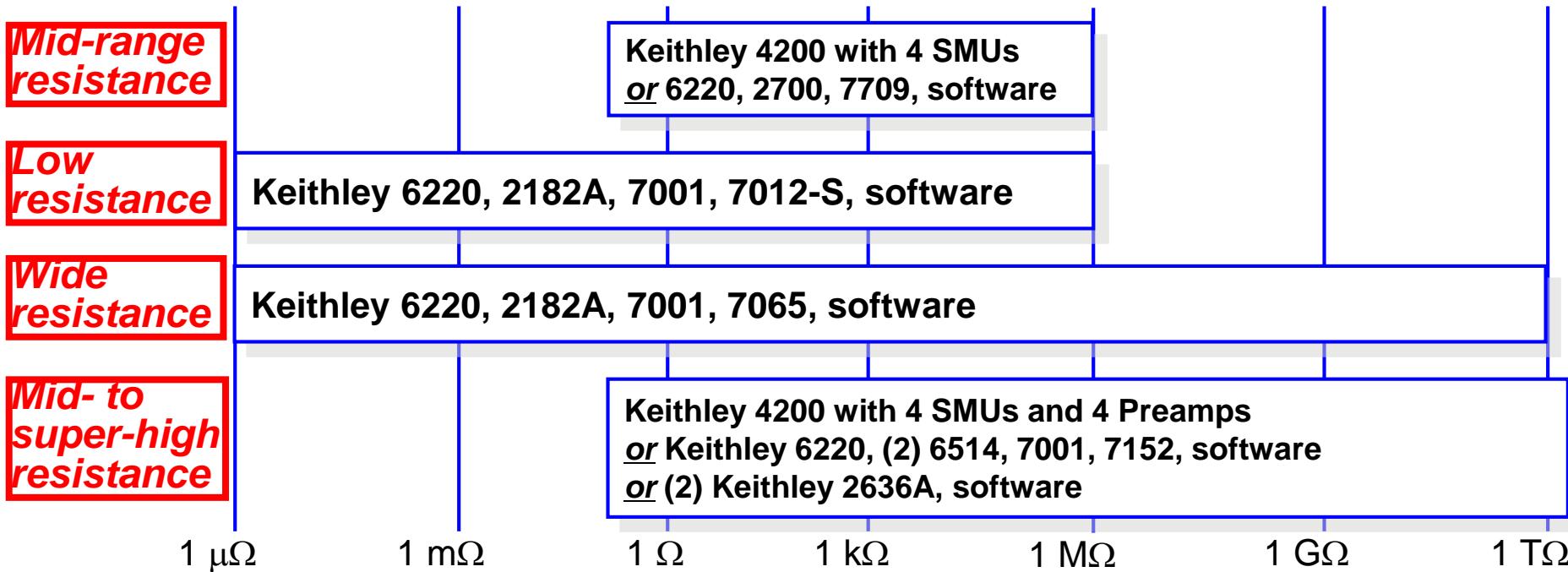
--霍尔效应测试设备概览

半导体

材料

数据
采集

电源



样品电阻 (Ω)

(实际 Total Resistance = Sample Resistance + Contact Resistance)
Sample Resistance $\approx \rho/t$

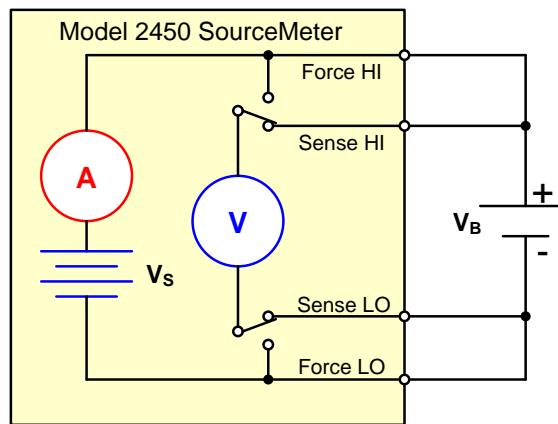
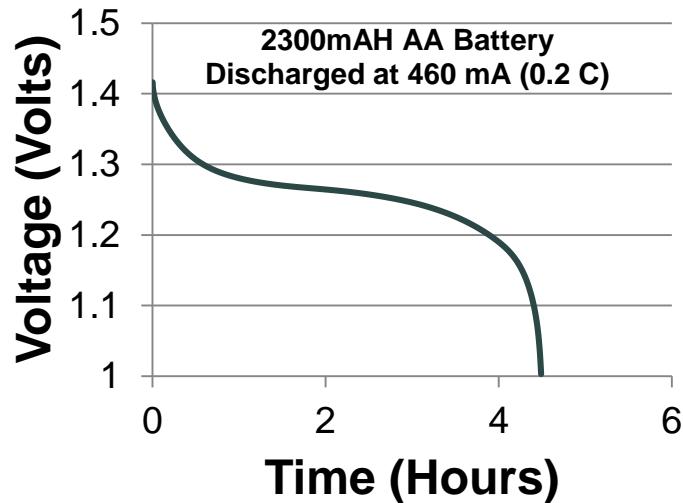


KEITHLEY

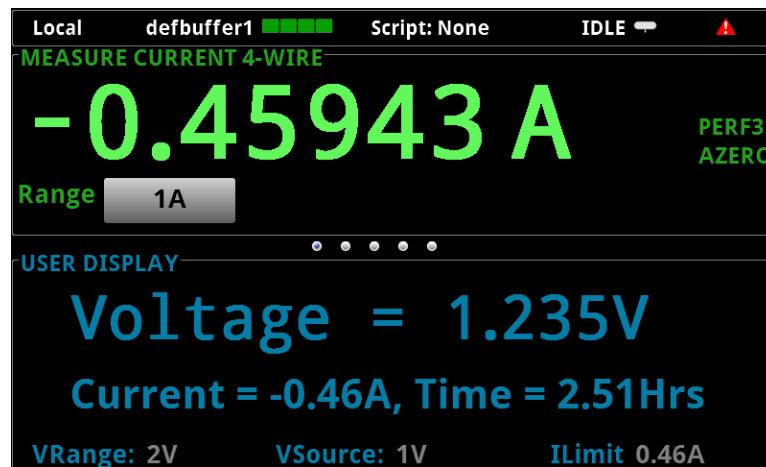
A Tektronix Company

材料应用五

--电化学材料相关应用（电池充放电测试）



Model 2450或2460配置
为电池充电/放电



触摸屏显示器可以编程，
为用户提供更新的测试数
据，如电池电压、负载电
流和经过的测试时间

Keithley SMU for Electrochemistry Applications

- Cyclic Voltammetry
- Linear Sweep Voltammetry
- Open Circuit Potential
- Potential Pulse and Square Wave with Current Measure
- Current Pulse and Square Wave with Voltage Measure
- Chronoamperometry
- Chronopotentiometry

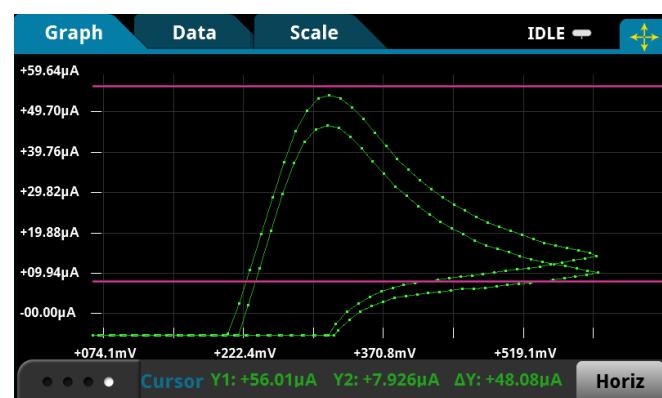
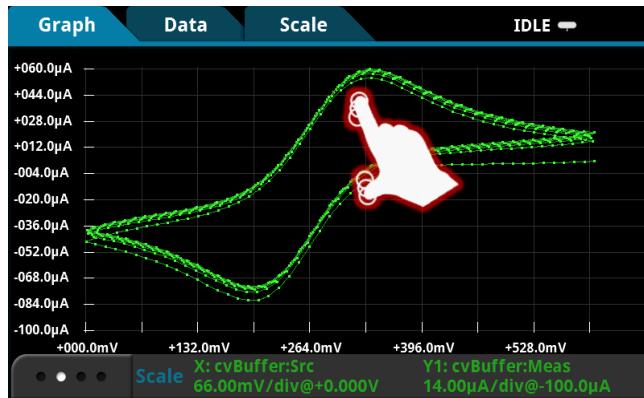
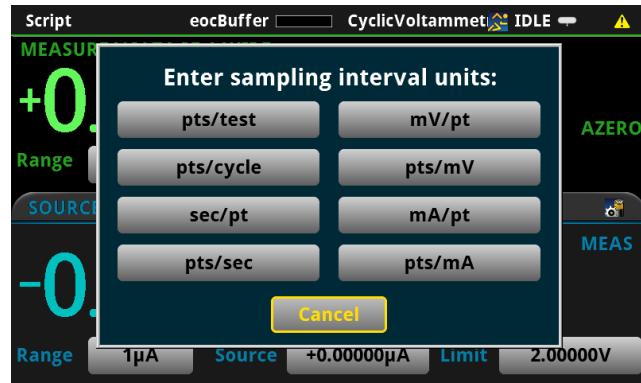
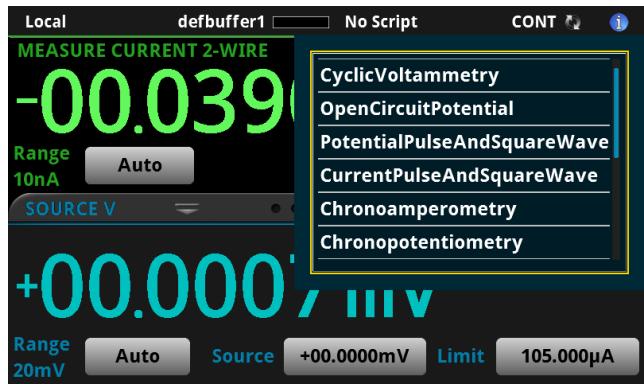


Distinctive differences

SIMPLICITY

- Configure test, run experiment, generate voltammogram plot, analyze results

Simplify learning
and test set-up



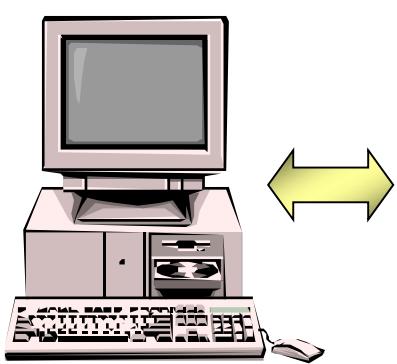
数据采集应用一 --多点温度监测

半导体
材料
数据
采集
电源

Model 2700 System Diagram

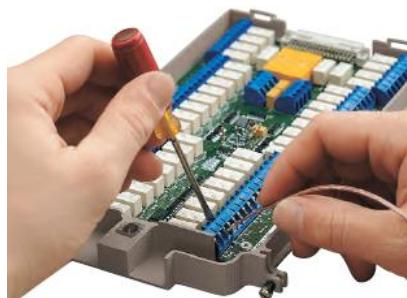


2700系统架构



Model 2700

2700/2701/2750



Universal Input
Modules



**770x, 771x switch
cards**

Measure
DCV
Ohms
Temp
ACV
Freq
Current
Totalizer

Control
Isolated Switching
Analog Output
Digital Output



数据采集应用二

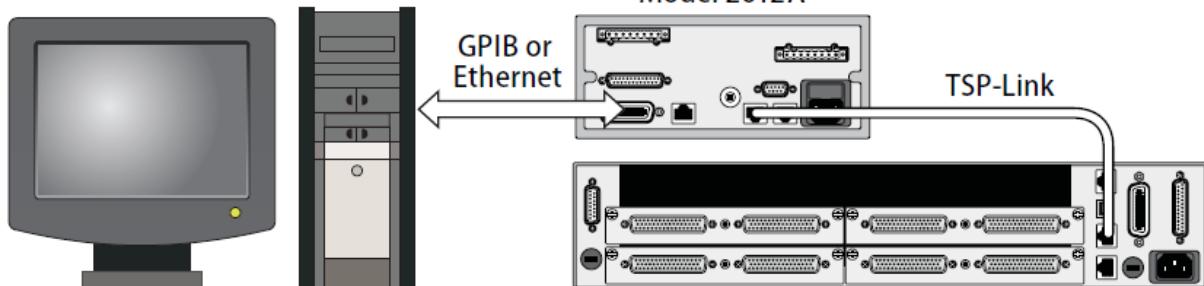
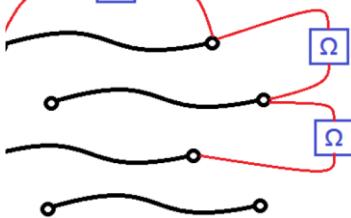
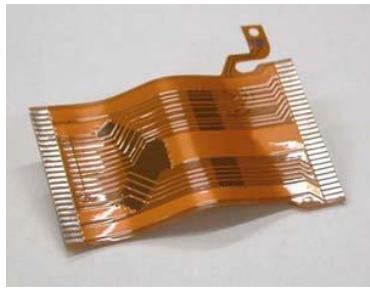
--连接器/电缆的导通性与绝缘性测试(LLCR)

半导体

材料

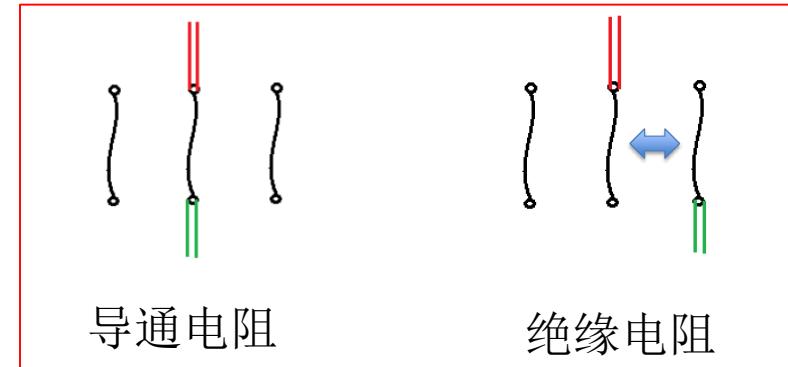
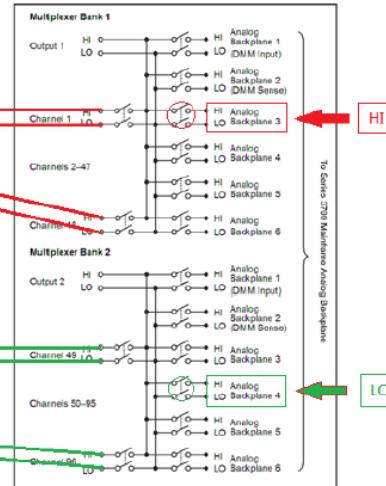
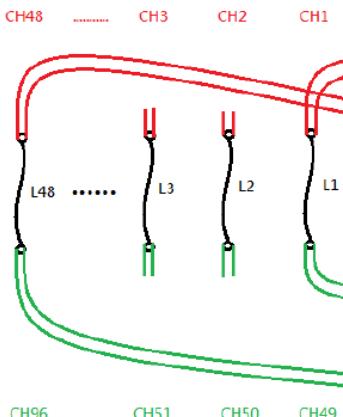
数据
采集

电源



Model 3706

Figure 16: Schematic for the Model 3722



导通电阻

绝缘电阻



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3706A开关系统

半导体

材料

数据
采集

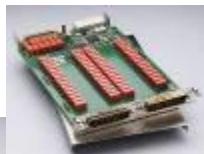
电源

- 6 Slots
- 10 Card choices
- Up to 576 two-pole switching channels per mainframe



- 3 remote interfaces (Ethernet/USB/GPIB)

3700 Series should be the first consideration in any new application



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数据采集应用三

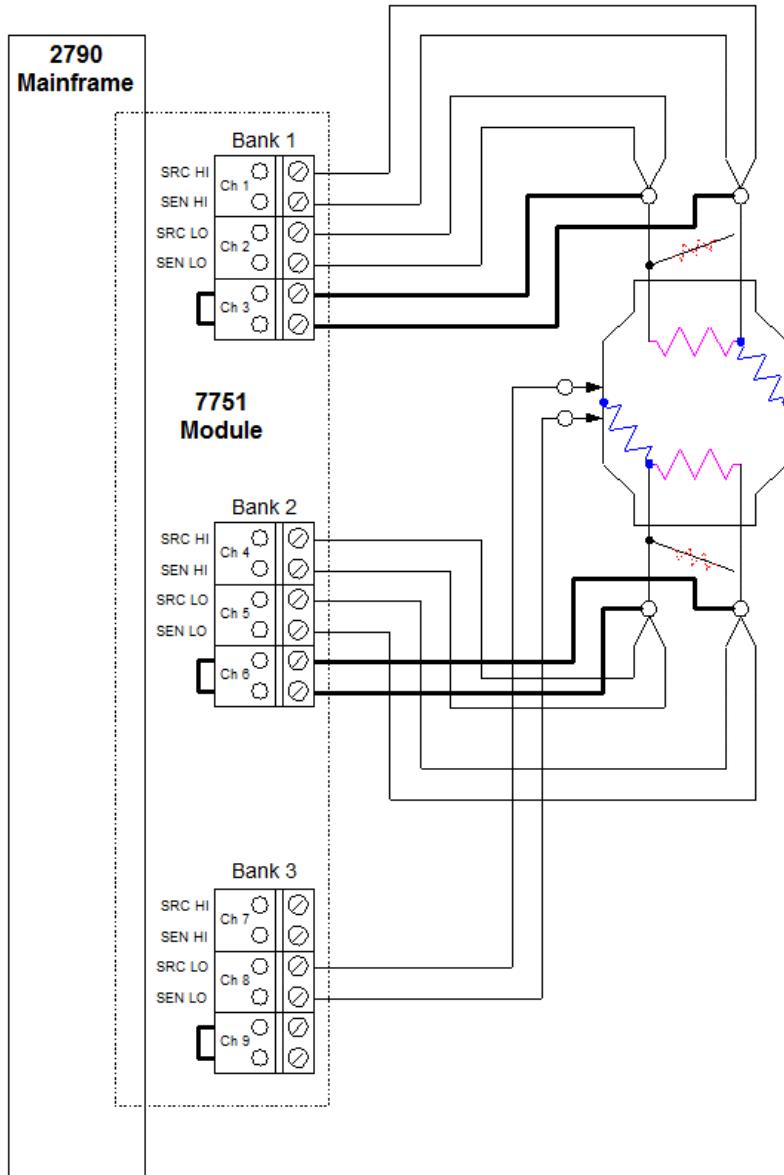
--汽车安全气囊桥路，短路，绝缘电阻测试

半导体

材料

数据
采集

电源



短路电阻 $< 0.1\Omega$

桥路电阻 = $2\Omega \pm Tol$

绝缘电阻 $> 10M\Omega$ ($1M\Omega$)

触点检查 $< \sim 20\Omega$



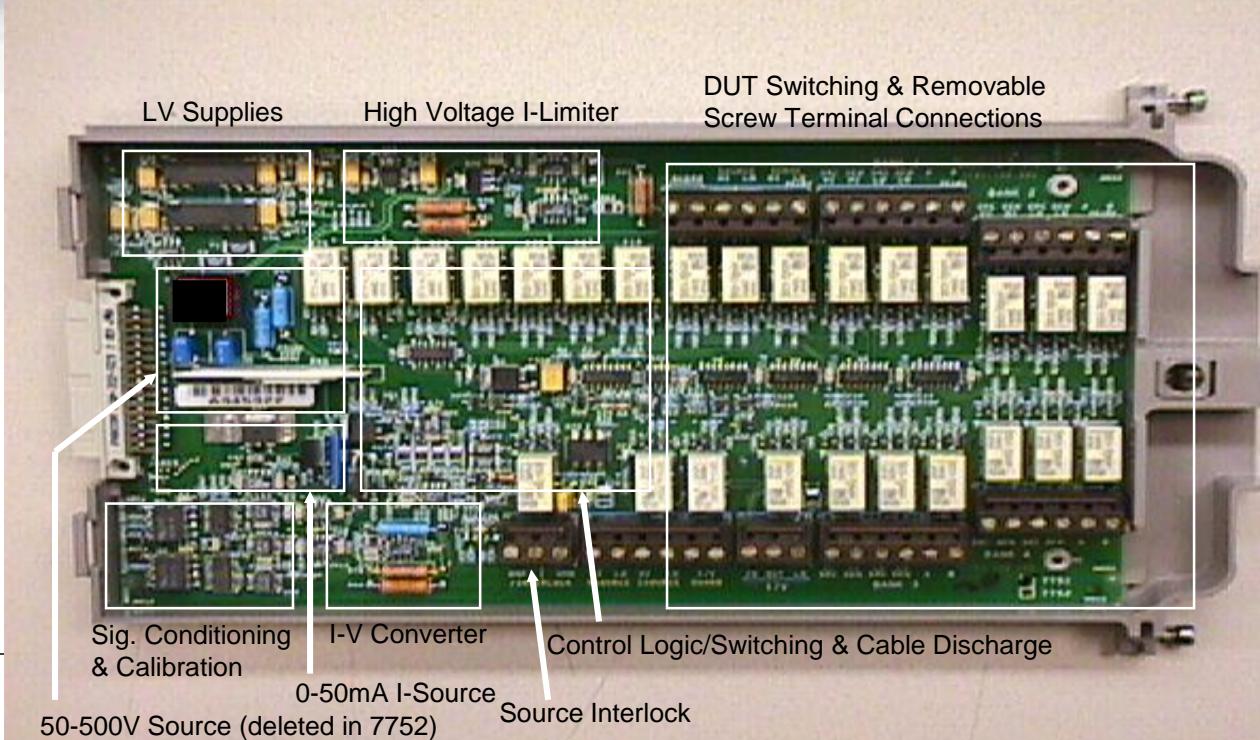
2790安全气囊测试系统

半导体

材料

数据
采集

电源



2790安全气囊测试系统

半导体

材料

数据
采集

电源

Standard Models (Catalog Items)

2790-H: One 7751 HV card

For single- and dual-stage inflators

2790-A: One 7753 HV card

For single- and dual-stage inflators

2790-HH: Two 7751 HV cards

For dual-stage and/or parallel soak applications

2790-HL: One 7751 HV card plus one 7752 LV card

For safety integrated steering wheel applications

2790-L: One 7752 LV card

For LV-only continuity

Sub-Modules (Available only as spares)

7751 – Source/switch module with 50mA and 500V I/V sources

7752 – Source/switch module with 50mA I-source only

7753 – Source/switch module with 50mA and higher power 500V I/V sources

7702 – 20/40 channel multiplexer module (standard)

2790 – Two-slot mainframe



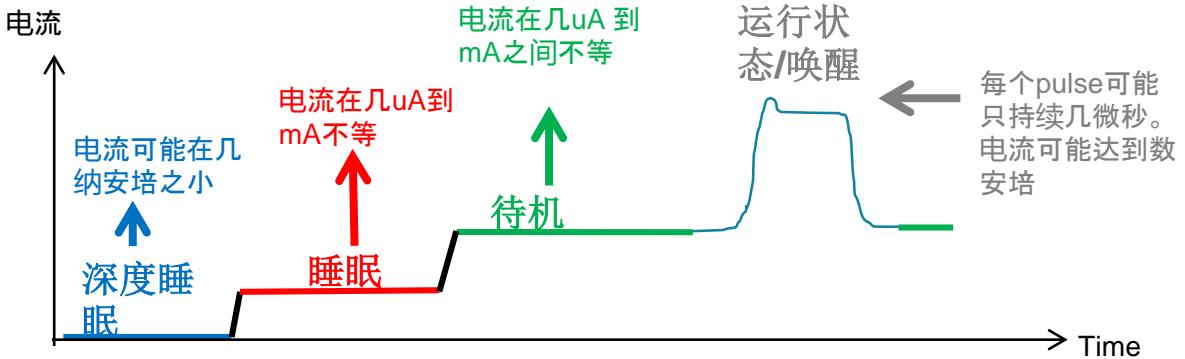
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电源应用一

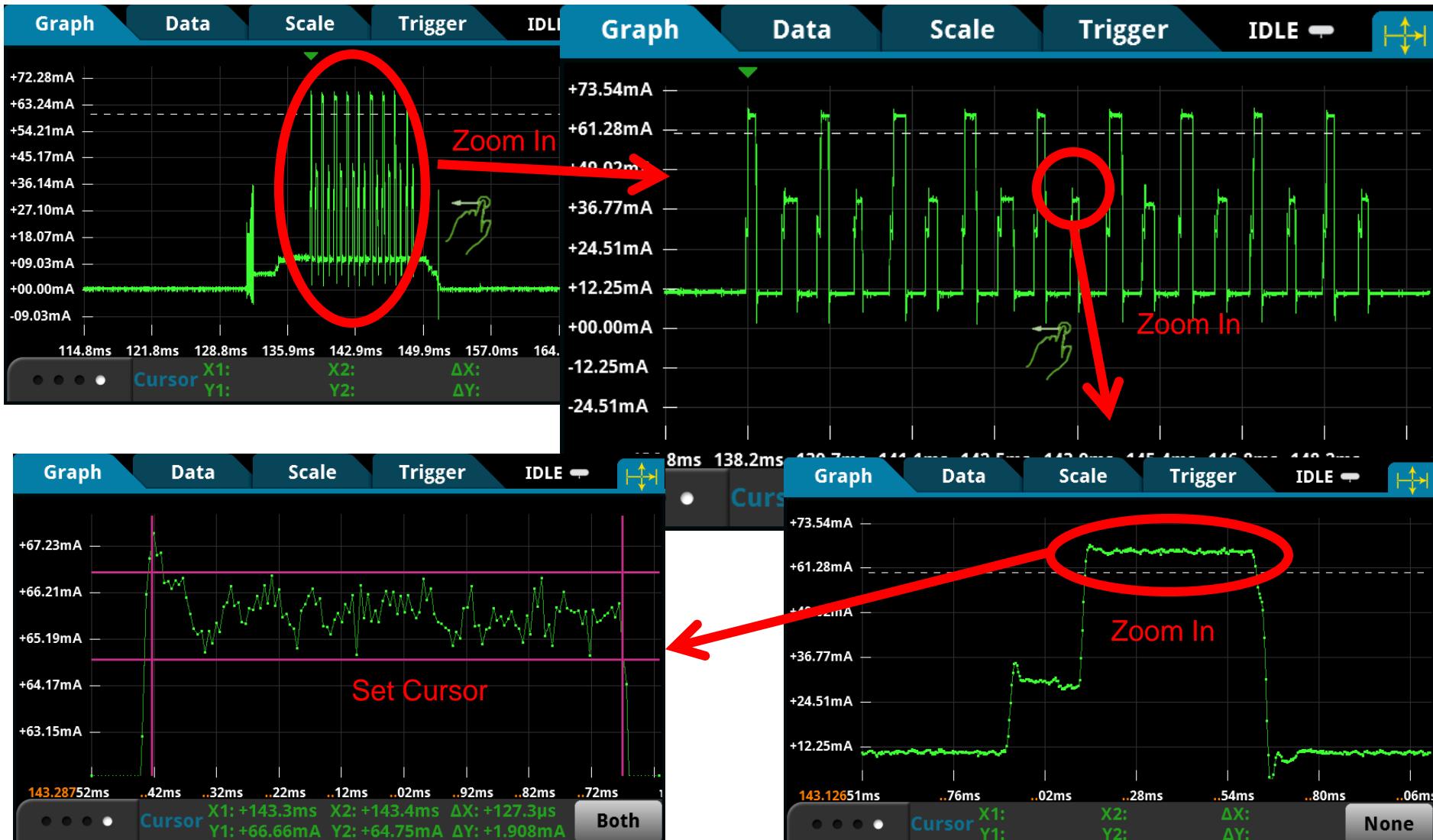
--可穿戴设备的低功耗测试

半导体
材料
数据采集
电源



Example Application

More Detailed Power Consumption Info with DMM7510



电源应用二

--待机功耗测试

“待机功耗指的是当电子设备在其最低功率模式下运行时所消耗的功率”

半导体

材料

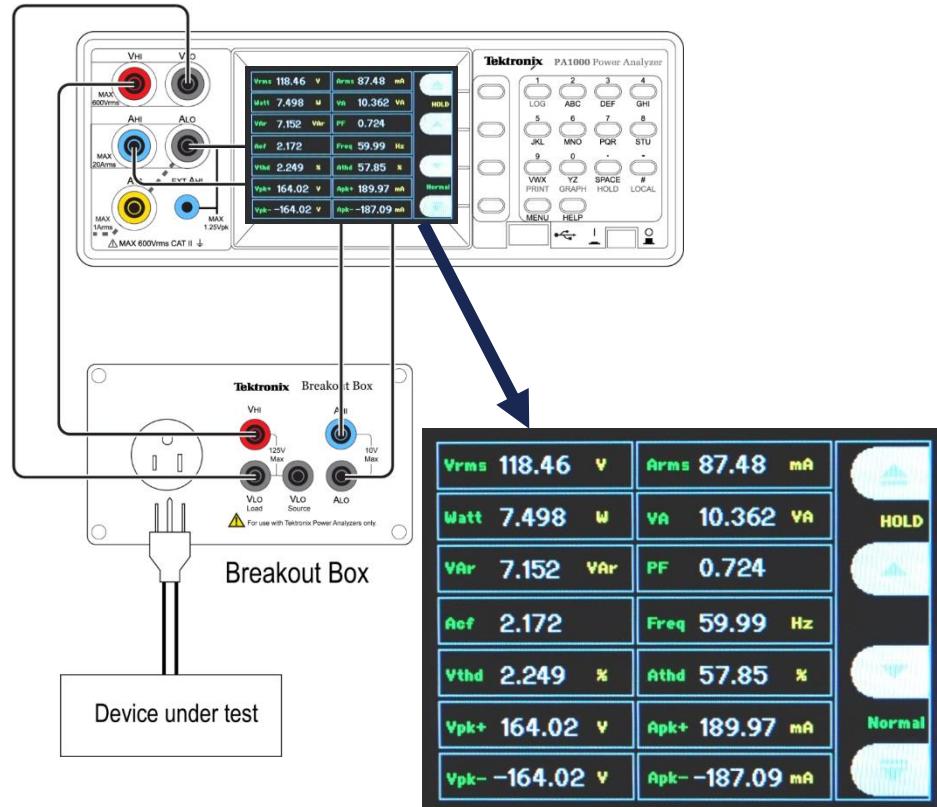
数据
采集

电源

--Lawrence Berkley National Laboratory.

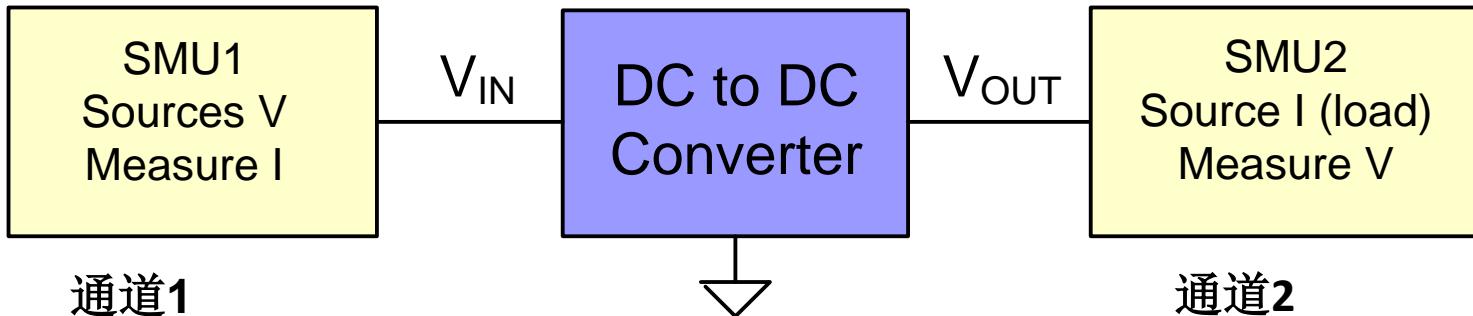
例如：

- 笔记本/平板电脑/手机充电器
- 带时钟显示的家电
- 等待遥控操作的音频播放设备



半导体应用三

--DC到DC转换器测试



SMUs可以让用户灵活地同时提供和测量电流和电压。

V_{OUT}端子上的电流源使得用户能够改变负载。

通过使用两条通道，吉时利SMU进一步简化了测试，因为用户只需要对一台仪器编程。



A Greater Measure of Confidence

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