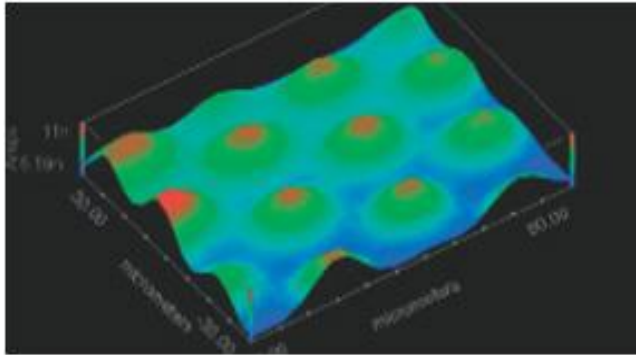




CLEAR VISION

SOUND STRATEGIES

SOLID PERFORMANCE



# Versa Studio 操作指南

Manual of Versa Studio

何长荣



**Princeton  
Applied  
Research**



<http://www.ametek.com>



## VersaStudio 软件

界面简单  
易于操作

功能强大

免费下载  
及升级

可嵌入自  
定义程序

**The VersaStudio makes "Echem Easy!"**

More Options. More Solutions.



<http://www.par-solartron.com.cn>



# 目录

1

• [Versa Studio软件下载与安装](#)

2

• [仪器安装、检验与校准](#)

3

• [电极线连接方法](#)

4

• [Versa Studio软件操作](#)

5

• [FAQ与注意事项](#)

6

• [具体应用讲解](#)





## 1 Versa Studio 下载与安装

1. Versa Studio 目前仅适用于普林斯顿VersaSTAT 3、VersaSTAT 3F、VersaSTAT 4、VersaSTAT Multi-Channel、PARSTAT 4000及PARSTAT Multi-Channel电化学工作站
2. Versa Studio 软件可从随机附送的光盘中安装或者从官方网站**免费**下载最新版本：  
<http://www.ameteki.com/products/software/versastudio-software>
1. 首先安装软件包中的硬件驱动程序VersaStudioUsbInstaller.exe
2. Versa Studio 支持32位及64位操作系统，根据电脑操作系统实际情况选择相应版本Versa Studio进行安装。建议选择默认安装路径，以避免潜在的软件冲突
3. Versa Studio 安装过程中如提示须安装.NET Framework文件，则需下载或双击光盘中dotnetfx35.exe安装Microsoft .NET Framework 3.5







## 2 仪器安装、检验与校准

(一)安装：确保电源线、USB通讯线及电极电缆连接正确



显示面板

USB通讯线接口  
(另一端与PC相连)

电极电缆接口

电源开关

电源线接口  
120-240V AC



FIGURE 4. PARSTAT 4000 Rear Panel

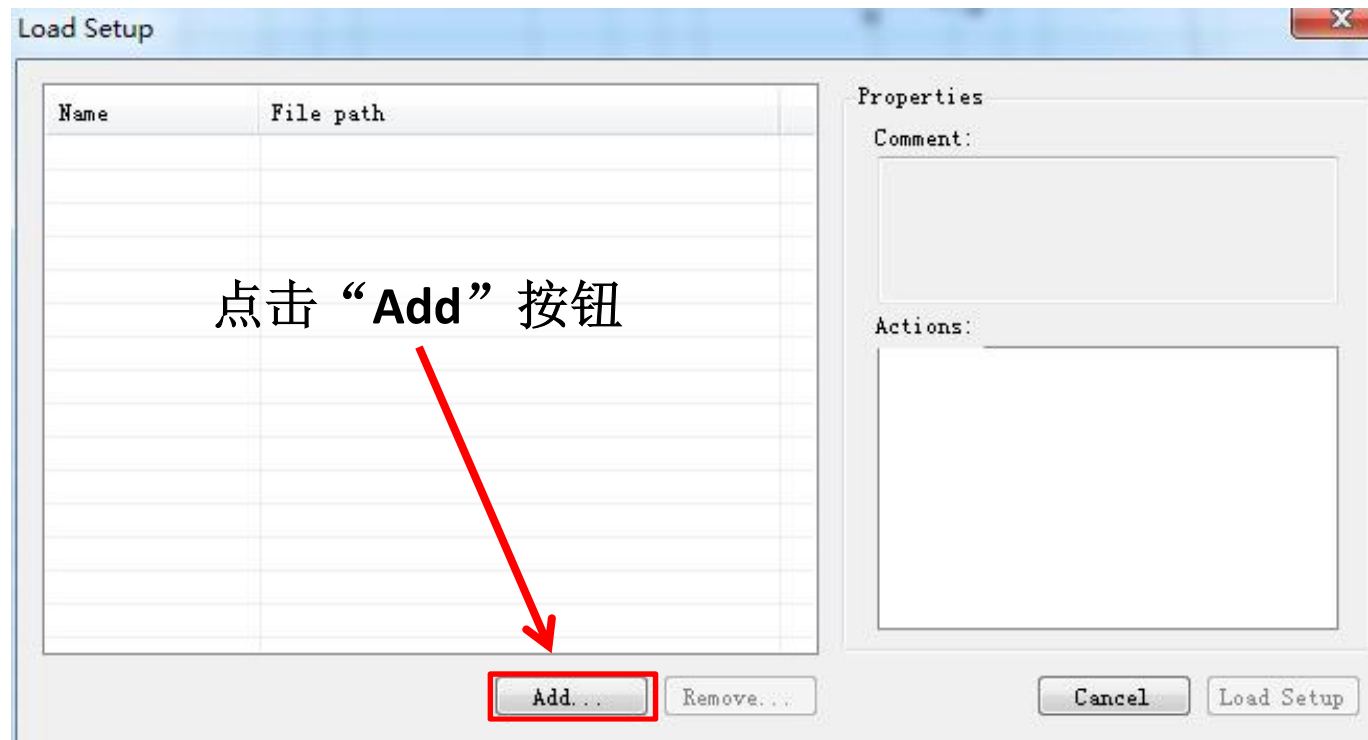




## 2 仪器安装、检验与校准

### (二) 仪器检验 (Checkout)

Versa Studio预置了用于检验的实验文件。打开仪器电源开关，运行Versa Studio软件。点击菜单栏**Experiment > Load Setup**，弹出如下窗口





## 2 仪器安装、检验与校准

### (二)仪器检验 (Checkout)

Versa Studio提供了Voltammetry Checkout, Corrosion Checkout和Impedance Checkout三个实验模板, 可以使用直流或交流方法以及通过仪器内置的1KΩ标准电阻对仪器进行检验。选择其中一个文件, 点击“打开”

直流检验

交流检验

名称	修改日期	类型	大小
ASTM G01 Cyclic Potentiodynamic PO...	2009/8/27 15:43	versastudio file	4 KB
ASTM G108 EPR.par	2009/8/27 15:25	VersaStudio File	5 KB
Constant Current Discharge Example ...	2013/5/8 14:56	VersaStudio File	11 KB
Constant Potential Example on 1.2V S...	2013/5/8 15:04	VersaStudio File	8 KB
Constant Power Charging Example o...	2013/5/8 15:12	VersaStudio File	50 KB
Constant Resistance Discharging Exa...	2013/5/8 15:14	VersaStudio File	26 KB
Corrosion Checkout.par	2011/6/1 17:44	VersaStudio File	23 KB
Current CCDPL Example on Li Ion Sec...	2013/5/8 15:00	VersaStudio File	1,026 KB
CV 100 Example.par	2008/4/22 16:35	VersaStudio File	239 KB
Impedance Checkout.par	2011/6/2 17:38	VersaStudio File	13 KB
Power CCD Example on Capacitor.par	2013/5/8 14:56	VersaStudio File	7,722 KB
Resistance CCD Example on Capacito...	2013/5/8 15:18	VersaStudio File	3,349 KB
Tafel Example.par	2008/7/16 10:46	VersaStudio File	121 KB
Voltammetry Checkout.par	2011/6/1 17:45	VersaStudio File	101 KB





## 2 仪器安装、检验与校准

### (二) 仪器检验 (Checkout)

选中checkout文件并点击“Load Setup”，输入**新文件名**，点击“保存”。  
保持默认参数设置，点击工具栏  按钮运行测试

**①选中checkout文件**

**②点击“Load Setup”**

**③输入新文件名**

**④点击“保存”**

名称	修改日期	类型
Corrosion Checkout.par	2011/6/1 17:44	Versa
Current CCDPL Example on Li Ion Sec...	2013/5/8 15:00	Versa
CV 100 Example.par	2008/4/22 16:35	Versa
Impedance Checkout.par	2011/6/2 17:38	Versa
Power CCD Example on Capacitor.par	2013/5/8 14:56	Versa
Resistance CCD Example on Capacito...	2013/5/8 15:18	Versa
Tafel Example.par	2008/7/16 10:46	Versa
Voltammetry Checkout.par	2011/6/1 17:45	Versa



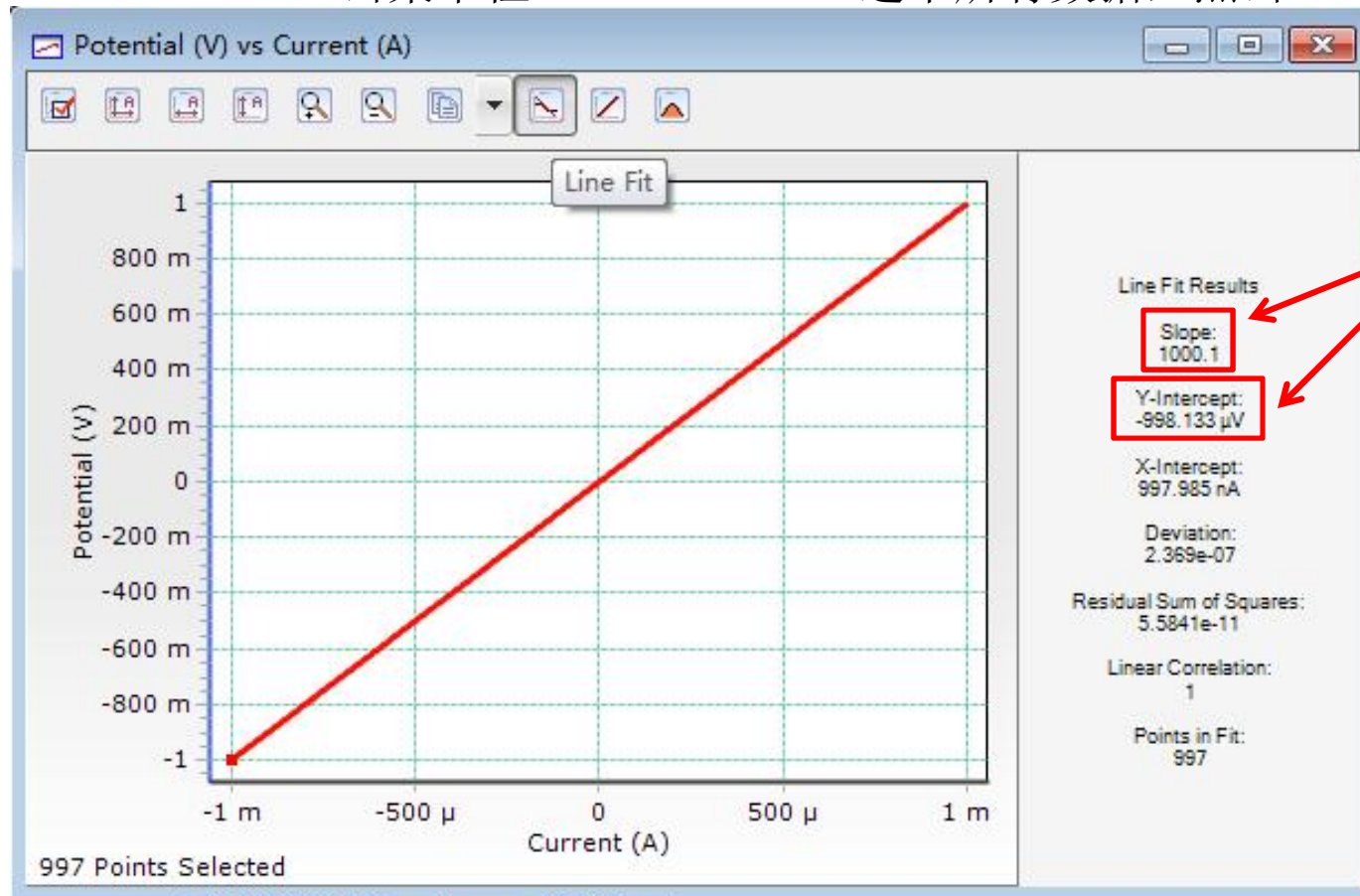




## 2 仪器安装、检验与校准

### (二) 仪器检验 (Checkout)

a) Voltammetry Checkout/Corrosion Checkout 直流检验结果如下图所示。点击菜单栏 Data > Select All 选中所有数据，点击“Line Fit”进行线性拟合



斜率（即阻值）应该在  $1000 \pm 10 \Omega$  以内，即误差在 1% 以内，且 Y 轴截距在  $\pm 4 \text{mV}$  以内，否则请联系我们



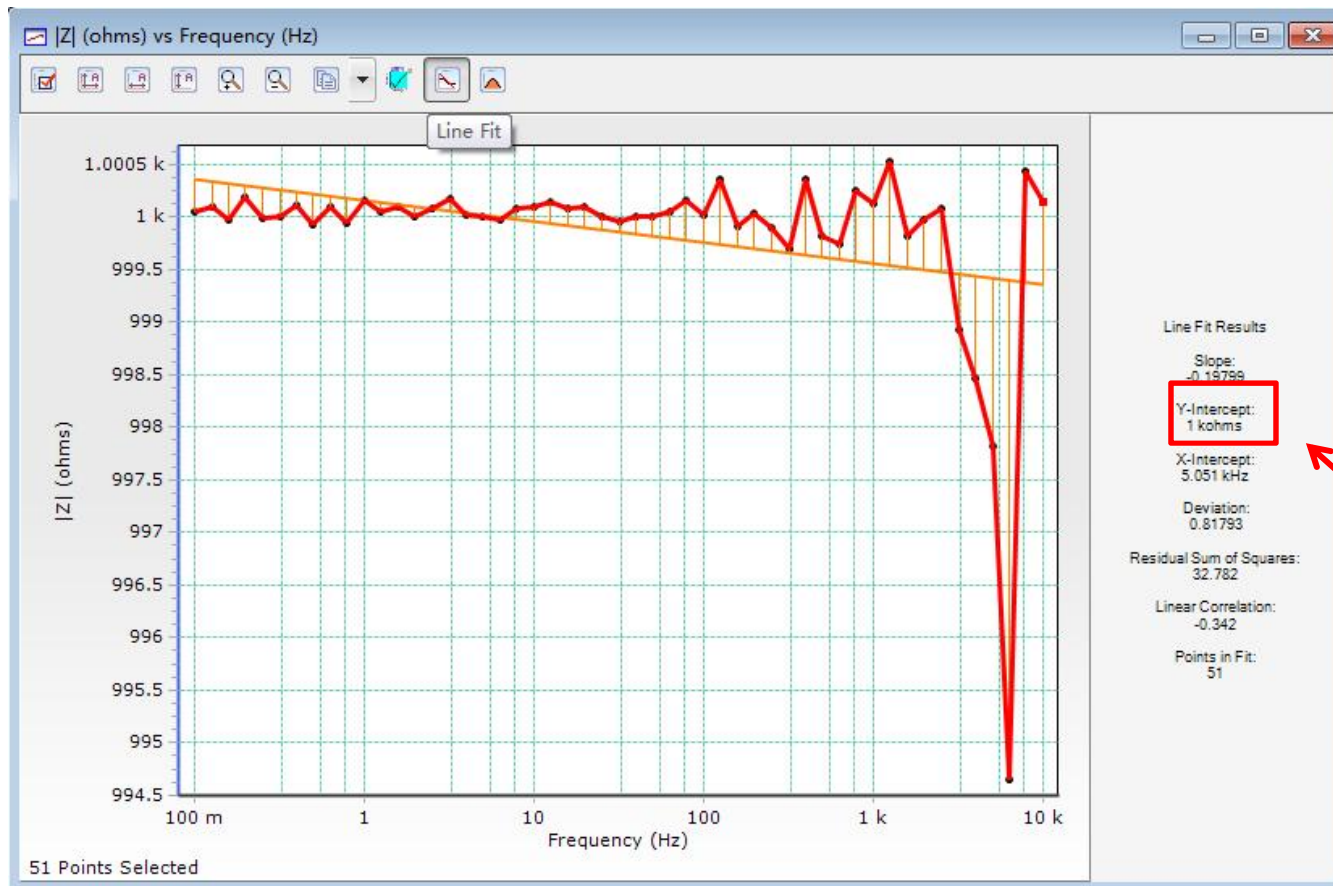




## 2 仪器安装、检验与校准

### (二) 仪器检验 (Checkout)

b) Impedance Checkout交流检验结果如下图所示。点击菜单栏Data > Select All选中所有数据，点击“Line Fit”进行线性拟合



Y轴截距应该在  $1000 \pm 10\Omega$  以内，即误差在1%以内，否则请联系我们





## 2 仪器安装、检验与校准

### (二) 仪器检验 (Checkout)

c) 运用前面两个方法测试外部Dummy Cell, 可判断电极线是否正常

Experiment Properties

Actions to be Performed:

Common

- Linear Scan Voltammetry

Properties for Linear Scan Voltammetry

Step Properties	Value	Versus
Initial Potential (V)	0	vs Ref
Final Potential (V)	1	vs Ref

Limits	Direction	Value
None	≤	0
None	≤	0

Cell Properties	Value
Leave Cell ON	No
Cell to Use	External
	External
	Internal

Scan Properties	Value
Scan Rate (V/s)	1
Total Points	1000

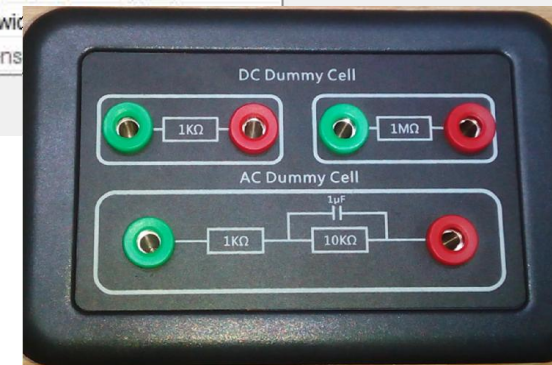
Instrument Properties	Value
Current Range	Auto
Electrometer Mode	Auto
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth	
iR Compens	

Click "Advanced"

Cell to Use:

Internal-测试仪器内部Dummy Cell;

External-测试样品或外部Dummy Cell.



外部Dummy Cell

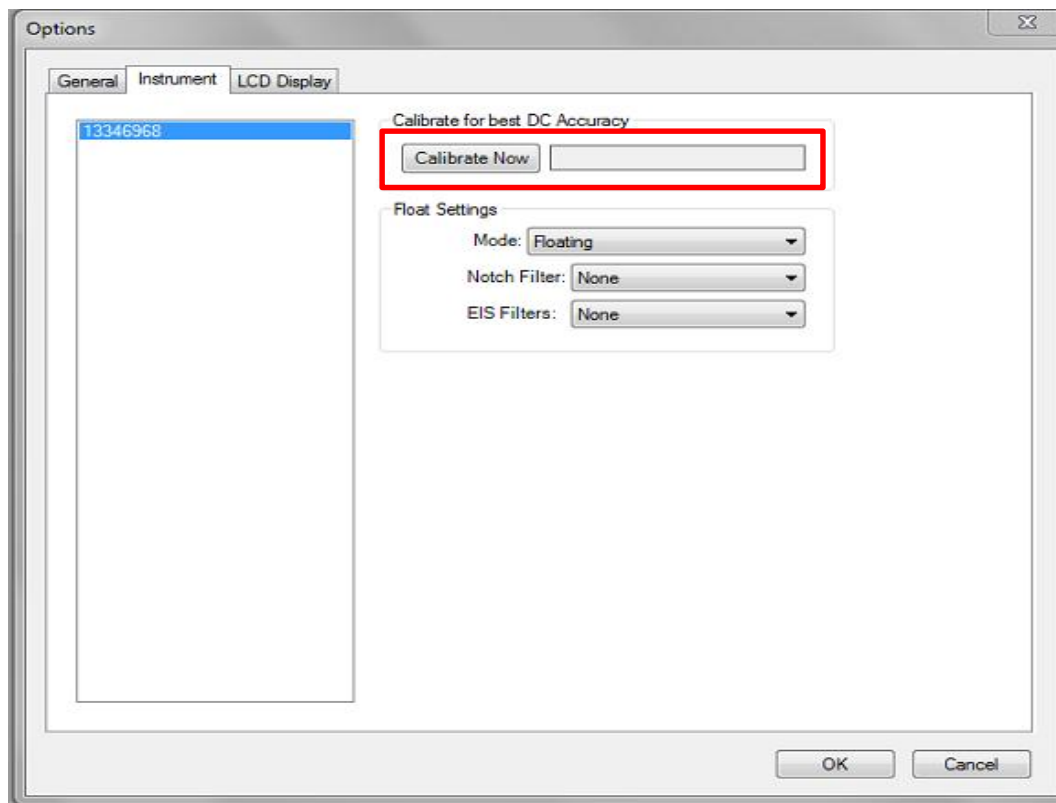




## 2 仪器安装、检验与校准

### (三)仪器校准 (Calibration)

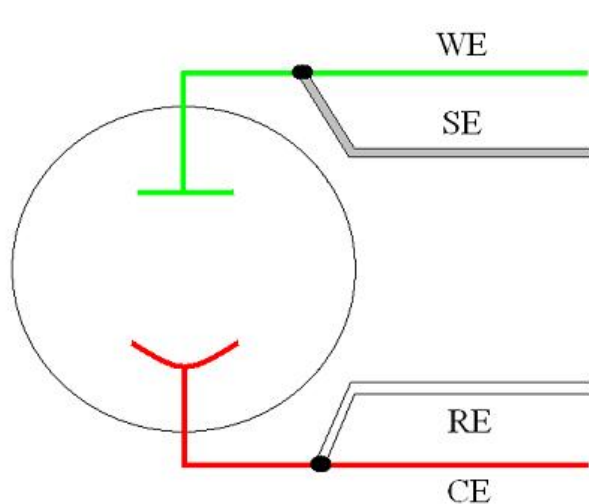
打开电化学工作站，待达到工作温度（至少10分钟）后，运行Versa Studio软件，依次点击Tools > Options... > Instrument > Calibrate Now，此过程大概需要2分钟，且中途不得断电





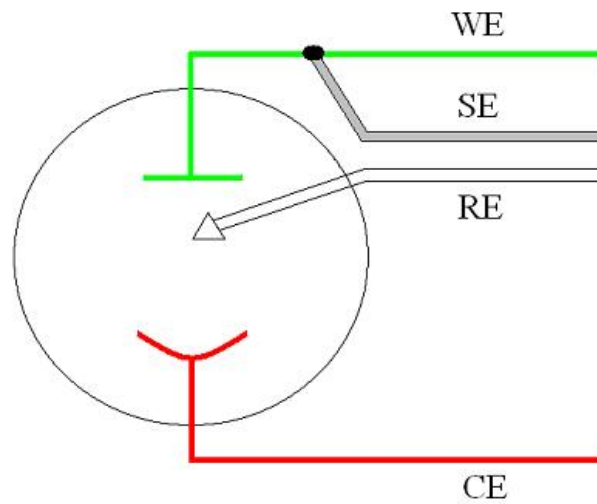
### 3 电极线连接方法

绿色：工作电极（working electrode）      灰色：传感电极（sense electrode）  
 白色：参比电极（reference electrode）      红色：辅助电极（counter electrode）  
 黑色：地线，一般不用，可接屏蔽箱外壳



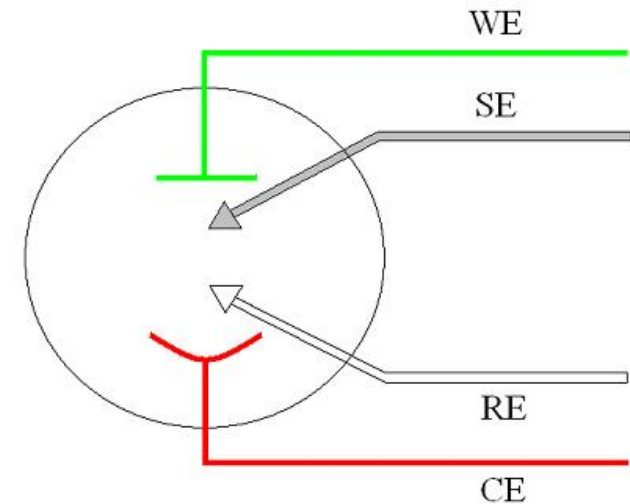
*Two-Electrode Connection*

- Batteries
- Capacitors
- Fuel Cells
- Sensors
- Resistors



*Three-Electrode Connection*

- Aqueous Electrochemistry
- Corrosion
- EIS



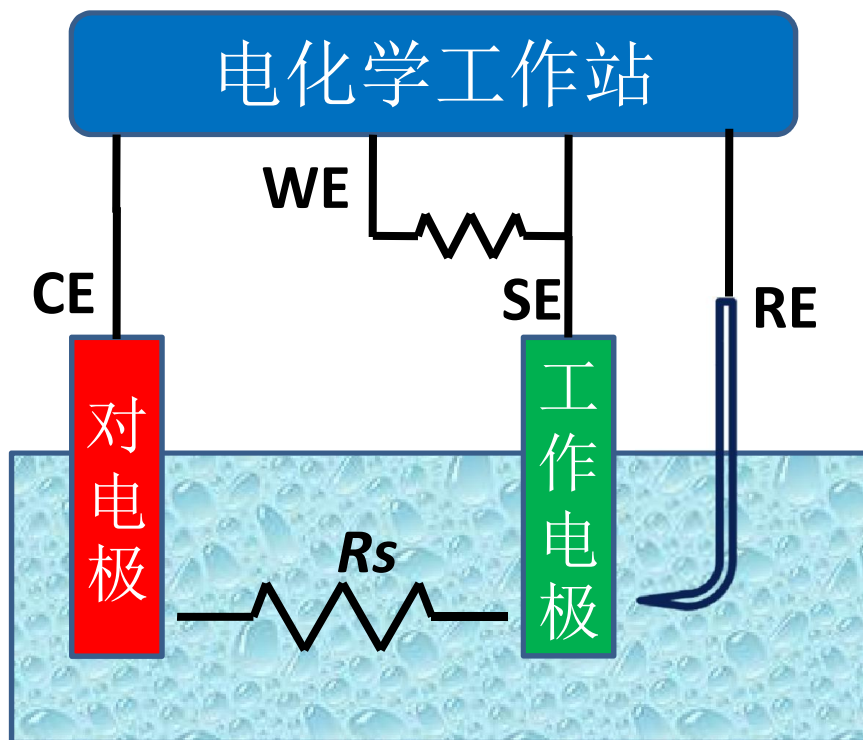
*Four-Electrode Connection*

- H-Cell Setup
- Liquid –liquid interface

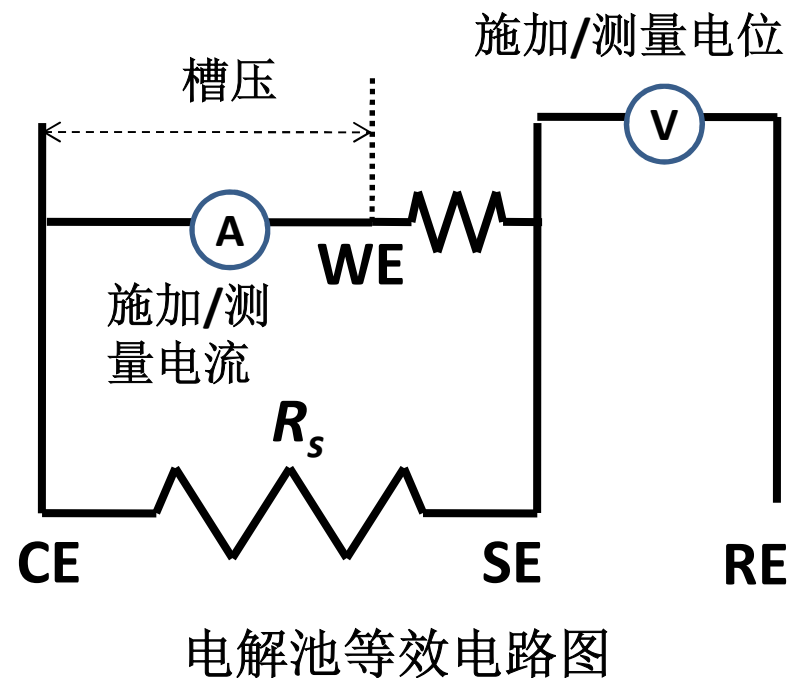




### 3 电极线连接方法



电解池示意图



电解池等效电路图







## 4 Versa Studio软件操作

### ① 软件界面结构

菜单栏

工具栏

The screenshot displays the Versa Studio software interface with several key components labeled:

- 菜单栏 (Menu Bar):** Located at the top, containing options like Experiment, Data, View, Tools, Security, Window, and Help.
- 工具栏 (Toolbar):** Located below the menu bar, containing various icons for file operations and data management.
- 数据图形显示窗口 (Data Graph Display Window):** Contains two plots:
  - Zim (ohms) vs Zre (ohms):** A Nyquist plot showing a semi-circular arc in the upper half-plane.
  - |Z| (ohms) vs Frequency (Hz):** A Bode magnitude plot showing a peak in impedance at a specific frequency.
- 数据列表窗口 (Data List Window):** A table titled "Data View - 31 Points (All)" showing experimental data points.
 

Potential (V)	Current (A)	Elapsed Ti...
3.586 mV	-13.62 $\mu$ A	0.811
3.559 mV	-13.293 $\mu$ A	1.231
3.633 mV	-19.66 $\mu$ A	1.922
3.628 mV	-19.824 $\mu$ A	2.353
3.606 mV	-19.248 $\mu$ A	2.714
3.625 mV	-19.608 $\mu$ A	3.0849999
3.602 mV	-22.292 $\mu$ A	3.485
3.589 mV	-21.957 $\mu$ A	3.8649999
3.605 mV	-22.019 $\mu$ A	4.2149999
3.561 mV	-25.655 $\mu$ A	4.6159999
3.462 mV	-17.449 $\mu$ A	5.0169999
3.499 mV	-17.883 $\mu$ A	5.4179999
3.473 mV	-18.242 $\mu$ A	5.8189999
3.474 mV	-18.985 $\mu$ A	6.2199999
3.455 mV	-16.811 $\mu$ A	6.6209999
3.453 mV	-17.202 $\mu$ A	7.0219999
3.494 mV	-17.65 $\mu$ A	7.4229999
3.49 mV	-17.273 $\mu$ A	7.8239999
3.456 mV	-16.622 $\mu$ A	8.2249999
3.504 mV	-18.433 $\mu$ A	8.6259999
3.474 mV	-17.305 $\mu$ A	9.0269999
3.472 mV	-17.613 $\mu$ A	9.4279999
3.49 mV	-18.146 $\mu$ A	9.8289999
3.47 mV	-17.375 $\mu$ A	10.2299999
3.465 mV	-17.846 $\mu$ A	10.6309999
3.47 mV	-17.523 $\mu$ A	11.0319999
3.484 mV	-17.627 $\mu$ A	11.4329999
3.472 mV	-17.411 $\mu$ A	11.8339999
3.466 mV	-18.003 $\mu$ A	12.2349999
3.456 mV	-17.072 $\mu$ A	12.6359999
- 实验参数设置窗口 (Experiment Properties Window):** Located at the bottom, containing sections for:
  - Actions to be Performed:** Potentiostatic EIS.
  - Properties for Potentiostatic EIS:**
    - AC Properties: Start Frequency (10000 Hz), End Frequency (1 Hz), Amplitude (10 mV RMS).
    - DC Properties: Step or Scan (Step), Potential (0 V), Versus (vs OC).
    - Scan Properties: Point Spacing (Logarithmic), Number of Points (30), Points Per Decade (10), Data Quality (1), Measurement Delay (0 s).
  - Frequency List (Hz):** A list of frequencies ranging from 10000.000000 to 894.407700.
- 正常连接时显示工作站型号及其序列号 (Instrument: None):** Located at the bottom left of the interface.





## 4 Versa Studio软件操作

### ② 实验前：仪器参数及偏好设置

The screenshot shows the Versa Studio software interface. The 'Reference Electrodes' dialog box is open, displaying a list of electrodes and their voltages. The 'Add / Edit Reference Electrode' dialog box is also open, with red arrows pointing to the 'Electrode Name' and 'Voltage' input fields. The 'Tools' menu is open, highlighting 'Reference Electrode List...'. The 'Experiment Properties' window shows 'Linear Scan Voltammetry' as the action to be performed.

Electrode Name	Voltage (V)
Ag, AgCl / NaCl (sat'd)	0.194
Ag, AgCl / KCl (3.5M)	0.205
Ag / Ag <sup>+</sup> (0.1M) in acetonitrile	0.8
NHE Normal Hydrogen Electrode	0
SCE Saturated Calomel (sat'd KCl) (unspecified)	0.242
Ag, AgCl / KCl (sat'd)	0.197
SCE Saturated Calomel (sat'd NaCl)	0.236

可对参比电极列表进行编辑或删除

如果列表中没有，可点击“Add”自行添加





## 4 Versa Studio软件操作

### ② 实验前：仪器参数及偏好设置

The screenshot shows the Versa Studio software interface with the Options dialog box open. The dialog box has two tabs: General and Instrument. The Instrument tab is selected, and several sections are highlighted with orange boxes and Chinese annotations:

- Current Polarity Convention:** Two radio buttons are shown. The second one, "Define cathodic current as negative", is selected. An annotation reads "电流极性定义, 国内标准" (Current polarity definition, domestic standard).
- Corrosion Properties:** Three input fields are shown: Cathodic Beta Constant (100 mV), Anodic Beta Constant (100 mV), and Corrosion Rate Units (mV). An annotation reads "腐蚀参数, 建议使用默认值" (Corrosion parameters, recommended to use default values).
- General Settings:** A group of checkboxes is shown, including "Enable Periodic Data Storage", "Restore Last Experiment", "Cell to Internal at Experiment End", "Lock Experiment Properties to Data", "Automatically Save Data File", "USB Compatibility Mode", and "Display Advanced Experiment Properties". An annotation reads "一般设置, 建议使用默认选项" (General settings, recommended to use default options).
- Language:** A dropdown menu is shown with "Chinese (Simplified, PRC)" selected. An annotation reads "界面语言可选择简体中文" (Interface language can be selected as Simplified Chinese).

The background shows the main software window with a graph of Current (A) vs Potential (V) and a menu where "Options..." is highlighted in red. The "Experiment Properties" panel at the bottom left shows "Linear Scan Voltammetry" as the action to be performed.





## 4 Versa Studio软件操作

### ② 实验前：仪器参数及偏好设置

Options

General Instrument LCD Display

13346968

选择Instrument标签

Calibrate for best DC Accuracy

Calibrate Now

Float Settings

Mode: Floating

Notch Filter: None

EIS Filters: None

可设置浮地选项，仅支持VersaSTAT 3F、PARSTAT 4000或PARSTAT MC型号电化学工作站

OK Cancel







## 4 Versa Studio软件操作

### ② 实验前：仪器参数及偏好设置

如果多台V3/V3F/V4/P4000工作站联用或者使用多通道工作站VMC/PMC则需要选择相应通道（见下页），单通道则不需选择







## 4 Versa Studio软件操作

### ② 实验前：仪器参数及偏好设置

当其他通道正在测量时，选择“**No Instrument**”可以打开已保存的文件进行分析

Versa Studio最多可以同时控制**32**个通道。双击可激活通道

“**Data**”表示此通道正在测量数据

点击此选项，则正在被选中的通道过载灯闪烁，提示该通道正被选中

通道名默认为通道序列号，可更改

Channel	Instrument	E (V)	I (A)	Status
No Instrument	No Instrument			
Channel 1	Channel 1	999.77 mV	999.12 μA	DATA
Channel 2	Channel 2	-337.37 μV	306.70 pA	
Channel 3	Channel 3	1.58 V	12.26 μA	DATA
Channel 4	Channel 4	-92.01 μV	576.60 pA	Warning

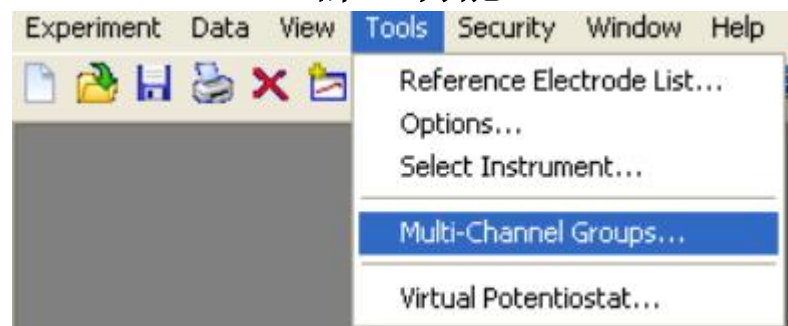




## 4 Versa Studio软件操作

### ② 实验前：仪器参数及偏好设置

#### 群组功能



3. 群组中各通道同时开始测试

2. 添加所需通道至群组

Add Instrument to Group  
Select Instrument  
Locate Instrument  
Rename Instrument...  
Assign Setup File...  
Remove Setup File

1111111	1111113	1111118	1111110
E: 521.40 $\mu$ V	E: 61.34 $\mu$ V	E: 306.70 $\mu$ V	E: 214.69 $\mu$ V
I: 1.11 nA	I: 343.51 pA	I: 79.74 pA	I: 36.80 pA
Voltammetry Checkout	No Setup File	Voltammetry Checkout	No Setup File

1. 加载实验模板

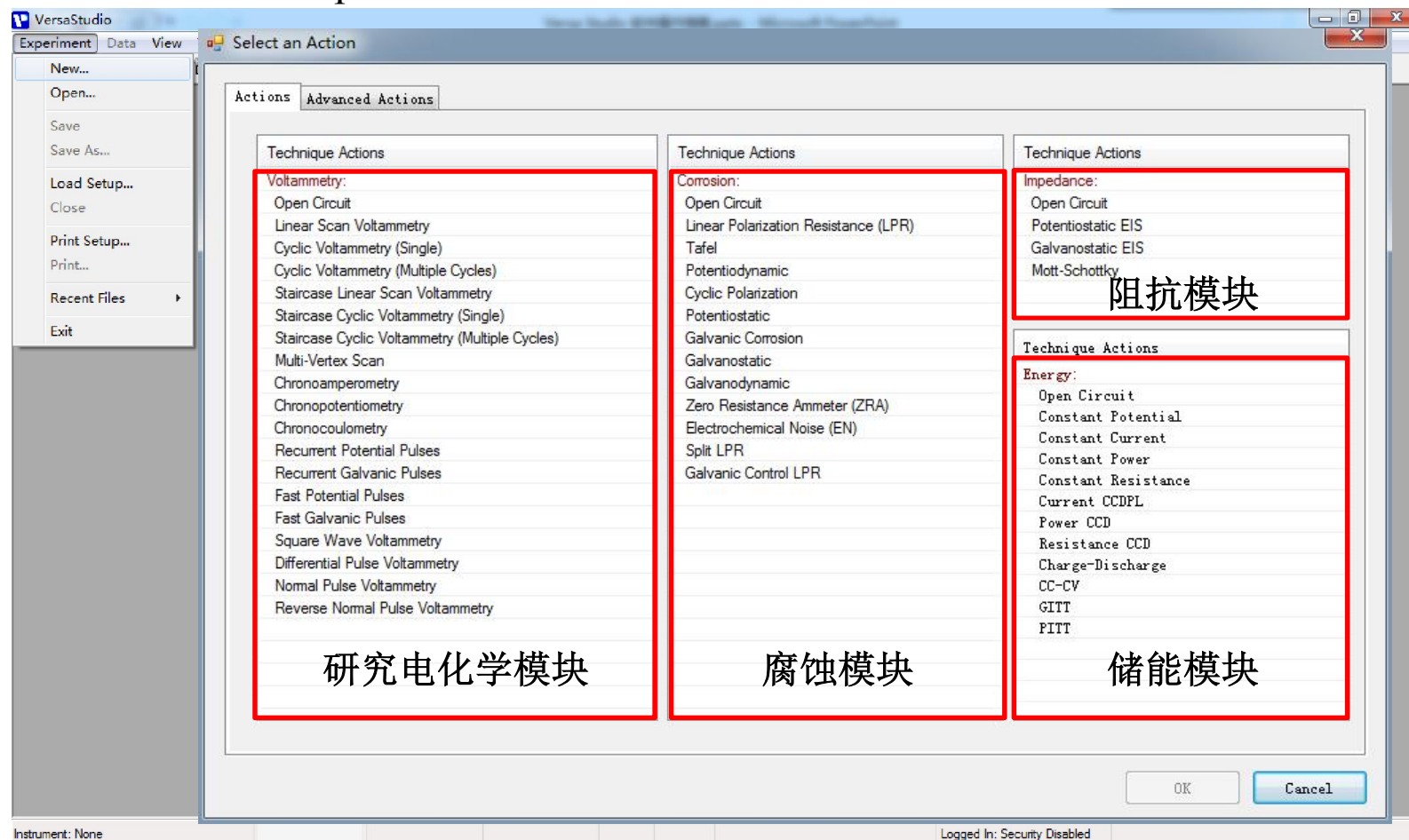




## 4 Versa Studio软件操作

### ③ 实验参数设置

打开软件，点击Experiment > New，选择相应测量方法，点击OK

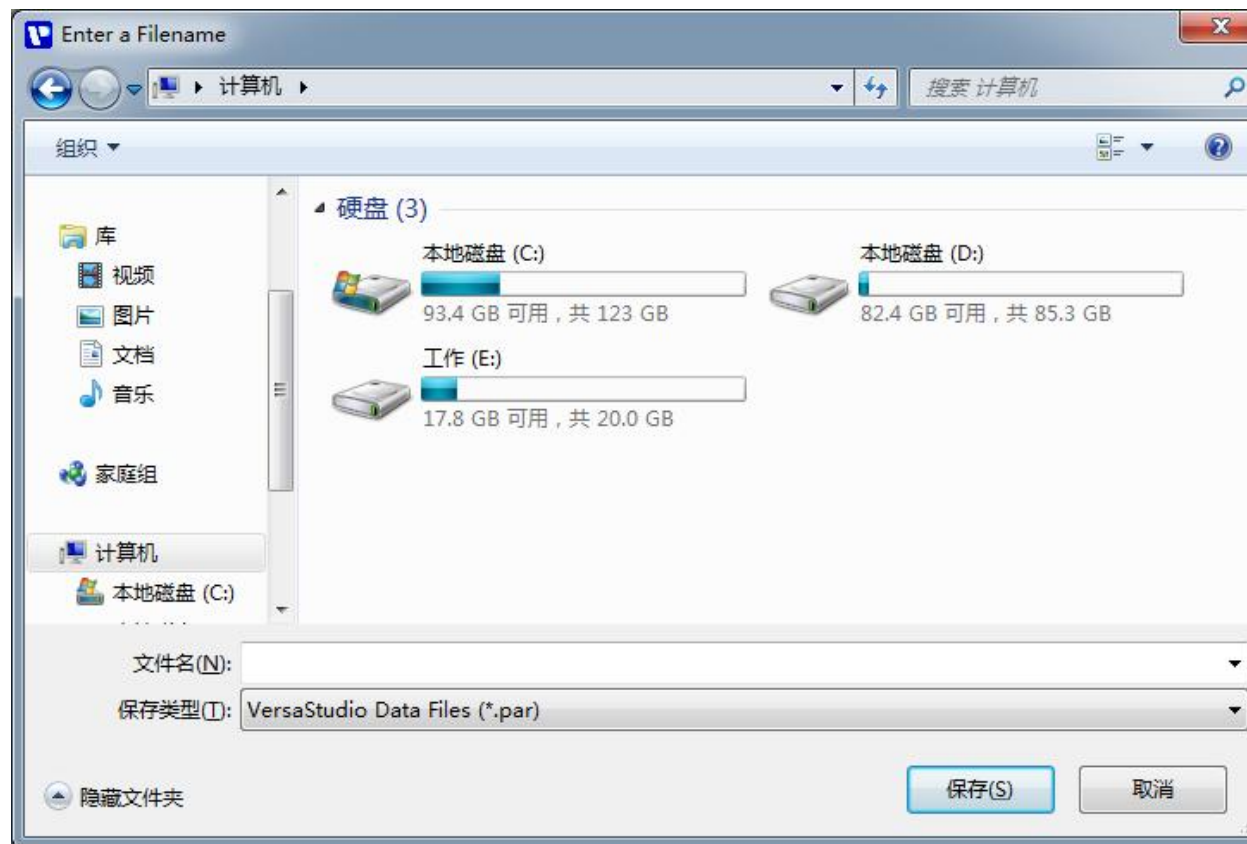




## 4 Versa Studio软件操作

### ③ 实验参数设置

选择相应测试方法后，须先指定数据文件保存路径及文件名，实验开始后会自动保存数据（勾选Tools > Options > General > Automatically Save Data File）





## 4 Versa Studio软件操作

### ③ 实验参数设置

在Experiment Properties中设定具体实验参数

Click **Common**

Select reference electrode and set working electrode parameters

Can choose whether to re-measure OCP before each experiment, especially for batch measurements of batteries

Safety limit, exceeding all limits will stop the experiment

实验笔记

Properties	Value
Reference Electrode	(unspecified) (0 Volts)
Working Electrode Type	Unspecified
RDE Speed (Volts)	0
Working Electrode Area (cm <sup>2</sup> )	1
Density (g/ml)	0
Equivalent Weight (g)	0
Mass (g)	0
Re-measure OC Per Action	No
Measured Open Circuit	0

Limits	Direction	Value
None	≤	0
None	≤	0







## 4 Versa Studio软件操作

### ③ 实验参数设置

在Experiment Properties中设定具体实验参数

**Click the corresponding test method**

**Click "Advanced", for external testing Cell to Use must select External**

**Click "Help", you can view the specific meaning of the parameters of the test method**

**Set the specific parameters of the measurement method**

**For any 4-electrode measurement system, Differential must be selected. Current above 200mA, Differential can eliminate the error brought by the working electrode wiring resistance, with high accuracy. While Single Ended has higher stability, suitable for fluctuating systems, such as corrosion, high-capacity electrochemical cells and EIS measurement, etc.**

Step Properties	Value	Versus
Initial Potential (V)	0	vs Re
Final Potential (V)	1	vs Re

Scan Properties	Value
Scan Rate (V/s)	0.005
Total Points	1000

Limits	Direction	Value
None	≤	0
None	≤	0

Instrument Properties	Value
Current Range	Auto
Electrometer Mode	Differential
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto
iR Compensation	Disabled

Cell Properties	Value
Leave Cell ON	No
Cell to Use	External
	External
	Internal

Graph: Voltage vs Time. Initial Potential (V) is marked at the start of the scan. Final Potential (V) is marked at the end. The scan rate is given as  $\text{Scan Rate (V/s)} = \frac{dE}{dt}$ . The Open Circuit (OC) potential is also indicated.





## 4 Versa Studio软件操作

### ③ 实验参数设置

Versa Studio可进行自动循环实验及批量实验，既省时省力，也免去编程的繁琐

**插入实验**

**调整实验顺序**

**删除实验**

**插入Loop循环**

Experiment Properties

Actions to be Performed:

- Common
  - Loop #1
    - Constant Current
    - Potentiostatic EIS
  - Loop #2
    - Cyclic Voltammetry
    - Chronoamperometry
    - Linear Scan Voltammetry

Properties for Linear Scan

Step Properties	Value	Versus
Initial Potential (V)	0	vs Ref
Final Potential (V)	1	vs Ref

Scan Properties	Value
Scan Rate (V/s)	0.005
Total Points	1000

Select an Action

Actions | Advanced Actions

Pre Experiment Actions	Sequence Actions
Condition	Loop
Deposition	Time Delay
Equilibration	Message Prompt
Purge	Measure Open Circuit
iR Determination	Auxiliary Interface
	Run External Application
	DAC Output Control
	EMail
	Auto Current Range Setup
	Display Message





## 4 Versa Studio软件操作

### ④ 运行实验

参数设置好后点击“Run”可运行实验，正常状态下为绿色

点击“Stop”可提前终止实验

点击“Skip”可跳过此实验开始下一实验

实验运行过程中，状态栏此处会显示“Cell On”，实验结束会显示“Cell Off”

Step Properties	Value	Versus
Initial Potential (V)	0	vs Ref
Final Potential (V)	1	vs Ref

Scan Properties	Value
Scan Rate (V/s)	0.005
Total Points	1000





## 4 Versa Studio软件操作

### ⑤ 数据查看与分析

实验进行时，软件会实时显示数据图表，点击工具栏中的“Add Graph View”按钮还可添加所需的数据关系图

The screenshot displays the Versa Studio software interface. The main window shows two graphs: a Nyquist plot (Z<sub>im</sub> vs Z<sub>re</sub>) and a Bode magnitude plot (|Z| vs Frequency). The 'Add Graph' dialog box is open, showing a grid of available graph templates. The 'Nyquist' template is highlighted.

**Available Graph Templates:**

- Admittance
- Aux Chn 0 vs t
- Aux Chn 1 vs t
- Aux Chn 2 vs t
- Aux Chn 3 vs t
- Bode Phase
- Bode Z<sub>im</sub>
- Bode Z<sub>mag</sub>
- Bode Z<sub>re</sub>
- Capacitance
- Capacity vs t
- Corrosion Rate vs t
- Delta I (F-R) vs E
- Delta I (R-F) vs E
- E vs Energy
- E vs I
- E vs Log(I)
- E vs t
- Foward I vs E
- Frequency vs t
- I vs E
- I vs t
- Mott-Sch...
- Nyquist
- Power vs Energy
- Q vs t
- Resistance vs t
- Reverse I vs E
- Sync ADC Input vs t

**Experiment Properties:**

Common		AC Properties		DC Properties	
Start Frequency (Hz)	10000	Value		Value	Versus
End Frequency (Hz)	1			Step or Scan	Step
Amplitude (mV RMS)	10			Potential (V)	0 vs OC
				Final Potential (V)	0 vs OC
Scan Properties		Instrument Properties		Cell Properties	
Point Spacing	Logarithmic	Value		Value	
Number of Points	30			Current Range	Auto
Points Per Decade	10			Electrometer Mode	Single Ended
Data Quality	1			Bandwidth Limit	Auto
Measurement Delay (s)	0			LCI Bandwidth Limit	Auto
Scan Rate (V/s)	005			Cell Properties	Value
				Leave Cell ON	No
				Cell to Use	External

More Options. More Solutions.



<http://www.par-solartron.com.cn>

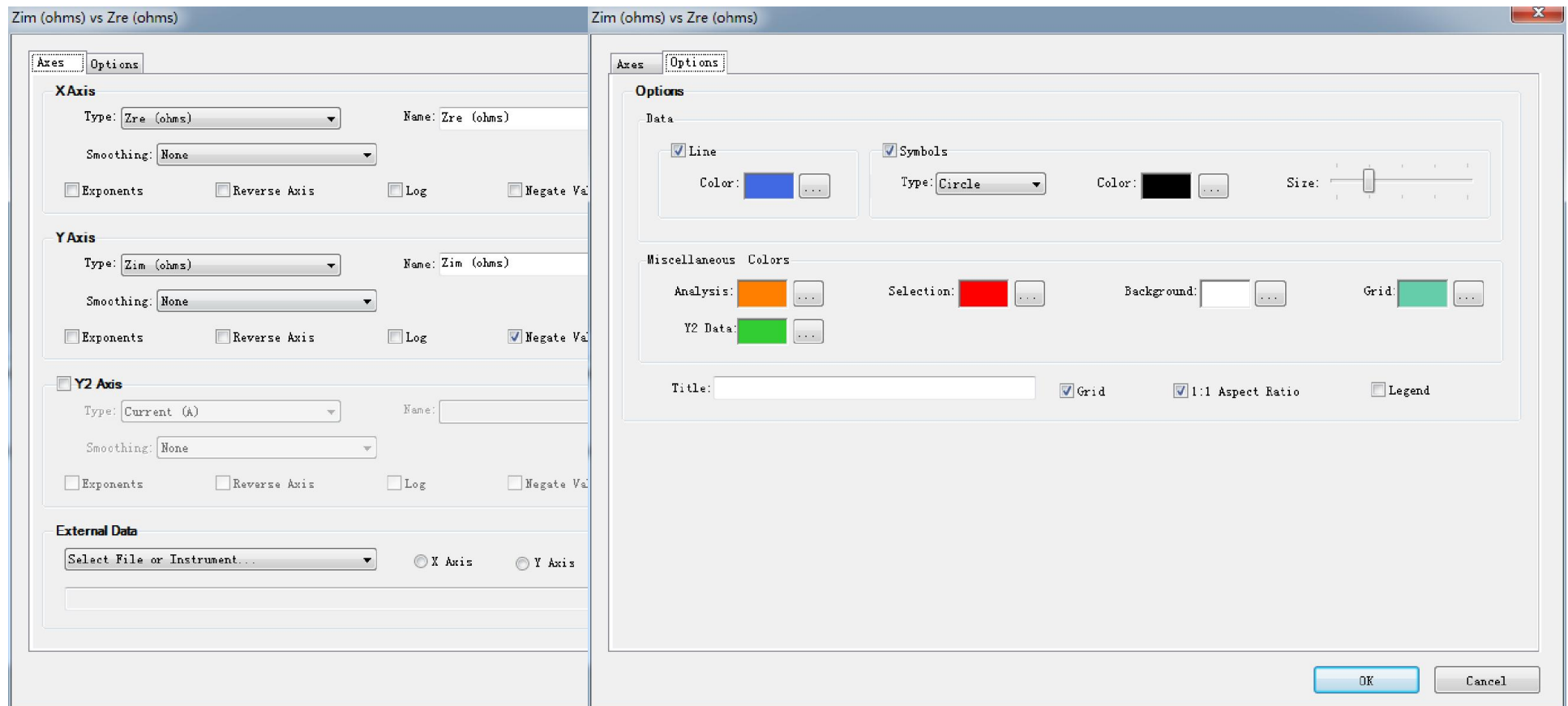




## 4 Versa Studio软件操作

### ⑤ 数据查看与分析

如果图形模板列表中没有所需的图形模板，可对其中的模板进行编辑或新建图形模板，从Axes及Options标签中分别设置需要显示的数据及图形属性



More Options. More Solutions.



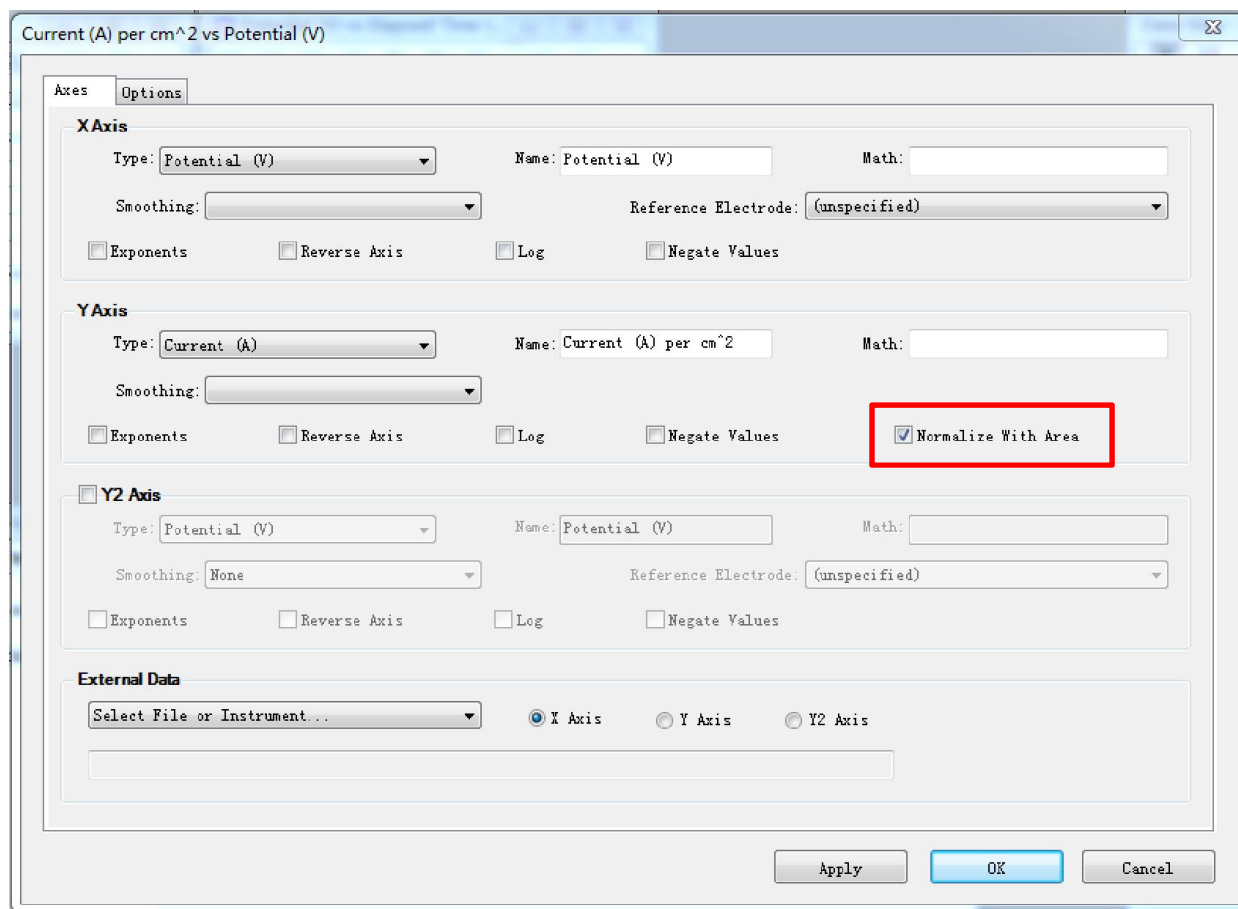
<http://www.par-solartron.com.cn>



## 4 Versa Studio软件操作

### ⑤ 数据查看与分析

如果需要显示电流密度，可在图形属性窗口中勾选“Normalize With Area”

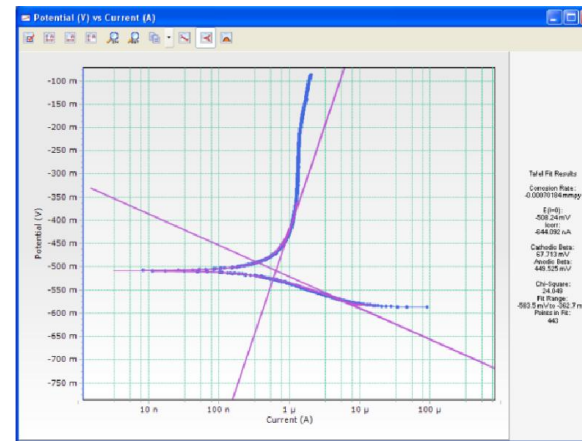
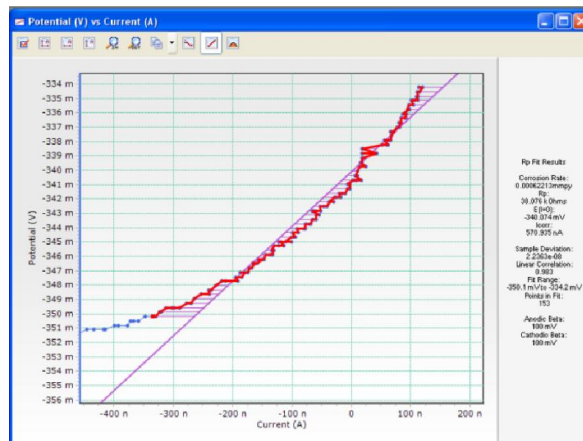
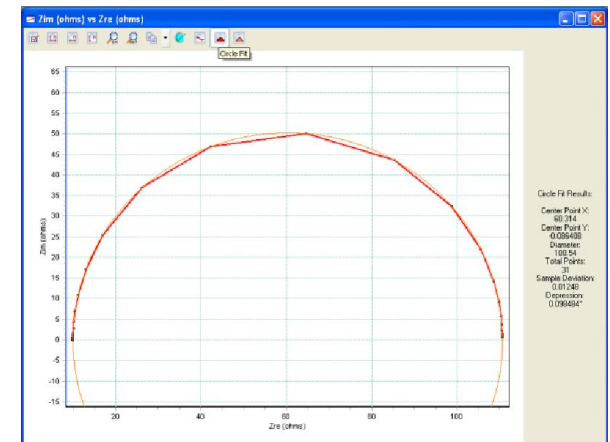
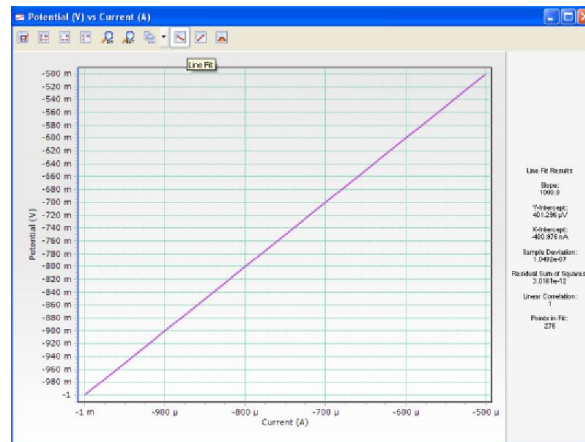
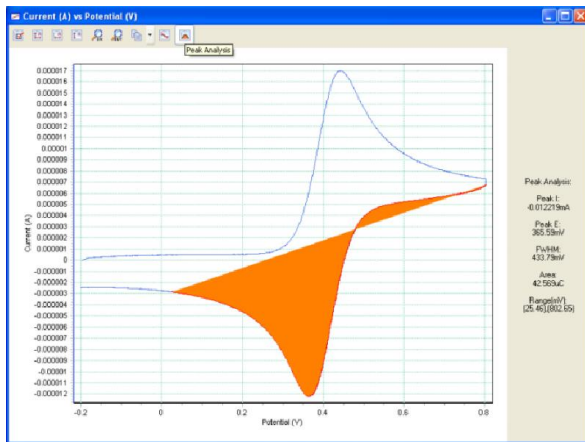




## 4 Versa Studio软件操作

### ⑤ 数据查看与分析

利用图形显示窗口的工具栏按钮，可对图形数据进行查看、复制、拟合或者峰形分析



More Options. More Solutions.



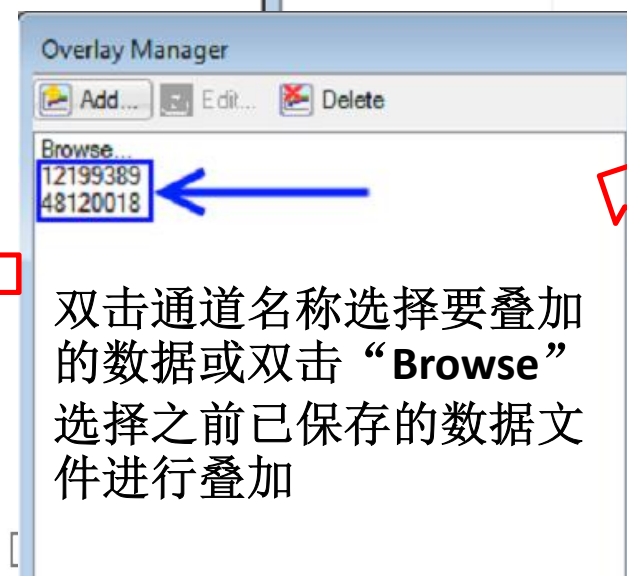
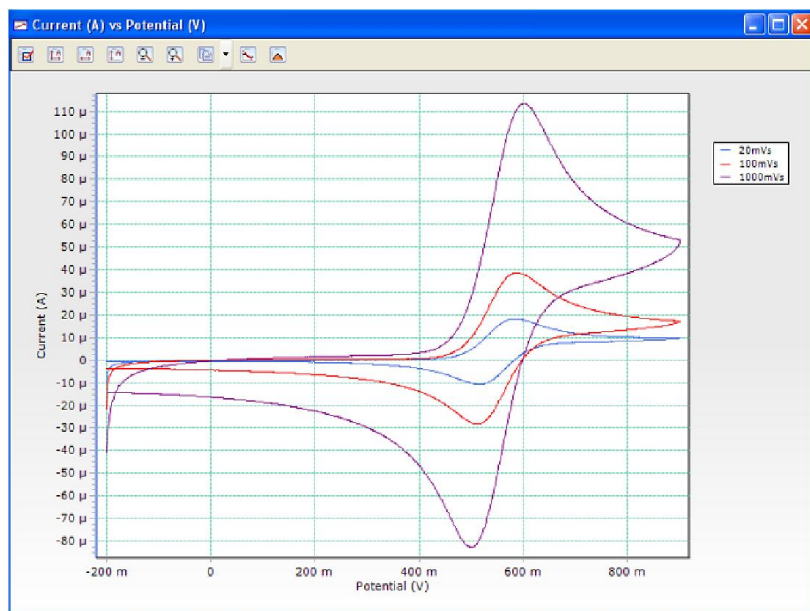
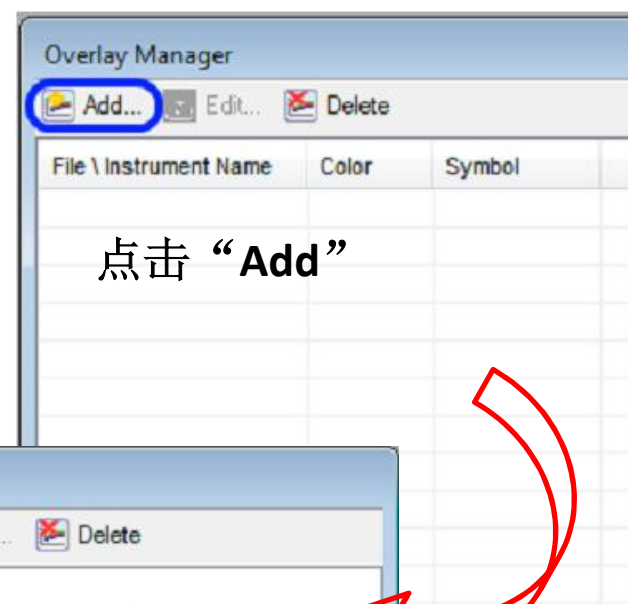
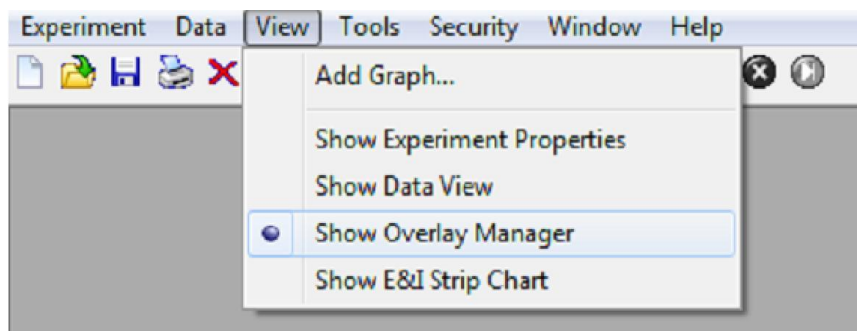
<http://www.par-solartron.com.cn>



## 4 Versa Studio软件操作

### ⑤ 数据查看与分析

不同实验的数据图形可以进行叠加显示







## 4 Versa Studio软件操作

### ⑤ 数据查看与分析

点击View > Show Data View可在软件最右侧的数据显示窗口查看详细的数据信息

The screenshot shows the 'View' menu with 'Show Data View' selected. The 'Data View' window displays a table of experimental data for 50,000 points across all segments.

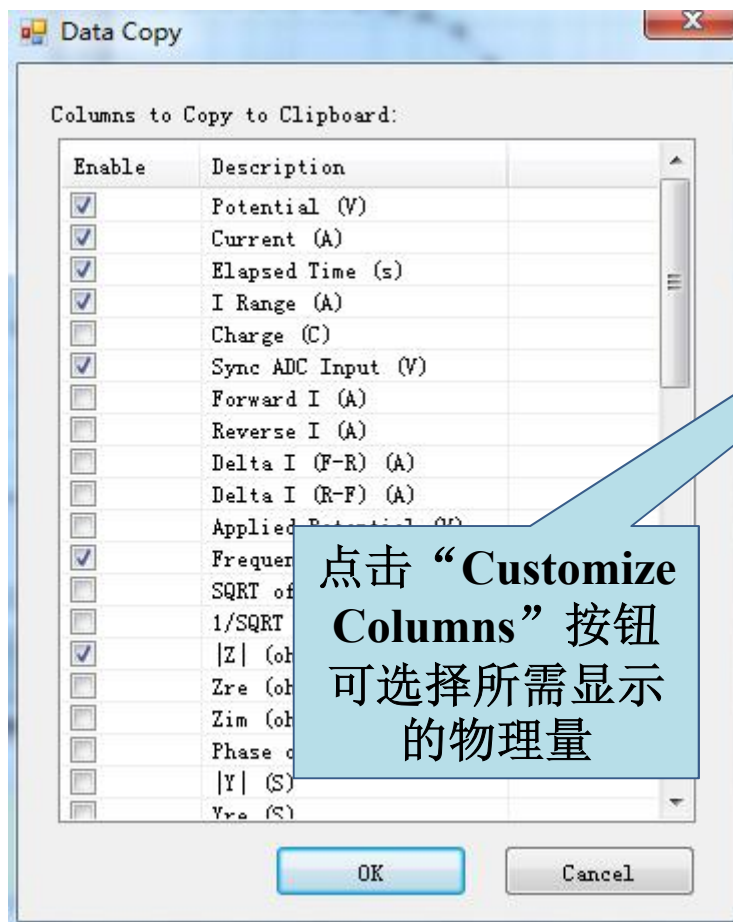
Potential (V)	Current (A)	Elapsed Tim...
999.249 mV	999.126 μA	1
999.249 mV	999.126 μA	2
999.249 mV	999.126 μA	3
999.249 mV	999.126 μA	4
999.249 mV	999.126 μA	5
999.249 mV	999.126 μA	6
999.249 mV	999.126 μA	7
999.249 mV	999.126 μA	8
999.249 mV	999.126 μA	9
999.249 mV	999.126 μA	10
999.249 mV	999.126 μA	11
999.249 mV	999.126 μA	12
999.249 mV	999.126 μA	13
999.249 mV	999.065 μA	14
999.249 mV	999.126 μA	15
999.249 mV	999.126 μA	16





## 4 Versa Studio软件操作

### ⑤ 数据查看与分析



Potential (V)	Current (A)	Elapsed Tim...
999.249 mV	999.126 $\mu$ A	1
999.249 mV	999.126 $\mu$ A	2
999.249 mV	999.126 $\mu$ A	3
999.249 mV	999.126 $\mu$ A	4
999.249 mV	999.126 $\mu$ A	5
999.249 mV	999.126 $\mu$ A	6
999.249 mV	999.126 $\mu$ A	7
999.249 mV	999.126 $\mu$ A	8
999.249 mV	999.126 $\mu$ A	9
999.249 mV	999.126 $\mu$ A	10
999.249 mV	999.126 $\mu$ A	11
999.249 mV	999.126 $\mu$ A	12
999.249 mV	999.126 $\mu$ A	13
999.249 mV	999.065 $\mu$ A	14
999.249 mV	999.126 $\mu$ A	15
999.249 mV	999.126 $\mu$ A	16

More Options. More Solutions.



<http://www.par-solartron.com.cn>



## 4 Versa Studio软件操作

### ⑤ 数据查看与分析

点击“Data Filter”按钮可对数据进行筛选

软件默认“虚拟数据压缩”方式为“Automatic”，如果数据点超过10K个，软件会按照10:1的比列压缩显示，即每10个数据点抽取一个进行显示。可更改为“None”或“Manual”

Data View - 31 Points (All)

Segment #0	Potential (V)	Current (A)	Elapsed Ti...	I Range
	3.566 mV	-13.62 μA	0.811	20 mA
	3.559 mV	-13.293 μA	1.231	20 mA
	3.633 mV	-19.66 μA	1.922	2 mA
	3.628 mV	-19.824 μA	2.353	2 mA
	3.606 mV	-19.248 μA	2.714	2 mA
	3.625 mV	-19.608 μA	3.0849999	2 mA
	3.602 mV	-22.292 μA	3.485	2 mA
	3.589 mV	-21.957 μA	3.8649999	2 mA
	3.605 mV	-22.019 μA	4.2149999	2 mA
	3.581 mV	-26.655 μA	4.6159999	2 mA
	3.462 mV	-14.586 μA	4.9769999	2 mA
	3.499 mV	-17.413 μA	5.3779999	2 mA
	3.499 mV	-17.863 μA	5.7589999	2 mA
	3.473 mV	-18.242 μA	6.1599999	2 mA
	3.474 mV	-16.965 μA	6.5309999	2 mA
	3.455 mV	-16.811 μA	7.0019999	2 mA
	3.453 mV	-17.262 μA	7.4029999	2 mA
	3.494 mV	-17.66 μA	7.7939999	2 mA
	3.49 mV	-17.273 μA	8.2039999	2 mA
	3.456 mV	-16.622 μA	8.6639999	2 mA
	3.504 mV	-18.433 μA	9.1449999	2 mA
	3.474 mV	-17.305 μA	9.7459999	2 mA
	3.472 mV	-17.613 μA	10.5579999	2 mA
	3.49 mV	-18.146 μA	11.7099999	2 mA
	3.47 mV	-17.375 μA	13.2929998	2 mA
	3.485 mV	-17.846 μA	15.6269999	2 mA
	3.47 mV	-17.523 μA	19.0719998	2 mA
	3.484 mV	-17.627 μA	24.399	2 mA
	3.472 mV	-17.411 μA	32.5910004	2 mA

Visual Data Reduction:  Automatic  None  Manual

100 th data point





## 4 Versa Studio软件操作

### ⑤ 数据查看与分析

如果是批量实验，  
这里可以选择其中  
某个（些）实验  
数据进行显示

这里可以对使用  
交流或直流方法的  
实验进行标记

Data View - 90 Points (Segments 3,6,9)

Segment	Potential (V)	Current (A)	Elapsed Time (s)
<input type="checkbox"/> Segment #0			
<input type="checkbox"/> Segment #1			
<input type="checkbox"/> Segment #2			
<input checked="" type="checkbox"/> Segment #3	998.942 mV	998.574 μA	15.1
<input type="checkbox"/> Segment #4	998.942 mV	998.635 μA	15.2
<input type="checkbox"/> Segment #5	998.942 mV	998.574 μA	15.3
<input checked="" type="checkbox"/> Segment #6	998.636 mV	998.635 μA	15.4
<input type="checkbox"/> Segment #7	999.249 mV	998.574 μA	15.5
<input type="checkbox"/> Segment #8	998.942 mV	998.513 μA	15.6
<input checked="" type="checkbox"/> Segment #9	998.942 mV	998.635 μA	15.7
<input type="checkbox"/> Segment #10	999.249 mV	998.513 μA	15.8
	999.249 mV	998.574 μA	15.9
	999.249 mV	998.574 μA	16
	999.249 mV	998.574 μA	16.1
	999.249 mV	998.513 μA	16.2
	998.942 mV	998.513 μA	16.3
	998.942 mV	998.635 μA	16.4
	998.942 mV	998.574 μA	16.5
	999.249 mV	998.635 μA	16.6
	998.942 mV	998.574 μA	16.7
	998.636 mV	998.574 μA	16.8
	998.942 mV	998.513 μA	16.9
	998.942 mV	998.635 μA	17

Label AC Segments  
 Label DC Segments  
 Visual Data Reduction  
 Automatic  
 None  
 Manual  
 100 th data point





## 4 Versa Studio软件操作

### ⑤ 数据查看与分析

Potential (V)	Current (A)	Elapsed Tim...	I Range (A)	Sync ADC In...	Frequency (Hz)	Z (ohms)	Segment	Point	Comment
-3.335 mV	-3.478 µA	2.49	20 uA	-1.525 mV			0	248	
-2.415 mV	-2.487 µA	2.5	20 uA	-1.831 mV			0	249	
-1.495 mV	-1.494 µA	2.51	20 uA	-1.831 mV			0	250	
-575 µV	38.706 nA	2.52	2 uA	-1.831 mV			0	251	Code 01 (see help)
345.118 µV	711.742 nA	2.53	2 uA	-1.525 mV			0	252	
1.265 mV	1.561 µA	2.54	2 uA	-1.525 mV			0	253	Overload
2.798 mV	20.1 µA	2.55	20 uA	-1.831 mV			0	254	Code 02 (see help)
3.412 mV	14.672 µA	2.56	20 uA	-1.525 mV			0	255	
4.332 mV	10.582 µA	2.57	20 uA	-1.525 mV			0	256	

数据显示窗口的最右端一列为“Comment”，显示某个特定数据点的备注信息，一般有三种：Code 01，Code 02和Overload

- a) **Code 01:** 表示此数据点已接近仪器的分辨率极限，不精确
- b) **Code 02:** 表示此数据点在获取过程中仪器发生了硬件改动，出现电压或电流增益，比如工作站在切换电流量程时
- c) **Overload:** 表示此数据已超出量程范围，不精确。这种情况多出现于工作站进行量程切换时，特别是量程设置为“Auto”的情况







## 4 Versa Studio软件操作

### ⑥ 数据拷贝、删除与导出

#### 数据拷贝方法一

**Data Copy**

Columns to Copy to Clipboard:

Enable	Description
<input checked="" type="checkbox"/>	Potential (V)
<input checked="" type="checkbox"/>	Current (A)
<input type="checkbox"/>	Elapsed Time (s)
<input type="checkbox"/>	I Range (A)
<input type="checkbox"/>	Charge (C)
<input type="checkbox"/>	Sync ADC Input (V)
<input type="checkbox"/>	Forward I (A)
<input type="checkbox"/>	Reverse I (A)
<input type="checkbox"/>	Delta I (F-R) (A)
<input type="checkbox"/>	Delta I (R-F) (A)
<input type="checkbox"/>	Applied Potential (V)
<input type="checkbox"/>	Frequency (Hz)
<input type="checkbox"/>	SQRT of Frequency
<input type="checkbox"/>	1/SQRT of Frequency
<input type="checkbox"/>	Z  (ohms)
<input type="checkbox"/>	Zre (ohms)
<input type="checkbox"/>	Zim (ohms)
<input type="checkbox"/>	Phase of Z (deg)
<input type="checkbox"/>	Y  (S)
<input type="checkbox"/>	Yre (S)

勾选所需参数后点击“Copy”

**Data View - 997 Points (All)**

Potential (V)	Current (A)	Elapsed Ti...	I
-996.636 mV	-997.531 $\mu$ A	0.02	2
-996.795 mV	-995.63 $\mu$ A	0.04	2
-994.648 mV	-993.728 $\mu$ A	0.06	2
-992.806 mV	-991.704 $\mu$ A	0.08	2
-990.661 mV	-989.618 $\mu$ A	0.1	2
-988.821 mV	-987.717 $\mu$ A	0.12	2
-986.981 mV	-985.692 $\mu$ A	0.14	2
-984.834 mV	-983.729 $\mu$ A	0.16	2
-982.994 mV	-981.593 $\mu$ A	0.18	2
-980.847 mV	-979.62 $\mu$ A	0.2	2
-978.7 mV	-977.595 $\mu$ A	0.22	2
-977.166 mV	-975.694 $\mu$ A	0.24	2
-975.019 mV	-973.67 $\mu$ A	0.26	2
-972.872 mV	-971.645 $\mu$ A	0.28	2
-970.725 mV	-969.682 $\mu$ A	0.3	2
-968.272 mV	-967.597 $\mu$ A	0.32	2
-966.738 mV	-965.572 $\mu$ A	0.34	2
-964.898 mV	-963.732 $\mu$ A	0.36	2
-962.751 mV	-961.708 $\mu$ A	0.38	2
-960.911 mV	-959.822 $\mu$ A	0.4	2
-958.764 mV	-957.659 $\mu$ A	0.42	2
-957.23 mV	-955.697 $\mu$ A	0.44	2
-954.777 mV	-953.611 $\mu$ A	0.46	2
-952.63 mV	-951.648 $\mu$ A	0.48	2
-951.096 mV	-949.624 $\mu$ A	0.5	2
-948.643 mV	-947.722 $\mu$ A	0.52	2
-947.109 mV	-945.698 $\mu$ A	0.54	2
-944.655 mV	-943.735 $\mu$ A	0.56	2
-942.815 mV	-941.649 $\mu$ A	0.58	2
-940.668 mV	-939.564 $\mu$ A	0.6	2
-939.135 mV	-937.795 $\mu$ A	0.62	2
-936.374 mV	-935.761 $\mu$ A	0.64	2
-934.841 mV	-933.614 $\mu$ A	0.66	2
-933 mV	-931.651 $\mu$ A	0.68	2







## 4 Versa Studio软件操作

### ⑥ 数据拷贝、删除与导出

#### 数据拷贝方法一

The screenshot shows a Microsoft Excel spreadsheet with the following data:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Potential	Current (A)																
2	0.000614	1.55E-07																
3	0.00092	1.15E-06																
4	0.002147	2.01E-06																
5	0.003374	3.16E-06																
6	0.004294	4.15E-06																
7	0.005828	5.15E-06																
8	0.006748	6.14E-06																
9	0.007668	7.15E-06																
10	0.008588	8.15E-06																
11	0.009508	9.15E-06																
12	0.010428	1.02E-05																
13	0.011348	1.11E-05																
14	0.012268	1.21E-05																
15	0.013188	1.31E-05																
16	0.014108	1.41E-05																
17	0.015028	1.51E-05																
18	0.015948	1.61E-05																
19	0.016868	1.71E-05																
20	0.017788	1.81E-05																
21	0.018708	1.91E-05																
22	0.019628	2.01E-05																
23	0.020548	2.11E-05																
24	0.021468	2.21E-05																
25	0.022388	2.31E-05																
26	0.023308	2.41E-05																
27	0.024228	2.51E-05																

A callout box with a blue border and a white background points to the data table. The text inside the callout box reads: "粘贴到Excel或Origin等软件中" (Paste into Excel or Origin software).

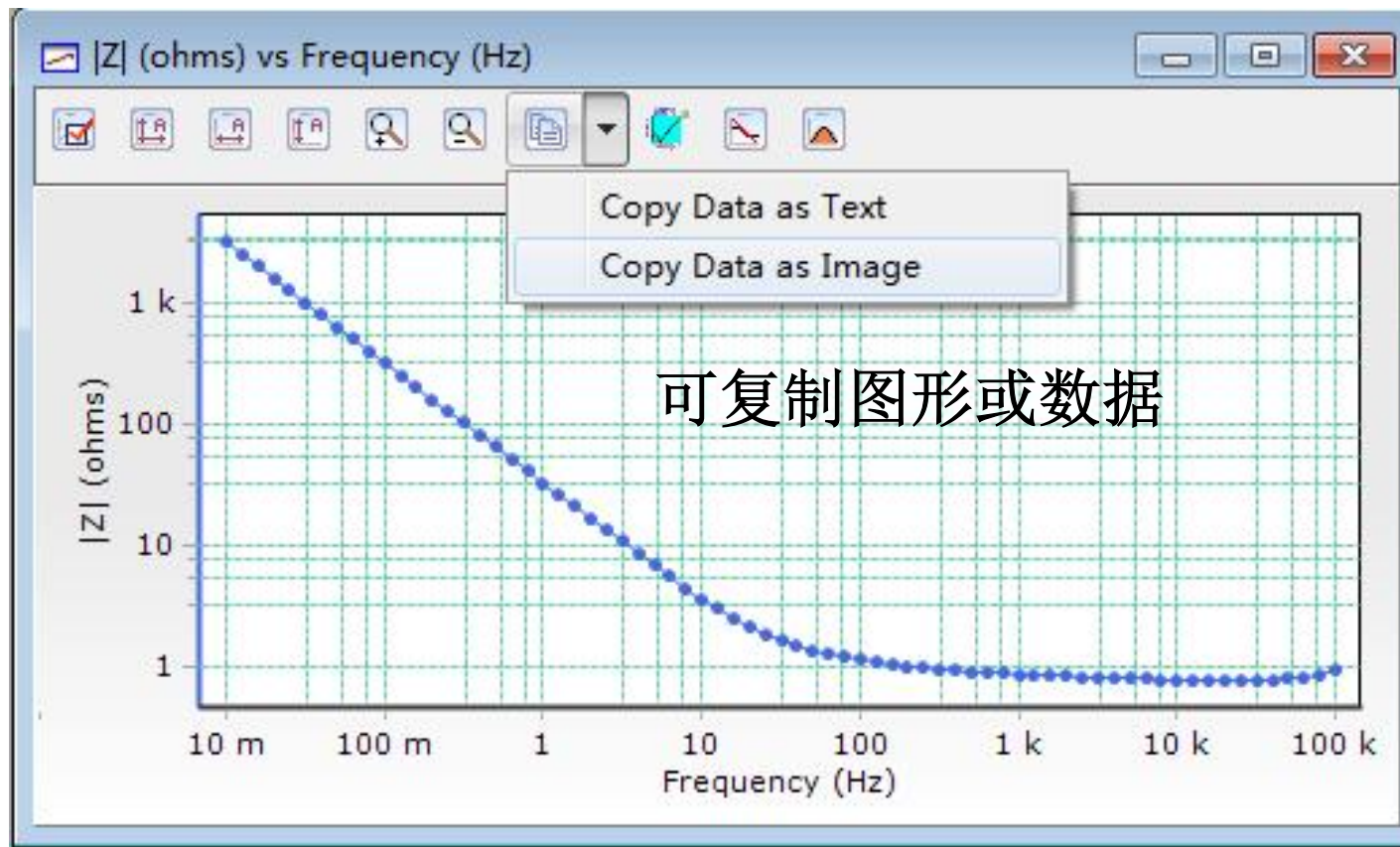




## 4 Versa Studio软件操作

### ⑥ 数据拷贝、删除与导出

数据拷贝方法二

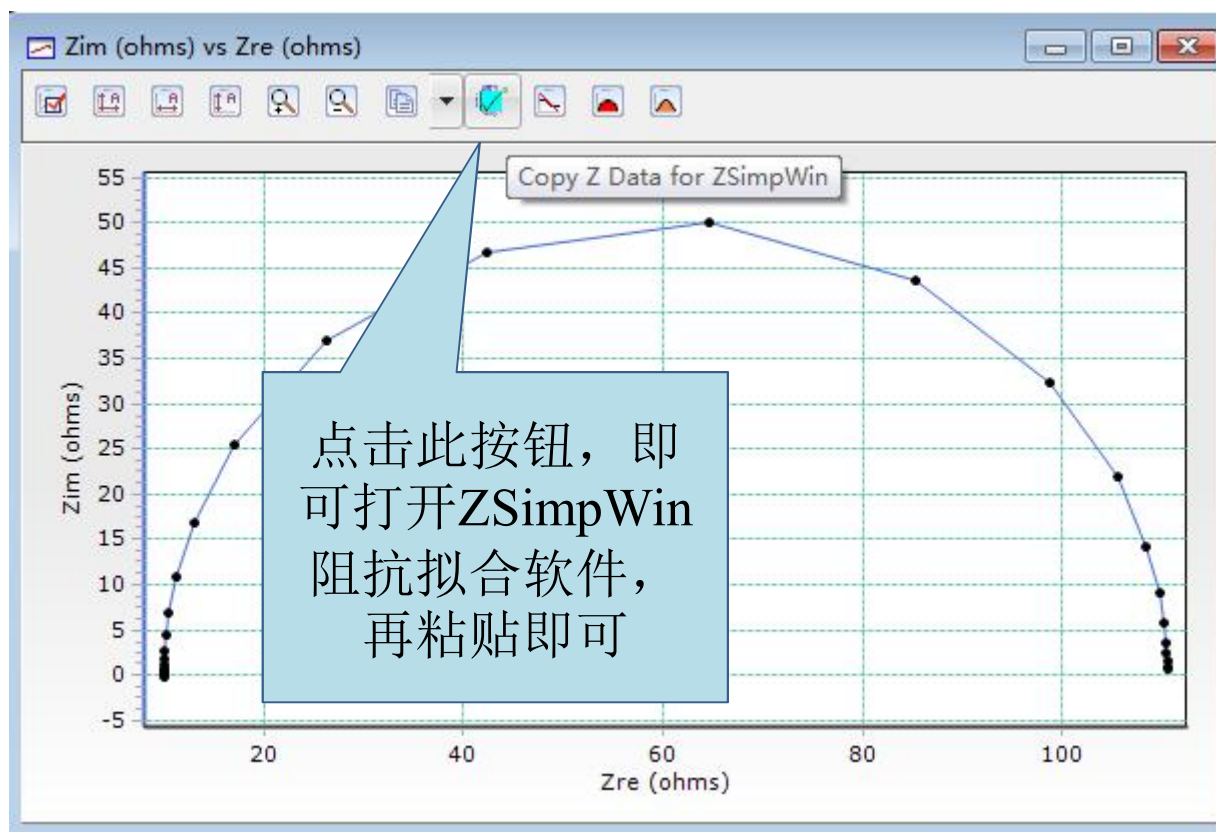




## 4 Versa Studio软件操作

### ⑥ 数据拷贝、删除与导出

数据拷贝方法三（仅限阻抗数据）





## 4 Versa Studio软件操作

### ⑥ 数据拷贝、删除与导出

#### 数据删除

可以选择删除所有数据或者选中的数据，或者过载的数据点



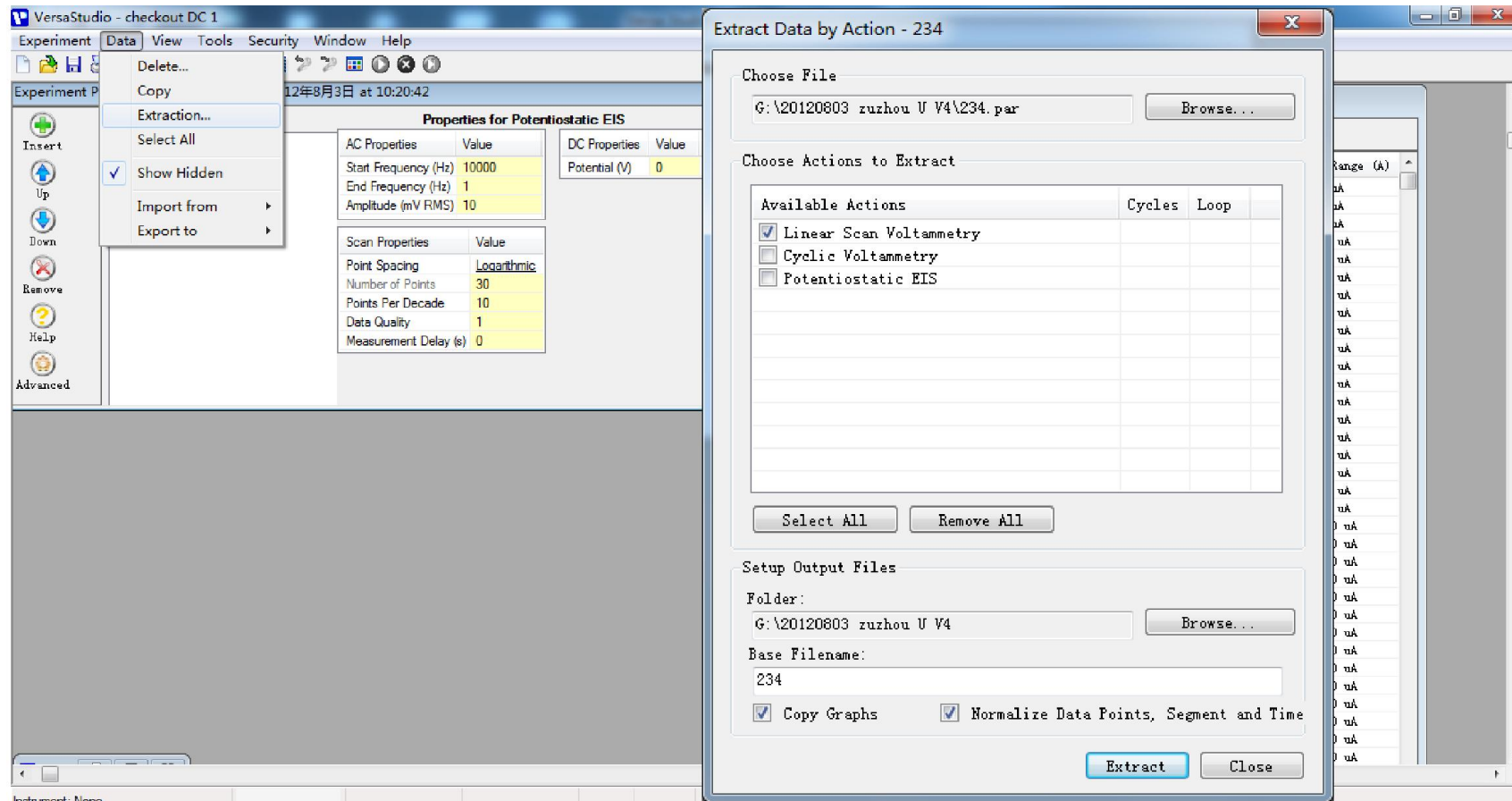




## 4 Versa Studio软件操作

### ⑥ 数据拷贝、删除与导出

数据导出：如果是批量实验，可抽取每个步骤的数据



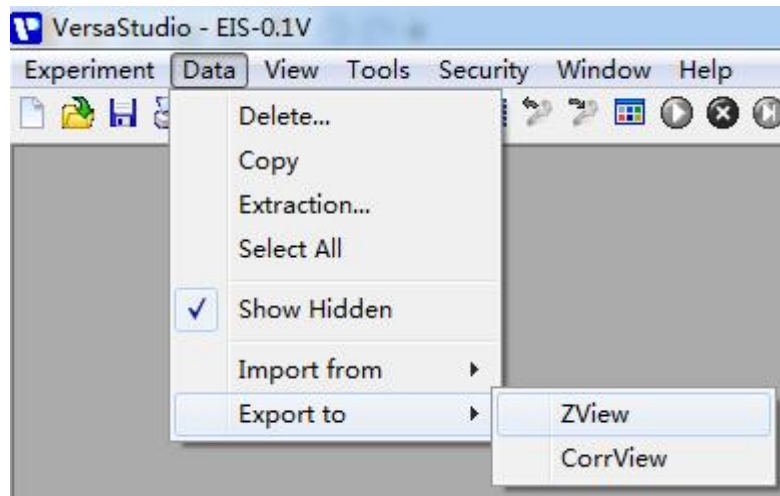




## 4 Versa Studio软件操作

### ⑥ 数据拷贝、删除与导出

数据导出：可导出Zview或Corrview格式文件

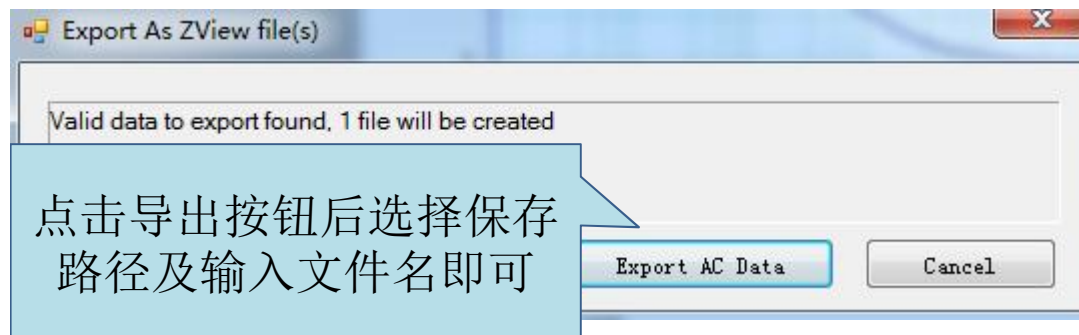


能导出为Zview格式的实验数据为

"Potentiostatic EIS"  
"Galvanostatic EIS"

能导出为Corrview格式的实验数据为

"Potentiostatic"  
"Open Circuit"  
"Potentiodynamic"  
"Cyclic Polarization"  
"Linear Polarization"  
"Galvanostatic"  
"Galvanodynamic"  
"Cyclic Voltammetry (Single and Multiple Cycles)"  
"Staircase Cyclic Voltammetry (Single and Multiple Cycles)"  
"Linear Scan Voltammetry"  
"Staircase Linear Scan Voltammetry"  
"Chronoamperometry"  
"Chronopotentiometry"  
"Chronocoulometry"  
"Tafel"





## 5 FAQ与注意事项

### FAQ

#### 1 充放电测试用哪个技术设置?

可选用**Chronopotentiometry** 或者**Galvanostatic** 进行, 插入**Loop** 来设置循环周次

#### 2 在使用小电流选件**VersaSTAT LCI**时, 需要每次都校正吗?

是的, 每次使用都需要**calibration** (过程参照**VersaSTAT LCI manual**)

#### 3 仪器一般多久需要校准?

建议每**6**个月校准一次





## 5 FAQ与注意事项

### FAQ

#### 4 伏安曲线为何某些地方存在微小振动？

很有可能是由于使用了自动量程引起，量程切换时硬件有改动会引起测量误差，可尝试设置固定量程来避免

#### 5 为何扫描伏安、计时电流或计时电位测试开始时出现异常数据点？

是因为开始所加电位或电流值偏离平衡值，体系出现短时波动，可剔除该数据点

#### 6 图形放大后如何拖动以查看别处数据点？

按住鼠标中间（滚轮）拖动

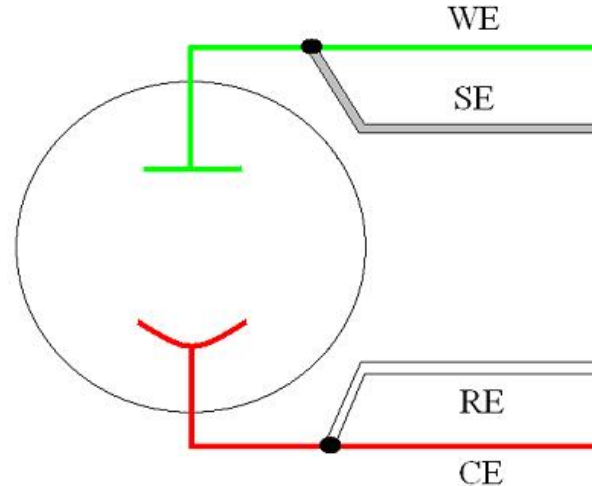




## 5 FAQ与注意事项

### 注意事项

1. 对于低阻抗体系（比如电池），或者实验过程中电流超过100mA的，请不要采用“piggy-back”（下图）方式连接两电极进行测量，正确方法是各接线应独立接在相应电极上，减少接触电阻对测量的影响







## 5 FAQ与注意事项

### 注意事项

2. 实验参数设置中，对于**Potential**一项（如果需要），应特别注意设置其值是相对于参比电极电势还是开路电位
3. **EIS**实验设置中，**Data Quality**如设置为**3**，则表示实验会循环测量**3**次然后取平均值得到数据点，因此所花时间是设置为**1**时的**3**倍
4. 三电极体系中，开路电位是指工作电极相对参比电极的电位，而不是相对于辅助电极的电位
5. 电化学工作站需要防尘、防潮和防止过热
6. 实验参数修改完后要按**Enter**键才能修改保存





## 5 FAQ与注意事项

### 注意事项

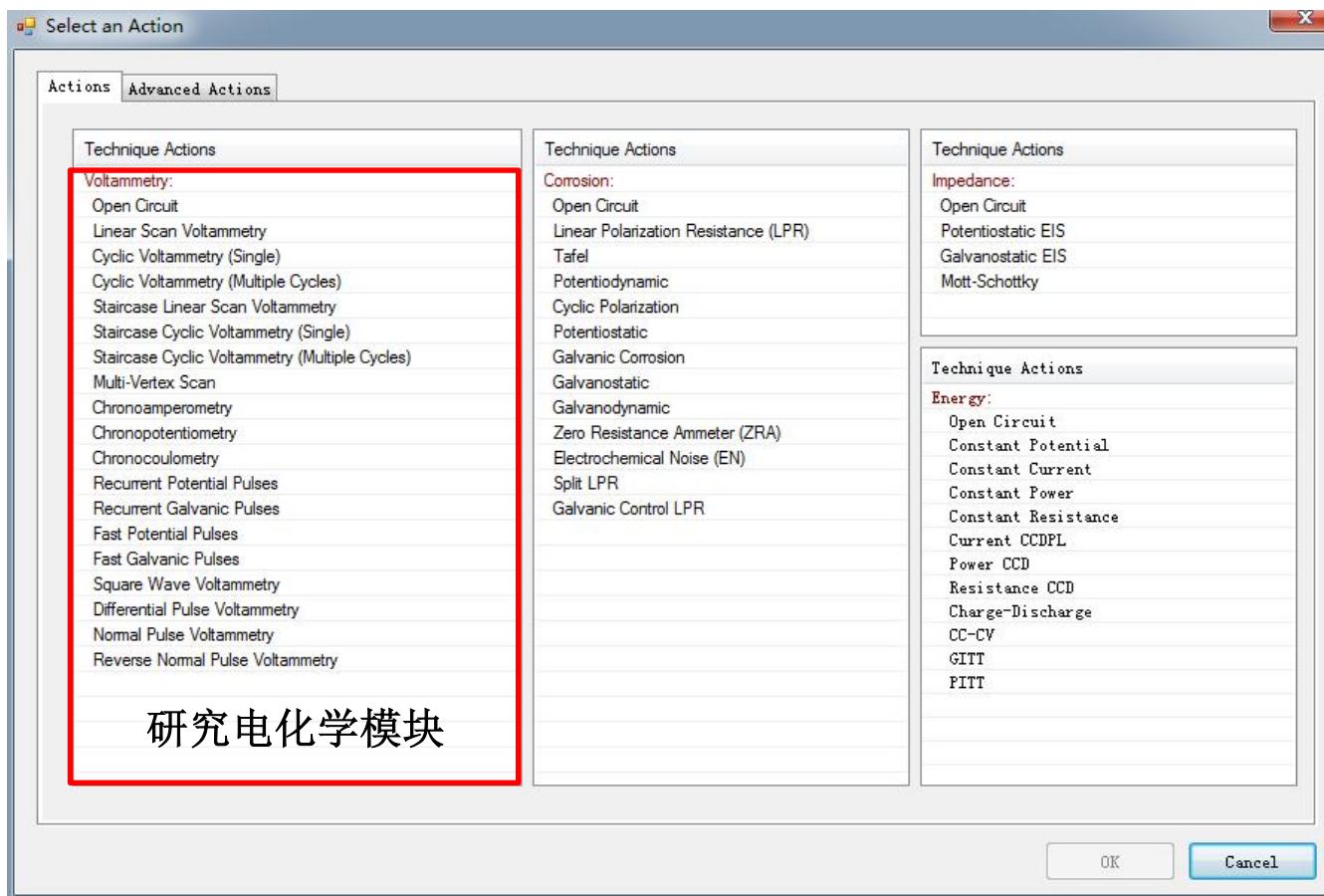
7. **LSV、CV和Multi CV**本质上也是跃阶扫描，其跃阶点数根据扫描范围和扫描速率尽可能多取，但数据读取与施加波形不同步，所以在测量中会删去跃阶过程中的点，最终数据点数会少于预计值。
8. 数据保存路径和文件名建议使用英文





## 6 具体应用讲解

### 6.1 研究电化学模块





## 6 具体应用讲解

### 6.1 研究电化学模块

#### 6.1.1 Open Circuit: 开路电位

**Experiment Properties**

**Actions to be Performed:**

- Common
  - Open Circuit
  - Measure Open Circuit
  - Linear Scan Voltammetry

**Properties for Open Circuit**

Scan Properties	Value
Time Per Point (s)	0.2
Duration (s)	60
Drift Rate (mV/min)	10
Total Points	300

Instrument Properties	Value
Current Range	2mA
Acquisition Mode	Auto
Electrometer Mode	Differential
E Resolution	Auto
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto

Limits	Direction	Value
None	≤	0

Cell Properties	Value
Cell to Use	External

**Drift Rate:** 如果在测量过程中开路电位变化率小于此设定值, 则可认为开路电位已达稳定值, 测量自动结束, 不管时间是否达到设定的**Duration**

Ps: OCP测试过程中软件状态栏会显示Cell Off。测试过程中显示的电流值已经达到仪器分辨率极限, 不能当作有效数据。



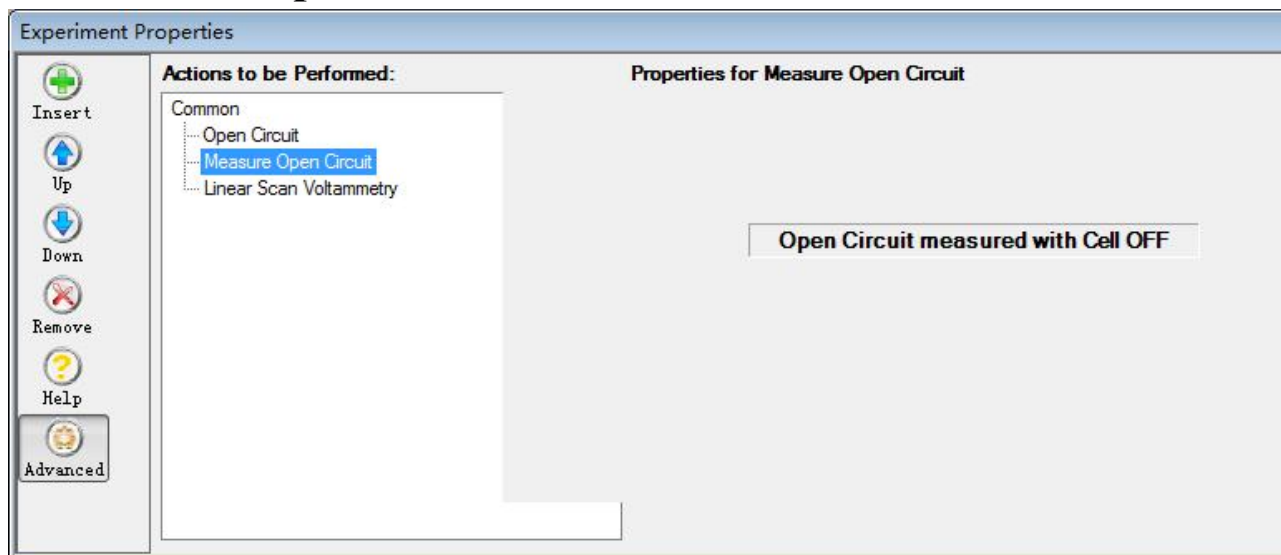




## 6 具体应用讲解

### 6.1 研究电化学模块

#### 6.1.1 Open Circuit: 开路电位



Or

Equivalent Weight (g)	0
Mass (g)	0
Remeasure OC Per Action	Yes
Measured Open Circuit	0

Ps: 在进行批量实验时，如果在OCP之后的测量中需要设置相对于开路电位的电势参数，则需要OCP之后插入“Measure Open Circuit”步骤，以更新开路电位的值，或者在Common页面中选择“Remeasure OC per Action”为“Yes”，否则将依旧使用OCP测量之前的值。





## 6 具体应用讲解

### 6.1 研究电化学模块

#### 6.1.2 Linear Scan Voltammetry (LSV):线性扫描伏安

Experiment Properties

Actions to be Performed:

- Common
  - Linear Scan Voltammetry

Properties for Linear Scan Voltammetry

Step Properties	Value	Versus
Initial Potential (V)	-1	vs Ref
Final Potential (V)	1	vs Ref

Limits	Direction	Value
None	≤	0
None	≤	0

Cell Properties	Value
Leave Cell ON	No
Cell to Use	External

Scan Properties	Value
Scan Rate (V/s)	0.02
Total Points	1000

Instrument Properties	Value
Current Range	Auto
Electrometer Mode	Differential
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto
iR Compensation	Disabled

Annotations:

- 扫描电位范围 (Scan Potential Range)
- 扫描速率最大10V/s (Maximum Scan Rate 10V/s)
- 每次扫描固定取1000个数据点 (Fixed 1000 data points per scan)

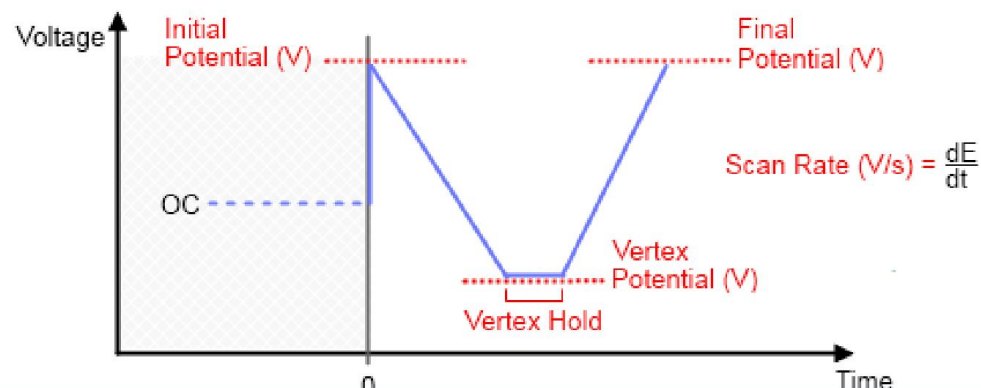




## 6 具体应用讲解

### 6.1 研究电化学模块

#### 6.1.3 Cyclic Voltammetry (Single): 单圈循环伏安



拐点电位  
持续时间

Experiment Properties

Actions to be Performed:

- Common
  - Cyclic Voltammetry

Properties for Cyclic Voltammetry

Endpoint Properties	Value	Versus	Vertex Hold	Acquire at Hold
Initial Potential (V)	-1	vs Ref		
Vertex Potential (V)	1	vs Ref	0	Yes
Final Potential (V)	-1	vs Ref		

Scan Properties	Value
Scan Rate (V/s)	1
Total Points	1999

Instrument Properties	Value
Current Range	Auto
Electrometer Mode	Differential
E Filter	Auto

Limits	Direction	Value
None	≤	0
None	≤	0

Cell Properties	Value
Leave Cell ON	No
Cell to Use	External

拐点电位

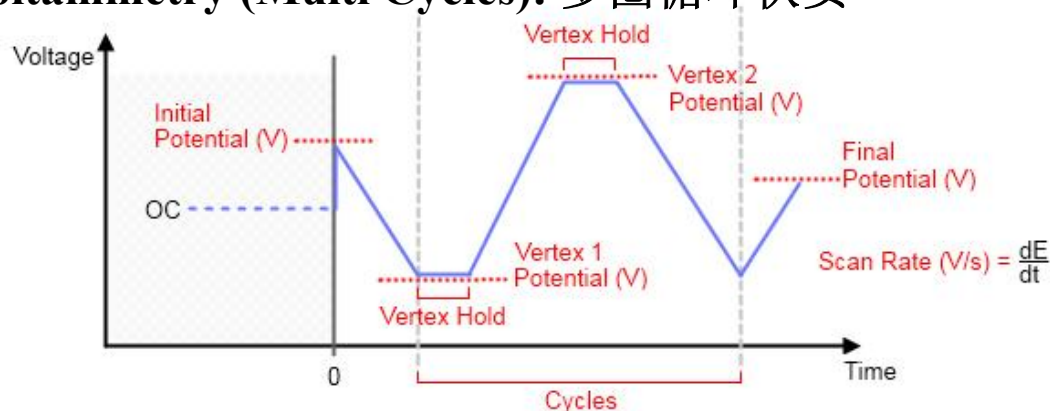




## 6 具体应用讲解

### 6.1 研究电化学模块

#### 6.1.4 Cyclic Voltammetry (Multi Cycles): 多圈循环伏安



Experiment Properties

Actions to be Performed:

- Common
  - Cyclic Voltammetry (Multiple Cycles)

Properties for Cyclic Voltammetry (Multiple Cycles)

Endpoint Properties	Value	Versus	Vertex Hold	Acquire at Hold
Initial Potential (V)	0.5	vs Ref		
Vertex 1 Potential (V)	1	vs Ref	0	Yes
Vertex 2 Potential (V)	-1	vs Ref	0	Yes
Final Potential (V)	0	vs Ref		

Scan Properties	Value
Scan Rate (V/s)	0.1
Cycles	10
Points Per Cycle	2000
Total Points	22000

Instrument Properties	Value
Current Range	Auto
Electrometer Mode	Auto
E Filter	Auto
I Filter	Auto

两个拐点  
之间循环

循环(Vertex 1→Vertex  
2→Vertex 1)次数



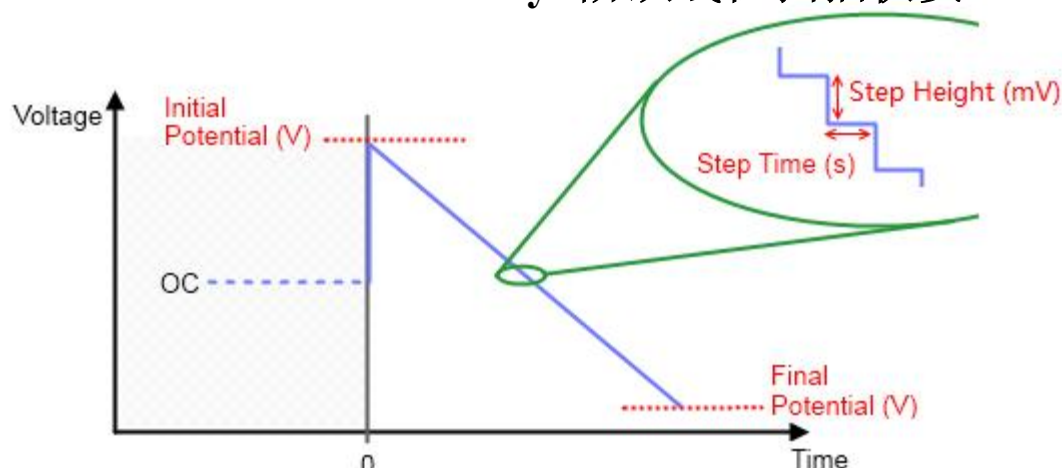




## 6 具体应用讲解

### 6.1 研究电化学模块

#### 6.1.5 Staircase Linear Scan Voltammetry: 阶跃线性扫描伏安



Experiment Properties

Actions to be Performed:

- Common
  - Staircase Linear Scan Voltammetry

Properties for Staircase Linear Scan Voltammetry

Endpoint Properties	Value	Versus	Limits	Direction	Value
Initial Potential (V)	0	vs Ref	None	≤	0
Final Potential (V)	1	vs Ref	None	≤	0

Scan Properties	Value
Step Height (mV)	10
Step Time (s)	1
Scan Rate (mV/s)	10
Total Points	101

Instrument Properties	Value
Current Range	Auto
Acquisition Mode	Auto
Electrometer Mode	Differential
E Filter	Auto

Step Height至少应该设置为1mV或以上

More Options. More Solutions.



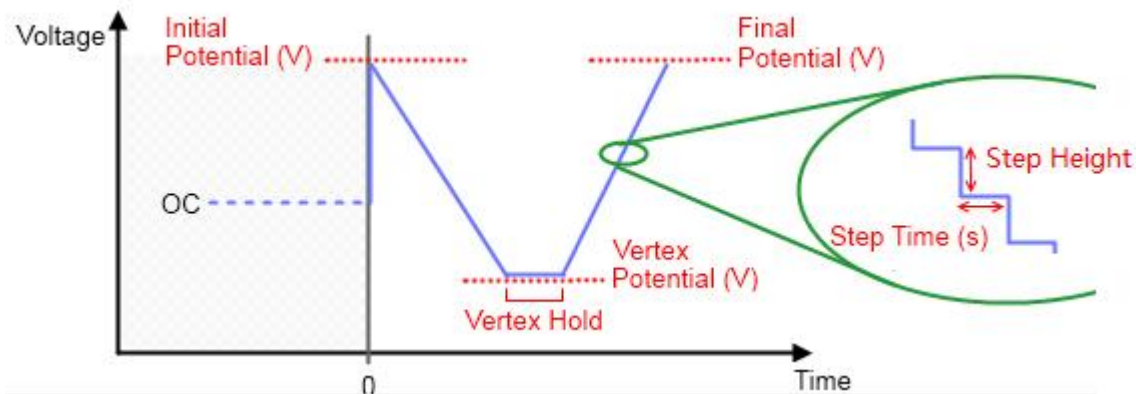
<http://www.par-solartron.com.cn>



## 6 具体应用讲解

### 6.1 研究电化学模块

#### 6.1.6 Staircase Cyclic Voltammetry (Single): 单圈阶跃循环伏安



Experiment Properties

Actions to be Performed:

- Common
  - Staircase Cyclic Voltammetry

Properties for Staircase Cyclic Voltammetry				
Endpoint Properties	Value	Versus	Vertex Hold	Acquire at Hold
Initial Potential (V)	-1	vs Ref		
Vertex Potential (V)	1	vs Ref	5	Yes
Final Potential (V)	-1	vs Ref		

Scan Properties	Value
Step Height (mV)	10
Step Time (s)	1
Scan Rate (mV/s)	10
Total Points	407

Instrument Properties	Value
Current Range	Auto
Acquisition Mode	Auto
Electrometer Mode	Differential
E Filter	Auto

More Options. More Solutions.



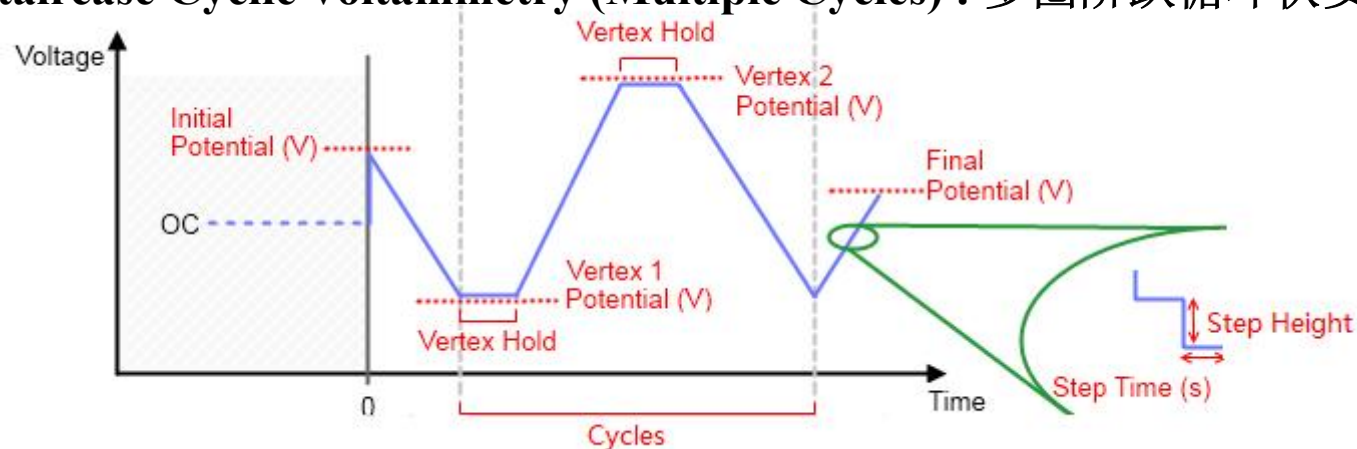
<http://www.par-solartron.com.cn>



## 6 具体应用讲解

### 6.1 研究电化学模块

#### 6.1.7 Staircase Cyclic Voltammetry (Multiple Cycles) : 多圈阶跃循环伏安



Experiment Properties

Actions to be Performed:

- Common
  - Staircase Cyclic Voltammetry (Multiple Cycles)

Endpoint Properties		Value	Versus	Vertex Hold	Acquire at Hold
Initial Potential (V)	0.1	vs Ref			
Vertex 1 Potential (V)	1	vs Ref	0	Yes	
Vertex 2 Potential (V)	-1	vs Ref	0	Yes	
Final Potential (V)	0	vs Ref			

Scan Properties		Value
Step Height (mV)	10	
Step Time (s)	1	
Cycles	10	

Cell Properties		Value
Leave Cell ON	No	
Cell to Use	External	

Instrument F  
Current Ran  
Acquisition I  
Electromete  
E Filter  
I Filter  
Bandwidth I  
LCI Bandwid  
iR Compens

More Options. More Solutions.



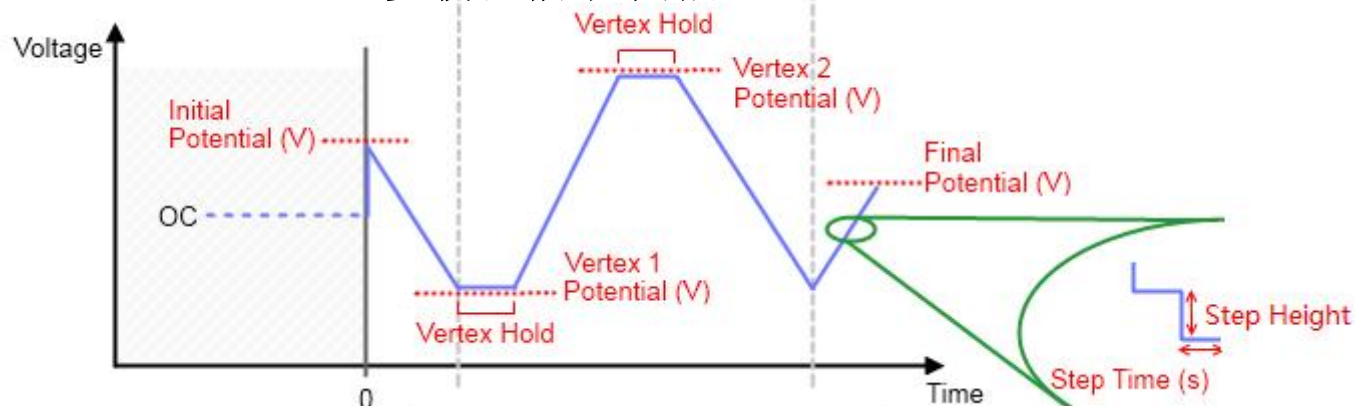
<http://www.par-solartron.com.cn>



## 6 具体应用讲解

### 6.1 研究电化学模块

#### 6.1.8 Multi-Vertex Scan : 多拐点阶跃扫描



Experiment Properties

Actions to be Performed:

- Common
  - Multi-Vertex Scan

Properties for Multi-Vertex Scan

Endpoint Properties	Value	Versus	Vertex Hold	Acquire at Hold
Initial Potential (V)	0	vs OC		
Vertex 1 Potential ...	1	vs OC	0	Yes
Not Used	0	vs OC	0	Yes
Final Potential (V)	0.1	vs OC		

Scan Properties	Value	Limits	Direction	Value
Step Height (mV)	10	None	≤	0
Step Time (s)	1	None	≤	0
Scan Rate (mV/s)	10			
Total Points	191			

Cell Properties Value

最多可选择设置两个拐点

More Options. More Solutions.



<http://www.par-solartron.com.cn>





## 6 具体应用讲解

### 6.1 研究电化学模块

#### 6.1.9 Chronoamperometry : 计时电流法

**Experiment Properties**

**Actions to be Performed:**

- Common
  - Chronoamperometry

**Properties for Chronoamperometry**

Step Properties	Value	Versus
Potential (V)	1	vs Ref

Limits	Direction	Value
None	≤	0
None	≤	0

Cell Properties	Value
Leave Cell ON	No
Cell to Use	External

Scan Properties	Value
Time Per Point (s)	1
Duration (s)	1000
Total Points	1000

Instrument Properties	Value
Current Range	Auto
Electrometer Mode	Differential
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto
iR Compensation	Disabled

Callout: 施加恒电位, 测量I-t曲线

对于序列实验中连续两步计时电流测量，可在第一步中设置结束时“Leave Cell On”为Yes





## 6 具体应用讲解

### 6.1 研究电化学模块

#### 6.1.10 Chronopotentiometry : 计时电位法

Experiment Properties

Actions to be Performed:

- Common
  - Chronopotentiometry

Properties for Chronopotentiometry

Step Properties	Value
Current (mA)	5

Limits	Direction	Value
None	≤	0
None	≤	0

Cell Properties	Value
Leave Cell ON	No
Cell to Use	External

Scan Properties	Value
Time Per Point (s)	1
Duration (s)	100
Total Points	100

Instrument Properties	Value
Electrometer Mode	Differential
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto

施加恒电流，  
测量  $V-t$  曲线

对于序列实验中连续两步计时电位测量，可在第一步中设置结束时“Leave Cell On”为Yes





## 6 具体应用讲解

### 6.1 研究电化学模块

#### 6.1.11 Chronocoulometry : 计时库伦（电量）法

对于电解实验，可输入预电解时间，用于测量溶剂背景电流，然后添加溶质，所测量电流会扣除背景电流得出净电解电流

Experiment Properties

Actions to be Performed:

- Insert
- Up
- Down
- Remove
- Help
- Advanced

Common

- Chronocoulometry

Properties for Chronocoulometry

Step Properties	Value	Versus	Pre-Elect (s)
Potential (V)	1	vs Ref	10

Limits	Direction	Value
None	≤	0
None	≤	0

Cell Properties	Value
Leave Cell ON	No
Cell to Use	External

Scan Properties	Value
Time Per Point (s)	1
Duration (s)	100
Total Points	100

Instrument Properties	Value
Current Range	Auto
Electrometer Mode	Differential
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto
iR Compensation	Disabled

施加恒电位，测量  $I-t$  曲线并积分，得出  $Q-t$  曲线





## 6 具体应用讲解

### 6.1 研究电化学模块

#### 6.1.12 Recurrent Potential Pulses : 周期电位脉冲法

Recurrent Pulsing

Number of pulses:  ← 脉冲数

Number of loops:  ← 周期数

OK

Experiment Properties

- Insert
- Up
- Down
- Remove
- Help
- Advanced

**Actions to be Performed:**

- Common
- Loop #1
  - Recurrent Potential Pulses
  - Recurrent Potential Pulses
  - Recurrent Potential Pulses
  - Recurrent Potential Pulses

**Properties for Recurrent Potential Pulses**

Pulse Properties	Value	Versus
Potential (V)	1	vs Ref

Scan Properties	Value
Time Per Point (s)	1
Duration (s)	10
Total Points	10

Limits	Direction	Value
None	≤	0
None	≤	0

Cell Properties	Value
Leave Cell ON	Yes
Cell to Use	External

可分别设置每一脉冲电位和时间







## 6 具体应用讲解

### 6.1 研究电化学模块

#### 6.1.13 Recurrent Galvanic Pulses : 周期电流脉冲法

Recurrent Pulsing

Number of pulses:  ← 脉冲数

Number of loops:  ← 周期数

OK

Experiment Properties

Actions to be Performed:

- Common
- Loop #1
  - Recurrent Galvanic Pulses
  - Recurrent Galvanic Pulses
  - Recurrent Galvanic Pulses
  - Recurrent Galvanic Pulses

Properties for Recurrent Galvanic Pulses	
<b>Pulse Properties</b>	<b>Value</b>
Current (A)	0.01
<b>Scan Properties</b>	<b>Value</b>
Time Per Point (s)	1
Duration (s)	10
Total Points	10

Limits	Direction	Value
None	≤	0
None	≤	0

Instrument Properties	Value
Current Range	Auto
Electrometer Mode	Differential
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto

Cell Properties	Value
Leave Cell ON	Yes
Cell to Use	External

可分别设置每一脉冲电流和时间



## 6 具体应用讲解

### 6.1 研究电化学模块

#### 6.1.14 Fast Potential Pulses : 快速电位脉冲法

Experiment Properties

Actions to be Performed:

- Common
  - Fast Potential Pulses

Properties for Fast Potential Pulses

Pulse Properties	Value	Versus	Width (s)
Number of pulses	5		
Potential (V) 1	1	vs Ref	0.100
Potential (V) 2	-1	vs Ref	0.100
Potential (V) 3	0.5	vs Ref	0.050
Potential (V) 4	-0.5	vs Ref	0.050
Potential (V) 5	0.75	vs Ref	0.100

Instrument Properties	Value
Current Range	2mA
Acquisition Mode	Auto
Electrometer Mode	Differential
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto

Scan Properties	Value
Time Per Point (s)	0.025
Cycles	2
Total Points	32
Total Duration	0.8

Limits	Direction	Value
None	≤	0
None	≤	0

Cell Properties	Value
Leave Cell ON	No
Cell to Use	External

可设置2~5个脉冲，一般用于电沉积

需要注意，如果设置的Time per Point值比脉冲宽度大，则数据采集速度较电压波形变化慢





## 6 具体应用讲解

### 6.1 研究电化学模块

#### 6.1.15 Fast Galvanic Pulses : 快速电流脉冲法

Experiment Properties

Actions to be Performed:

- Common
  - Fast Galvanic Pulses

Properties for Fast Galvanic Pulses

Pulse Properties	Value	Width (s)
Number of pulses	5	
Current (A) 1	0.0005	0.100
Current (A) 2	0.00075	0.100
Current (A) 3	0.001	0.050
Current (A) 4	0.00125	0.050
Current (A) 5	0.001	0.200

Scan Properties	Value
Time Per Point (s)	0.025
Cycles	2
Total Points	40
Total Duration	1

Limits	Direction	Value
None	≤	0
None	≤	0

Instrument Properties	Value
Current Range	2mA
Acquisition Mode	Auto
Electrometer Mode	Auto
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto

Cell Properties	Value
Leave Cell ON	No
Cell to Use	External

Navigation: Insert, Up, Down, Remove, Help, Advanced

类似于Fast Potential Pulses

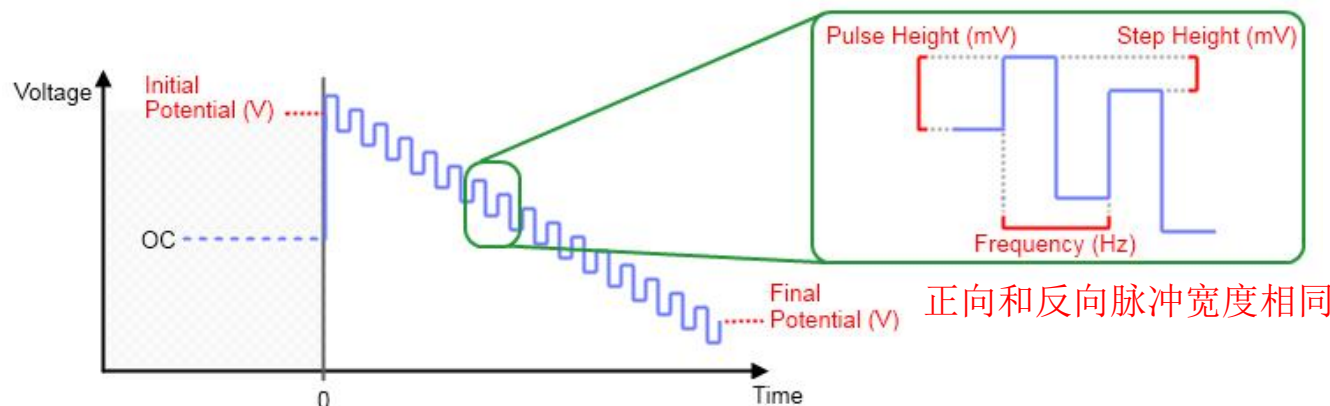




## 6 具体应用讲解

### 6.1 研究电化学模块

#### 6.1.16 Square Wave Voltammetry : 方波伏安法



Experiment Properties

Actions to be Performed:  
Common  
Square Wave Voltammetry

Properties for Square Wave Voltammetry					
Endpoint Properties	Value	Versus	Limits	Direction	Value
Initial Potential (V)	0	vs Ref	None	≤	0
Final Potential (V)	-1	vs Ref	None	≤	0

Scan Properties	Value
Pulse Height (mV)	25
Step Height (mV)	10
Frequency (Hz)	100
Scan Rate (mV/s)	1000
Total Points	202

Instrument Properties	Value
Current Range	2mA
Electrometer Mode	Auto
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto

**Scan Rate=Step Height\*Frequency**

More Options. More Solutions.



<http://www.par-solartron.com.cn>

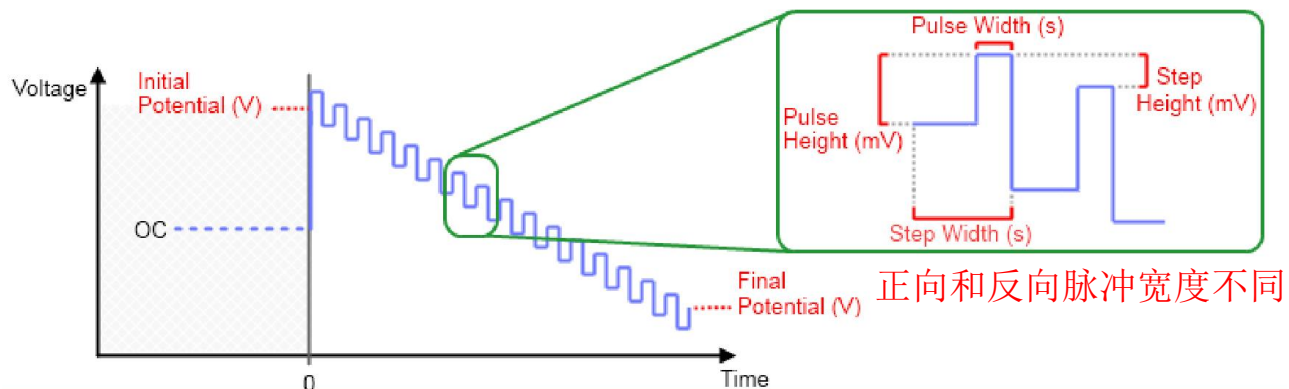




## 6 具体应用讲解

### 6.1 研究电化学模块

#### 6.1.17 Differential Pulse Voltammetry : 差分脉冲伏安法



Experiment Properties

Actions to be Performed:  
Common  
Differential Pulse Voltammetry

Endpoint Properties			Value	Versus	Limits	Direction	Value
Initial Potential (V)	0	vs Ref			None	≤	0
Final Potential (V)	-1	vs Ref			None	≤	0

Scan Properties		Value
Pulse Height (mV)		25
Pulse Width (s)		1
Step Height (mV)		10
Step Width (s)		2
Scan Rate (mV/s)		5
Total Points		202

Instrument Properties		Value
Current Range		2mA
Electrometer Mode		Auto
E Filter		Auto
I Filter		Auto
Bandwidth Limit		Auto
LCI Bandwidth Limit		Auto

Scan Rate=Step Height/Step Width

More Options. More Solutions.



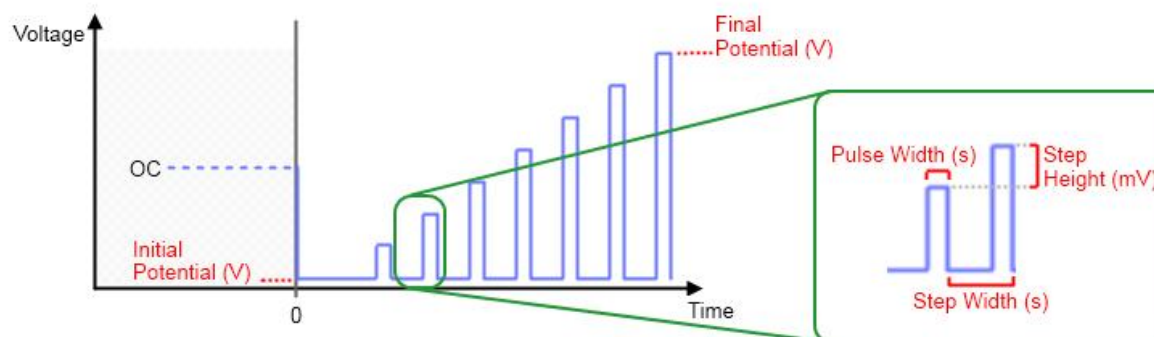
<http://www.par-solartron.com.cn>



## 6 具体应用讲解

### 6.1 研究电化学模块

#### 6.1.18 Normal Pulse Voltammetry: 常规脉冲伏安法



Experiment Properties

Actions to be Performed:

- Common
  - Normal Pulse Voltammetry

Properties for Normal Pulse Voltammetry

Endpoint Properties	Value	Versus	Limits	Direction	Value
Initial Potential (V)	0	vs Ref	None	≤	0
Final Potential (V)	-1	vs Ref	None	≤	0

Scan Properties	Value
Pulse Width (s)	1
Step Height (mV)	10
Step Width (s)	2
Scan Rate (mV/s)	5
Total Points	202

Instrument Properties	Value
Current Range	2mA
Electrometer Mode	Auto
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto

**Scan Rate=Step Height/Step Width**

More Options. More Solutions.



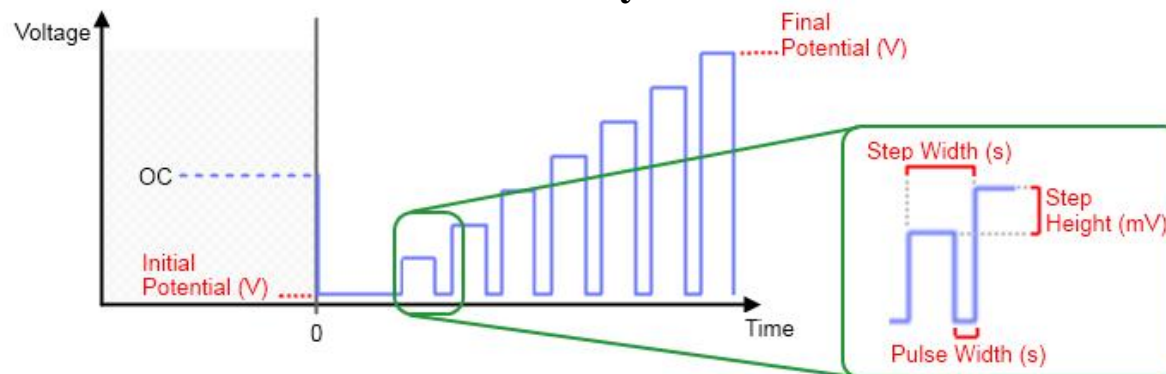
<http://www.par-solartron.com.cn>



## 6 具体应用讲解

### 6.1 研究电化学模块

#### 6.1.19 Reverse Normal Pulse Voltammetry : 反常规脉冲伏安法



Experiment Properties

Actions to be Performed:

- Common
  - Reverse Normal Pulse Voltammetry

Endpoint Properties			Value	Versus	Limits	Direction	Value
Initial Potential (V)	0	vs Ref			None	≤	0
Final Potential (V)	-1	vs Ref			None	≤	0

Scan Properties	Value	Instrument Properties	Value
Pulse Width (s)	1	Current Range	2mA
Step Height (mV)	10	Electrometer Mode	Auto
Step Width (s)	2	E Filter	Auto
Scan Rate (mV/s)	5	I Filter	Auto
Total Points	202	Bandwidth Limit	Auto

Scan Rate=Step Height/Step Width

More Options. More Solutions.

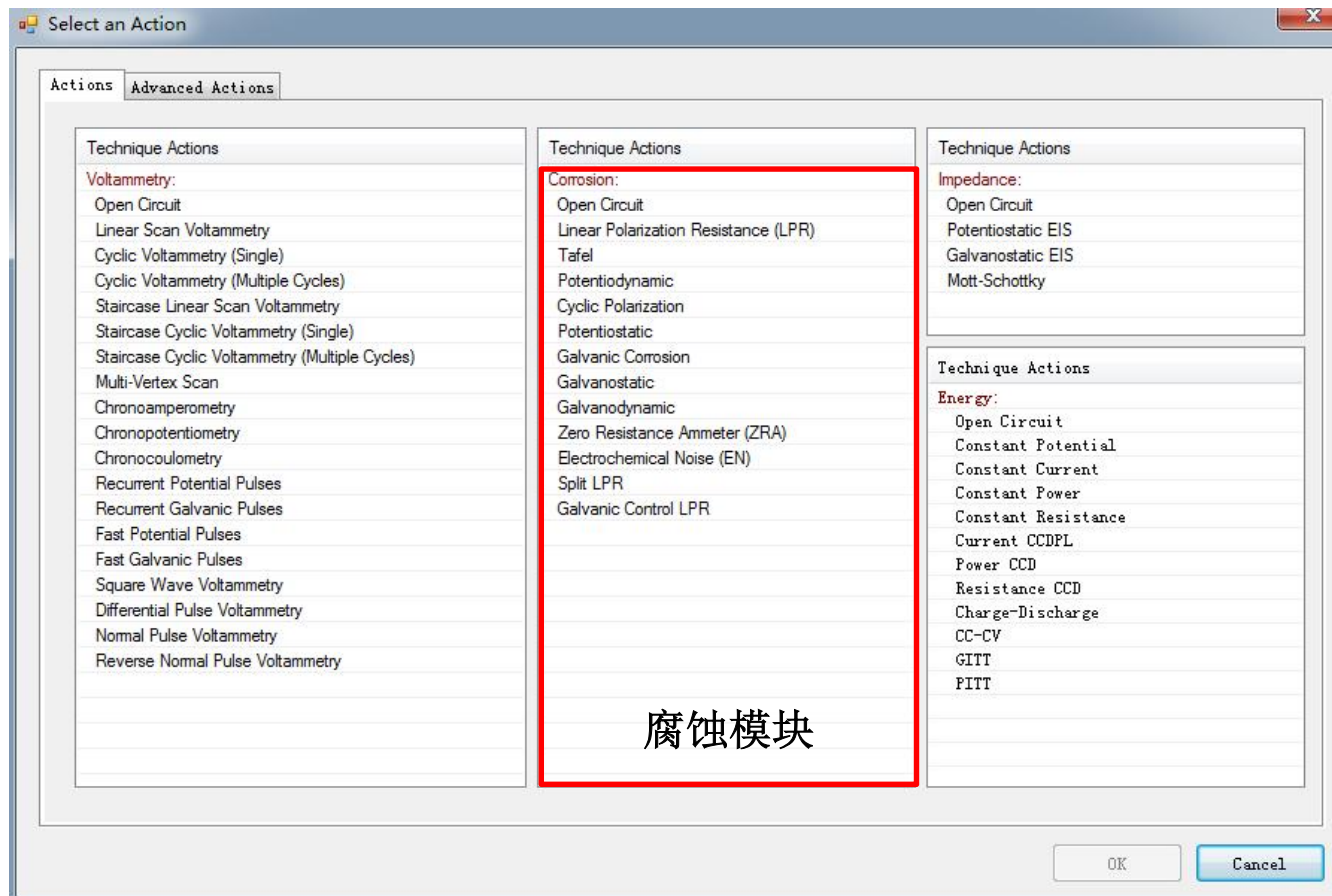


<http://www.par-solartron.com.cn>



## 6 具体应用讲解

### 6.2 腐蚀模块







## 6 具体应用讲解

### 6.2 腐蚀模块

#### 6.2.1 Corrsion Open Circuit----开路电位

The screenshot shows the 'Experiment Properties' window. On the left is a navigation pane with 'Insert', 'Up', 'Down', 'Remove', 'Help', and 'Advanced' buttons. The main area is titled 'Actions to be Performed:' and lists 'Corrosion Open Circuit', 'Measure Open Circuit', and 'Linear Scan Voltammetry'. A callout box points to the 'Drift Rate' property in the 'Scan Properties' table.

Properties for Corrosion Open Circuit	
Scan Properties	Value
Time Per Point (s)	0.2
Duration (s)	60
Drift Rate (mV/min)	10
Total Points	300

Instrument Properties	Value
Current Range	2mA
Acquisition Mode	Auto
Electrometer Mode	Auto
E Resolution	Auto
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto

Limits	Direction	Value
None	≤	0

Cell Properties	Value
Cell to Use	External

**Drift Rate:** 如果在测量过程中开路电位变化率小于此设定值, 则可认为开路电位已达稳定值, 测量自动结束, 不管时间是否达到设定的Duration

Ps: OCP测试过程中软件状态栏会显示Cell Off。测试过程中显示的电流值已经达到仪器分辨率极限, 不能当作有效数据。

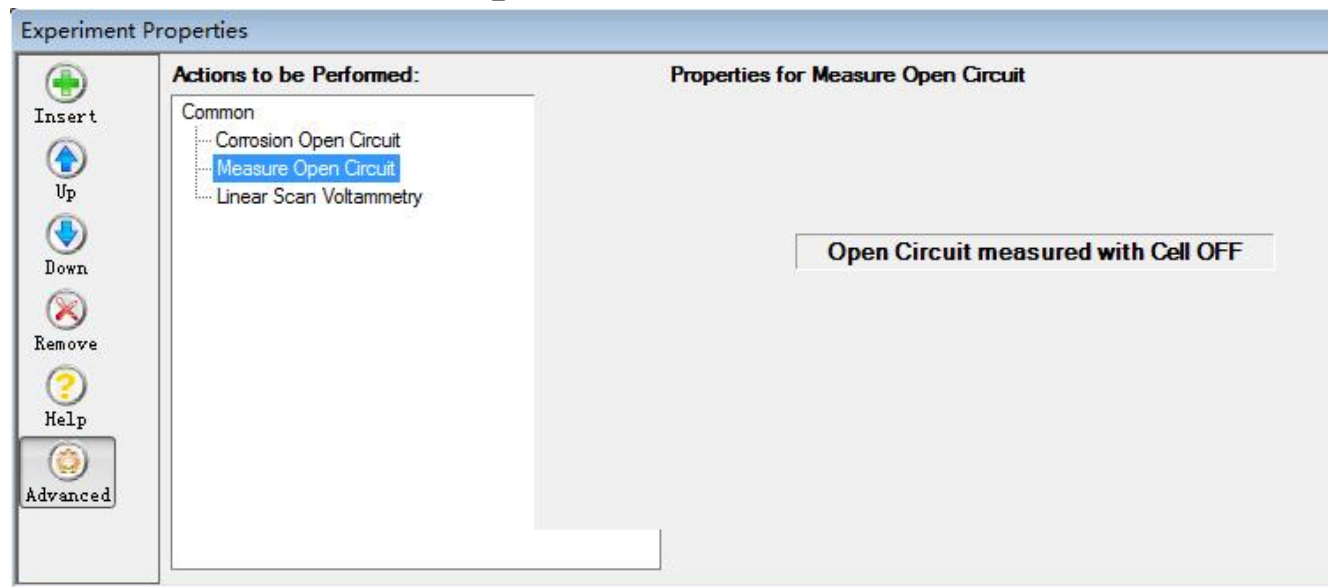




## 6 具体应用讲解

### 6.2 腐蚀模块

#### 6.2.1 Corrosion Open Circuit----开路电位



Or

Equivalent Weight (g)	0
Mass (g)	0
Remeasure OC Per Action	Yes
Measured Open Circuit	0

Ps: 在进行批量实验时，如果在OCP之后的测量中需要设置相对于开路电位的电势参数，则需要在OCP之后插入“Measure Open Circuit”步骤，以更新开路电位的值，或者在Common页面中选择“Remeasure OC per Action”为“Yes”，否则将依旧使用OCP测量之前的值。





## 6 具体应用讲解

### 6.2 腐蚀模块

#### 6.2.2 Linear Polarization Resistance (LPR)—线性极化电阻

Experiment Properties

Actions to be Performed:

Common

- Linear Polarization Resistance (LPR)

Properties for Linear Polarization Resistance (LPR)

Step Properties	Value	Versus
Initial Potential (V)	-0.02	vs OCP
Final Potential (V)	0.02	vs OCP

Limits	Direction	Value
None	≤	0
None	≤	0

Scan Properties	Value
Step Height (mV)	0.1
Step Time (s)	0.6
Scan Rate (mV/s)	0.1666
Total Points	401

Instrument Properties	Value
Current Range	Auto
Acquisition Mode	Auto
Electrometer Mode	Auto
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto
iR Compensation	Disabled

Cell Properties	Value
Leave Cell ON	No
Cell to Use	External

一般设置为±20mV vs OCP。可用于测定腐蚀速率





## 6 具体应用讲解

### 6.2 腐蚀模块

#### 6.2.3 Tafel—塔菲尔曲线

**Experiment Properties**

**Actions to be Performed:**

- Common
  - Tafel

**Properties for Tafel**

Endpoint Properties	Value	Versus
Initial Potential (V)	-0.25	vs OCP
Final Potential (V)	0.25	vs OCP

Limits	Direction	Value
None	≤	0
None	≤	0

Cell Properties	Value
Leave Cell ON	No
Cell to Use	External

Scan Properties	Value
Step Height (mV)	0.5
Step Time (s)	3
Scan Rate (mV/s)	0.1666
Total Points	1001

Instrument Properties	Value
Current Range	Auto
Acquisition Mode	Auto
Electrometer Mode	Differential
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto
iR Compensation	Disabled

**Callout Box:** 一般设置为 ±250mV vs OCP。可用于测定 Tafel 常数和腐蚀速率







## 6 具体应用讲解

### 6.2 腐蚀模块

#### 6.2.4 Potentiodynamic—动电位扫描

**Experiment Properties**

**Actions to be Performed:**

- Common
  - Potentiodynamic

**Properties for Potentiodynamic**

Endpoint Properties	Value	Versus
Initial Potential (V)	-0.25	vs OC
Final Potential (V)	1.6	vs Ref

Limits	Direction	Value
None	≤	0
None	≤	0

Cell Properties	Value
Leave Cell ON	No
Cell to Use	External

Scan Properties	Value
Step Height (mV)	1
Step Time (s)	6
Scan Rate (mV/s)	0.1666
Total Points	1851

Instrument Properties	Value
Current Range	Auto
Acquisition Mode	Auto
Electrometer Mode	Differential
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto
iR Compensation	Disabled

**Callout Box:** 一般设置为1.5V vs OCP。可用于分析材料的钝化机理





## 6 具体应用讲解

### 6.2 腐蚀模块

#### 6.2.5 Cyclic Polarization—循环极化

Start Level指当扫描电位达到此设定值时才会检测电流是否到达Threshold值，避免过早反向扫描。

Experiment Properties

Actions to be Performed:

- Common
  - Cyclic Polarization

Properties for Cyclic Polarization

Endpoint Properties	Value	Versus	Threshold Property	Value
Initial Potential (V)	-0.1	vs OC	Threshold	Enabled
Vertex Potential (V)	1.2	vs Ref	Start Level (V)	0.2
Final Potential (V)	0	vs OC	Threshold (mA)	1

Cell Properties	Value
Leave Cell ON	No
Cell to Use	External

Scan Properties	Value
Step Height (mV)	1
Step Time (s)	1
Scan Rate (mV/s)	1
Total Points	2501

Instrument Properties	Value
Current Range	Auto
Acquisition Mode	Auto
Electrometer Mode	Differential
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto
iR Compensation	Disabled

Vertex Potential和 Threshold, 满足其中之一即反向扫描

循环极化一般用于点蚀或裂纹腐蚀测试

Threshold电流指当电流超过此设定值时, 电位即反向扫描。





## 6 具体应用讲解

### 6.2 腐蚀模块

#### 6.2.6 Potentiostatic—恒电位极化

**Experiment Properties**

**Actions to be Performed:**

- Common
  - Potentiostatic

**Properties for Potentiostatic**

Step Properties	Value	Versus
Potential (V)	1	vs Ref

Apply Potential Change Now

Scan Properties	Value
Time Per Point (s)	0.1
Duration (s)	60
Total Points	600

Limits	Direction	Value
None	≤	0
None	≤	0

Cell Properties	Value
Leave Cell ON	No
Cell to Use	External

Instrument Properties	Value
Current Range	Auto
Acquisition Mode	Auto
Electrometer Mode	Auto
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto
iR Compensation	Disabled

不同于普通恒电位极化，此方法可以在测试过程中途改变电位参数，可用于测量临界点蚀电位





## 6 具体应用讲解

### 6.2 腐蚀模块

#### 6.2.7 Galvanic Corrosion—电偶腐蚀测量

Experiment Properties

Actions to be Performed:

Common

Galvanic Corrosion

Properties for Galvanic Corrosion

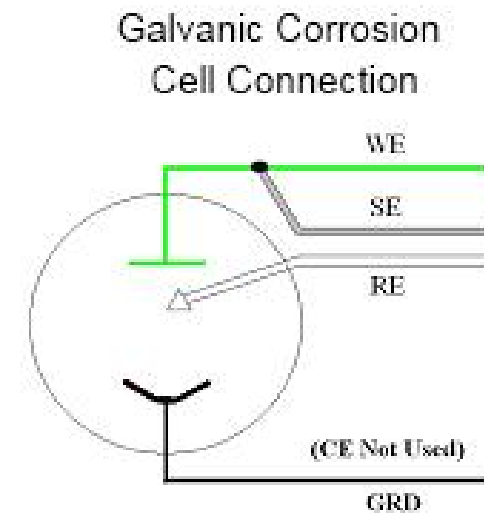
Scan Properties	Value
Time Per Point (s)	0.5
Duration (s)	200
Total Points	400

Limits	Direction	Value
None	≤	0
None	≤	0

Cell Properties	Value
Cell to Use	External

Instrument Properties	Value
Current Range	Auto
Acquisition Mode	Auto
Electrometer Mode	Auto
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto

不施加任何电流或电位(cell off), 只测量电流和电位。



电极线接法: CE不用, WE和Ground分别接两不同样品, RE接参比电极







## 6 具体应用讲解

### 6.2 腐蚀模块

#### 6.2.8 Galvanostatic—恒电流极化

Experiment Properties

Actions to be Performed:

- Common
  - Galvanostatic

Properties for Galvanostatic

Step Properties	Value
Current (mA)	1

Scan Properties	Value
Time Per Point (s)	0.1
Duration (s)	60
Total Points	600

Limits	Direction	Value
None	≤	0
None	≤	0

Instrument Properties	Value
Acquisition Mode	Auto
Electrometer Mode	Auto
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto

Cell Properties	Value
Leave Cell ON	No
Cell to Use	External

可用于去除钝化膜或者通过恒电流腐蚀测量薄膜的厚度





## 6 具体应用讲解

### 6.2 腐蚀模块

#### 6.2.9 Galvanodynamic—动电流极化

Experiment Properties

Actions to be Performed:

- Common
  - Galvanodynamic

Properties for Galvanodynamic

Step Properties	Value
Initial Current (mA)	0
Final Current (mA)	1

Limits	Direction	Value
None	≤	0
None	≤	0

Cell Properties	Value
Leave Cell ON	No
Cell to Use	External

Scan Properties	Value
Step Height (mA)	0.1
Step Time (s)	10
Scan Rate (mA/s)	0.01
Total Points	11

Instrument Properties	Value
Acquisition Mode	Auto
Electrometer Mode	Auto
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto

Insert  
 Up  
 Down  
 Remove  
 Help  
 Advanced





## 6 具体应用讲解

### 6.2 腐蚀模块

#### 6.2.10 Zero Resistance Ammeter (ZRA)—零阻计

Experiment Properties

Actions to be Performed:

Common

ZRA

Properties for ZRA

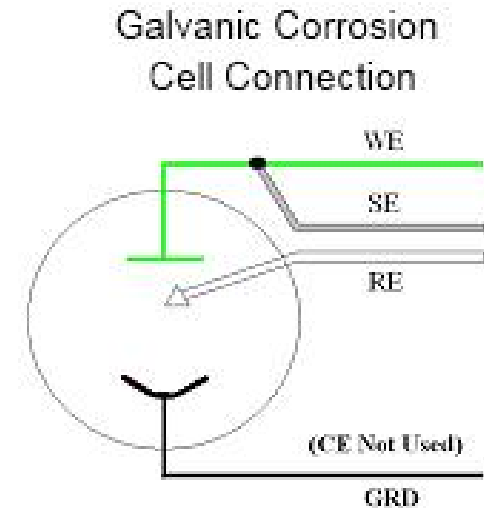
Scan Properties	Value
Time Per Point (s)	.1
Duration (s)	200
Total Points	2000

Instrument Properties	Value
Current Range	Auto
Electrometer Mode	Auto
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto

Limits	Direction	Value
None	≤	0
None	≤	0

Cell Properties	Value
Cell to Use	External

不施加任何电流或电位(cell off), 只测量电流和电位。



电极线接法：CE不用，WE和Ground分别接两不同样品，RE接参比电极。如果是两电极法，则RE和Ground相接，但会带来微弱噪音。

注意：样品与接线一旦连接好，便会产生电流





## 6 具体应用讲解

### 6.2 腐蚀模块

#### 6.2.11 Electrochemical Noise—电化学噪声测量

Experiment Properties

Actions to be Performed: Common

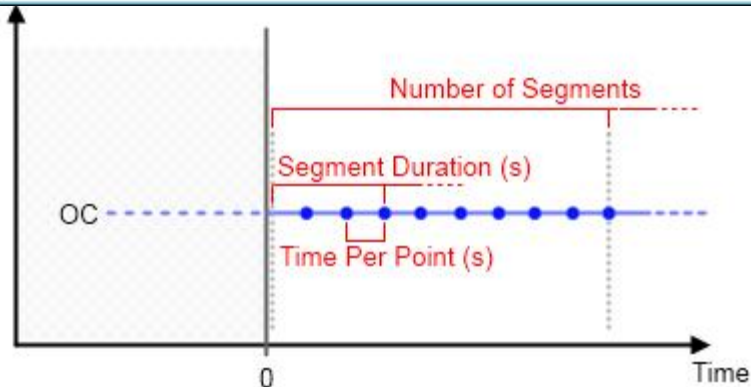
Properties for EN

Scan Properties	Value
Time Per Point (s)	.1
Segment Duration (s)	200
Number of Segments	5
Total Points	10000

Limits	Direction	Value
None	≤	0
None	≤	0

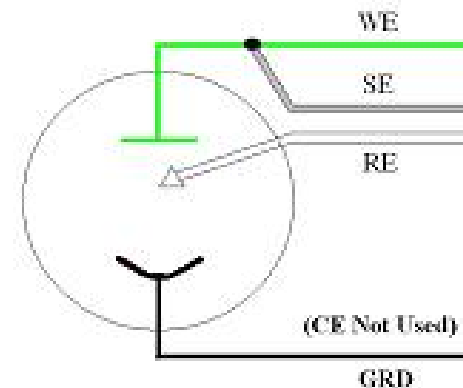
Instrument Properties	Value
Current Range	Auto
Electrometer Mode	Auto
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto

Cell Properties	Value
Cell to Use	External



More Options. more solutions.

#### Galvanic Corrosion Cell Connection



<http://www.par-solartron.com.cn>

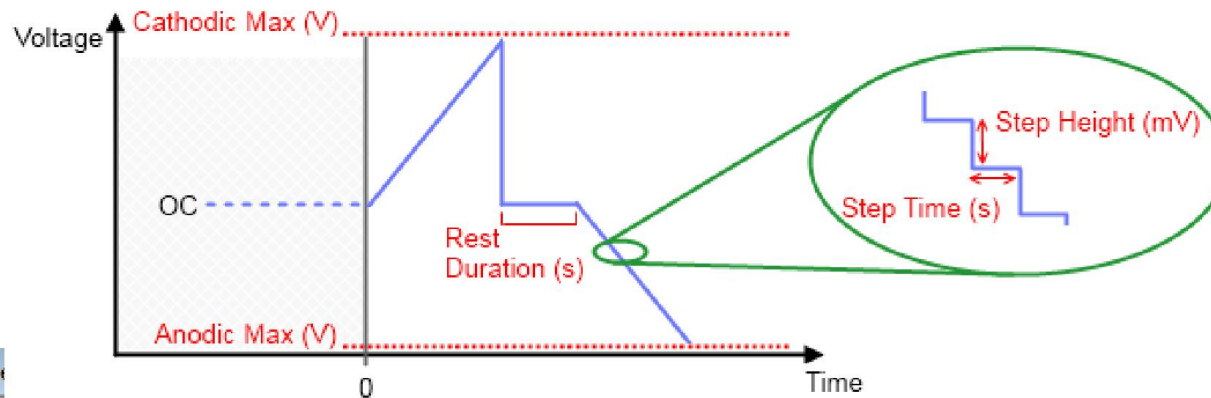




## 6 具体应用讲解

### 6.2 腐蚀模块

#### 6.2.12 Split LPR—分裂线性极化法



Experiment Properties

Insert

Up

Down

Remove

Help

Advanced

**Actions to be Performed:**

- Common
  - Split LPR

**Properties for Split LPR**

Endpoint Properties	Value	Versus	Limits	Direction	Value	Cell Properties	Value
Cathodic Max (V)	-0.02	vs OC	None	≤	0	Leave Cell ON	No
Anodic Max (V)	0.02	vs OC	None	≤	0	Cell to Use	External

Scan Properties	Value
Step Height (mV)	0.1
Step Time (s)	0.6
Rest Duration (s)	200
Rest Drift Rate (mV/min)	0
Scan Rate (mV/s)	0.16666666
Total Points	401

Instrument Properties	Value
Current Range	Auto
Acquisition Mode	Auto
Electrometer Mode	Auto
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto
iR Compensation	Disabled

More Options. More Solutions.



<http://www.par-solartron.com.cn>



## 6 具体应用讲解

### 6.2 腐蚀模块

#### 6.2.13 Galvanic Control LPR—电流控制的线性极化法

Experiment Properties

Actions to be Performed:

- Common
  - Galvanic Control LPR

Properties for Galvanic Control LPR

Step Properties	Value
Initial Current (mA)	0
Final Current (mA)	1

Limits	Direction	Value
None	≤	0
None	≤	0

Cell Properties	Value
Leave Cell ON	No
Cell to Use	External

Scan Properties	Value
Step Height (mA)	0.1
Step Time (s)	10
Scan Rate (mA/s)	0.01
Total Points	11

Instrument Properties	Value
Acquisition Mode	Auto
Electrometer Mode	Auto
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto

用于替代电压控制的线性极化。防止电位失控导致样品烧坏。

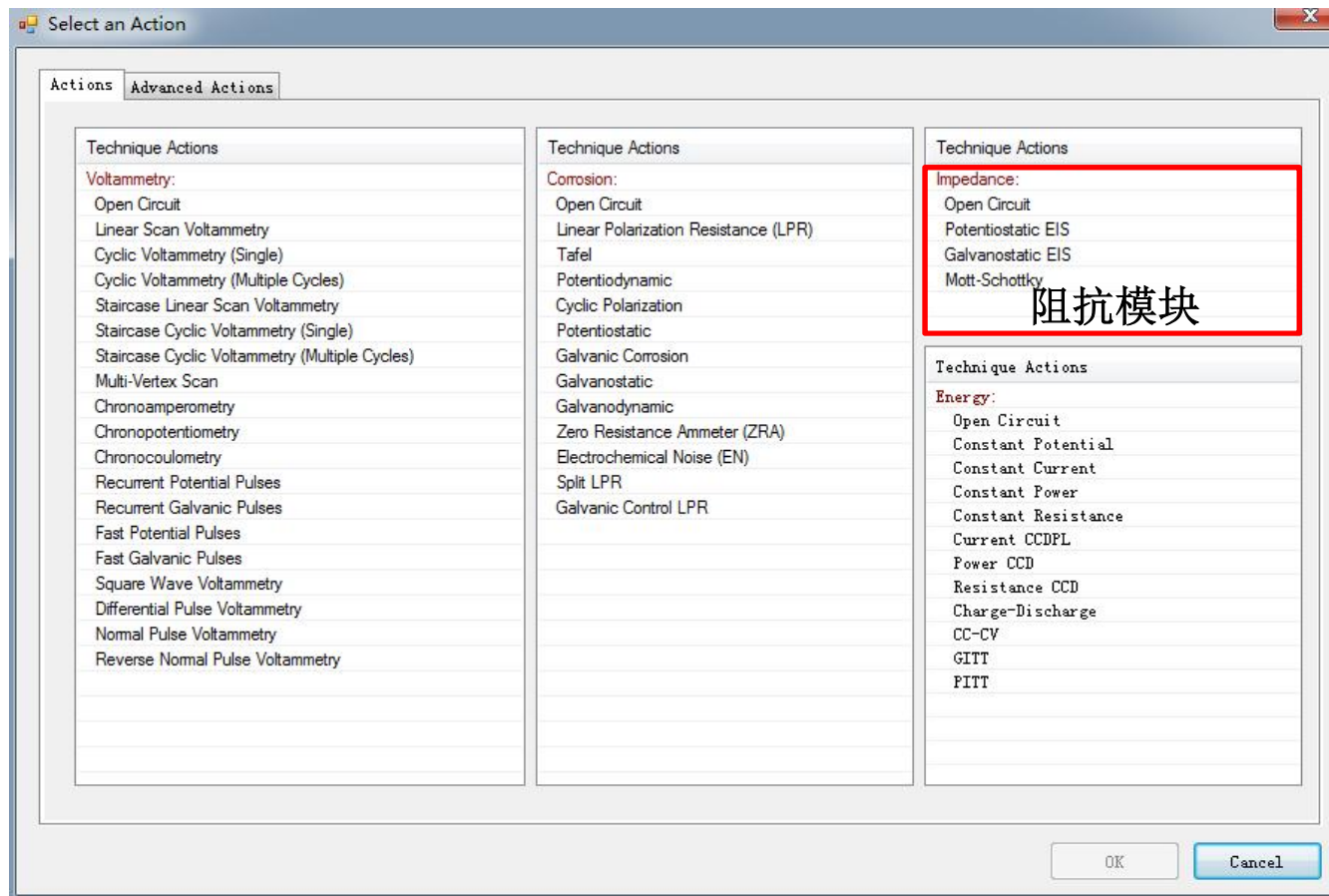
Insert  
Up  
Down  
Remove  
Help  
Advanced





## 6 具体应用讲解

### 6.3 阻抗模块





## 6 具体应用讲解

### 6.3 阻抗模块

#### 6.3.1 Open Circuit----开路电位

**Experiment Properties**

**Actions to be Performed:**

- Common
  - Open Circuit
  - Measure Open Circuit
  - Linear Scan Voltammetry

**Properties for Open Circuit**

Scan Properties	Value
Time Per Point (s)	0.2
Duration (s)	60
Drift Rate (mV/min)	10
Total Points	300

Instrument Properties	Value
Current Range	2mA
Acquisition Mode	Auto
Electrometer Mode	Differential
E Resolution	Auto
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto

Limits	Direction	Value
None	≤	0

Cell Properties	Value
Cell to Use	External

**Drift Rate:** 如果在测量过程中开路电位变化率小于此设定值, 则可认为开路电位已达稳定值, 测量自动结束, 不管时间是否达到设定的**Duration**

Ps: OCP测试过程中软件状态栏会显示Cell Off。测试过程中显示的电流值已经达到仪器分辨率极限, 不能当作有效数据。



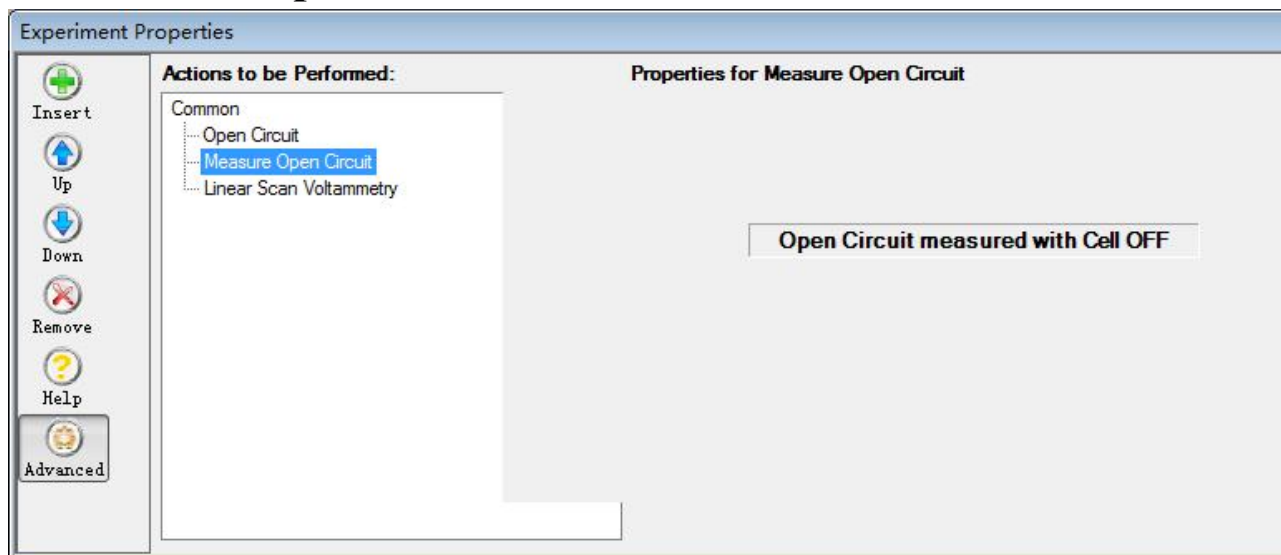




## 6 具体应用讲解

### 6.3 阻抗模块

#### 6.3.1 Open Circuit----开路电位



Or

Equivalent Weight (g)	0
Mass (g)	0
Remeasure OC Per Action	Yes
Measured Open Circuit	0

Ps: 在进行批量实验时，如果在OCP之后的测量中需要设置相对于开路电位的电势参数，则需要在OCP之后插入“Measure Open Circuit”步骤，以更新开路电位的值，或者在Common页面中选择“Remeasure OC per Action”为“Yes”，否则将依旧使用OCP测量之前的值。





## 6 具体应用讲解

### 6.3 阻抗模块

#### 6.3.2 Potentiostatic EIS----基于恒电位的电化学阻抗谱

**起**止频率及交流幅值 (0.1mV-1V)

频率点设置

直流偏压设置, Step为直接加载

这里列出要测量的频率点

AC Properties		Value
Start Frequency (Hz)	1000000	
End Frequency (Hz)	0.01	
Amplitude (mV RMS)	10	

Scan Properties		Value
Point Spacing	Logarithmic	
Number of Points	30	
Points Per Decade	10	
Data Quality	1	
Measurement Delay (s)	0	

DC Properties		
Step or Scan	Step	
Potential (V)	0.1	vs OC

Instrument Properties		Value
Current Range	Auto	
Electrometer Mode	Single Ended	
Bandwidth Limit	Auto	
LCI Bandwidth Limit	Auto	

Cell Properties		Value
Leave Cell ON	No	
Cell to Use	External	

Frequency List (Hz)	
1000000.000000	
794328.234724	
630957.344480	
501187.233627	
398107.170553	
316227.766017	
251188.643151	
199526.231497	
158489.319246	
125892.541179	
100000.000000	
79432.823472	
63095.734448	
50118.723362	

注: Electrometer Mode 建议选择Single Ended





## 6 具体应用讲解

### 6.3 阻抗模块

#### 6.3.2 Potentiostatic EIS----基于恒电位的电化学阻抗谱

Experiment Properties

Actions to be Performed:

Common

Potentiostatic EIS

设置起止频率相同可以实现单一频率测量

单一频率测量时需要设置为“Linear”并指定数据点数。Measurement Delay 可以设置两个相邻测量频率点之间的延时，用于控制数据点获取的速率

Properties for Potentiostatic EIS

AC Properties	Value
Start Frequency (Hz)	100
End Frequency (Hz)	100
Amplitude (mV RMS)	10

DC Properties	Value	Versus
Step or Scan	Scan	
Initial Potential (V)	0	vs OC
Final Potential (V)	0.2	vs OC

Scan Properties	Value
Point Spacing	Linear
Number of Points	20
Points Per Decade	10
Data Quality	1
Measurement Delay (s)	300
Scan Rate (V/s)	0.01

Instrument Properties	Value
Current Range	Auto
Electrometer Mode	Single Ended
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto

Cell Properties	Value
Leave Cell ON	No
Cell to Use	External

Frequency List (Hz)

100.000000  
100.000000  
100.000000  
100.000000  
100.000000  
100.000000  
100.000000  
100.000000  
100.000000  
100.000000  
100.000000  
100.000000  
100.000000  
100.000000  
100.000000  
100.000000  
100.000000  
100.000000  
100.000000  
100.000000

直流偏压加载方式还可以设置为从初始电位以指定速率增加至最终电位并保持恒定，以防直接加载直流偏压相对于开路电位较大时导致电流过载，比如超级电容器等容性体系





## 6 具体应用讲解

### 6.3 阻抗模块

#### 6.3.2 Potentiostatic EIS----基于恒电位的电化学阻抗谱

Experiment Properties

Actions to be Performed:

- Common
  - Potentiostatic EIS
    - Loop #1
      - Potentiostatic EIS

Properties for Potentiostatic EIS

AC Properties	Value
Start Frequency (Hz)	10000
End Frequency (Hz)	1
Amplitude (mV RMS)	10

DC Properties	Value	Versus
Step or Scan	Step	
Potential (V)	0.02	vs Previc

Scan Properties	Value
Point Spacing	Logarithmic
Number of Points	30
Points Per Decade	10
Data Quality	1
Measurement Delay (s)	0

Frequency List (Hz)
10000.000000
7943.282347
6309.573445

Control Panel: Insert, Up, Down, Remove, Help, Advanced

阻抗测量的灵活设置

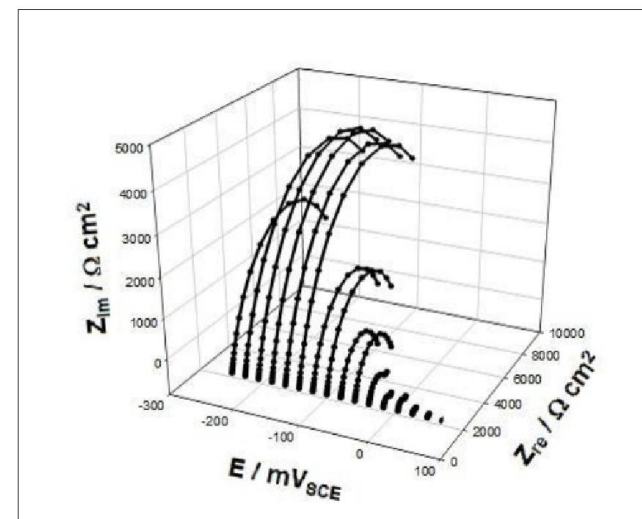


Figure 5. Electrochemical impedance versus potential diagrams measured for a bronze sample immersed in artificial rainwater at 25°C.







## 6 具体应用讲解

### 6.3 阻抗模块

#### 6.3.2 Galvanostatic EIS----基于恒电流的电化学阻抗谱

设置直流偏置电流

根据体系阻抗大小，注意选择合适的交流电流幅值，使得所产生的交流电压在1mV量级以上。适用于低阻抗体系，防止电流过载。

Experiment Properties

Actions to be Performed:

- Common
  - Galvanostatic EIS

Properties for Galvanostatic EIS

AC Properties	Value
Start Frequency (Hz)	100000
End Frequency (Hz)	0.1
Amplitude (uA RMS)	100

DC Properties	Value
Current (A)	0

Instrument Properties	Value
Electrometer Mode	Single Ended
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto

Cell Properties	Value
Leave Cell ON	No
Cell to Use	External

Frequency List (Hz)
100000.000000
79432.823472
63095.734448
50118.723363
39810.717055
31622.776602
25118.864315
19952.623150
15848.931925
12589.254118
10000.000000





## 6 具体应用讲解

### 6.3 阻抗模块

#### 6.3.2 Mott-Schottky----莫特-肖特基曲线

Experiment Properties

Actions to be Performed: Mott-Schottky

Properties for Mott-Schottky		
AC Properties	Value	
Start Frequency (Hz)	1000	
End Frequency (Hz)	1000	
Amplitude (mv RMS)	10	

DC Properties	Value	Versus
Initial Potential (V)	0	vs Ref
Final Potential (V)	1	vs Ref
Number of Steps	20	

Instrument Properties	Value
Current Range	Auto
Electrometer Mode	Single Ended
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto

Cell Properties	Value
Leave Cell ON	No
Cell to Use	External

Frequency List (Hz)	
1000.000000	

起  
止  
频  
率  
必  
须  
相  
同,  
建  
议  
在  
1KHz  
以  
上

设置电压扫描范围

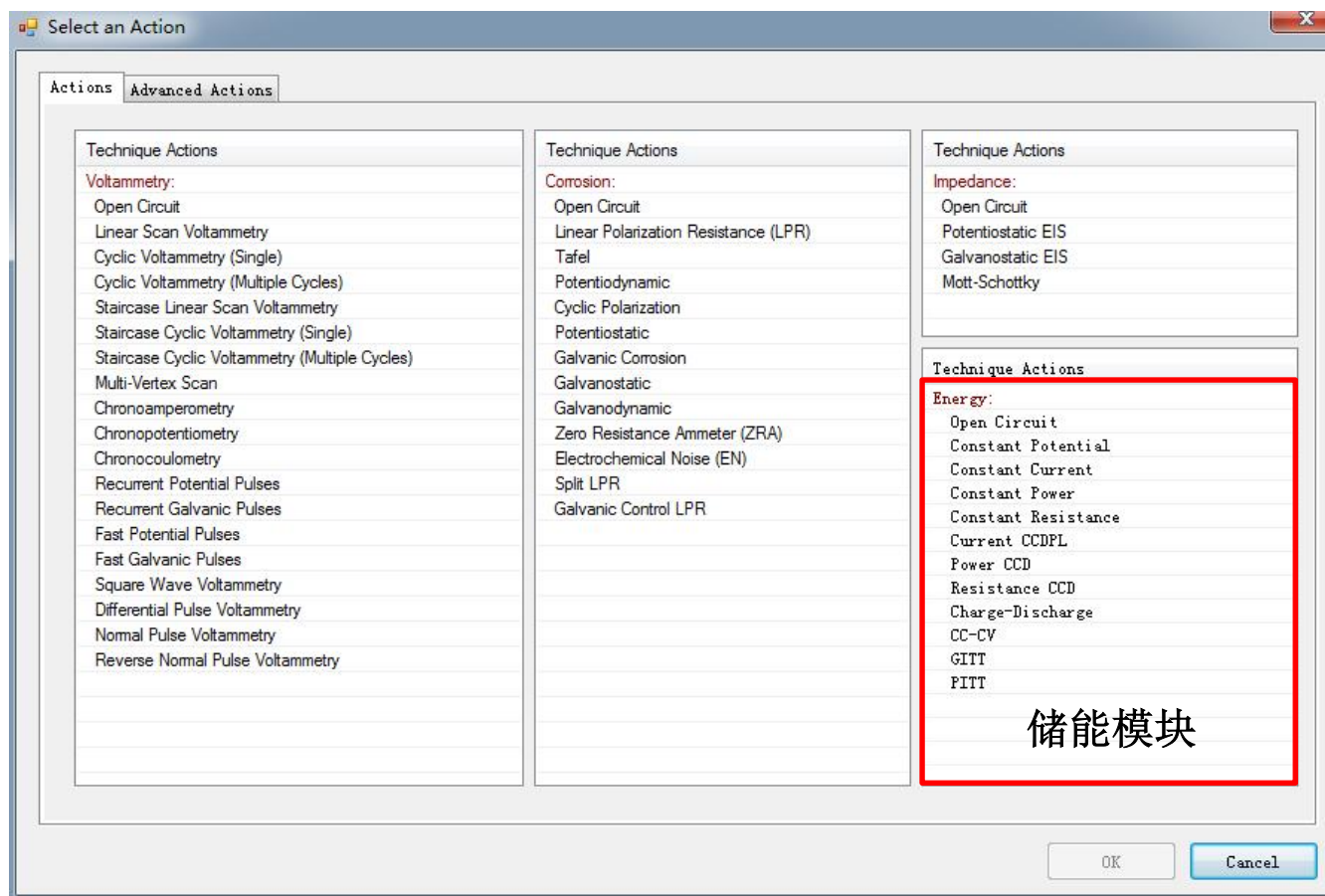
建议选择不同频率多测量几组数据, 保证所选频率对结果参数影响较小





## 6 具体应用讲解

### 6.4 储能模块





## 6 具体应用讲解

### 6.4 储能模块

#### 6.4.1 Energy Open Circuit----开路电位

Experiment Properties

Actions to be Performed:

- Energy Open Circuit
- Measure Open Circuit
- Linear Scan Voltammetry

Properties for Energy Open Circuit

Scan Properties	Value
Time Per Point (s)	0.2
Duration (s)	60
Drift Rate (mV/min)	10
Delta Resolution	10
Delta E (mV)	0
Min. Tot	300
Max	300

Instrument Properties	Value
Current Range	2mA
Acquisition Mode	Auto
Electrometer Mode	Differential
E Resolution	Auto
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto

Limits	Direction	Value
None	≤	0

Cell Properties	Value
Cell to Use	External

**Drift Rate:** 如果在测量过程中开路电位变化率小于此设定值,则可认为开路电位已达稳定值,测量自动结束,不管时间是否达到设定的Duration

Ps: OCP测试过程中软件状态栏会显示Cell Off。测试过程中显示的电流值已经达到仪器分辨率极限,不能当作有效数据。



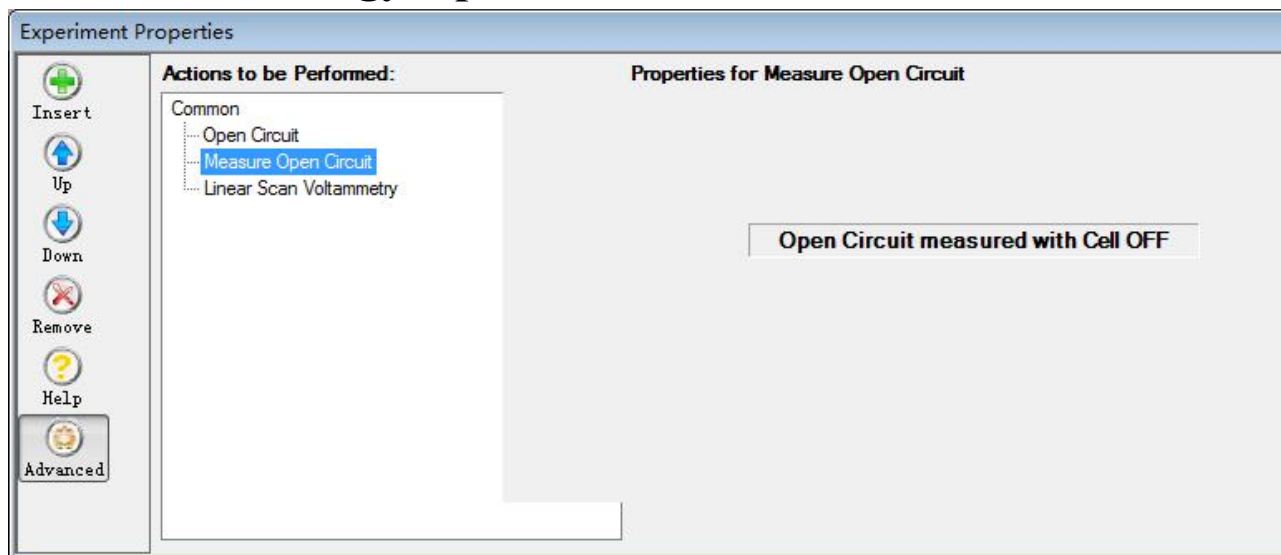




## 6 具体应用讲解

### 6.4 储能模块

#### 6.4.1 Energy Open Circuit----开路电位



Or

Equivalent Weight (g)	0
Mass (g)	0
Remeasure OC Per Action	Yes
Measured Open Circuit	0

Ps: 在进行批量实验时，如果在OCP之后的测量中需要设置相对于开路电位的电势参数，则需要在OCP之后插入“Measure Open Circuit”步骤，以更新开路电位的值，或者在Common页面中选择“Remeasure OC per Action”为“Yes”，否则将依旧使用OCP测量之前的值。





## 6 具体应用讲解

### 6.4 储能模块

#### 6.4.2 Constant Potential----恒电压充/放电

Experiment Properties - Data Acquired Monday, July 23, 2012 at 8:54:36 AM

Insert

Up

Down

Remove

Help

Advanced

**Actions to be Performed:**

Common

Constant Potential

在序列实验中，若Accrue Q设置为Yes，则上一步骤的电荷Q会累计到这一步中，多用于电池的充电测试中

Properties for Constant Potential		
Step Properties	Value	Versus
Potential (V)	-0.05	vs OC
Accrue Q	Yes	

Limits	Direction	Value
None	≤	0
None	≤	0

Cell Properties	Value
Leave Cell ON	No
Cell to Use	External

Scan Properties	Value
Time Per Point (s)	1
Duration (s)	600
Delta Resolution	5
Delta I (mA)	0.5
Delta Q (mAh)	1
Min. Total Points	601
Max Total Points	3000

Properties	Value
Current(A)	2A
Potential(V)	
Capacity(mAh)	
Aux Input(V)	Auto
Electrometer Mode	Differential
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto
iR Compensation	Disabled

在此例中，Time per Point=1s，Data Resolution=5，除每隔1秒采集数据外，每0.2s系统还会检测Delta I或Delta Q是否达到设定值，若达到设定值则记录此刻的数据





## 6 具体应用讲解

### 6.4 储能模块

#### 6.4.3 Constant Current----恒电流充/放电

Experiment Properties - Data Acquired Monday, July 23, 2012 at 11:33:49 AM

Insert

Up

Down

Remove

Help

Advanced

**Actions to be Performed:**

Common

Constant Current

此方法用于测试电池充放电至某一指定电压或容量

Step Properties		Value
Current (A)		-0.1

Instrument Properties		Value
Acquisition Mode		Average
Electrometer Mode		Auto 4/4
E Filter		Average
I Filter		None
Bandwidth Limit		Auto
LCI Bandwidth Limit		Auto

Scan Properties		Value
Time Per Point (s)		10
Duration (s)		1000
Delta Resolution		100
Delta E (mV)		1
Delta Q (mAh)		0
Min. Total Points		101
Max Total Points		10000

Cell Properties		Value
Leave Cell ON		No
Cell to Use		External

Limits	Direction	Value
Potential(V)	≤	1.2
None	≤	0

**Acquisition Mode: 4/4**表示采用每一指定的Time per Point末端时刻的值作为数据点；**Average**表示在每一指定的Time per Point时间内以最快速率（10μs）读取数据点，并将最后50%数据点的平均值作为此时间间隔的数据



## 6 具体应用讲解

### 6.4 储能模块

#### 6.4.3 Constant Current----恒电流充/放电

**Experiment Properties**

**Actions to be Performed:**

- Common
  - Constant Current

**Properties for Constant Current**

Step Properties	Value
C-Rate (C)	0.1
Current	Discharging
ICapacity (mAh)	100
Applied I (mA)	-10

Scan Properties	Value
Time Per Point (s)	1
Duration (s)	10
Delta Resolution	10
Delta E (V)	0
Delta Q (mAh)	
Min. Total Points	10
Max Total Points	10

Cell Properties	Value
Leave Cell ON	No
Cell to Use	External

Instrument Properties	Value
Acquisition Mode	Auto
Electrometer Mode	Differential
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto

Limits	Direction	Value
None	≤	0
None	≤	0

**Callout 1:** 此外，电流大小还可以用倍率来设置，且需设定容量大小，系统自动计算电流值

**Callout 2:** Discharge则电流为 - ， charge则电流为 +

$$1 C = 1 \text{ Capacity/h}$$







## 6 具体应用讲解

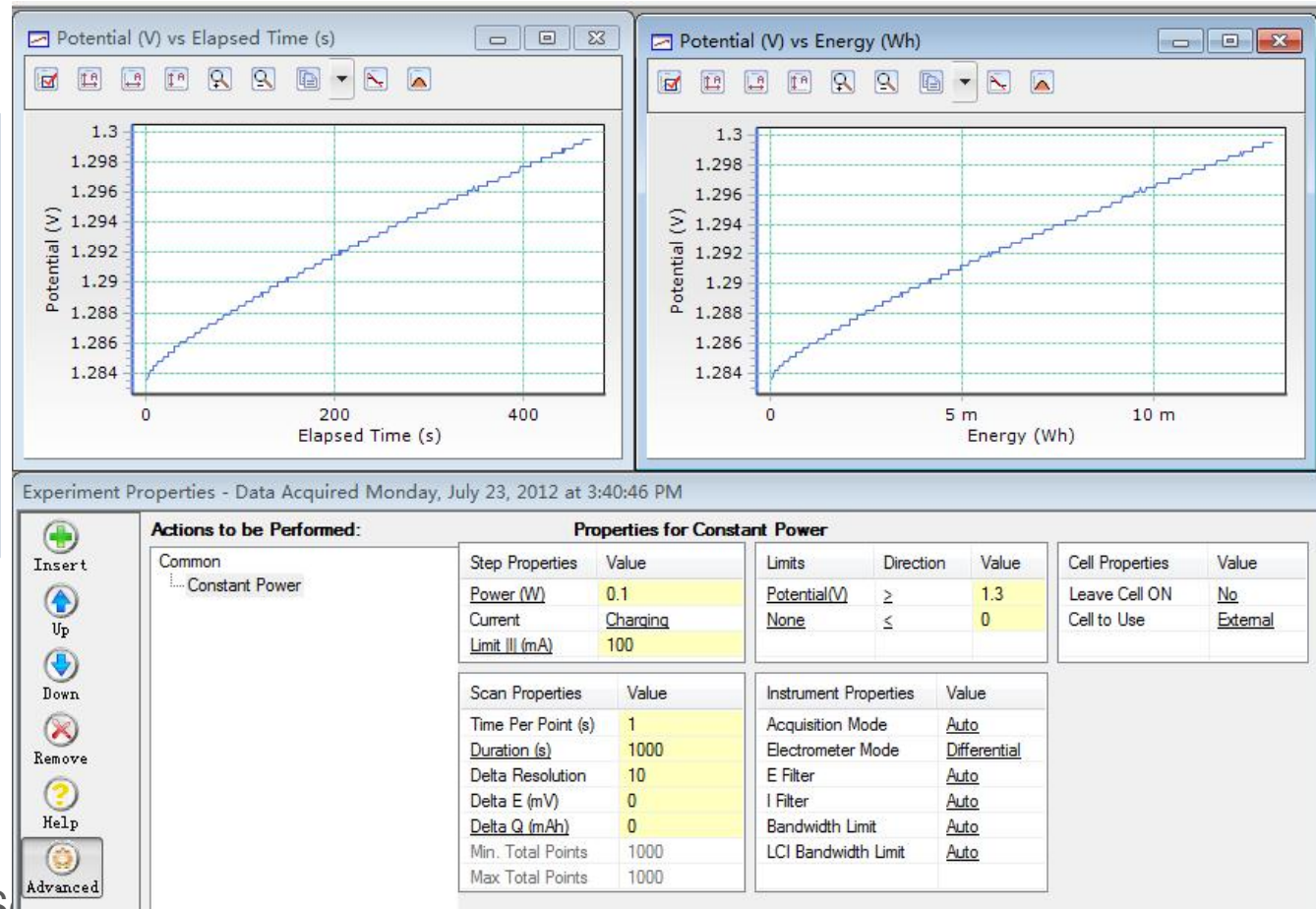
### 6.4 储能模块

#### 6.4.4 Constant Power----恒功率充/放电

$$P=U \times I$$

$$U=OCP$$

工作站实时监测电池端电压，并调整电流实现恒功率，用于电池充放电至某一指定电压或容量





## 6 具体应用讲解

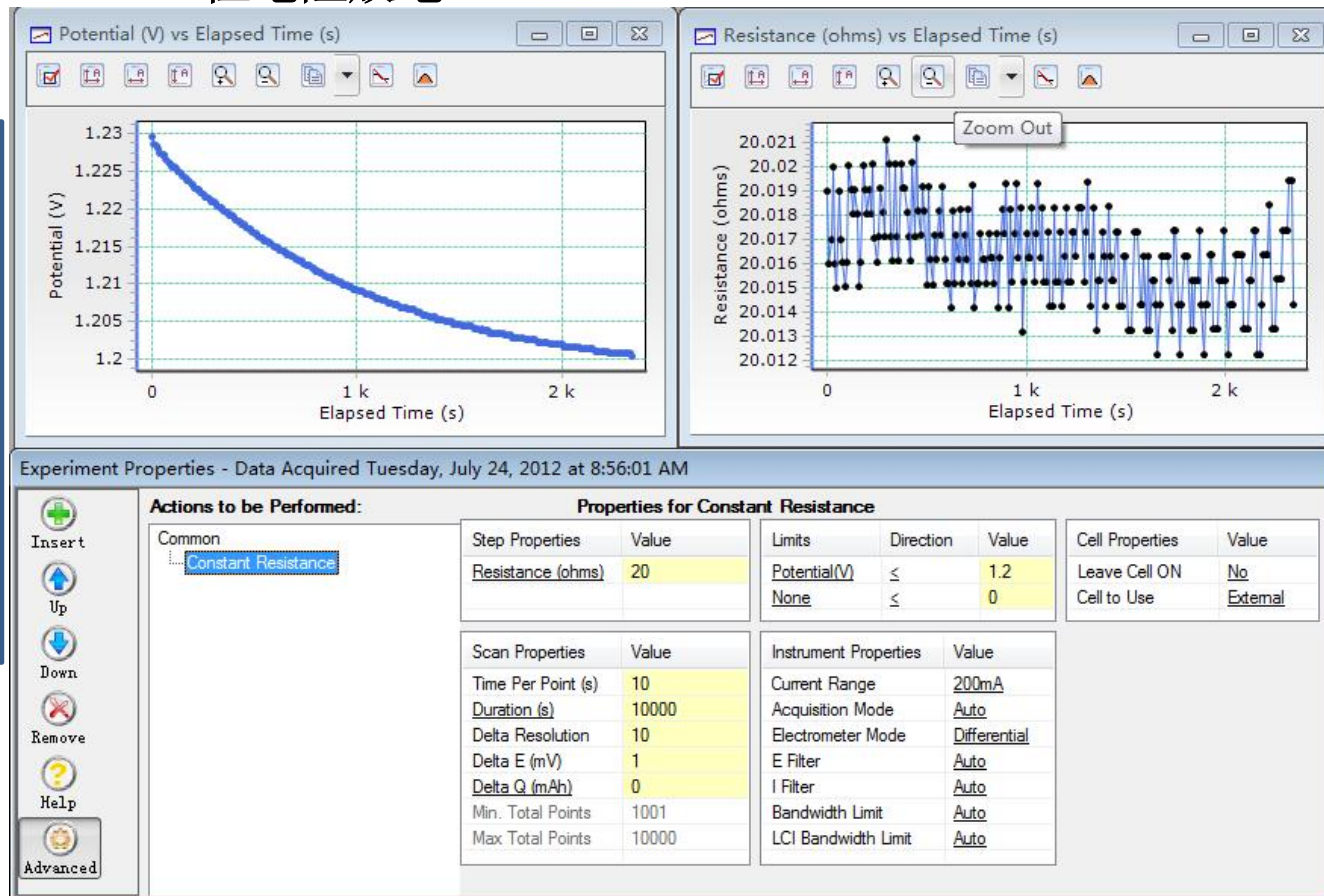
### 6.4 储能模块

#### 6.4.5 Constant Resistance----恒电阻放电

$$R=U/I$$

$$U=OCP$$

工作站实时监测电池端电压，并调整电流实现恒电阻，用于电池放电至某一指定电压或容量（注：只可放电，不可充电）





## 6 具体应用讲解

### 6.4 储能模块

#### 6.4.6 Current CCDPL (Cyclic Charge-Discharge with Potential Limitation)

----电压限制的恒电流充放电循环

Experiment Properties - Data Acquired Thursday, July 19, 2012 at 5:25:42 PM

**Actions to be Performed:**

Common

- Loop #1
  - Constant Current
  - Constant Potential
  - Energy Open Circuit
  - Constant Current
  - Constant Potential
  - Energy Open Circuit

**Properties for Loop #1**

Properties	Value
<input checked="" type="checkbox"/> Number of Iterations	10
<input type="checkbox"/> Time (H:M:S)	00:00:00

设置循环次数及时间长度

每一循环由6个步骤组成：  
 恒电流放电→恒电压放电  
 →开路电位→恒电流充电  
 →恒电压充电→开路电位。  
 亦可根据电池循环需要添加或删除某些步骤







## 6 具体应用讲解

### 6.4 储能模块

#### 6.4.6 Current CCDPL (Cyclic Charge-Discharge with Potential Limitation)

----电压限制的恒电流充放电循环

电压限制是指在恒电流充（放）电达到限定的电压时改用该电压恒电压充（放）电

Experiment Properties - Data Acquired Thursday, July 19, 2012 at 5:25:42 PM

**Actions to be Performed:**

- Common
  - Loop #1
    - Constant Current
    - Constant Potential
    - Energy Open Circuit
    - Constant Current
    - Constant Potential
    - Energy Open Circuit

**Properties for Constant Current**

Step Properties	Value
Current (mA)	-500

Instrument Properties	Value
Acquisition Mode	Auto
Electrometer Mode	Differential
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto

Scan Properties	Value
Time Per Point (s)	10
Duration (s)	10000
Delta Resolution	10
Delta E (mV)	1
Delta Q (mAh)	0
Min. Total Points	1001
Max Total Points	10000

Limits	Direction	Value
Potential(V)	≤	2.8
None	≤	0

Experiment Properties - Data Acquired Thursday, July 19, 2012 at 5:25:42 PM

**Actions to be Performed:**

- Common
  - Loop #1
    - Constant Current
    - Constant Potential
    - Energy Open Circuit
    - Constant Current
    - Constant Potential
    - Energy Open Circuit

**Properties for Constant Potential**

Step Properties	Value	Versus
Potential (V)	0	vs Previ...
Accrue Q	No	

Limits	Direction	Value
None	≤	0
None	≤	0

Cell Properties	Value
Leave Cell ON	No
Cell to Use	External

Scan Properties	Value
Time Per Point (s)	1
Duration (s)	10

Instrument Properties	Value
Current Range	2A
Acquisition Mode	Auto

More Options. More Solutions.



<http://www.par-solartron.com.cn>





## 6 具体应用讲解

### 6.4 储能模块

#### 6.4.7 Power CCD (Cyclic Charge-Discharge) ----恒功率充放电循环

**设置循环次数及时间长度**

每一循环由4个步骤组成：  
恒功率放电→开路电位→  
恒电流充电→开路电位。  
亦可根据循环需要添加或  
删除某些步骤





## 6 具体应用讲解

### 6.4 储能模块

#### 6.4.7 Power CCD (Cyclic Charge-Discharge)----恒功率充放电循环

恒功率放电至指定电压，然后恒电流充电至另一指定电压

Experiment Properties - Data Acquired Saturday, July 14, 2012 at 11:14:26 AM

Actions to be Performed:		Properties for Constant Power				
Common		Step Properties	Value	Limits	Direction	Value
Loop #1	Constant Power	Power (W)	0.02	Potential(V)	≤	0.5
	Energy Open Circuit	Current	Discharging	None	≤	0
	Constant Current	Limit III (mA)	50			

Experiment Properties - Data Acquired Saturday, July 14, 2012 at 11:14:26 AM

Actions to be Performed:		Properties for Constant Current		Instrument Properties		Value	
Common		Step Properties	Value	Acquisition Mode	Auto		
Loop #1	Constant Current	Current (A)	0.05	Electrometer Mode	Auto		
	Energy Open Circuit			E Filter	Auto		
	Constant Power			I Filter	Auto		
	Energy Open Circuit			Bandwidth Limit	Auto		
				LCI Bandwidth Limit	Auto		

Limits	Direction	Value
Potential(V)	≥	2
None	≤	0

More Options. More Solutions.



<http://www.par-solartron.com.cn>



## 6 具体应用讲解

### 6.4 储能模块

#### 6.4.8 Resistance CCD (Cyclic Charge-Discharge) ----恒电阻充放电循环

Experiment Properties - Data Acquired Sunday, July 15, 2012 at 5:04:56 PM

**Actions to be Performed:**

Common

- [-] Loop #1
  - ... Constant Resistance
  - ... Energy Open Circuit
  - ... Constant Current
  - ... Energy Open Circuit

**Properties for Loop #1**

Properties	Value
<input checked="" type="checkbox"/> Number of Iterations	10
<input type="checkbox"/> Time (H:M:S)	00:00:00

Resistance (ohms) vs Elapsed Time (s)

设置循环次数及时间长度

每一循环由4个步骤组成：  
恒电阻放电→开路电位→  
恒电流充电→开路电位。  
亦可根据循环需要添加  
或删除某些步骤







## 6 具体应用讲解

### 6.4 储能模块

#### 6.4.8 Resistance CCD (Cyclic Charge-Discharge)----恒电阻充放电循环

每一循环由恒电阻放电至指定电压，然后恒电流充电至另一指定电压

Experiment Properties - Data Acquired Sunday, July 15, 2012 at 5:04:56 PM

**Actions to be Performed:**

**Properties for Constant Resistance**

Step Properties	Value	Limits	Direction	Value
Resistance (ohms)	50	Potential(V)	≤	1
		None	≤	0

Experiment Properties - Data Acquired Sunday, July 15, 2012 at 5:04:56 PM

**Actions to be Performed:**

**Properties for Constant Current**

Step Properties	Value
Current (A)	0.05

Scan Properties	Value
Time Per Point (s)	0.1
Duration (s)	5000
Delta Resolution	10
Delta E (mV)	0
Delta Q (mAh)	0
Min. Total Points	50000
Max Total Points	50000

Limits	Direction	Value
Potential(V)	≥	2
None	≤	0







## 6 具体应用讲解

### 6.4 储能模块

#### 6.4.9 Charge-Discharge---充放电循环

设置循环次数及时间长度

每一循环由恒电流充电、恒电压充电、恒电流放电组成

Properties	Value
<input checked="" type="checkbox"/> Number of Iterations	10
<input type="checkbox"/> Time (H:M:S)	00:00:00

Step Properties	Value
Current (mA)	100

Instrument Properties	Value
Acquisition Mode	Auto
Electrometer Mode	Differential
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto

Scan Properties	Value
Time Per Point (s)	1
Duration (s)	10
Delta Resolution	10
Delta E (mV)	0
Delta Q (mAh)	0
Min. Total Points	10
Max Total Points	10

Limits	Direction	Value
Potential(V)	>	3
None	≤	0





## 6 具体应用讲解

### 6.4 储能模块

#### 6.4.9 Charge-Discharge---充放电循环

**Properties for Constant Potential**

Step Properties	Value	Versus	Limits	Direction	Value
Potential (V)	0	vs Previ...	Current(A)	≤	0.0001
Accrue Q	Yes		Capacity(mAh)	≥	100

**Properties for Constant Current**

Step Properties	Value	Scan Properties	Value
Current (mA)	-100	Time Per Point (s)	1
		Duration (s)	10
		Delta Resolution	10
		Delta E (mV)	0
		Delta Q (mAh)	0
		Min. Total Points	10
		Max Total Points	10

Limits	Direction	Value
Potential(V)	≤	2
None	≤	0

**Callout 1 (Left):** 一般为上一充电终止电压

**Callout 2 (Right):** 恒压充电至指定容量或电流极限





## 6 具体应用讲解

### 6.4 储能模块

#### 6.4.10 CC-CV (Constant Current – Constant Voltage) ----恒电流恒电压充放电

Experiment Properties

+  
Insert

↑  
Up

↓  
Down

✖  
Remove

?  
Help

⚙  
Advanced

**Actions to be Performed:**

Common

CC-CV

Properties for CC-CV

Step Properties	Value	Versus	Scan Properties	Value
Current (mA)	10		Time Per Point (s)	1
Potential (V)	0	vs Previ...	Duration (s)	10
Accrue Q	Yes		Delta Resolution	10
			Delta E (mV)	0
			Delta I (mA)	0
			Delta Q (mAh)	0
			Min. Total Points	20
			Max Total Points	20

Instrument Properties	Value	Cell Properties	Value
Current Range	2A	Leave Cell ON	No
Acquisition Mode	Auto	Cell to Use	External
Electrometer Mode	Differential		
E Filter	Auto		
I Filter	Auto		
Bandwidth Limit	Auto		
LCI Bandwidth Limit	Auto		

CC Limits	Direction	Value	CV Limits	Direction	Value
Potential(V)	≥	3.5	Capacity(mAh)	≥	1150
None	≤	0	None	≤	0

将恒电流充放电和恒电压充放电集成与一个方法中，即先进行恒电流充放电，再进行恒电压充放电。一般用于电池充电

注意：正在执行CC步骤时按下“Skip”则进入CV步骤





## 6 具体应用讲解

### 6.4 储能模块

#### 6.4.10 GITT (Galvanostatic Intermittent Titration Technique) ----恒电流间歇滴定技术

Experiment Properties

Actions to be Performed:

- Common
  - Loop #1
    - Constant Current
    - Energy Open Circuit

Properties for Constant Current

Step Properties	Value
Current (mA)	10

Instrument Properties	Value
Acquisition Mode	Auto
Electrometer Mode	Differential
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto

Scan Properties	Value
Time Per Point (s)	1
Duration (s)	10
Delta Resolution	10
Delta E (mV)	0
Delta Q (mAh)	0
Min. Total Points	10
Max Total Points	10

Cell Properties	Value
Leave Cell ON	No
Cell to Use	External

Limits	Direction	Value
None	≤	0
None	≤	0

每一循环先恒电流充电，然后测定开路电压弛豫

此方法可用于分析固溶相中嵌入/脱嵌过程动力学的性质。从开路电压稳定性可进一步分析出嵌入/脱嵌的可逆性。







## 6 具体应用讲解

### 6.4 储能模块

#### 6.4.11 PITT (Potentiostatic Intermittent Titration Technique) ----恒电压间歇滴定技术

Experiment Properties

Insert

Up

Down

Remove

Help

Advanced

**Actions to be Performed:**

Common

- Loop #1
  - Constant Potential

**Properties for Constant Potential**

Step Properties	Value	Versus
Potential (V)	0	vs OC
Accrue Q	No	

Limits	Direction	Value
None	≤	0
None	≤	0

Cell Properties	Value
Leave Cell ON	No
Cell to Use	External

Scan Properties	Value
Time Per Point (s)	1
Duration (s)	10
Delta Resolution	10
Delta I (mA)	0
Delta Q (mAh)	0
Min. Total Points	10
Max Total Points	10

Instrument Properties	Value
Current Range	2A
Acquisition Mode	Auto
Electrometer Mode	Differential
E Filter	Auto
I Filter	Auto
Bandwidth Limit	Auto
LCI Bandwidth Limit	Auto
iR Compensation	Disabled

恒电压循环:第一个循环电压为平衡电压,此后每一循环电压较之上一循环增加一个很小值。用于测定固溶相中嵌入/脱嵌动力学参数以及不同电位下离子嵌入或脱出的摩尔数





更多信息请访问：[www.par-solartron.com.cn](http://www.par-solartron.com.cn)

如有疑问，欢迎拨打免费热线

**400 1100 282**

如需订购，欢迎拨打销售热线

**400 1100 281**

欢迎加入用户QQ群进行讨论

**184416704**

**感谢您的关注！**

