SEY test for SPPC

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Outline

- Introduction
- Test principle
- Secondary electron yield test equipment with high precision
- SEY test results
- Comparison with foreign labs
- Future plans

Introduction

- **Suppression of second electron emission**
  - clearing electrode
  - coating with low SEY material, amorphous carbon coating, etc.
  - weak solenoid field (10-20 G) along the vacuum chamber to keep e-cloud separated from beam path;
  - SEY test and surface impedance measurement under low temperature and high magnet field;
  - grooves on the wall of vacuum chamber to enhance electron loss near wall of the vacuum chamber
- **SEY test is an important means of characterization.**

Test principle 1

- A secondary electron emission measurement system with 50eV~5000eV low energy electron gun has been designed and used to measure the SEY of different materials.
- $\sigma = 1 - I_t / I_p$
- I_p, is measured by applying a +150 V bias voltage that recaptures all secondary electrons. The total current I_t is measured by applying -40 V bias voltage that repels all low energy secondary electrons. So the secondary emission current is given by $I_{SEY} = I_t - I_p$.

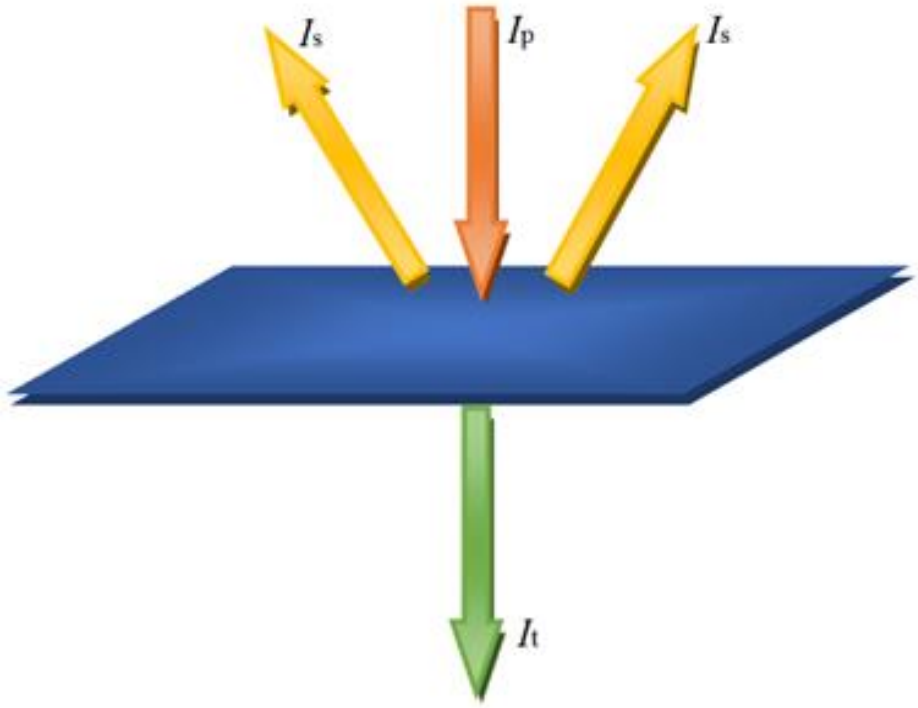
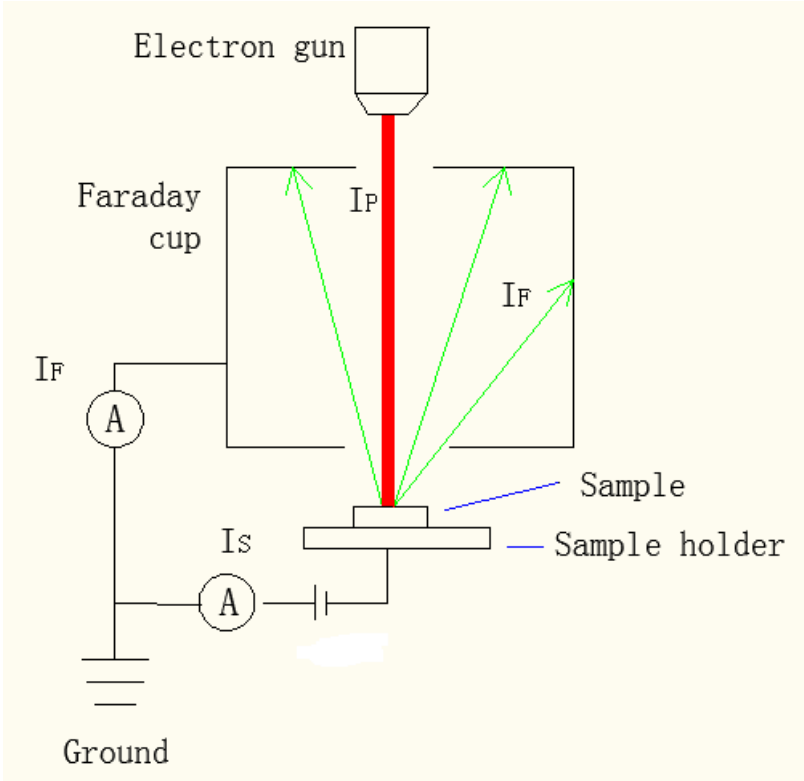


Fig.1 The schematic diagram of SEY test.

Test principle 2

$$\delta_{\mathrm{SEY}} = \frac{\boldsymbol{I}_f}{\boldsymbol{I}_\mathrm{p}} = \frac{I_\mathrm{f}}{(I_\mathrm{f} + I_\mathrm{s})}$$

The SEY is the ratio of the current of secondary electrons, $\boldsymbol{I}_{\mathrm{SEY}}$, to the current of incident electrons, $\boldsymbol{I}_\mathrm{p}$. Sample-to-ground current $\boldsymbol{I}_\mathrm{s}$ measured at the sample and faraday cup-to-ground current $\boldsymbol{I}_\mathrm{f}$ are measured by Keithley 2400 Source Meter.



Schematic diagram of secondary electron test equipment.

Secondary electron yield test equipment with high precision

- **A secondary electron emission measurement system with 50eV~5000eV low energy electron gun has been designed and used to measure the SEY of different materials.**
- **The SEY of stainless steel and oxygen free copper (OFC) were obtained. The maximum SEY of stainless steel and OFC are 1.78 and 1.943.**
- **Compared with the results of other research institutions.**
- **The SEY test-stand is mainly composed of vacuum chamber, electron gun, Turbo molecular pump, ion pump, sample holder, data collection system and power system.**

Secondary electron yield test equipment with high precision

- 电子枪

- 选用EGL-2022B（KIMBALL）电子枪以满足实验要求，其束流能量为50eV～5000eV，发射电流为1nA～100μA，标准工作距离为20mm，束斑半径为1mm～5mm，发射电子密度为10^{-5}～10^{-4}C•mm^{-2},有恒流和脉冲两种工作方式。电子枪设计为竖直放置于样品正上方，使电子束垂直入射到样品表面。

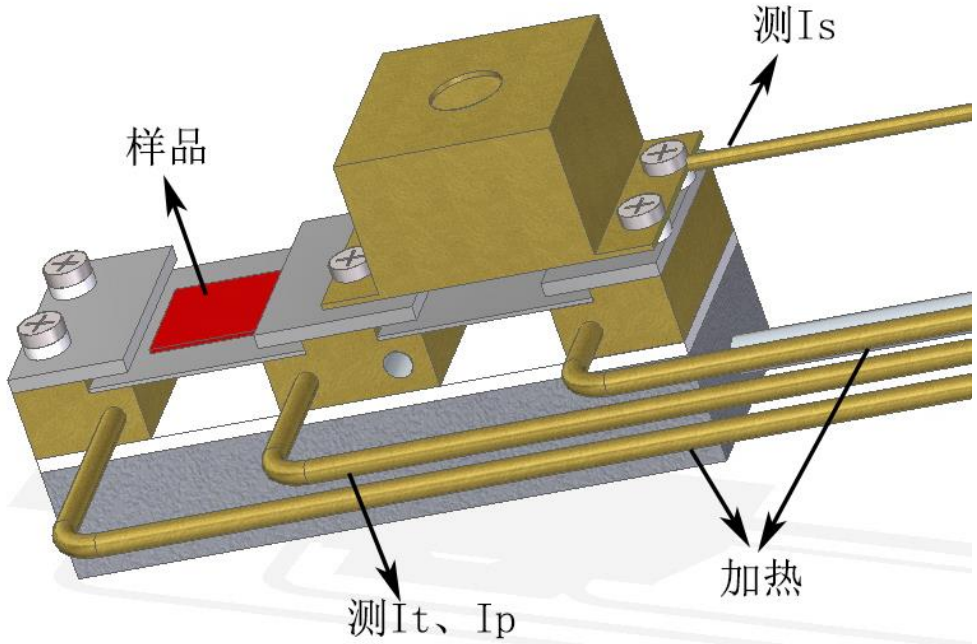
Secondary electron yield test equipment with high precision

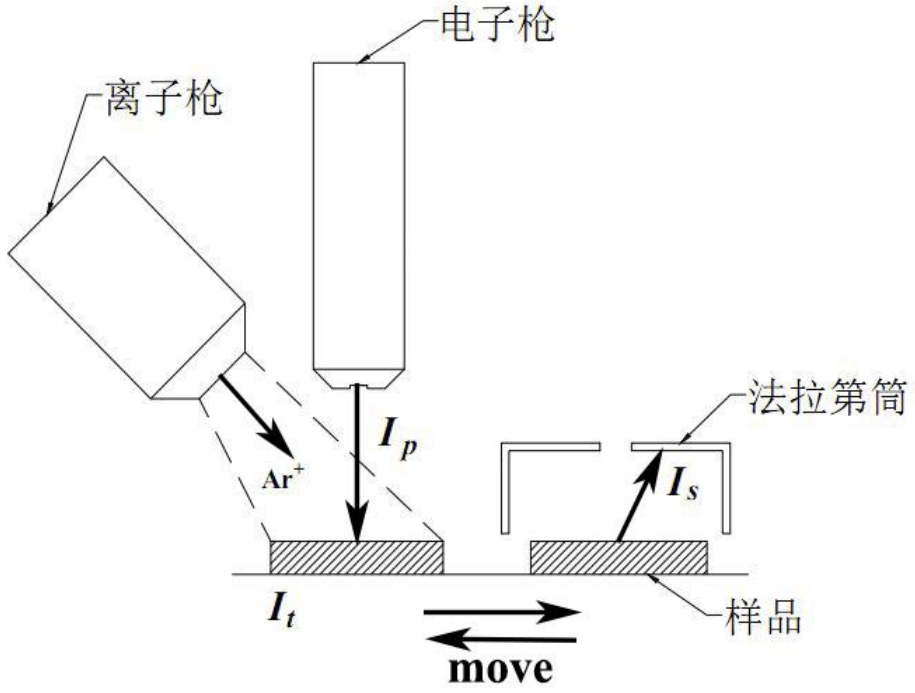
- 离子枪

- 采用IS40C1(PREVAC)离子枪对样品表面进行处理。离子枪位于电子枪左方45°位置，工作距离为80mm。此外，该离子枪还可以进行绝缘样品测试时的离子中和，同样可以提高绝缘材料二次电子产额测试精度。

Secondary electron yield test equipment with high precision

- 样品架





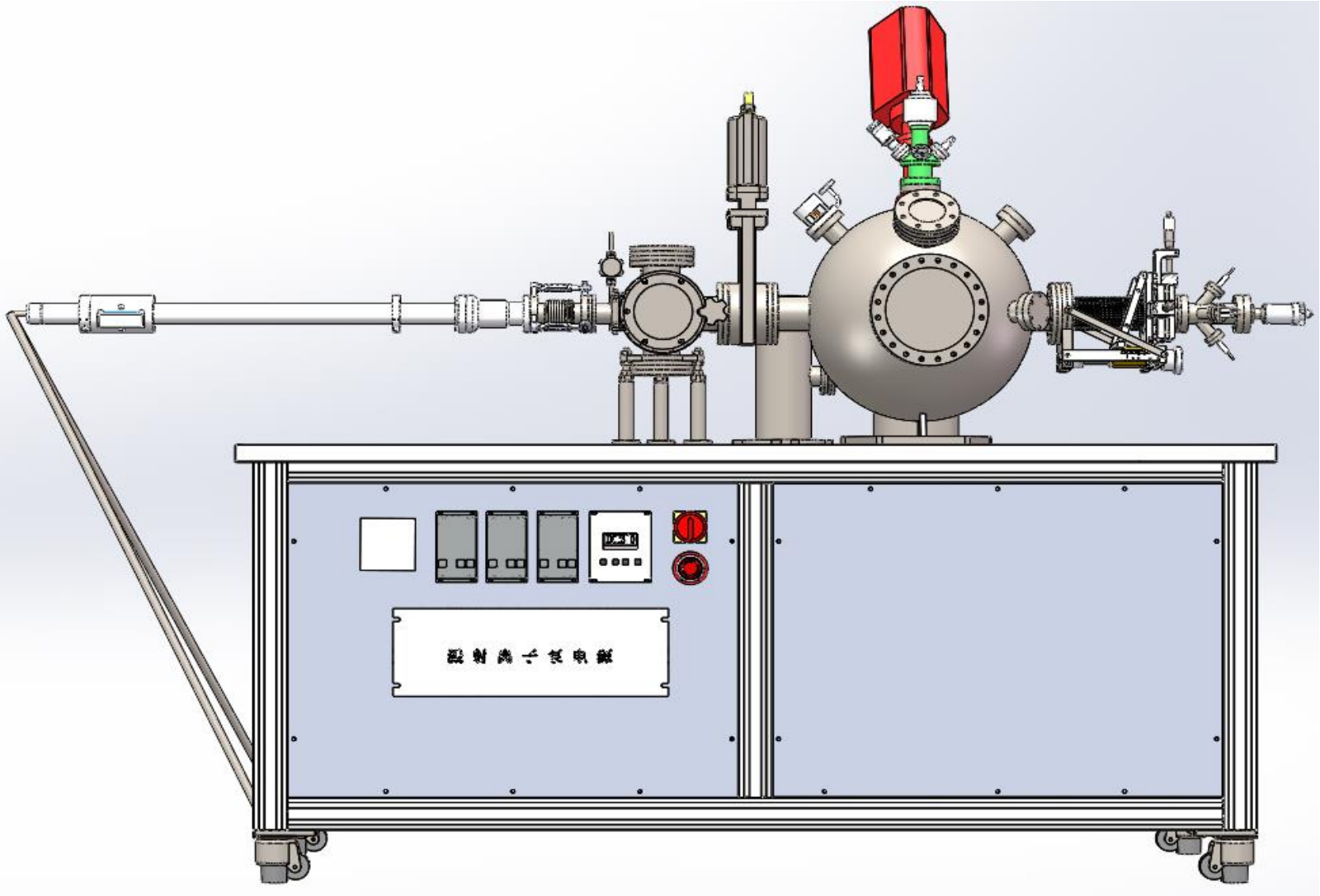
Secondary electron yield test equipment with high precision

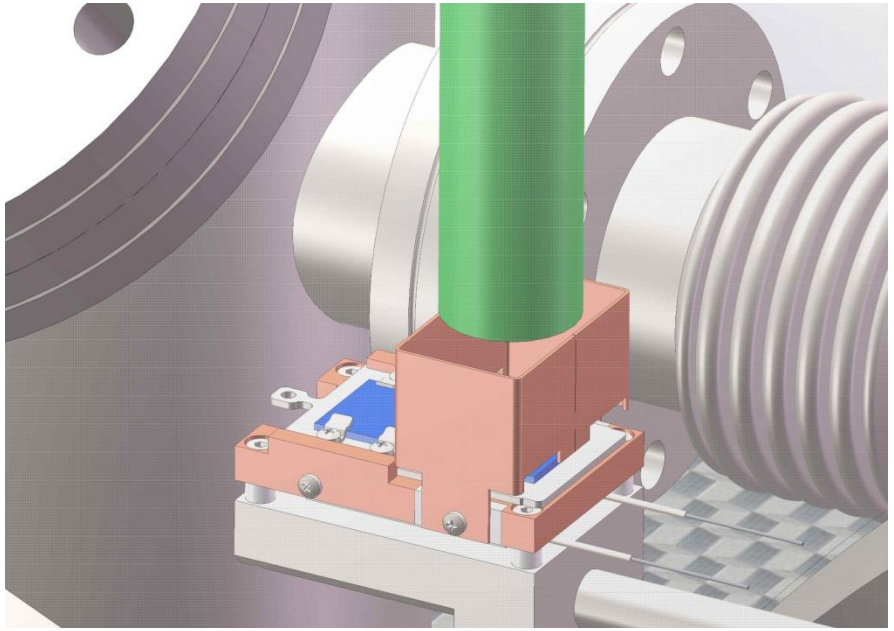
- 控制及数据采集系统

- 采用Keithley 240皮安表测量二次电子电流，该电流计的误差为0.012%，在误差范围内可以精确测得二次电子发射电流和入射电流大小。采用NI数据采集卡模块PCI-6713和PCIe-6341，分别通过专用电缆SH68-68-EPM和SHC68-68-EPM将电子枪控制电源与计算机连接，可以实时记录并精确控制电子枪束流参数。

Secondary electron yield test equipment with high precision

- 测试系统



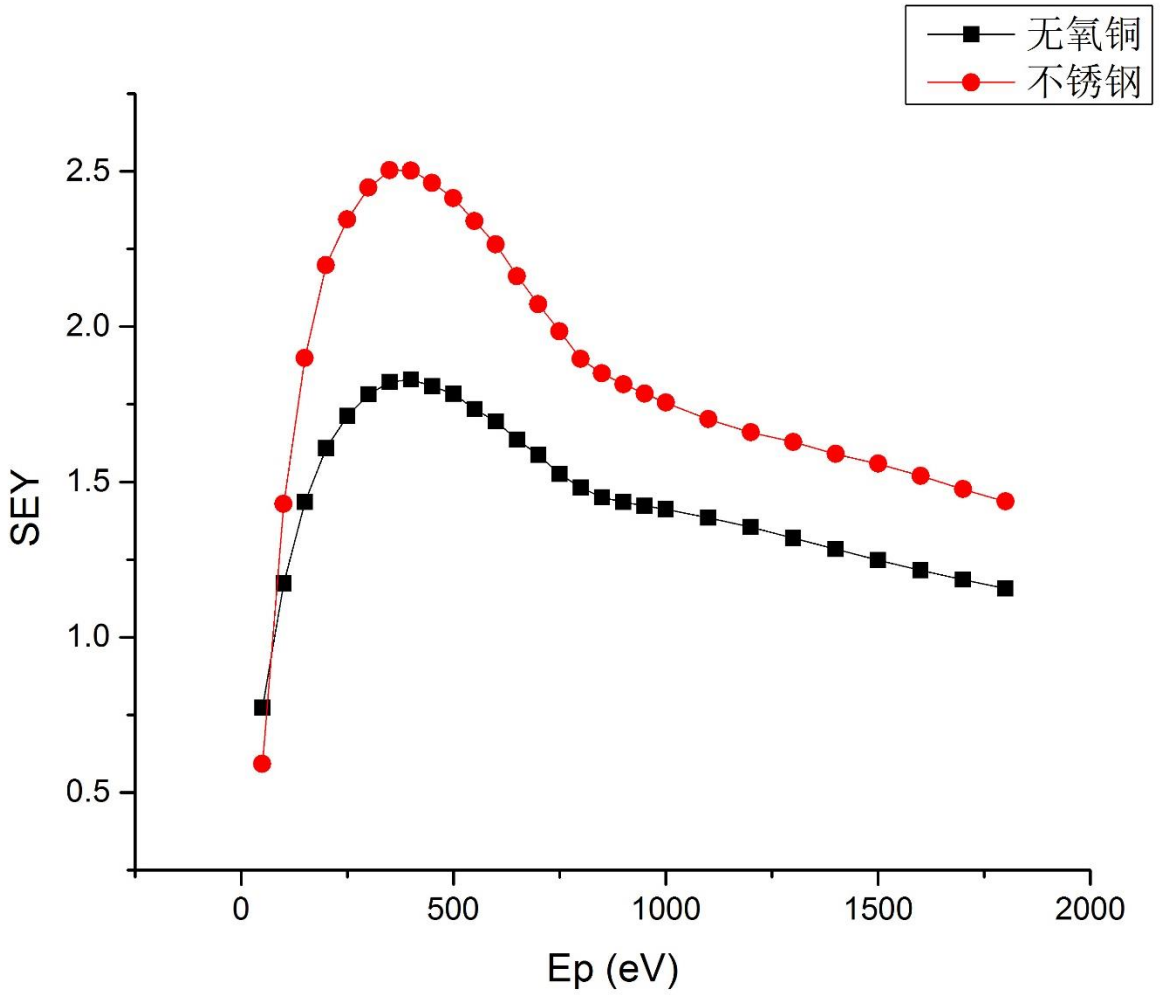


SEY TEST RESULTS

- A secondary electron emission measurement system with 50eV~5000eV low energy electron gun has been designed and used to measure the SEY of different materials.

- The SEY of stainless steel and oxygen free copper (OFC) were obtained. The maximum SEY of stainless steel and OFC are 1.78 and 1.943.

SEY TEST RESULTS

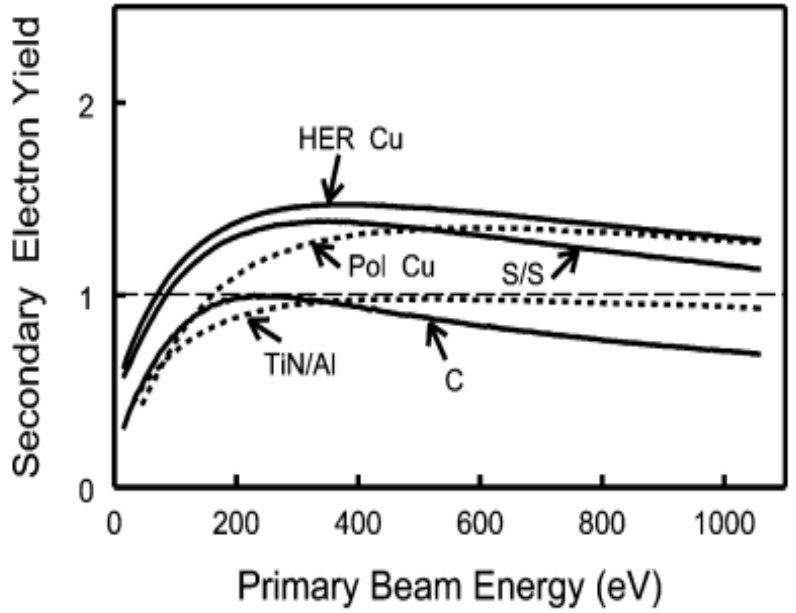


Measurement results of SEY on stainless steel and OFC, $1*10^{-8}$ C·mm^{-2}

Compared with the results of other research institutions

A. Stanford Linear Accelerator Center

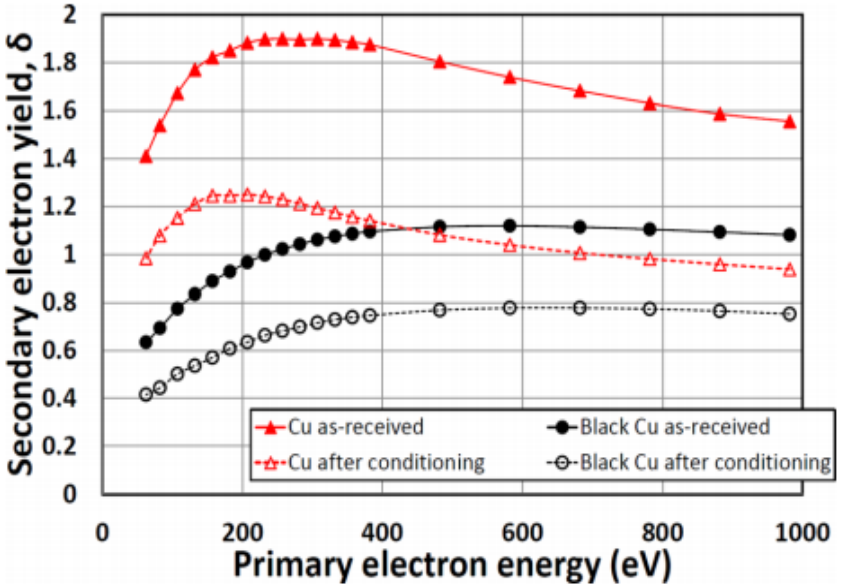
Sample	mechanically mirror-polished (0.25 mm diamond) and degreased OFE copper
Method	$\delta=1-I_t/I_p$
Test conditions	cleaned for UHV operation and unbaked with a pressure of 1 nTorr
Test results	1.5
Reference	R.E. Kirby, F.K. King, Nuclear Instruments and Methods in Physics Research A 469 (2001) 1–12

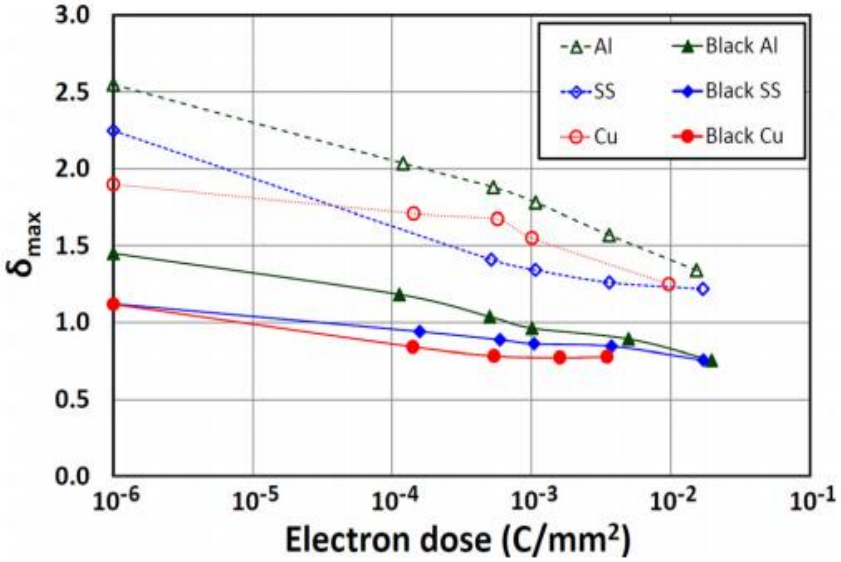


SEY TEST RESULTS

B. STFC

Sample	OFE copper
Method	$\delta=I_f/(I_f+I_s)$
Test conditions	A negative bias voltage (-18 V) with respect to the Faraday cup, which is held at ground, is applied to the sample; Electrons dose per unit: $1*10^{-6}$ C·mm^{-2}, $1*10^{-2}$ C·mm^{-2}
Test results	1.85~1.25,
Reference	Reza Val izadeh et al., APPLIED PHYSICS LETTERS 105, 231605 (2014)

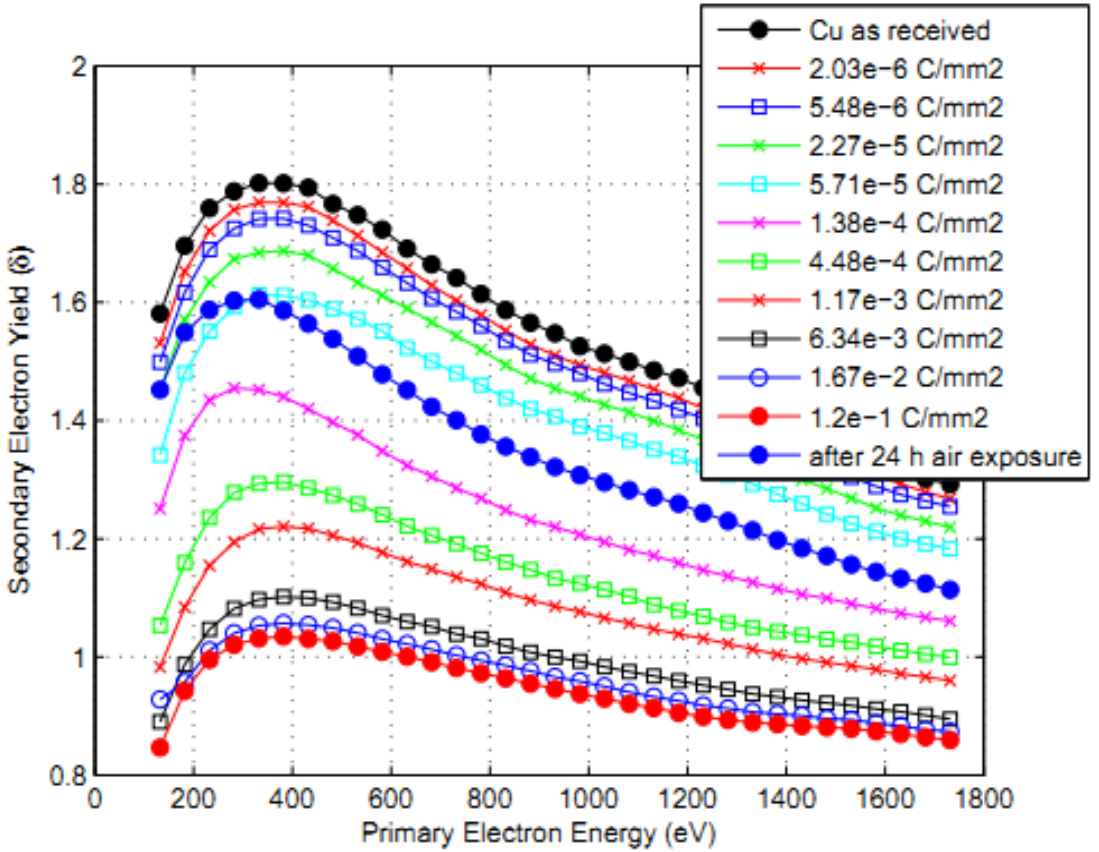




SEY TEST RESULTS

C. CERN

Sample	OFE copper
Method	$\delta=I_f/(I_f+I_s)$
Test conditions	bias voltage: +45, -18V
Test results	1.8~1.05, when the electrons dose per unit is $5.48*10^{-6}$ $C\cdot mm^{-2}$, $SEY_{max}=1.75$
Reference	CHRISTINA YIN VALLGREN, 2011



SEY TEST RESULTS

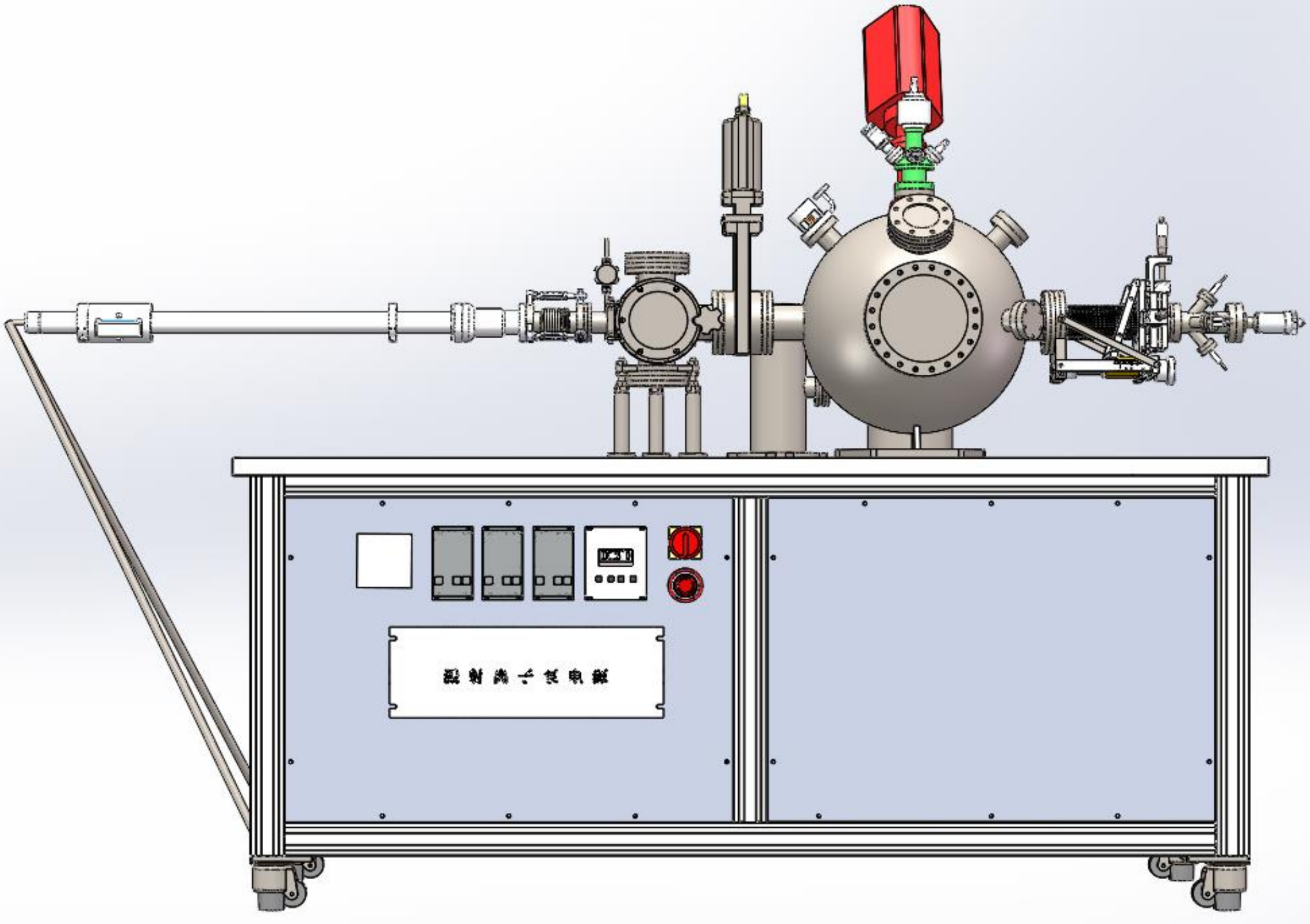
- 与以上三个实验室的测试数据相比，从加偏压的角度看，我们的参数与CREN的偏压参数最为接近;

Research institutions	Bais voltage of Faraday cup	Bais voltage of sample holder/V	SEY_{max} of OFC	Electrons dose/ $C \cdot mm^{-2}$
CERN	+45	-18	1.75	$5.48*10^{-6}$
NSRL	+50	-18	1.96	$5*10^{-8}$

Future plans

- **Study of Wall impedance**
  - Wall impedance is increased when operating temperature is 40-60K
  - Beam instability is caused by increase of wall impedance
  - Coating silver/Cu film could be considered to decrease the wall impedance.(coating super conductor film, is it possible?)
- **SEY test at low temperature (4K~60K)**


THANKS


溅射离子泵电源