A novel fabrication method of the Y-Gd-Hf-O W base directly-heated cathode

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Outline

1. Introduction: The history of the Thermionic Cathode
2. Continues Improved Production Techniques
3. Experiment and Analysis
4. Conclusion

1. Introduction: the history of the thermionic cathode

Low chamber vacuum
Strong electric fields

carbon filaments

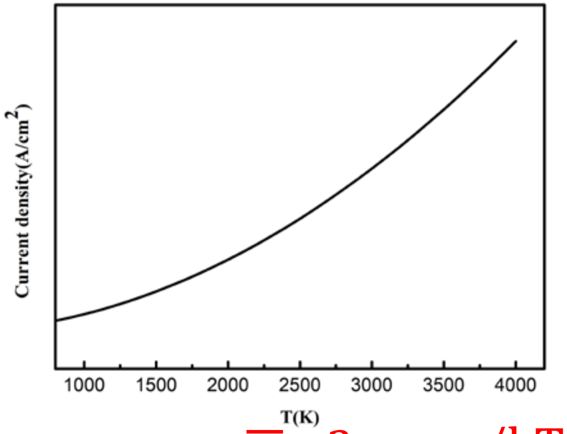
Advantages:

- Relatively low work function
- Easy stable
- Good anti-electron bombardment ability

Disadvantages:

- High operating temperature
- Low emission
- Bad chemical stability

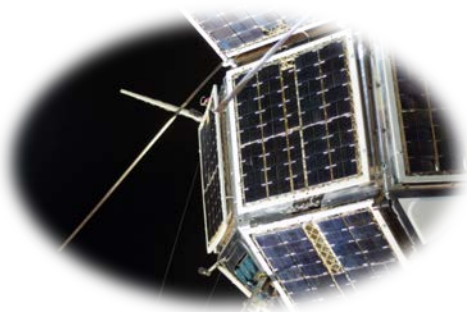
W filaments



$$j_e = A\bar{D}T^2 e^{-e\varphi/kT}$$

1. Introduction: the history of the thermionic cathode

Broadcasting



Aviation

Application

Display Panel

Communication

1. Introduction: the history of the thermionic cathode

Types of thermionic cathodes in commercial tubes

Type	Abbrev.	Top/K	$j_e/A \cdot cm^{-2}$	$\emptyset/eV$	Lifetime
Thoriated - Tungsten	W	2510	0.6	4.5	100h
Ba oxide	Th-W	2000	4	2.6	10kh
Ba-dispenser, W-base	W-I or A or B	1300	3	2.05	≥ 20 kh
Os/Ru coating	M or Os/Ru-I	1300	10	1.85	≥ 20 kh
Ba-Scandate	Imp. (TL)	1300	15	1.7 (1.45)	≥ 10 kh
Ba-Scandate	SDD	1320	40	1.45	≥ 4000h

Influence the emitted property factors

- Base structure
- Coating component
- **Fracture process**

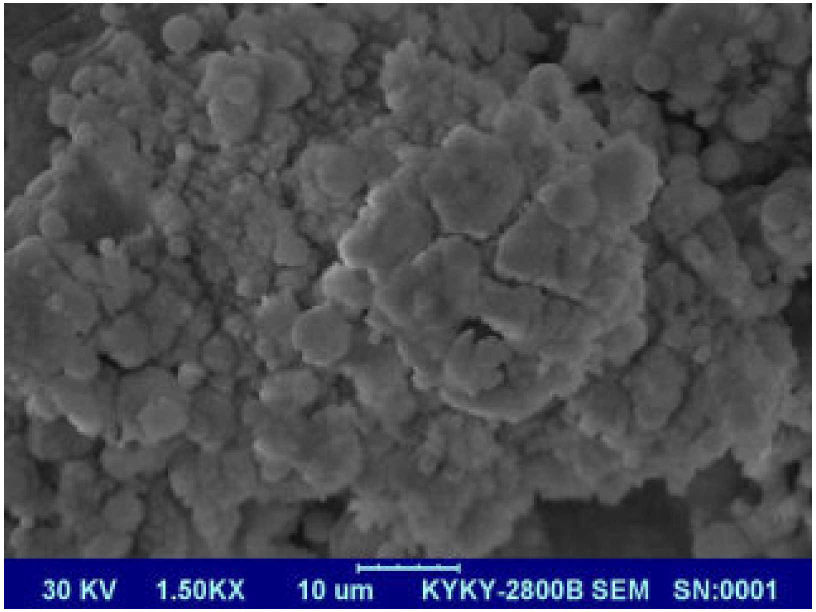
Fracture process

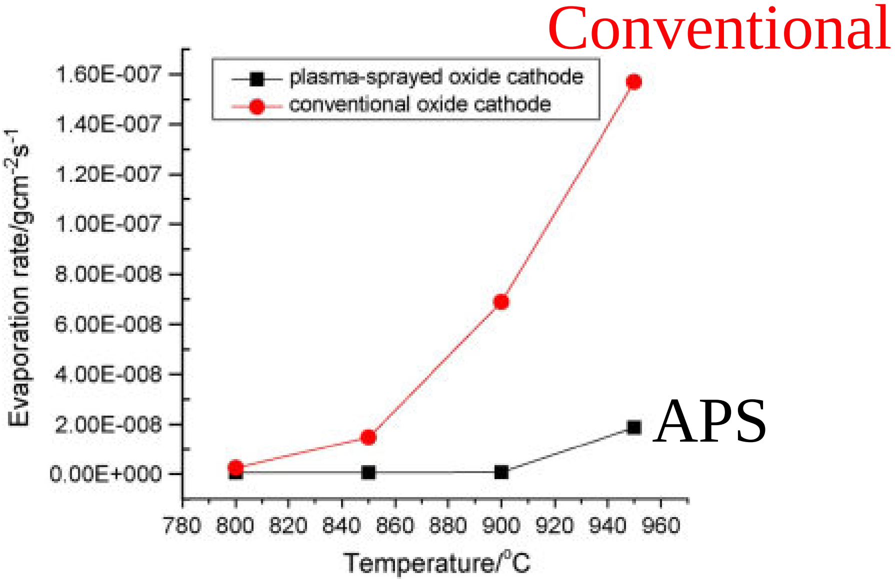
Technologies improvement

- Directly doped/Mechanical mixing + Coating impregnate
- Spray drying + Two step reduction
- Powder metallurgy/ Liquid-liquid doping using Sol-Gel +Reduced in the dry atmosphere
- Sol-gel + SPS
- Separation process + High temperature reduction
- Magnetron Sputtering
- Mechanical mixing + Spray
- CVD
- Air plasma spray (APS)

2. Continues improvement production techniques

■ APS

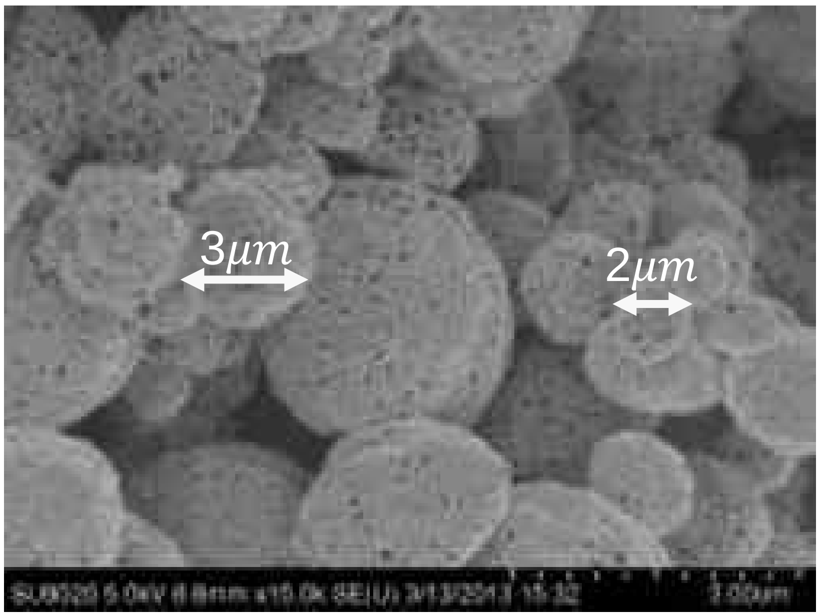




Evaporate rate versus temperature for the two types cathode

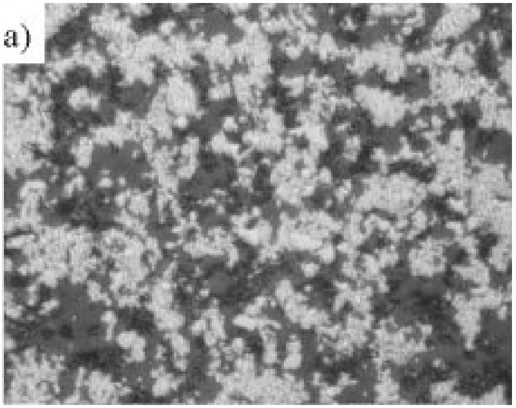
In the Ref[1], Min Zhang et al. use APS coating oxide emission material on the base.

■ Spray drying + Two step reduction

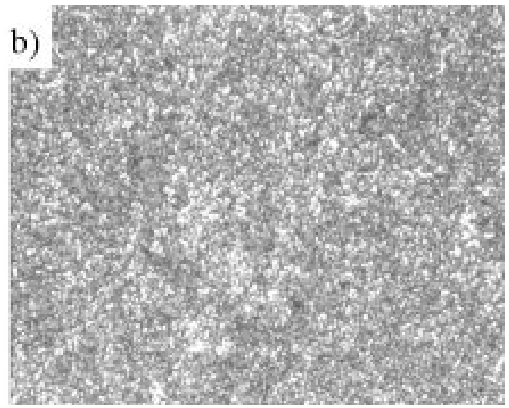


This doped mixing method is at the atomic level. The result shows the porous W-Re sphere powder with the particle size about 1-3μm[2].

2. Continues improvement production techniques

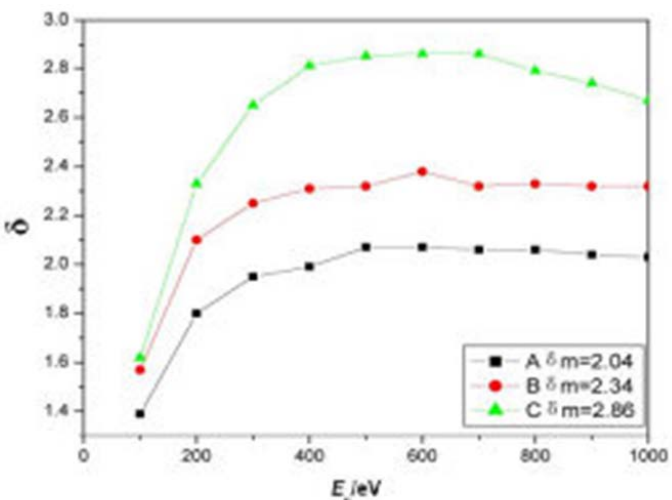


Solid-solid doping



Solid-liquid doping

Sol-gel doping[3]



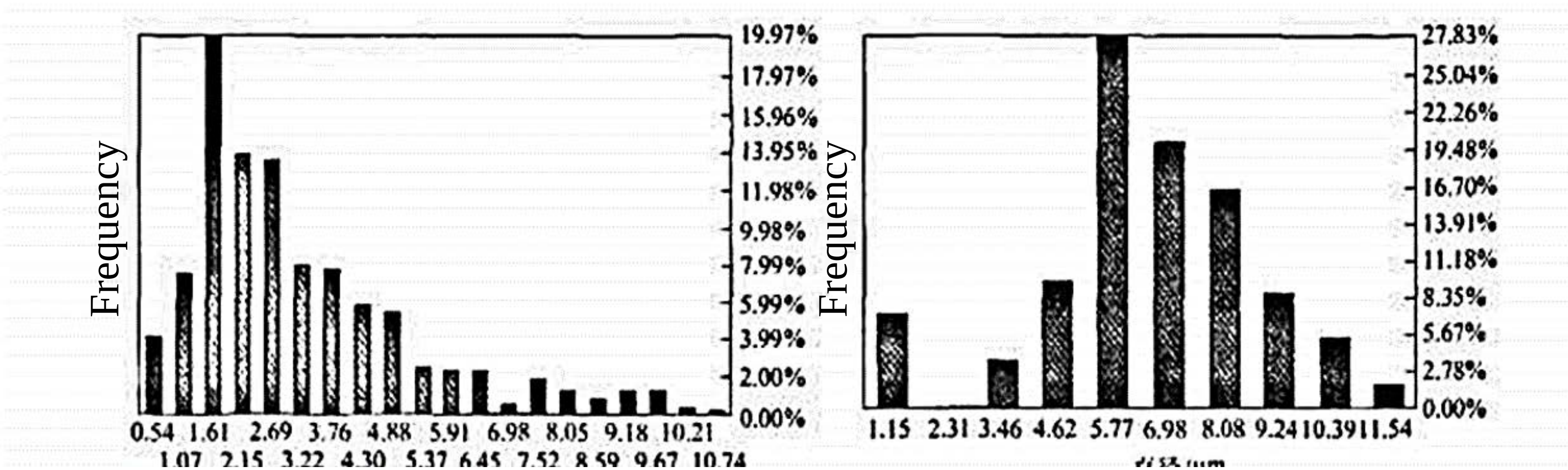
$\delta - E_p$ curves of SPS-sintered samples based on different doping method after activation

Sol-gel doping

Solid-liquid doping

Solid-solid doping[3]

■ Separation process + High temperature reduction

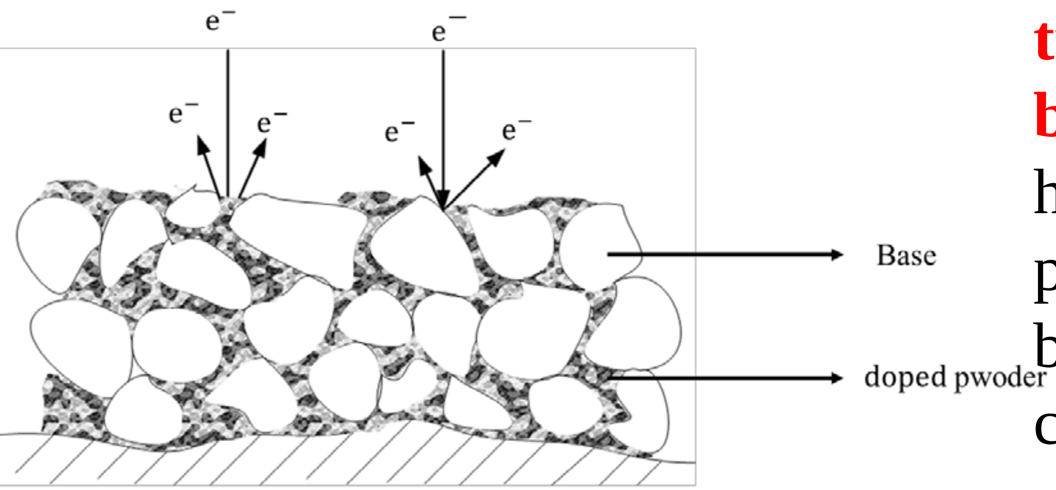


(a) (b)

Diameter distribution (a)before (b)after

Lu et al. prepared the W powder in the impregnated cathode by separation process(mechanical combined with ultrasonic) and high temperature reduction method[4].

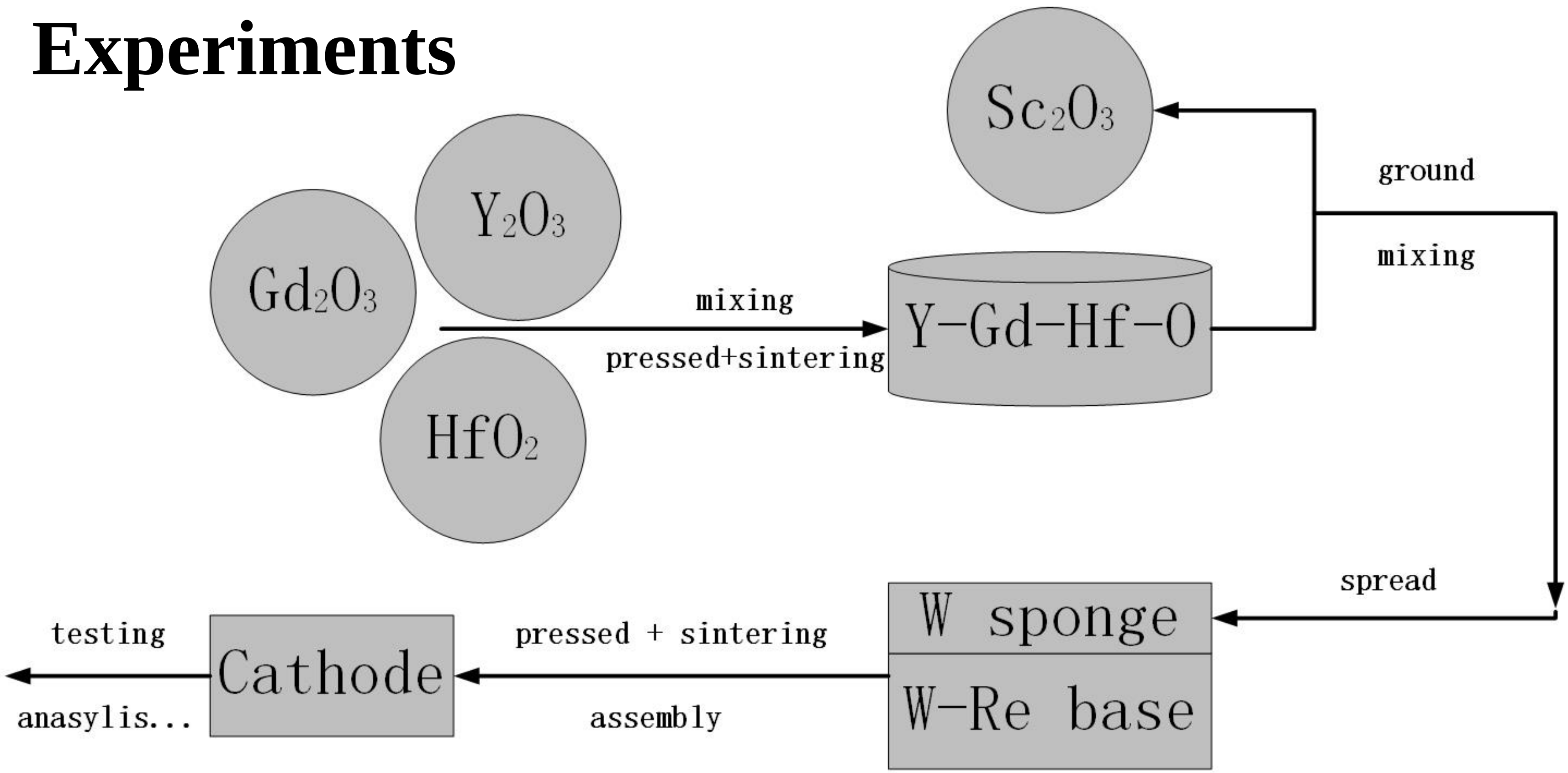
■ Aims



The schematic diagram of the secondary emittiing

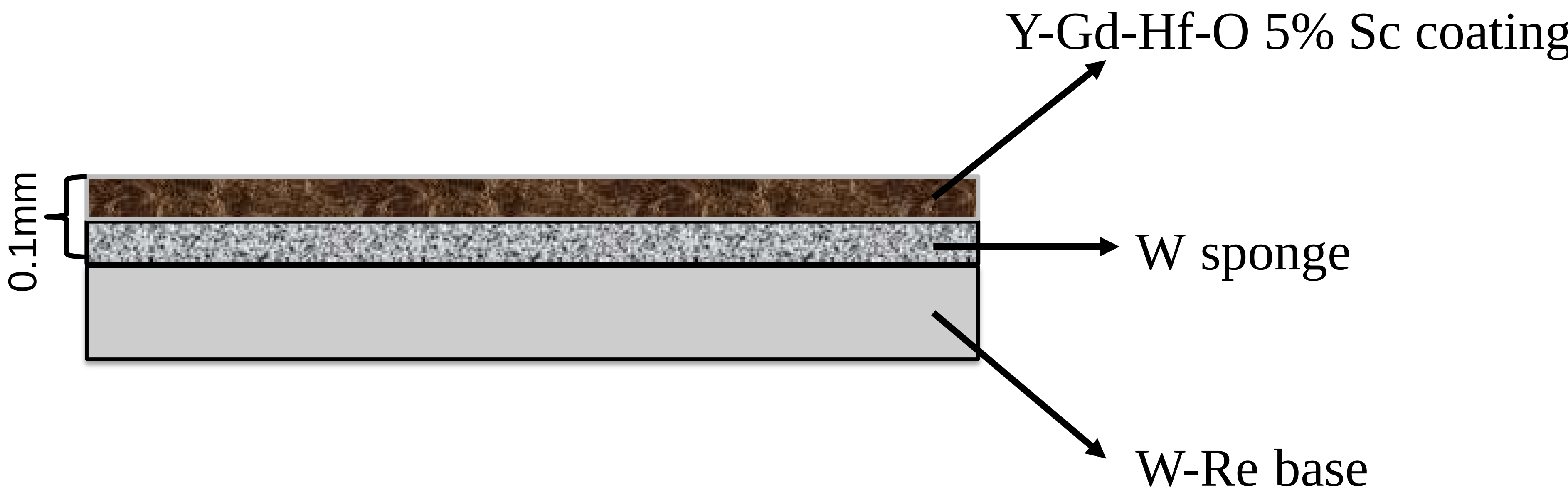
The 90% of the magnetron tube anode current is acquired by the secondary emission. The higher the magnetron output power, the greater the bombardment of electrons to cathode. So, in the high power continuous magnetrons, the cathode must have a **strong anti-electron-bombardment ability.**

■ Experiments



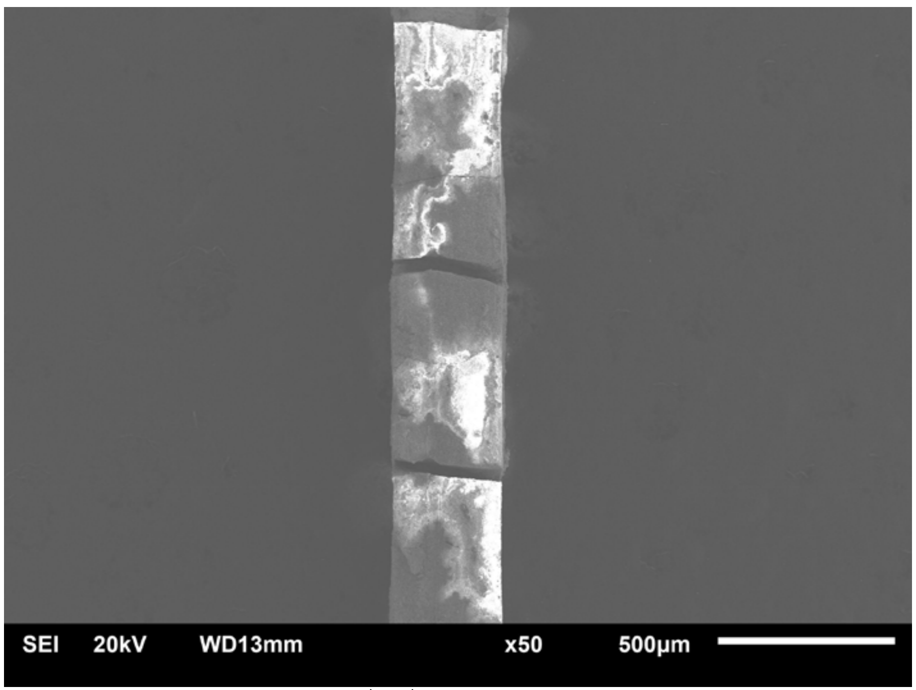
The fabrication process of the cathode

3. Experiment and analysis

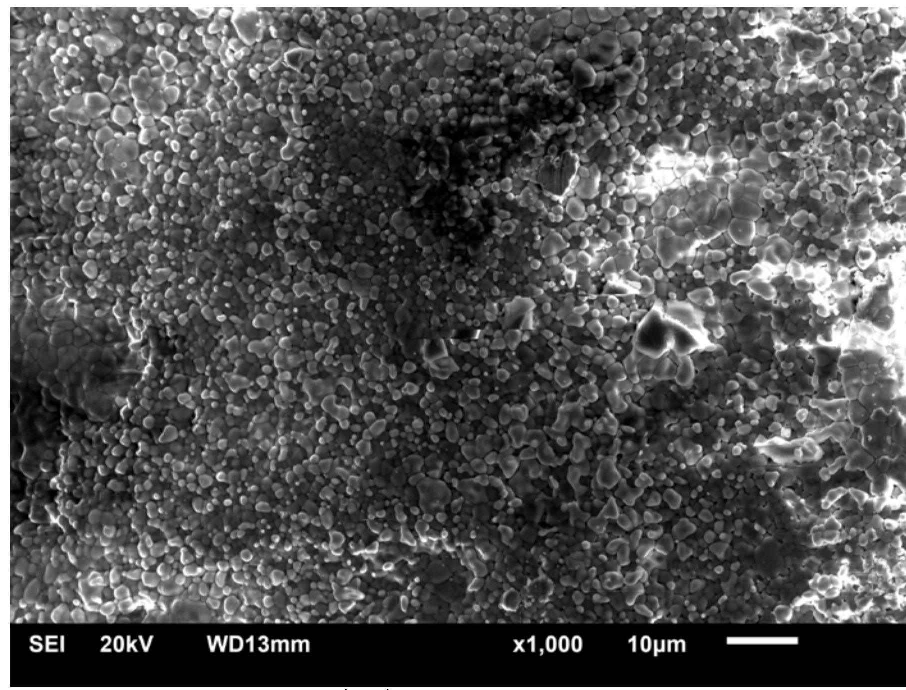


The schematic of the Y-Gd-Hf-O (5%Sc doped) impregnated cathode

■ SEM Imagines

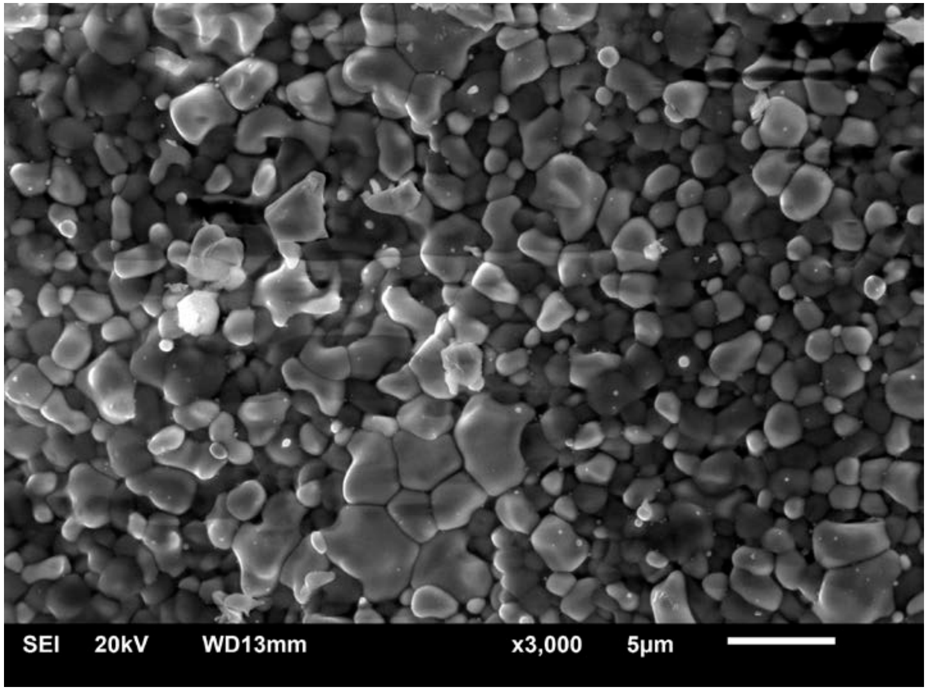


(a) 50X

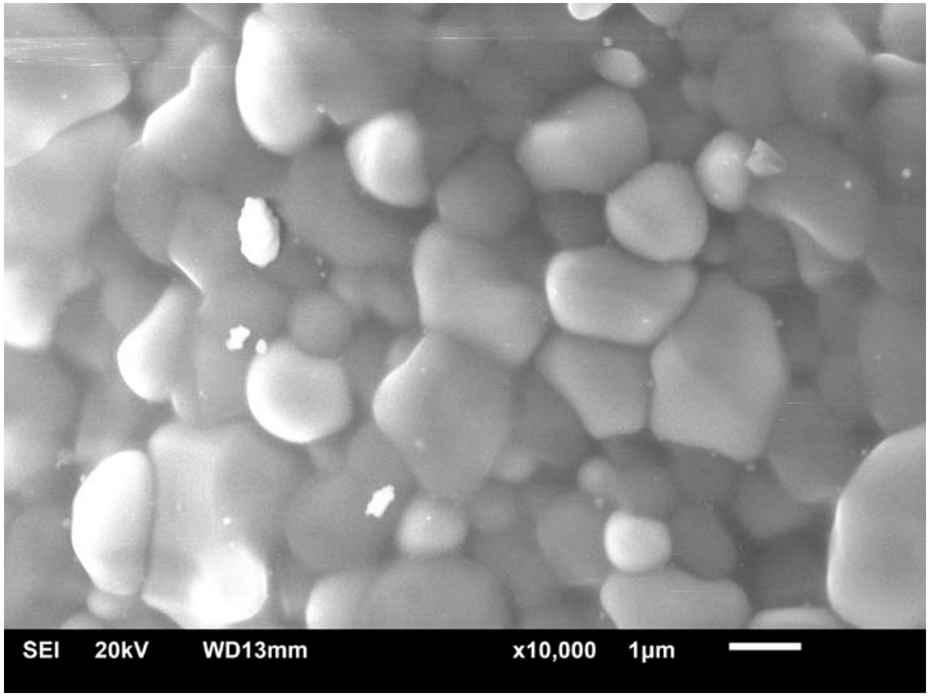


(b) 1000X

■ SEM Imagines

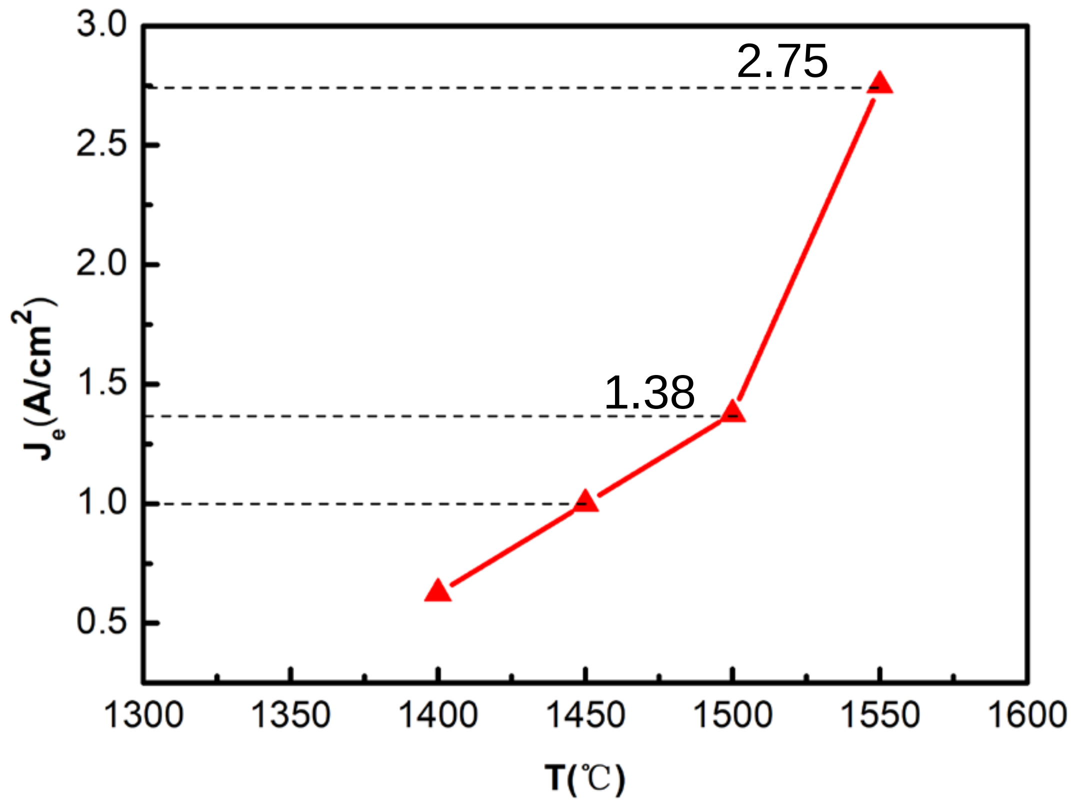


(c) 3000X



(d) 10000X

■ Thermionic Emission Test



Emission characteristic at different temperature

4. Conclusion

- Homogeneous microstructure and uniform distribution
- Relatively flatted surface provides even emitted area
- Uniform distribution supplies the required current density
- Densified structure increases the anti-electron bombardment ability

4. Conclusion

The anti-ion electron test and the lifetime test is undergoing

References

[1]M. Zhang et al. IEEE Transactions on Electron Devices, vol. 58, no. 7, pp. 2143-2148, 2011.
[2]L. Chen et al. in rare *materials and engineering*, vol. 45, no. 07, pp. 1871-1875, 2016.
[3] L. Wei et al. in 2006 IEEE International Vacuum Electronics Conference held Jointly with 2006 IEEE International Vacuum Electron Sources, 2006, pp. 129-130.
[4] P.Lu et al. powder metallurgy industry,vol.20,no,5,2010.
[5]N.N. Chubun, L.N. Sudakova. [J]. Applied Surface Science,1997,111.
[6]Liang Chaolong, et al. Rare Metal Materials and Engineering[J].2016,45(12):3267-3270.

Thank you for your attention

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