中国科学技术大学
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Study on secondary electron emission characteristics of material surface by laser etched

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創寰宇學府
育天下英才
嚴濟慈題
一九八八年五月

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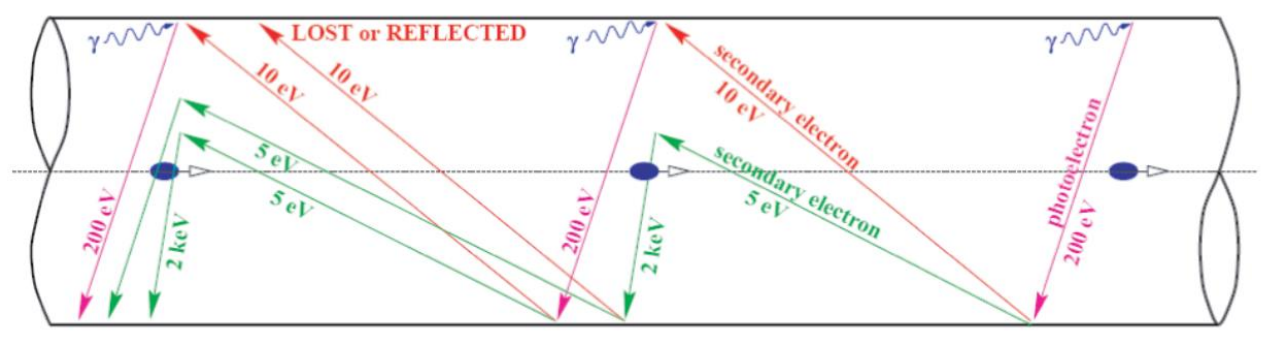
- Electron-cloud(E-cloud) in accelerator.
- How to solved E-cloud.
- Laser treatment to suppress secondary electron emission.
- Conclusion

Electron-cloud in accelerator

Primary electrons

- Residual electron
- Beam particles collided with residual gas
- Synchrotron radiation irradiate on the wall

⇨ Collide with chamber wall ⇨ Secondary electrons ⇨ Multiplication (SEY>1) ⇨ E-cloud



Disadvantage:

1. Beam loss
2. Beam lifetime decline
3. Emittance increase
4. Heat load increase

How to solved the E-cloud

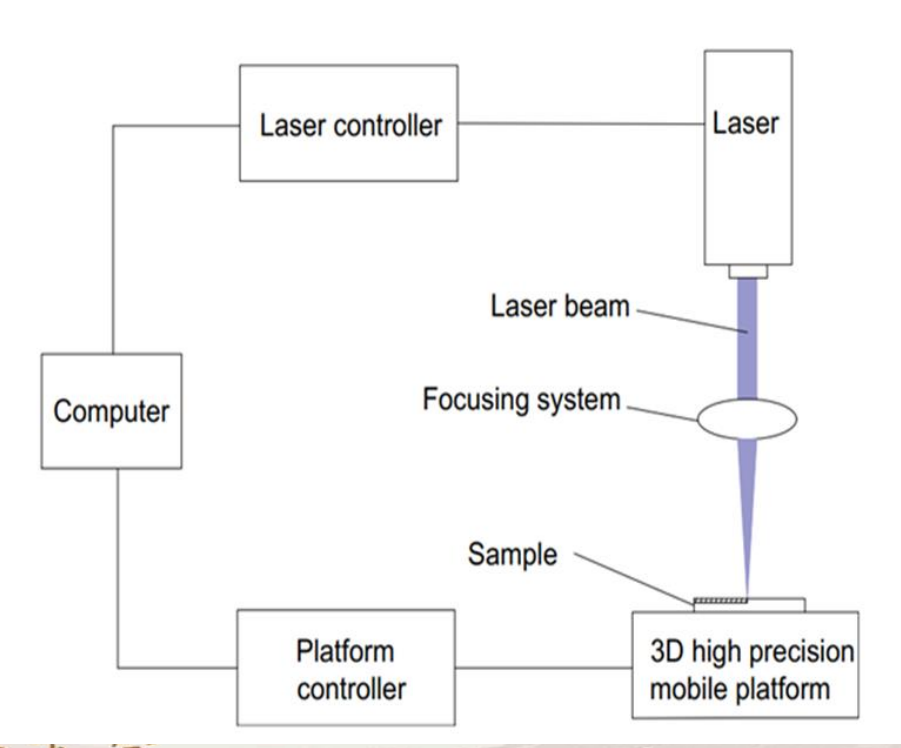
Methods to suppress the secondary electron emission:

1. Using low secondary electron yield(SEY) materials.
2. Coating low SEY film on the chamber wall(NEG, a-C,).
3. Machining groove.
4. Laser treatment on the surface of vacuum chamber.

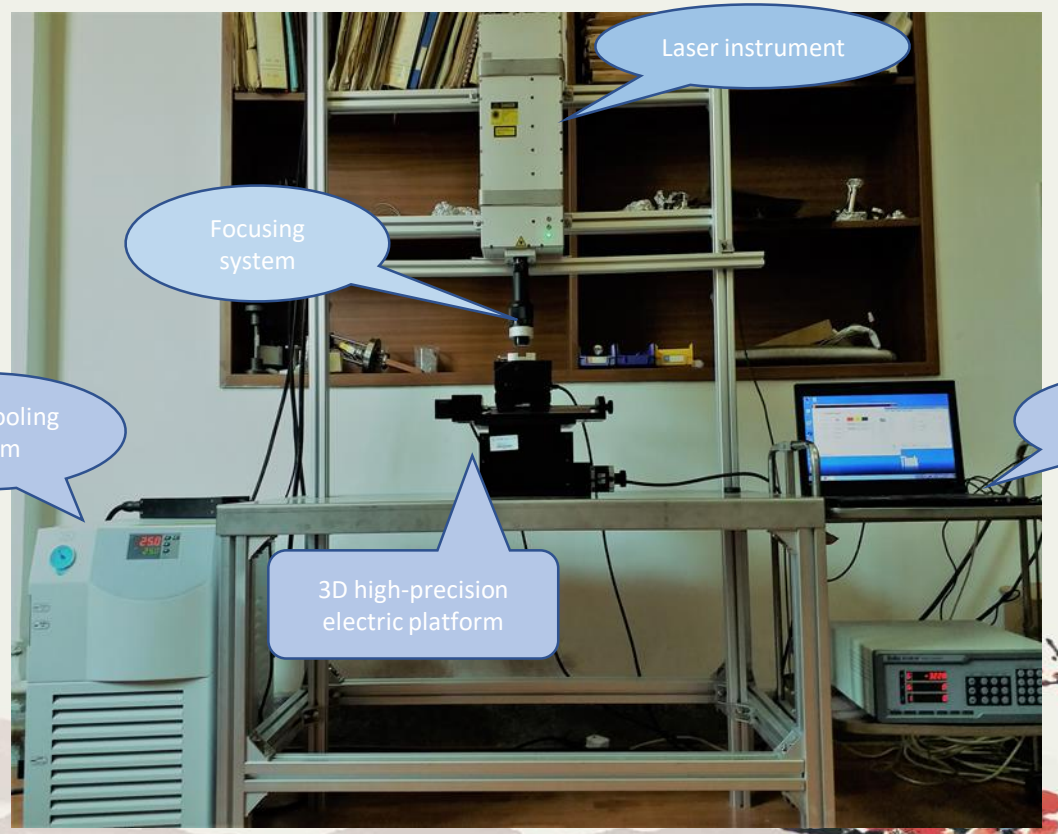
Advantage:

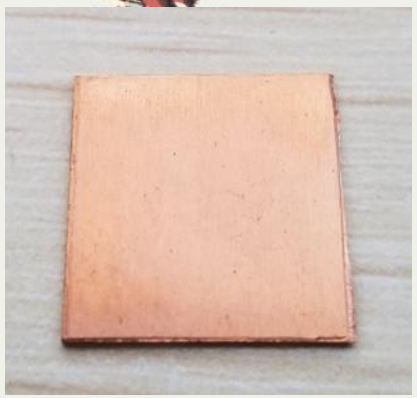
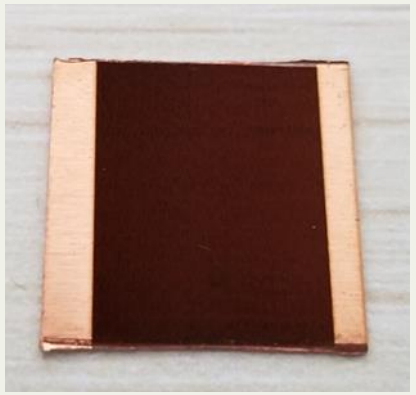
1. low cost,
2. easy to be carry out,
3. good stability.
4. Under the atmosphere

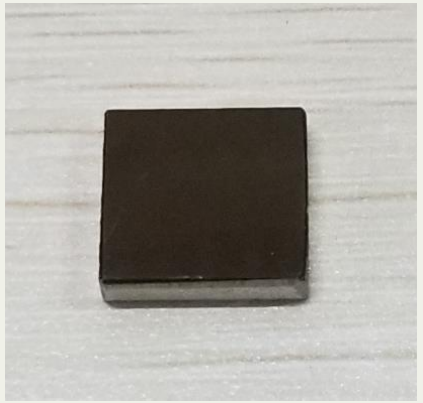

Laser treatment to suppress secondary electron emission.



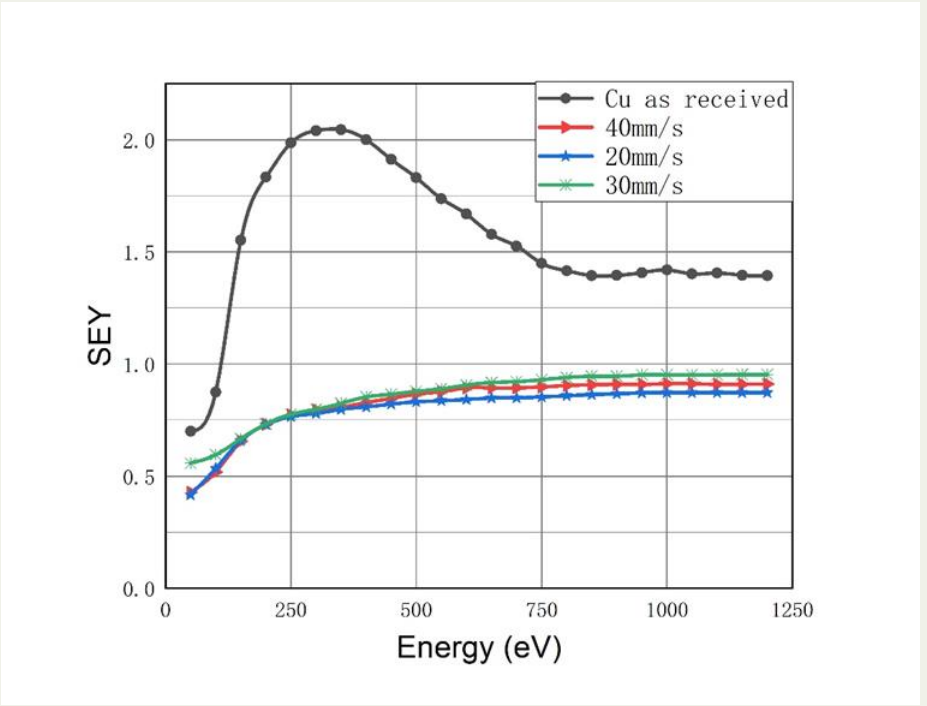
Schematic diagram of laser treatment system



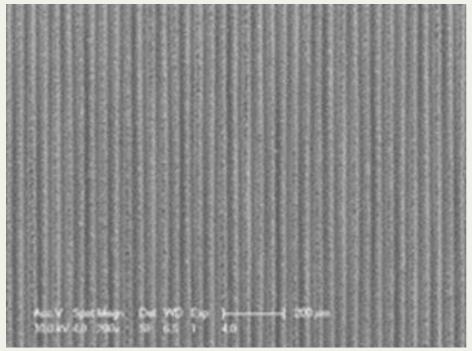





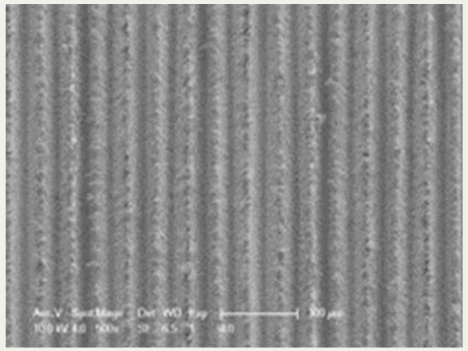
Copper and stain steel treated by laser



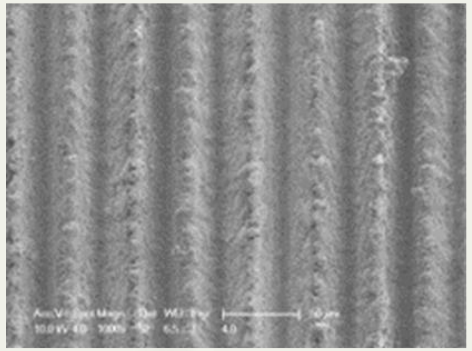
1. Primary copper sample has a bigger than 1 secondary electron yield(SEY) value .
2. After laser treatment, SEY is blow 1.



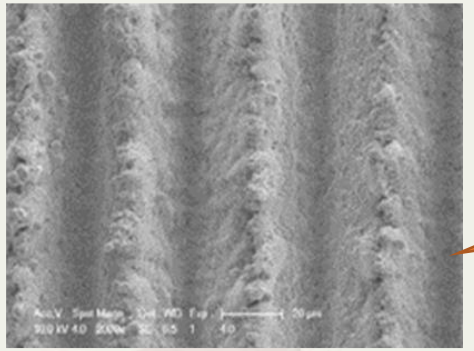
200x



500x



1000X

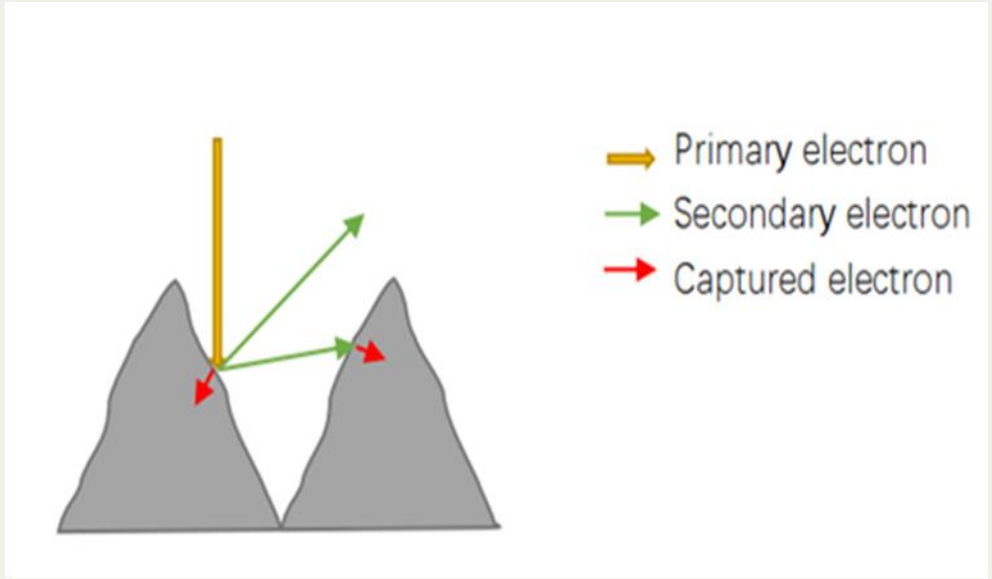


2000X

SEM micrograph of copper sample

- Regular parallel gullies
- 40μm wide.

These regular structures are the main reason for the reducing SEY



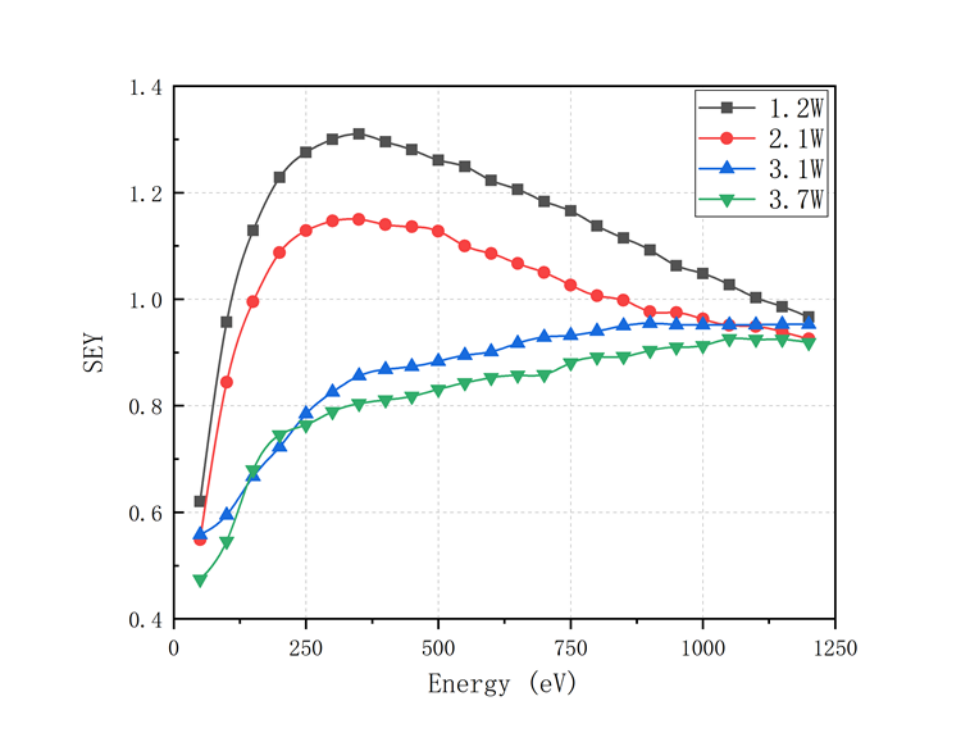
Electron trajectory on the sample surface

- When primary electrons (PE) incident on sample surface, part of PE is trapped by the surface.
- Other part of PE collide on the surface and generate secondary electrons as the blue trajectory shows the left figure.
- For these secondary electrons, some of them enter into the space and some of them are trapped by other side of gully.
- Most of electrons are trapped by the gullies, so SEY reduce.

Composition of C, O, Cu in four samples. Condition 1, 2 ,3 correspond to 20mm/s, 30mm/s,40mm/s.

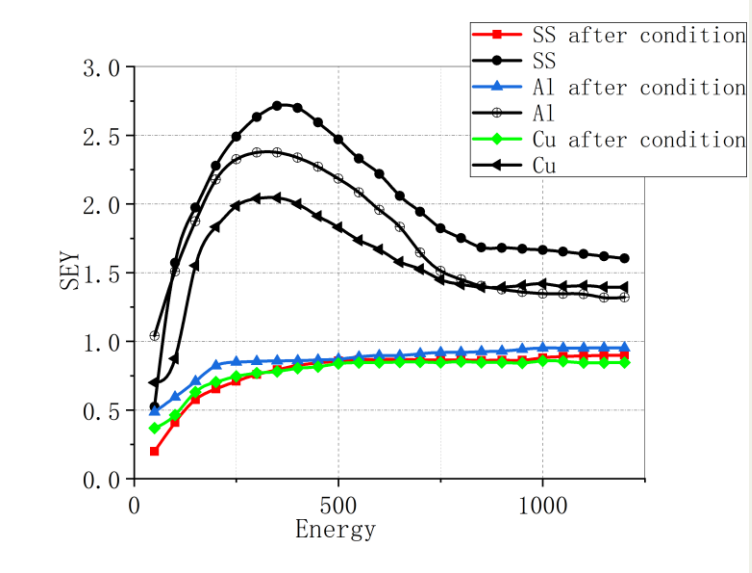
Sample	C	Cu	O
Cu as received	56.8	10.06	33.15
Cu after condition 1	26.65	24.32	49.03
Cu after condition 2	25.83	26.89	47.28
Cu after condition 3	26.88	25.83	47.29

- Cu/O ratio rise. C element decrease.
- Cu and C element were oxidized with the high energy laser beam.
- The internal Cu element turn to sample surface.
- C element oxidized and emit out from surface



SEY of copper treated with different pulse energy

- The maximal SEY decrease with the pulse energy rise.
- For 3.7/3.1W laser power, SEY of sample is below 1 at the entire range of incident energy.
- For 1.2/ 2.1W, SEY curves has peak values bigger than 1.
- Higher laser energy is much easier to gain a lower SEY sample surface.



SEY curves of copper, stainless steel, aluminum before and after laser treatment

- Before laser treatment, maximum SEY of copper, stainless steel and aluminum are 2.1, 2.7, 2.4
- After laser treatment, the maximum decrease to 0.8, 0.8, 0.9 at the entire range of incident energy.
- SEY<1 meet the basic conditions for suppressing electron multiplication.

Conclusion

- Laser treatment on materials can change the topography and component with the high energy
- Higher laser energy is easier to obtain the sample whose SEY is below 1.
- For the reason SEY<1, sample surface can suppress secondary electron emission and solved the E-cloud.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Thank you!!


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嚴濟慈題
一九八八年五月