

Design of a thermal field electron gun immersed in the magnetic lens field

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Introduction

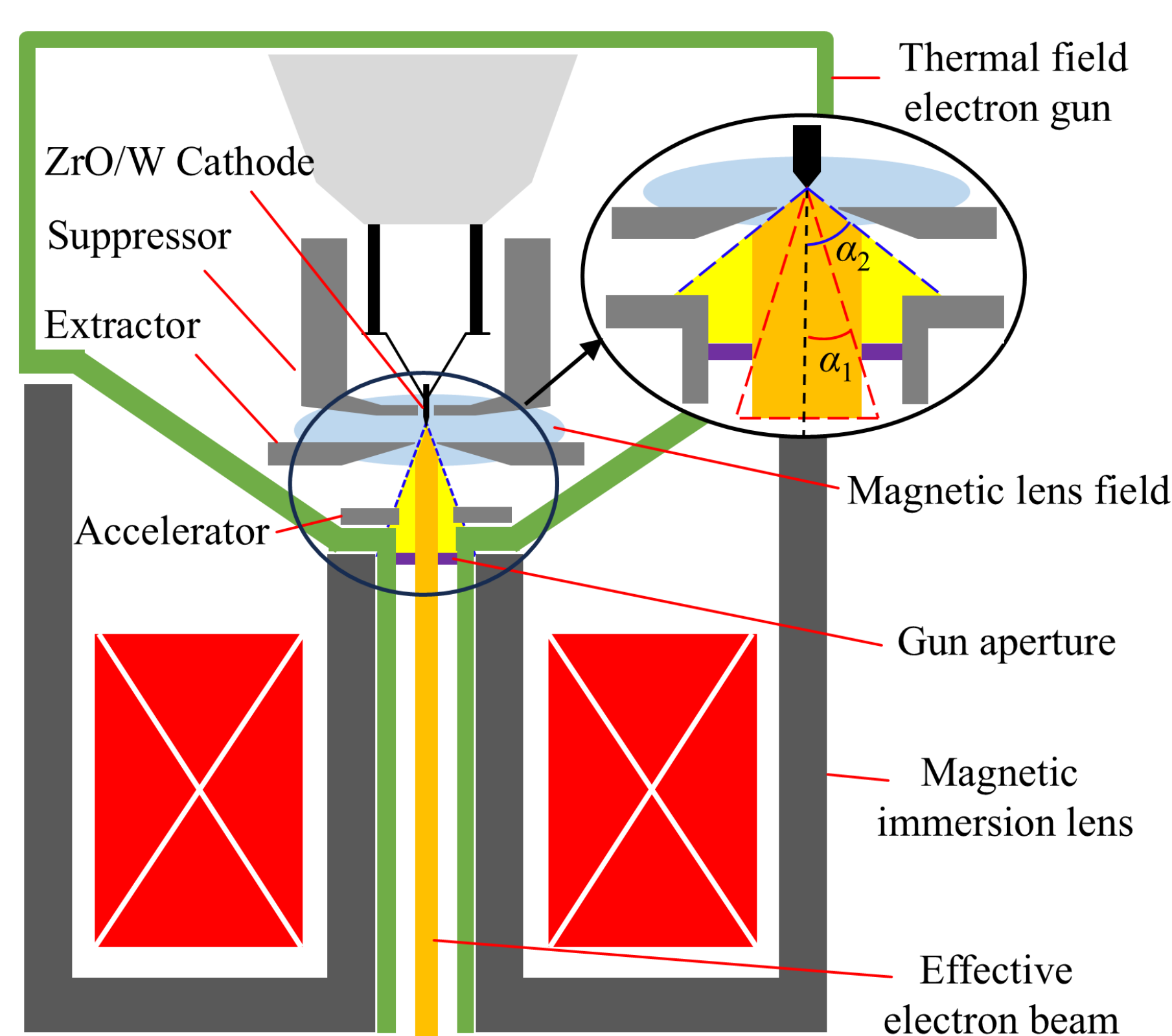
To enhance the probe beam current of scanning electron microscopes and related devices for high throughput and rapid imaging, a thermal field electron gun immersed in a magnetic lens field was designed to collect electrons emitted from the cathode and increase the effective emitted beam current. The optical characteristics of the magnetic field-immersed electron gun were analyzed theoretically. The performance of three magnetic lens configurations—single polepiece, double polepiece with axial gap, and double polepiece with radial gap—was simulated and compared. Based on the double polepiece with axial gap lens, a magnetic field-immersed electron gun was developed and the variations in beam spot size, beam current, and angular current density in response to the magnetic immersion lens were simulated. The magnetic field distribution of the immersion lens and the effective emitted beam current of the gun were measured based on an experimental platform. The results reveal an approximately fourfold increase relative to that of conventional thermal field electron guns.

Experiment Method

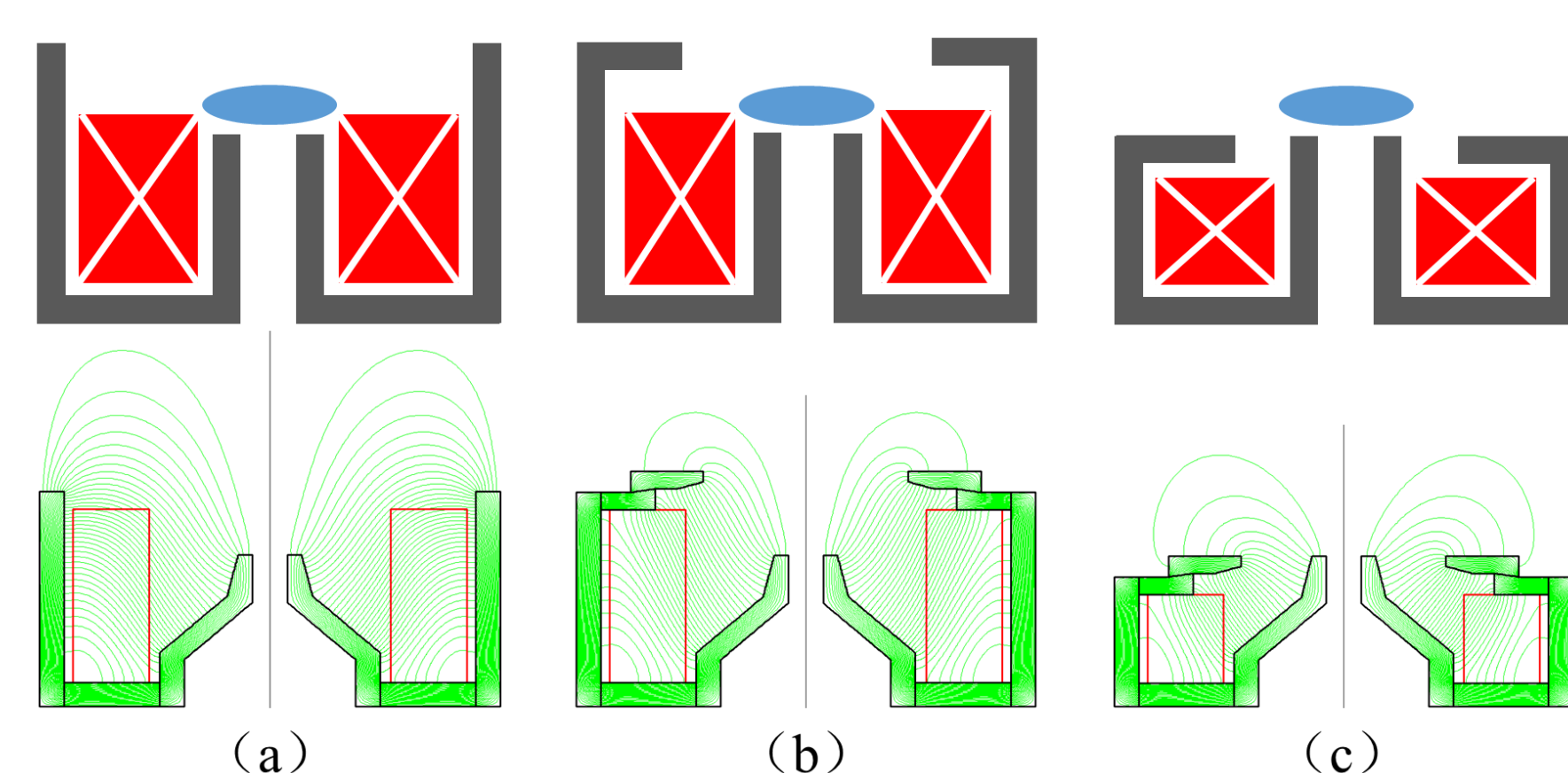
The Structures and principles of three magnetic lens and magnetic field-immersed electron gun were introduced, and the effective emitted beam current of magnetic field-immersed electron gun was measured.

Results and Discussion

I. Structures and principles

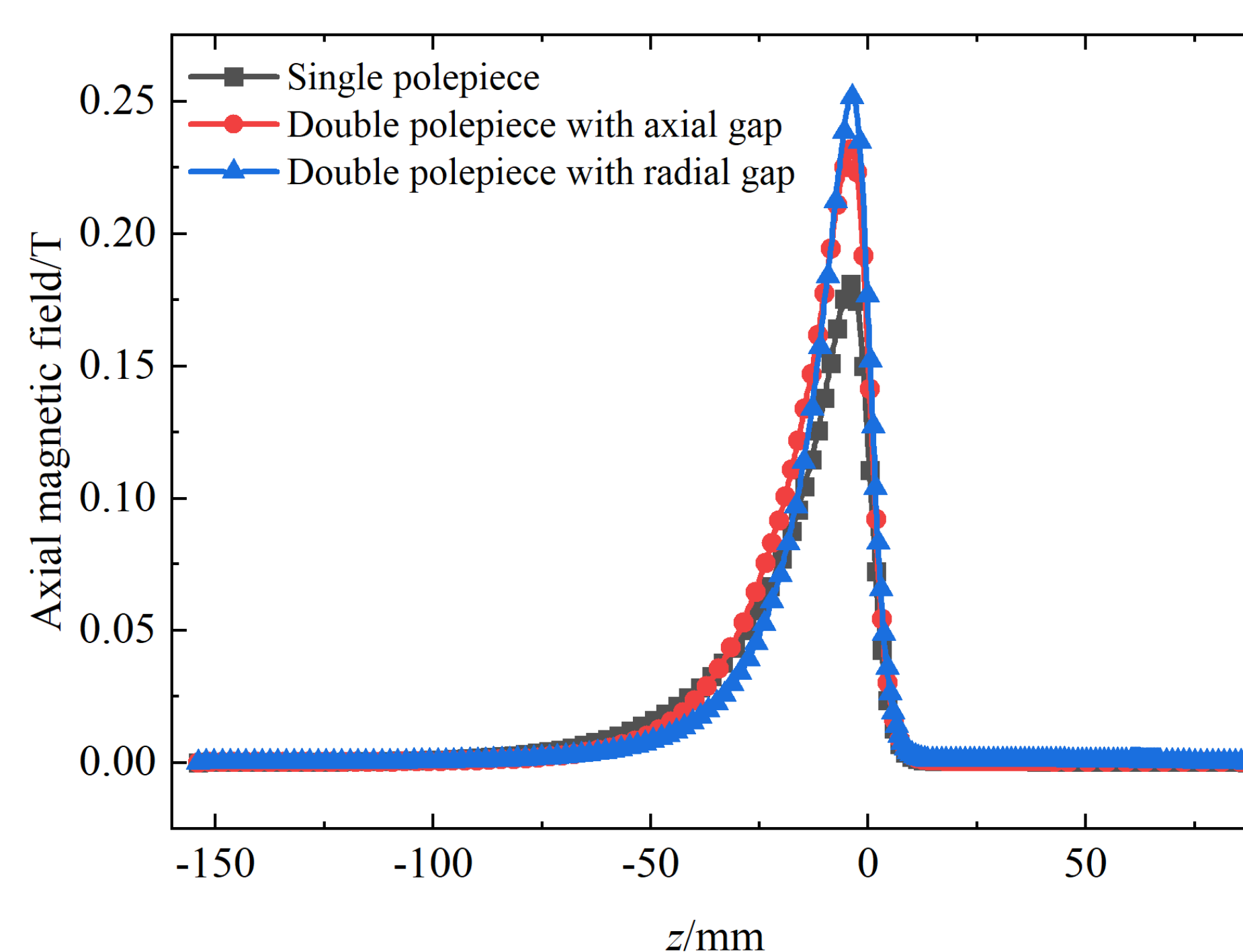


Thermal field electron gun immersed in a magnetic lens field.

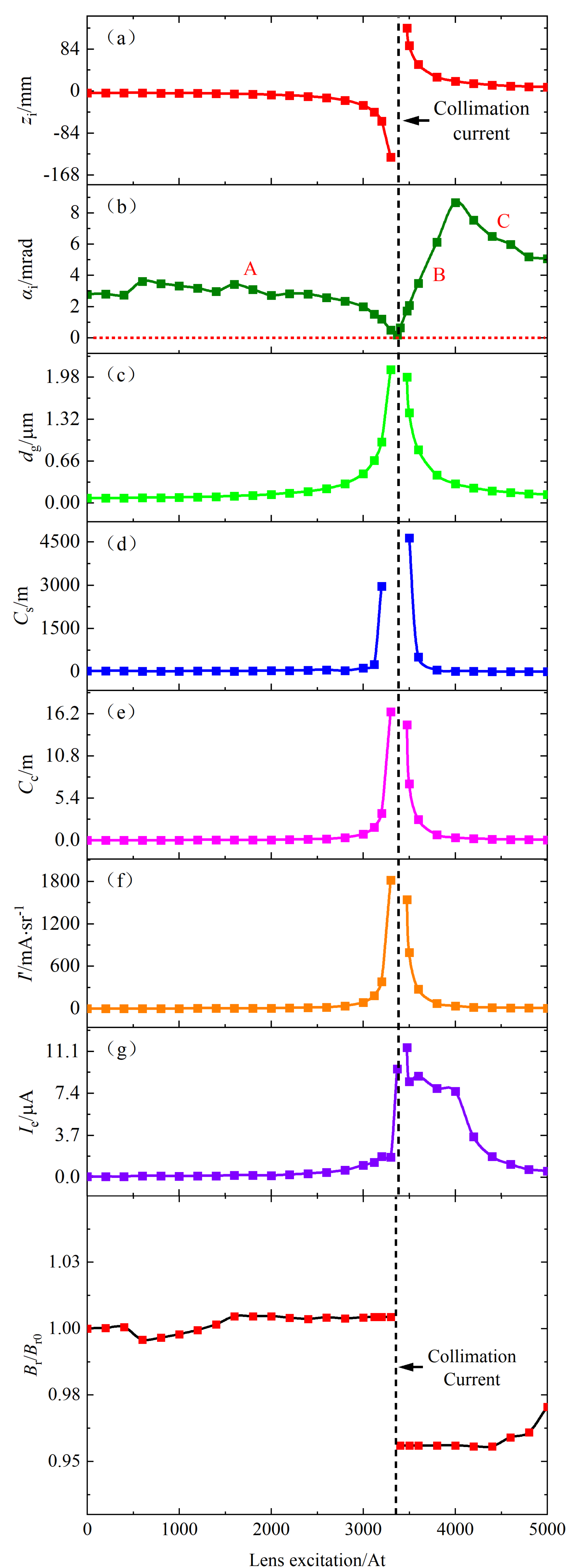


Magnetic immersion lenses: (a) single polepiece; (b) double polepiece with axial gap; (c) double polepiece with radial gap.

II. Simulation results

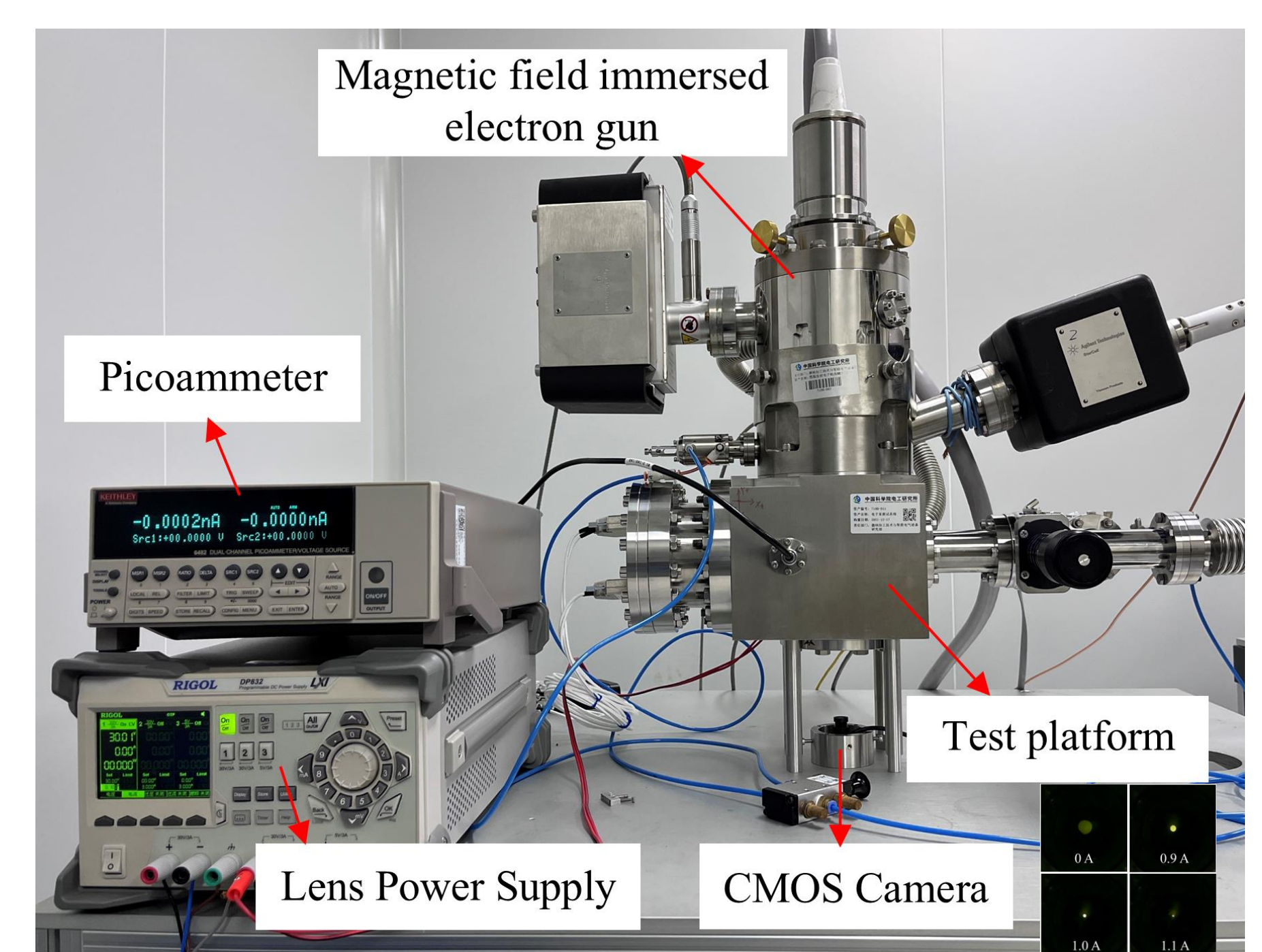


Distributions of the axial magnetic field of the three magnetic immersion lenses under the same excitation.

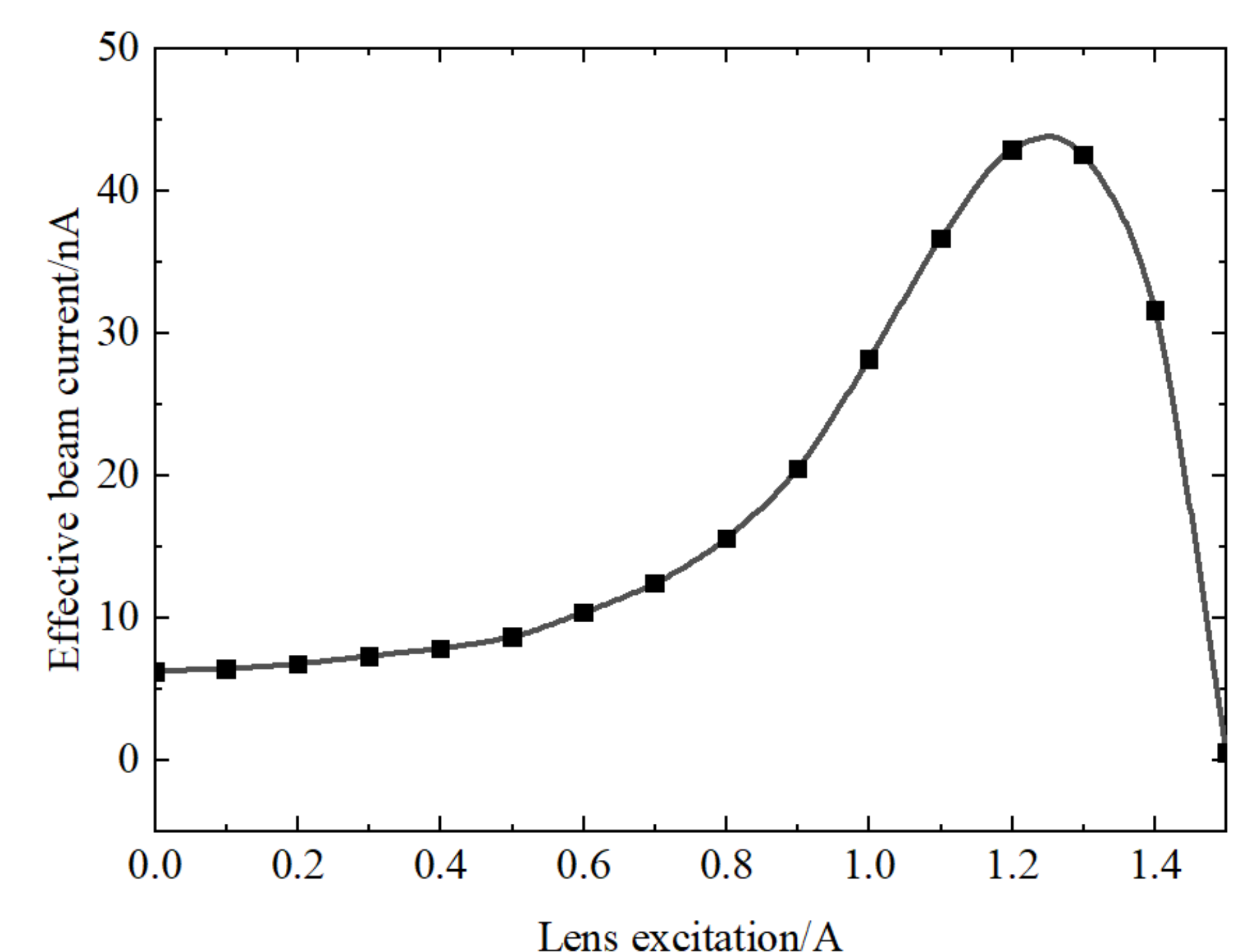


Performance variation of the magnetic field immersed thermal field electron gun with the lens current.

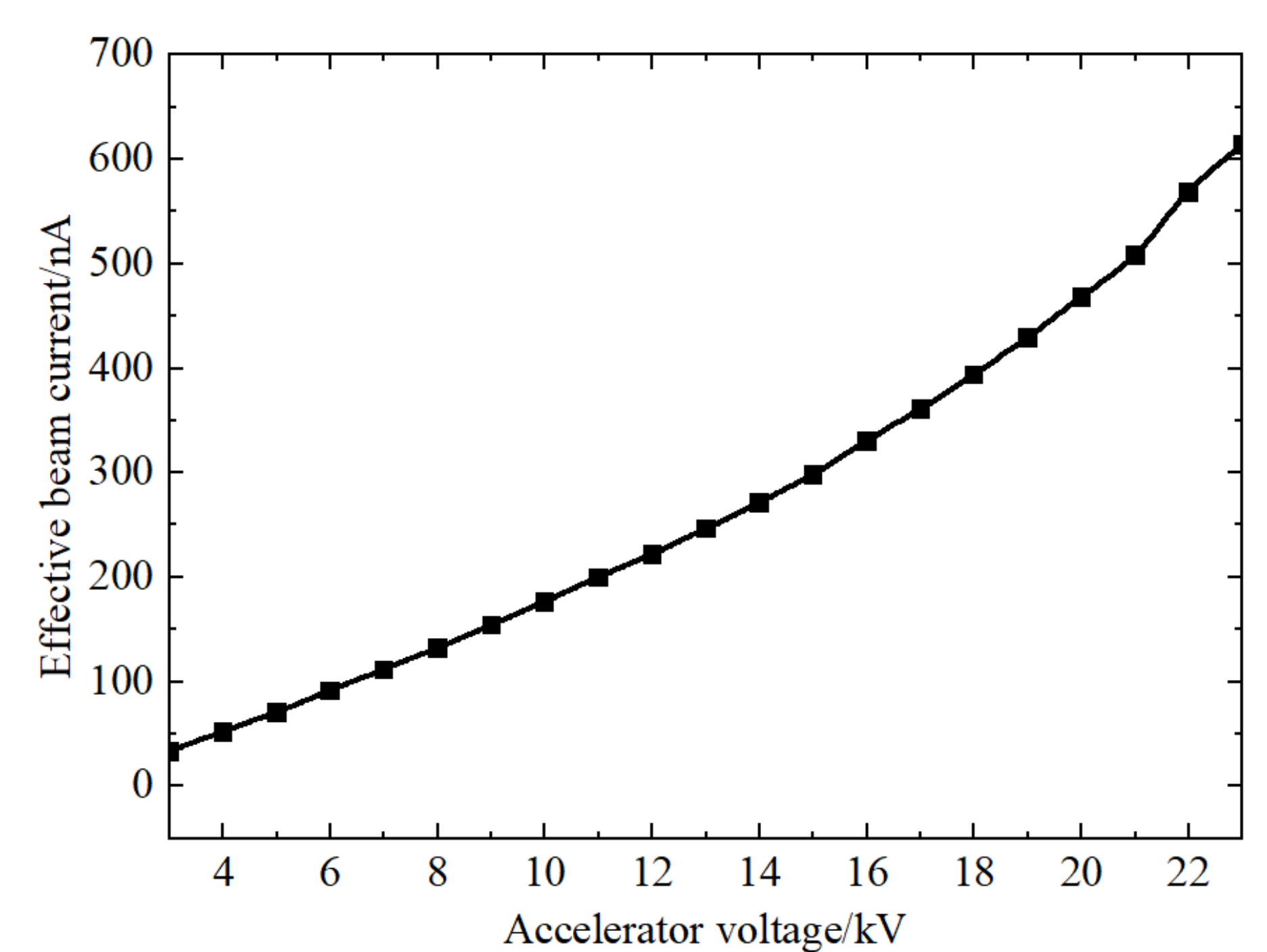
III. Experimental results



Experimental platform of magnetic field immersed thermal field electron gun.



The effective beam current variation of the electron gun with the magnetic immersion lens excitation.



Experimental results of the effective beam current variation with the accelerator voltage.

SUMMARY

The effective emitted beam current of magnetic field-immersed thermal field electron gun initially increases and subsequently decreases with the lens excitation, while the brightness remains approximately constant. Experimental results show that the current reached 44.97 nA at a low acceleration voltage of 3.3 kV and 638.12 nA at a high acceleration voltage of 23.5 kV, representing an approximately fourfold increase compared to that of a conventional thermal field electron gun.