CLAIMS

1. A magnetic immersion electron gun comprising:

a magnetic lens forming a magnetic field;

a cathode tip disposed in the magnetic field; and

a multi-filament heater configured to directly heat the cathode tip to emit electrons through the magnetic lens;

wherein the multi-filament heater comprises:

a first filament connected at each end to a first positive terminal and a second positive terminal of a power source; and

a second filament connected at each end to a first negative terminal and a second negative terminal of the power source;

wherein the first positive terminal, the second positive terminal, the first negative terminal, and the second negative terminal are arranged alternately around the cathode tip such that the first filament and the second filament intersect at the cathode tip and magnetic forces applied by the magnetic field to the first filament and the second filament cancel out to reduce a resultant magnetic force applied to the cathode tip.

2. The magnetic immersion electron gun of claim 1, wherein the first filament and the second filament have a same cross-section, are made from a same material, and carry a same current.

3. The magnetic immersion electron gun of claim 2, wherein the material is a tungsten-rhenium alloy including up to 27% rhenium.

4. The magnetic immersion electron gun of claim 1, wherein the first filament is comprised of a first material, the second filament is comprised of a second material different from the first material, and a cross-section of the first filament and a cross-section of the second filament are inversely proportional to a specific resistance of the first material and a specific resistance of the second material.

5. The magnetic immersion electron gun of claim 4, wherein the first material is a tungsten-rhenium alloy including up to 5% rhenium, and the second material is a tungsten-rhenium alloy including from 20 to 27% rhenium.

6. The magnetic immersion electron gun of claim 1, wherein the first filament and the second filament are orthogonal.

7. The magnetic immersion electron gun of claim 1, wherein the multi-filament heater is configured to directly heat the cathode tip to a temperature between 1600 K and 1900 K.

8. The magnetic immersion electron gun of claim 1, wherein the magnetic field has a magnetic flux density between 100 Gauss and 1000 Gauss.

9. A method of generating an electron beam using a magnetic immersion electron gun comprising:

applying a current from a power source to a first filament and a second filament of a multi-filament heater, wherein the first filament is connected at each end to a first positive terminal and a second positive terminal of the power source, and the second filament is connected at each end to a first negative terminal and a second negative terminal of the power source;

heating a cathode tip using the first filament and the second filament, wherein the first filament and the second filament intersect at the cathode tip, and the first positive terminal, the second positive terminal, the first negative terminal, and the second negative terminal are arranged alternately around the cathode tip; and

emitting electrons from the cathode tip through a magnetic lens toward a target, wherein the cathode tip is disposed in a magnetic field formed by the magnetic lens, and magnetic forces applied by the magnetic field to the first filament and the second filament cancel out to reduce a resultant magnetic force applied to the cathode tip.

10. The method of claim 9, wherein applying a current from a power source to the first filament and the second filament comprises:

applying a first current to the first filament; and

applying a second current to the second filament;

wherein the first current is equal to the second current.

11. The method of claim 9, wherein the first filament and the second filament are comprised of a tungsten-rhenium alloy including up to 27% rhenium.

12. The method of claim 9, wherein the first filament is comprised of a first material, the second filament is comprised of a second material different from the first material,

and a cross-section of the first filament and a cross-section of the second filament are inversely proportional to a specific resistance of the first material and a specific resistance of the second material.

13. The method of claim 12, wherein the first material is a tungsten-rhenium alloy including up to 5% rhenium, and the second material is a tungsten-rhenium alloy including from 20 to 27% rhenium.

14. The method of claim 9, wherein the first filament and the second filament are orthogonal.

15. The method of claim 9, wherein heating the cathode tip using the first filament and the second filament comprises:

heating the cathode tip using the first filament and the second filament to a temperature between 1600 K and 1900 K.

16. The method of claim 9, wherein the magnetic field has a magnetic flux density between 100 Gauss and 1000 Gauss.