CLAIMS

1. An electron-beam device, comprising:

a laser;

a photocathode film having a front side and a back side, to emit a plurality of electron beamlets when illuminated from the back side using the laser; and

electrodes to extract the plurality of electron beamlets from the front side of the photocathode film and to control shapes of the plurality of electron beamlets,

wherein the electrodes comprise:

a Wehnelt electrode having a first plurality of openings for the plurality of electron beamlets,

an extractor electrode having a second plurality of openings for the plurality of electron beamlets, and

an anode having a third plurality of openings for the plurality of electron beamlets; and

wherein:

the Wehnelt electrode is disposed between the front side of the photocathode film and the extractor electrode; and

the extractor electrode is disposed between the Wehnelt electrode and the anode.

2. The electron-beam device of claim 1, wherein:

the photocathode film comprises a plurality of emission regions separated from each other by a non-emission region;

the plurality of emission regions is thinner than the non-emission region; and

the plurality of electron beamlets is to be emitted from the plurality of emission regions when the back side of the photocathode film is illuminated using the laser.

3. The electron-beam device of claim 2, wherein:

the photocathode film is gold; and

the plurality of emission regions has a first thickness of 10-20 nm.

4. The electron-beam device of claim 3, wherein the non-emission region has a second thickness that is at least five times as thick as the first thickness.

5. The electron-beam device of claim 1, further comprising a light-aperture array, disposed between the laser and the back side of the photocathode film, to divide a laser beam from the laser into a plurality of optical beamlets to illuminate respective regions of the photocathode film from the back side of the photocathode film;

wherein the plurality of electron beamlets is to be emitted from the respective regions when the respective regions are illuminated by the plurality of optical beamlets.

6. The electron-beam device of claim 5, further comprising a pair of lenses, disposed between the laser and the light-aperture array, to magnify the laser beam.

7. The electron-beam device of claim 1, further comprising a plurality of beam-limiting apertures to select central portions of the plurality of electron beamlets and block non-central portions of the plurality of electron beamlets, wherein:

the anode is disposed between the extractor electrode and the plurality of beam-limiting apertures; and

a bore size of the third plurality of openings of the anode is larger than a bore size of the plurality of beam-limiting apertures.

8. The electron-beam device of claim 1, further comprising image lensing to focus the plurality of electron beamlets onto an intermediate image plane.

9. The electron-beam device of claim 8, wherein the image lensing comprises an image-lens array, disposed between the anode and the intermediate image plane, to focus the plurality of electron beamlets onto the intermediate image plane.

10. The electron-beam device of claim 8, wherein:

the image lensing comprises a global image lens, disposed between the anode and the intermediate image plane, to form a crossover of the plurality of electron beamlets and to focus the plurality of electron beamlets onto the intermediate image plane after the crossover, wherein the crossover is situated between the global image lens and the intermediate image plane; and

the electron-beam device further comprises a field lens, coincident with the intermediate image plane, to collimate the plurality of electron beamlets.

11. The electron-beam device of claim 8, further comprising:

a transfer lens, disposed on an opposite side of the intermediate image plane from the image lensing, to form a crossover of the plurality of electron beamlets; and

an objective lens to focus the plurality of electron beamlets onto a target;

wherein the crossover is situated between the transfer lens and the objective lens.

12. The electron-beam device of claim 11, further comprising a first Wien filter and a second Wien filter disposed between the transfer lens and the objective lens, wherein:

the second Wien filter is closer to the objective lens than is the first Wien filter;

the second Wien filter is to deflect secondary electrons from the target to a detector; and

the first Wien filter is to compensate for the second Wien filter.

13. The electron-beam device of claim 1, wherein:

the photocathode film is disposed on a front side of a substrate;

the substrate is integrated into an electron-optical column that comprises a vacuum chamber;

the front side of the substrate faces into the vacuum chamber, the photocathode film being situated within the vacuum chamber; and

a back side of the substrate, to be illuminated using the laser to illuminate the back side of the photocathode film, is exposed to air.

14. The electron-beam device of claim 1, wherein the laser has an adjustable laser power to vary currents of the plurality of electron beamlets.

15. A method of operating an electron-beam device, comprising:

illuminating a back side of a photocathode film using a laser, causing the photocathode film to emit a plurality of electron beamlets;

extracting the plurality of electron beamlets from a front side of the photocathode film using an extractor electrode; and

directing the plurality of electron beamlets to a target, to inspect the target, the directing comprising:

controlling shapes of the plurality of electron beamlets using a Wehnelt electrode, and

accelerating the plurality of electron beamlets using an anode, wherein:

the Wehnelt electrode is disposed between the front side of the photocathode film and the extractor electrode; and

the extractor electrode is disposed between the Wehnelt electrode and the anode.

16. The method of claim 15, wherein:

the photocathode film comprises a plurality of emission regions separated from each other by a non-emission region;

the plurality of emission regions is thinner than the non-emission region;

the illuminating causes the photocathode film to emit the plurality of electron beamlets from the emission regions; and

the extracting comprises extracting the plurality of electron beamlets from the emission regions.

17. The method of claim 15, wherein the illuminating comprises:

generating a laser beam using the laser,

dividing the laser beam into a plurality of optical beamlets using a light-aperture array, and

illuminating respective regions of the photocathode film with the plurality of optical beamlets from the back side of the photocathode film; and

the extracting comprises extracting the plurality of electron beamlets from the respective regions.

18. The method of claim 15, further comprising selecting central portions of the plurality of electron beamlets and blocking non-central portions of the plurality of electron beamlets using a plurality of beam-limiting apertures, wherein:

the anode is disposed between the extractor electrode and the plurality of beam-limiting apertures; and

a bore size of openings in the anode for the plurality of electron beamlets is larger than a bore size of the plurality of beam-limiting apertures.

19. The method of claim 15, wherein the directing further comprises focusing the plurality of electron beamlets onto an intermediate image plane.

20. The method of claim 19, wherein focusing the plurality of electron beamlets onto the intermediate image plane is performed using an image-lens array disposed between the anode and the intermediate image plane.

21. The method of claim 19, wherein:

focusing the plurality of electron beamlets onto the intermediate image plane is performed using a global image lens disposed between the anode and the intermediate image plane;

focusing the plurality of electron beamlets onto the intermediate image plane comprises forming a crossover of the plurality of electron beamlets between the global image lens and the intermediate image plane; and

the directing further comprises collimating the plurality of electron beamlets as focused onto the intermediate image plane, using a field lens.

22. The method of claim 19, wherein the directing further comprises:

forming a crossover of the plurality of electron beamlets using a transfer lens, wherein the crossover is situated on an opposite side of the intermediate image plane from the anode; and

focusing and decelerating the plurality of electron beamlets onto the target using an objective lens, wherein the objective lens is disposed between the crossover and the target.

23. The method of claim 22, further comprising:

using a first Wien filter to compensate for effects of a second Wien filter on the plurality of electron beamlets, wherein the second Wien filter is closer to the objective lens than the first Wien filter; and

deflecting secondary electrons from the target to a detector, using the second Wien filter.

24. The method of claim 15, wherein:
the photocathode film is disposed on a front side of a substrate;
the substrate is integrated into an electron-optical column; and
the method further comprises:
exposing the photocathode film, as disposed on the front side of the substrate, to a vacuum in the electron-optical column; and
exposing the back side of the substrate to air.

25. The method of claim 15, wherein the target is a first target and the illuminating is performed with the laser configured to have a first laser power, the method further comprising:
after performing the illuminating, the extracting, and the directing, reconfiguring the laser to have a second laser power distinct from the first laser power; and
with the laser reconfigured to have the second laser power, repeating the illuminating, the extracting, and the directing to inspect a second target.

26. The method of claim 15, wherein the illuminating is performed with the laser configured to have a first laser power, the method further comprising:
after performing the illuminating, the extracting, and the directing, reconfiguring the laser to have a second laser power distinct from the first laser power; and
with the laser reconfigured to have the second laser power, repeating the illuminating, the extracting, and the directing.

27. The method of claim 15, wherein the illuminating is performed using circularly polarized light from the laser.

28. The method of claim 15, wherein the illuminating is performed using pulsed light from the laser.