Claims:

1. A thermal processing apparatus for processing a semiconductor substrate, comprising:

a substrate support;

a source of laser radiation for emitting laser radiation along an optical path;

an illumination optics disposed along the optical path comprising:

a set of slow-axis lenses having at least a first cylindrical lens and a second cylindrical lens spaced apart from each other; and

a set of fast-axis lenses having at least a first cylindrical lens and a second cylindrical lens spaced apart from each other, the set of fast-axis lenses being disposed between the first cylindrical lens and the second cylindrical lens of the set of slow-axis lenses; and

a homogenizer disposed between of the illumination optics and the substrate support along the optical path, the homogenizer comprising:

a first micro-optic lenslet array; and

a second micro-optic lenslet array, wherein the second micro-optic lenslet array has a relatively larger lenslet pitch than that of the first micro-optic lenslet array, and lenslet axes of the first micro-optic lenslet array and lenslet axes of the second micro-optic lenslet array are oriented along an axis that is parallel to a fast axis of the source of laser radiation.

2. The apparatus of claim 1, further comprising:

a plurality of condensing lenses disposed between the homogenizer and the substrate support along the optical path, wherein the plurality of condensing lenses have at least five lenses with all spherical surfaces.

3. The apparatus of claim 1, wherein the first micro-optic lenslet array and the second micro-optic lenslet array each has a plurality of curved surfaces.

4. The apparatus of claim 1, wherein the first micro-optic lenslet array and the second micro-optic lenslet array are cylindrical lenses.

5. The apparatus of claim 1, wherein the first cylindrical lens of the set of slow-axis lenses has a convex lens surface facing toward the source of laser radiation and the second cylindrical lens of the set of slow axis lenses has a convex lens surface facing toward the surface of the substrate.

6. The apparatus of claim 5, wherein the first cylindrical lens of the set of fast-axis lenses has a concave lens surface facing toward the source of laser radiation and the second cylindrical lens of the set of fast-axis lenses has a convex lens surface facing toward the surface of the substrate.

7. A thermal processing apparatus for processing a semiconductor substrate, comprising:

a substrate support;

an array of laser diode bars emitting laser radiation at a first wavelength, the array of laser diode bars being arranged in plural parallel rows extending along a slow axis, the rows of laser diode bars being arranged in a stack along a fast axis, wherein the slow axis and the fast axis are orthogonal to an optical path between the array of laser diode bars and the substrate support;

an illumination optics disposed between the array of laser diode bars and the substrate support along the optical path, the illumination optics comprising:

a polarizing beamsplitter;

a set of slow-axis lenses having at least a first cylindrical lens and a second cylindrical lens spaced apart from each other;

a set of fast-axis lenses having at least a first cylindrical lens and a second cylindrical lens spaced apart from each other, the set of fast-axis lenses being disposed between the first cylindrical lens and second cylindrical lens of the set of slow-axis lenses;

a dichroic mirror disposed downstream of the set of fast-axis lenses and configured to redirect laser radiation of a second and a third wavelengths reflected from the heated substrate to a pyrometer; and

a waveplate disposed downstream of the dichroic mirror to transform the linear polarization of laser radiation into circular polarization;

a homogenizer disposed between the illumination optics and the substrate support along the optical path for homogenizing laser radiation along the slow axis, the homogenizer comprising:

a first micro-optic lenslet array; and

a second micro-optic lenslet array, the second micro-optic lenslet array having a relatively larger lenslet pitch than that of the first micro-optic lenslet array; and

a condensing lens set disposed between the homogenizer and the substrate support along the optical path for focusing line image at a surface of the substrate, the condensing lens set having at least five lenses with all spherical surfaces.

8. The apparatus of claim 7, wherein the first cylindrical lens of the set of slow-axis lenses has a convex lens surface facing toward the array of laser diode bars and the second cylindrical lens of the set of slow-axis lenses has a convex lens surface facing toward the surface of the substrate.

9. The apparatus of claim 7, wherein the first cylindrical lens of the set of fast-axis lenses has a concave lens surface facing toward the array of laser diode bars and the second cylindrical lens of the set of fast-axis lenses has a convex lens surface facing toward the surface of the substrate.

10. The apparatus of claim 7, wherein lenslet axes of the first micro-optic lenslet array and lenslet axes the second micro-optic lenslet array are oriented along an axis that is parallel to a fast axis of the source of laser radiation.

11. The apparatus of claim 7, wherein the homogenizer further comprising:

a weak cylindrical lens placed in between the first micro-optic lenslet array of cylindrical lenses and the second micro-optic lenslet array of cylindrical lenses.

12. A thermal processing apparatus for processing a semiconductor substrate, comprising:

a substrate support;

an array of laser diode bars arranged in plural parallel rows extending along a slow axis, the rows of laser diode bars being arrayed in a stack along a fast axis, the slow-axis being generally perpendicular to the fast-axis;

an illumination optics disposed between the array of laser diode bars and the substrate support, the illumination optics comprising:

a set of slow-axis lenses having at least a first cylindrical lens and a second cylindrical lens spaced apart from each other, the set of slow-axis lenses collimate laser beam radiation in the slow axis; and

a set of fast-axis lenses having at least a first cylindrical lens and a second cylindrical lens spaced apart from each other, the set of fast-axis lenses being disposed between the first and second cylindrical lenses of the set of slow-axis lenses to collimate laser beam radiation in the fast axis; and

a homogenizer disposed between the illumination optics and the substrate support for homogenizing laser beam radiation collimated by the illumination optics along the slow axis, the homogenizer comprising:

a first micro-optic lenslet array of cylindrical lenses; and

a second micro-optic lenslet array of cylindrical lenses disposed parallel and spaced apart from the first micro-optic lenslet array of cylindrical lenses, wherein the second micro-optic lenslet array of cylindrical lenses has a relatively larger lenslet pitch than that of the first micro-optic lenslet array of cylindrical lenses, and lenslet axes of the first micro-optic lenslet array and lenslet axes of the second micro-optic lenslet array are oriented along an axis that is parallel to a fast axis of the source of laser radiation; and

a condensing lens set disposed between the homogenizer and the substrate support along the optical path for focusing line image at a surface of the substrate, the condensing lens set having at least five lenses with all spherical surfaces.

13. The apparatus of claim 12, wherein the first cylindrical lens of the set of slow-axis lenses has a convex lens surface facing toward the array of laser diode bars and the second cylindrical lens of the set of slow-axis lenses has a convex lens surface facing toward the surface of the substrate.

14. The apparatus of claim 12, wherein the first cylindrical lens of the set of fast-axis lenses has a concave lens surface facing toward the array of laser diode bars and the second cylindrical lens of the set of fast-axis lenses has a convex lens surface facing toward the surface of the substrate.

15. The apparatus of claim 12, wherein the first and second micro-optic lenslet array of cylindrical lenses have optical prescription shown in Table 2 of the specification.

Claims:

1. A thermal processing apparatus for processing a semiconductor substrate, comprising:

a substrate support having a substrate receiving surface;

a beam source having a fast axis for emitting a beam along an optical path intersecting the substrate receiving surface of the substrate support; and

a homogenizer disposed along the optical path between the beam source and the substrate support, the homogenizer comprising:

a first lens array having a lenslet array of cylindrical lenses; and

a second lens array having a lenslet array of cylindrical lenses, wherein at least two adjacent cylindrical lenses of the lenslet array of the second lens array have a larger pitch than a pitch of at least two adjacent cylindrical lenses of the lenslet array of the first lens array.

2. The apparatus of claim 1, further comprising:

a plurality of condensing lenses disposed between the homogenizer and the substrate support along the optical path, wherein the plurality of condensing lenses comprises at least five spherical lenses.

3. The apparatus of claim 1, wherein the beam source emits a beam at a wavelength between about 190nm and about 950nm.

4. A thermal processing apparatus for processing a semiconductor substrate, comprising:

a substrate support having a substrate receiving surface;

an array of laser diode bars emitting laser radiation at a first wavelength along an optical path intersecting the substrate receiving surface of the substrate support, the array of laser diode bars being arranged in plural parallel rows extending along a slow axis, the rows of laser diode bars being arranged in a stack along a fast axis, wherein the slow axis and the fast axis are orthogonal to the optical path between the array of laser diode bars and the substrate support;

an illumination optics disposed along the optical path between the array of laser diode bars and the substrate support, the illumination optics comprising:

a set of slow-axis lenses having at least a first cylindrical lens and a second cylindrical lens spaced apart from each other; and

a set of fast-axis lenses having at least a first cylindrical lens and a second cylindrical lens spaced apart from each other, the set of fast-axis lenses being disposed between the first cylindrical lens and second cylindrical lens of the set of slow-axis lenses; and

a homogenizer disposed between the illumination optics and the substrate support along the optical path for homogenizing laser radiation along the slow axis, the homogenizer comprising:

a first lens array having a lenslet array of cylindrical lenses; and

a second lens array having a lenslet array of cylindrical lenses, wherein at least two adjacent cylindrical lenses of the lenslet array of the second lens array have a larger pitch than a pitch of at least two adjacent cylindrical lenses of the lenslet array of the first lens array.

5. The apparatus of claim 4, wherein the illumination optics further comprises:

a dichroic mirror disposed downstream of the set of fast-axis lenses and configured to redirect laser radiation of a second and a third wavelengths reflected from the heated substrate to a pyrometer; and

a waveplate disposed downstream of the dichroic mirror to transform the linear polarization of laser radiation into circular polarization.

6. The apparatus of claim 4, further comprising:

a condensing lens set disposed between the homogenizer and the substrate support along the optical path for focusing a line image at a surface of the substrate.

7. The apparatus of claim 6, wherein the condensing lens set comprises at least five spherical lenses.

8. The apparatus of claim 4, wherein the first cylindrical lens of the set of slow-axis lenses has a convex lens surface facing toward the array of laser diode bars and the second cylindrical lens of the set of slow-axis lenses has a convex lens surface facing toward the surface of the substrate.

9. The apparatus of claim 4, wherein the first cylindrical lens of the set of fast-axis lenses has a concave lens surface facing toward the array of laser diode bars and the second cylindrical lens of the set of fast-axis lenses has a convex lens surface facing toward the surface of the substrate.

10. The apparatus of claim 4, wherein axis of each lens of the first lens array and axis of each lens of the second lens array are oriented parallel to the fast axis.

11. The apparatus of claim 4, wherein the first wavelength is approximately 808nm, the second wavelength is approximately 940nm, and the third wavelength is approximately 1550nm.

12. A thermal processing apparatus for processing a semiconductor substrate, comprising:

a substrate support having a substrate receiving surface;

an array of laser diode bars emitting laser radiation along an optical path intersecting the substrate receiving surface of the substrate support, the array of laser diode bars are arranged in plural parallel rows extending along a slow axis, wherein the rows of laser diode bars are arrayed in a stack along a fast axis, the slow-axis is generally perpendicular to the fast-axis, and the slow axis and the fast axis are orthogonal to the optical path;

an illumination optics disposed along the optical path between the array of laser diode bars and the substrate support;

a homogenizer disposed between the illumination optics and the substrate support, the homogenizer comprising:

a first lens array of cylindrical lenses; and

a second lens array of cylindrical lenses disposed parallel and spaced apart from the first lens array of cylindrical lenses, wherein at least two adjacent cylindrical lenses of the second lens array have a larger pitch than a pitch of at least

two adjacent cylindrical lenses of the first lens array, and axis of each lens of the first lens array and axis of each lens of the second lens array are oriented parallel to the fast axis; and

a condensing lens set disposed between the homogenizer and the substrate support along the optical path, the condensing lens set comprising at least five spherical lenses.

13. The apparatus of claim 12, wherein the illumination optics comprises:

a set of slow-axis lenses having at least a first cylindrical lens and a second cylindrical lens spaced apart from each other, the set of slow-axis lenses collimate laser beam radiation in the slow axis; and

a set of fast-axis lenses having at least a first cylindrical lens and a second cylindrical lens spaced apart from each other, the set of fast-axis lenses being disposed between the first and second cylindrical lenses of the set of slow-axis lenses to collimate laser beam radiation in the fast axis.

14. The apparatus of claim 12, wherein the first cylindrical lens of the set of slow-axis lenses has a convex lens surface facing toward the array of laser diode bars and the second cylindrical lens of the set of slow-axis lenses has a convex lens surface facing toward the surface of the substrate.

15. The apparatus of claim 12, wherein the first cylindrical lens of the set of fast-axis lenses has a concave lens surface facing toward the array of laser diode bars and the second cylindrical lens of the set of fast-axis lenses has a convex lens surface facing toward the surface of the substrate.

16. The apparatus of claim 1, wherein each cylindrical lens of the lenslet array of the second lens array and each cylindrical lens of the lenslet array of the first lens array is oriented along an axis that is parallel to the fast axis.