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(54) **APPARATUS FOR ILLUMINATING AND INSPECTING A SURFACE**

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(58) **Field of Classification Search** ... 356/237.1–237.6; 355/67; 353/28–30; 359/619, 621, 741; 362/268, 311
See application file for complete search history.

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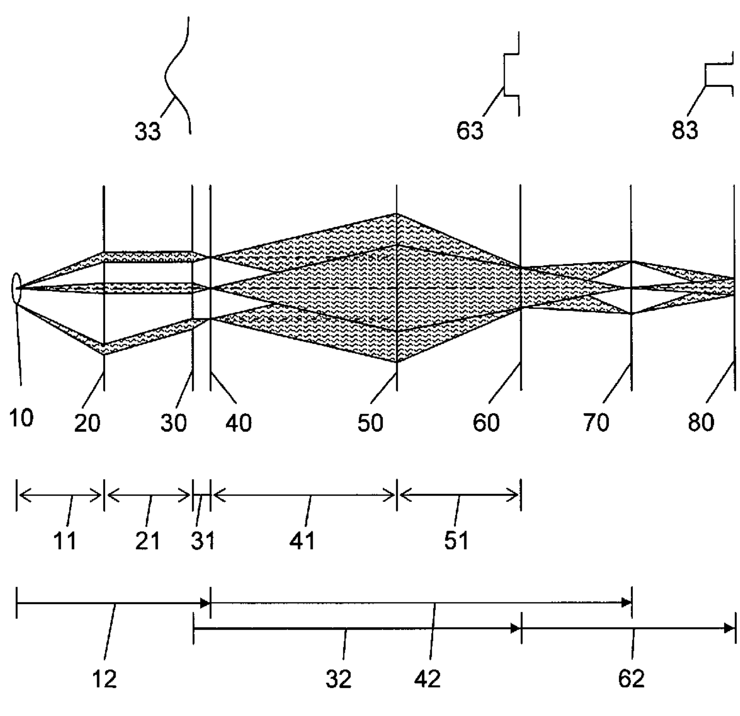
(57) **ABSTRACT**

The present invention relates to an apparatus for illuminating and inspecting a specular surface, comprising a light source, a collector optics for collecting the light from the light source, a homogenizing optics for transmitting the light from the collector optics having a first micro-lens array downstream of the collector optics, and a second micro-lens array downstream of the first micro-lens array, a Fourier optics for transmitting the light from the homogenizing optics onto the specular surface, an objective optics, and a detector for receiving an image, wherein the collector optics and the first micro-lens array project the light source onto the second micro-lens array and wherein the second micro-lens array and the Fourier optics project the first micro-lens array onto the specular surface, and wherein the objective optics projects the specular surface onto the detector.

15 Claims, 2 Drawing Sheets



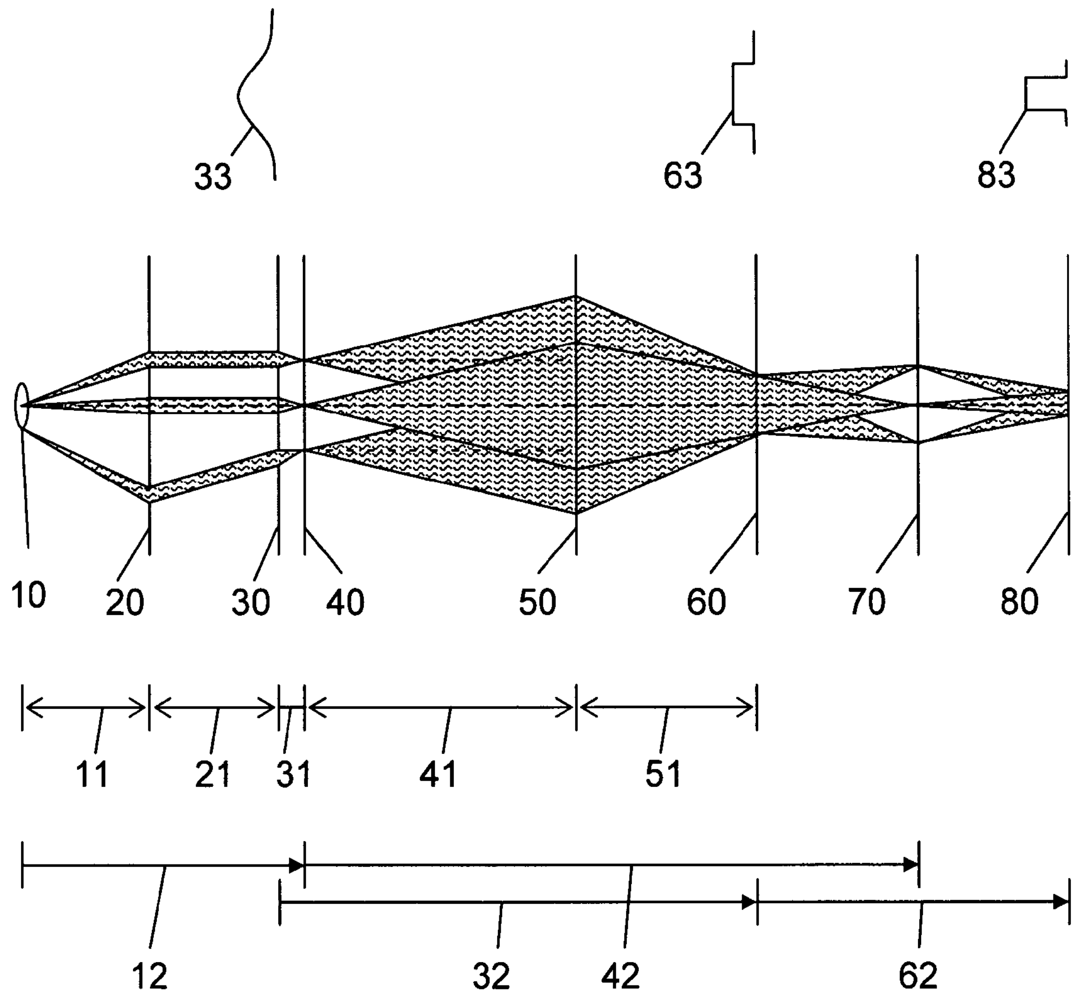


Fig. 1

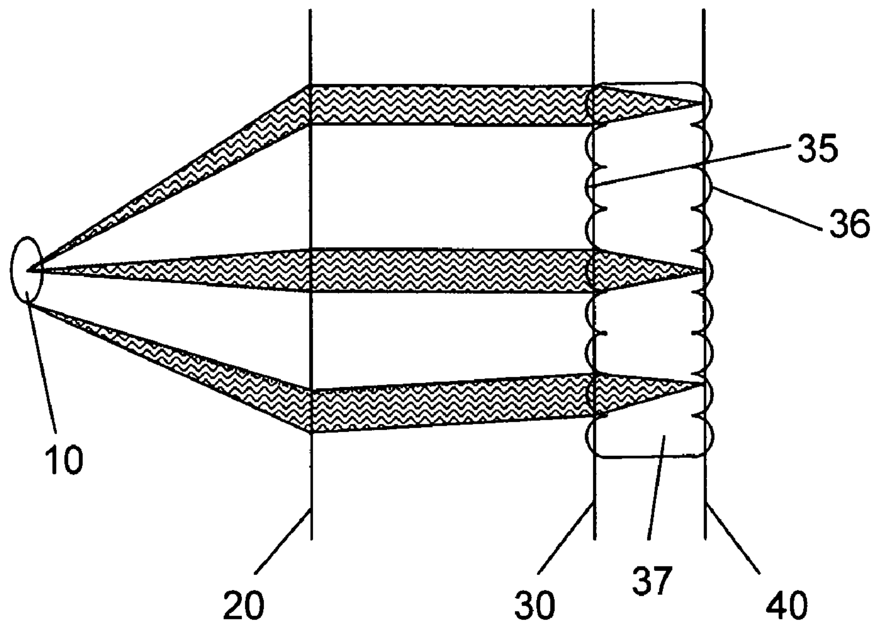


Fig. 2

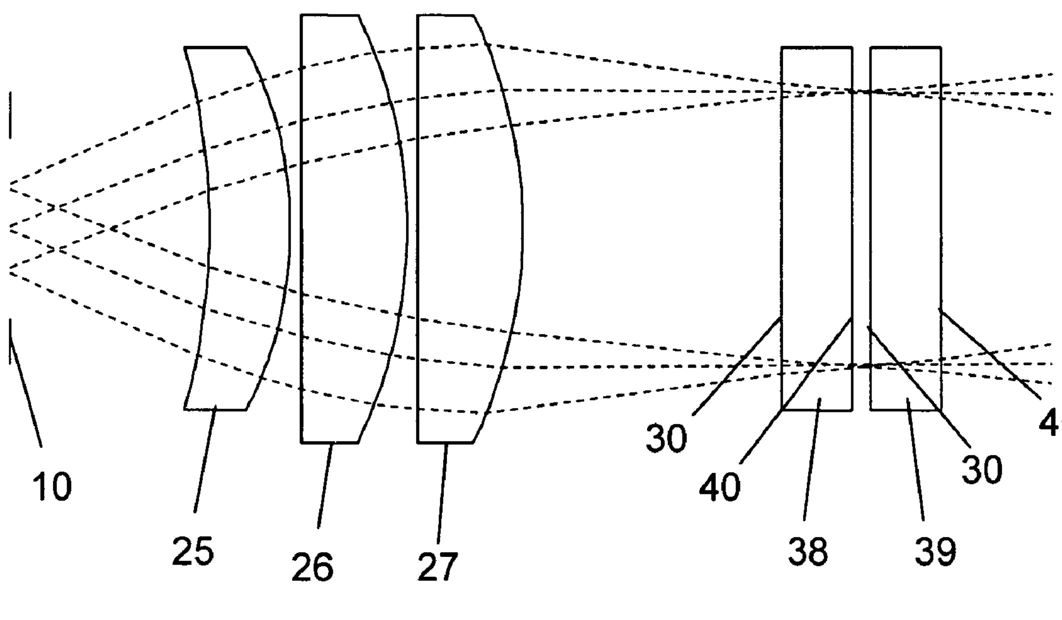


Fig. 3

APPARATUS FOR ILLUMINATING AND INSPECTING A SURFACE

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority of German Patent Application No. 10 2006 001 435.9, filed Jan. 10, 2006, which application is incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates to an apparatus for illuminating a surface and to an apparatus for inspecting a specular surface, such as of a wafer.

BACKGROUND OF THE INVENTION

For wafer inspection an illuminating intensity which is as high as possible is desirable while maintaining homogeneousness to the highest degree. The high intensity is necessary to increase wafer throughput with the shortest possible exposure times. The homogeneousness of illumination is necessary because when the images are evaluated they are compared with each other. Differences in the comparisons are evaluated as defects. Inhomogeneous illumination would therefore falsely indicate a defect.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide an apparatus for illuminating and inspecting a surface with high efficiency and homogeneousness of the illumination.

The object is fulfilled by an apparatus comprising:

a light source,

a collector optics for collecting the light from the light source,

a homogenizing optics for transmitting the light from the collector optics having a first micro-lens array downstream of the collector optics,

a second micro-lens array downstream of the first micro-lens array,

a Fourier optics for transmitting the light from the homogenizing optics onto the specular surface,

an objective optics,

a detector for recording an image, and

wherein the collector optics and the first micro-lens array project the light source onto the second micro-lens array, and wherein the second micro-lens array and the Fourier optics project the first micro-lens array onto the specular surface, and wherein the objective optics projects the specular surface onto the detector.

Additionally the object is fulfilled by an apparatus comprising:

a light source,

a collector optics for collecting the light from the light source,

a homogenizing optics for transmitting the light from the collector optics having a first micro-lens array downstream of the collector optics,

a second micro-lens array downstream of the first micro-lens array,

a Fourier optics for transmitting the light from the homogenizing optics onto the surface, wherein the collector optics and the first micro-lens array project the light source onto the second micro-lens array, and wherein the second micro-lens array and the Fourier optics project the first micro-lens array onto the surface.

Advantageous embodiments of the invention are defined in the dependent claims.

The basic idea of the invention is that the near-field distribution of the light source is homogenized by overlapping the images.

According to the present invention the object is solved by an apparatus for inspecting a specular surface, comprising a light source, a collector optics for collecting the light from the light source, a homogenizing optics for transmitting the light from the collector optics with a first micro-lens array downstream of the collector optics, and a second micro-lens array downstream of the first micro-lens array, and a Fourier optics for transmitting the light from the homogenizing optics onto the specular surface, an objective optics and a detector for receiving an image, wherein the collector optics and the first micro-lens array project the light source onto the second micro-lens array, wherein the second micro-lens array and the Fourier optics project the first micro-lens array onto the specular surface and wherein the objective optics projects the specular surface onto the detector.

Moreover, the object is achieved by an apparatus for illuminating a surface, comprising a light source, a collector optics for collecting the light from the light source, a homogenizing optics for transmitting the light from the collector optics with a first micro-lens array downstream of the collector optics, and a second micro-lens array downstream of the first micro-lens array, and a Fourier optics for transmitting the light from the homogenizing optics onto the surface, wherein the collector optics and the first micro-lens array project the light source onto the second micro-lens array, and wherein the second micro-lens array and the Fourier optics project the micro-lens array onto the surface.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described in more detail in the following with reference to the schematic representations of an exemplary embodiment. The same reference numerals refer to the same elements throughout the drawing figures, in which:

FIG. **1** illustrates an apparatus for inspecting a specular surface;

FIG. **2** illustrates an apparatus for illuminating a surface as a detail in FIG. **1**; and,

FIG. **3** shows an alternative to FIG. **2**.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** shows an apparatus for inspecting a specular surface with light source **10**, collector optics **20**, a homogenizing optics including first micro-lens array **30** and second micro-lens array **40**, Fourier optics **50**, with specular surface **60** to be inspected, objective optics **70** and detector **80**. The beam path is shown as continuous on specular surface **60** for clarity.

Light source **10** is formed by the output surface of a fiber-optic bundle. Other point-like light sources are also conceivable. The light is generated by a flash lamp with a reflector and coupled into the fiber-optic bundle.

Collector optics **20** is disposed at a distance **11** of its focal length from light source **10**.

First micro-lens array **30** of the homogenizing optics is disposed at a distance **21** of the focal length of the collector optics from the latter. A bell shaped intensity distribution **33** is formed on the input surface of the first micro-lens array.

The micro lenses of the two micro-lens arrays have essentially the same focal length. The second micro-lens array **40** is disposed at a distance **31** of the focal length of the micro lenses from the first micro-lens array. Collector optics **20** and first micro-lens array **30**, in an image **12**, project light source **10** onto second micro-lens array **40**.

Fourier optics **50** is at a distance **41** greater than its focal length from second micro-lens array **40**. Fourier optics **50** is composed of two identical plano-convex lenses having their curvatures face each other. Second micro-lens array **40** and Fourier optics **50**, in an image **32**, project first micro-lens array **30** onto specular surface **60**.

Specular surface **60** can be represented, for example, by a wafer to be inspected. A translucent surface or plate is also conceivable, so that the beam is radiated not to be reflected, but to be transmitted as shown for clarity. Specular surface **60** is at a distance **51** of the focal length of Fourier optics **50** from the latter. A cup-shaped intensity distribution **63** is formed on the specular surface. The light dot of the intensity distribution has a size of about 40 mm by 40 mm. Fourier optics **50** and specular surface **60** project second micro-lens array **40** onto objective optics **70** in a second image **42**. Imaging onto the input pupil of objective optics **70** is suitable.

Objective optics **70** is not telecentric on the side of the object. The objective should only be telecentric on the side of the object if the illumination is telecentric, too. Objective optics **70**, in an image **62**, projects specular surface **60** onto detector **80** at a reduction of 1:6.5. A cup-shaped intensity distribution **83** is formed in detector **80**. The detector is a 2d-array surface detector, such as a CCD.

FIG. **2** shows a light source **10**, collector optics **20** and the homogenizing optics with first micro-lens array **30** and second micro-lens array **40**. The two micro-lens arrays are combined in a double array in a single component. They are formed here as a cushion from the opposite surfaces of a plate. The micro lenses are curved toward the outside on the plate surface. The distance of the micro lenses in each array is about 1/10 of their focal length. The individual lenses **35** of the first micro-lens array **30** and the individual lenses **36** of the second micro-lens array **40** are arranged facing each other without being offset.

FIG. **3** shows an alternative embodiment to FIG. **2**. Collector optics **20** is composed of a first lens **25**, a second lens **26** and a third lens **27**. The homogenizing optics is formed here, as an alternative, by a first double array **38** and a second double array **39** each having a first micro-lens array **30** and a second micro-lens array **40**. Micro-lens arrays **30** and **40** of double arrays **38** and **39** are cylindrical micro-lens arrays. The cylindrical micro lenses and the micro-lens arrays of each double array are arranged facing each other in parallel and without being offset. Double arrays **38** and **39** have the alignment of their cylindrical lenses crossed and arranged at a small distance from each other.

The gaps between the individual micro lenses are suitably covered.

Light source **10**, collector optics **20**, the homogenizing optics and the Fourier optics form the apparatus for illuminating a surface.

The arrangements shown achieve an extremely uniform and high-intensity distribution on the surface to be inspected for the apparatus for illuminating as well as in the detector for the apparatus for inspection.

What is claimed is:

1. An apparatus for inspecting a specular surface, comprising:

a light source;

a collector optics for collecting the light from the light source;

a homogenizing optics for transmitting the light from the collector optics having a first micro-lens array downstream of the collector optics;

a second micro-lens array downstream of the first micro-lens array;

a Fourier optics for transmitting the light from the homogenizing optics onto the specular surface;

an objective optics;

a detector for recording an image; and

wherein the collector optics and the first micro-lens array project the light source onto the second micro-lens array, and wherein the second micro-lens array and the Fourier optics project the first micro-lens array onto the specular surface, and wherein the objective optics projects the specular surface onto the detector, the Fourier optics is arranged at a distance greater than its focal length downstream of the homogenizing optics and in that the objective optics is not telecentric on the side of an object.

2. The apparatus according to claim **1**, wherein the Fourier optics projects the second micro-lens array onto the input pupil of the objective optics via the specular surface.

3. The apparatus according to claim **1**, wherein the objective optics projects the surface at a reduction of 1:6.5.

4. An apparatus for illuminating a surface, comprising:

a light source;

a collector optics for collecting the light from the light source;

a homogenizing optics for transmitting the light from the collector optics having a first micro-lens array downstream of the collector optics;

a second micro-lens array downstream of the first micro-lens array;

a Fourier optics for transmitting the light from the homogenizing optics onto the surface; and,

wherein the collector optics and the first micro-lens array project the light source onto the second micro-lens array, and wherein the second micro-lens array and the Fourier optics project the first micro-lens array onto the surface, wherein the first micro-lens array is arranged at a distance of the focal length of the collector optics downstream of the collector optics and wherein the second micro-lens array is arranged at a distance of the focal length of the micro lenses downstream of the first micro-lens array in parallel.

5. The apparatus according to claim **4**, wherein the collector optics is arranged at a distance of its focal length from the light source.

6. The apparatus according to claim **4**, wherein the focal length of the micro lenses of the micro-lens array is between 1 mm and 4 mm.

7. The apparatus according to claim **4**, wherein the distance of the micro lenses of the micro-lens array is between 1/20 and 1/5, of their focal lengths.

8. The apparatus according to claim **4**, wherein the second micro-lens array is equal to the first micro-lens array.

9. The apparatus according to claim **4**, wherein the second micro-lens array is arranged with its lenses parallel and not offset with respect to the lenses of the first micro-lens array.

10. The apparatus according to claim **4**, wherein the first micro-lens array and the second micro-lens array are configured as an integral double array having the lens curvatures face outside.

11. The apparatus according to claim **4**, wherein the first micro-lens array and the second micro-lens array are provided with cushion-shaped lenses.

12. The apparatus according to claim **4**, wherein the first micro-lens array and the second micro-lens array are configured with cylindrical lenses and have two crossed micro-lens pairs, wherein the first micro-lens pair is of a first and a second micro-lens array with parallel and non-offset associated cylindrical lenses, and the second micro-lens pair is of a third and fourth micro-lens array with parallel non-offset associated cylindrical lenses.

13. The apparatus according to claim **4**, wherein the Fourier optics is at a distance of its focal length upstream of the surface.

14. The apparatus according to claim **4**, wherein the Fourier optics consists of two identical plano-convex lenses having their curvatures face each other.

15. The apparatus according to claim **4**, wherein the micro-lens array and the Fourier optics project a light dot of about 40 mm by 40 mm.

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