Appeal decision

Appeal No. 2019-6706

Appellant Jaiswal Supriya

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The case of appeal against the examiner's decision of refusal of Japanese Patent Application No. 2014-553485 entitled "Materials, components, and methods for use with extreme ultraviolet radiation in lithography and other applications" [July 25, 2013, International Publication No. WO2013/109986, April 9, 2015, Domestic Publication, National Publication of International Patent Application No. 2015-510688] has resulted in the following appeal decision:

Conclusion

The appeal of the case was groundless.

Reason

No. 1 History of the procedures

The present application was filed on January 18, 2013 as the international filing date (priority claim under the Paris Convention January 19, 2012, U.S.A.) and the history of the procedures are as follows:

September 30, 2016 : Notification of Reasons for Refusal

March 6, 2017 : Written Opinion and Written Amendment
May 26, 2017 : Notification of Reasons for Refusal
December 6, 2017 : Written Opinion and Written Amendment
March 8, 2018 : Notification of Reasons for Refusal
September 20, 2018 : Written Opinion and Written Amendment
January 10, 2019 : Decision of Refusal
May 22, 2019 : Written Request for Trial
July 4, 2019 : Written Amendment (Amendment of Written Request for Trial)
August 2, 2019 : Notification of Reasons for Refusal
February 6, 2020 : Written Opinion and Written Amendment

No. 2 Reasons for refusal by the body

Reasons of refusal notified by the body with Notification of Reasons for Refusal dated August 2, 2019 include the following reasons.

1 With respect to inventions recited in Claims 1 to 3 before the amendment with Written Amendment submitted on February 6, 2020 (hereinafter, referred to as the "Amendment"), since no principle of solving the problem to be solved by the present inventions is clear, and the detailed description of the invention or drawings of the present application does not disclose any concrete structure (materials, measurements, manufacturing method, etc.) such as working examples, inventions recited in each claim cannot be deemed to be identical with any invention described in the detailed description of the invention, and, therefore, the present application does not comply with the requirement set forth in Article 36(6)(i) of the Patent Act.

2 With respect to inventions recited in Claims 1 to 3 before the Amendment, since no principle of solving the problem to be solved by the present inventions is clear, and the detailed description of the invention or drawings of the present application does not disclose any concrete structure (materials, measurements, manufacturing method, etc.) such as working examples, descriptions in the detailed description of the invention of the present application cannot be deemed to have been described clearly and sufficiently as to enable a person skilled in the art to work the inventions, and, therefore, the present application does not comply with the requirement set forth in Article 36(4)(i) of the Patent Act.

3 Even if the present application complies with the enablement requirement and the supporting requirement, since inventions according to Claims 1 to 3 before the amendment could have been easily invented by a person skilled in the art based on the

invention described in the Cited Document that was distributed or made publicly available through an electric telecommunication line prior to the priority date of the present application and well-known art, the Appellant should not be granted a patent for the inventions under the provisions of Article 29(2) of the Patent Act.

Cited Document: Japanese Unexamined Patent Application Publication No. 2003-318094

Well-known example: Susumu Noda, "Photonic crystals," Optical Review (KOGAKU), 2001, Vol. 30, No. 1, pages 56 to 64

No. 3 Judgment by the body

The body judged that the present application should be rejected based on any one of the reasons in above No. 2 as explained below.

1 Descriptions in the specification, scope of claims, or drawings attached to the present application (hereinafter, referred to as "the specification, etc. of the present application")

The specification, etc. of the present application (after the Amendment) have the following descriptions.

(1) "Scope of claims

[Claim 1]

An element configured to be used in a light exposure system, wherein the light exposure system comprises a light source configured to transmit light having a wavelength, the element comprising:

a material having a plurality of nanostructural features that form voids or gaps, said plurality of nanostructural features having a first size between 250 nm and 0.01 nm;

wherein the plurality of nanostructural features are configured so that the reflectivity of the element is greater than 70% for a single target wavelength selected to be a single wavelength between 0.1 nm and 250 nm.

[Claim 2]

An element configured to be used in a light exposure system, wherein the light exposure system comprises a light source configured to transmit light having a wavelength, the element comprising:

a material having a plurality of nanostructural features that form voids or gaps, said plurality of nanostructural features having a first size between 250 nm and 0.01 nm;

wherein the plurality of nanostructural features are configured so that the transmission of the element is greater than 4% for a single target wavelength selected to be a single wavelength between 0.1 nm and 250 nm.

[Claim 3]

An element configured to be used in a light exposure system, wherein the light exposure system comprises a light source configured to transmit light having a wavelength, the element comprising:

a material having a plurality of nanostructural features that form voids or gaps, said plurality of nanostructural features having a first size between 250 nm and 0.01 nm;

wherein the plurality of nanostructural features are configured to control the electromagnetic radiation absorption for a single target wavelength selected to be a single wavelength between 0.1 nm and 250 nm.

[Claim 4]

The light exposure system according to Claim 1, 2, or 3, wherein the light exposure system includes a photolithography tool, a biotechnology system, a scanning or imaging system, an astronomical system, a material processing system, or a printing system.

[Claim 5]

The element according to any one of Claims 1 to 4, wherein the plurality of nanostructural features have a first size, said first size substantially correlating with the target wavelength.

[Claim 6]

The element according to any one of Claims 1 to 5, wherein the plurality of nanostructural features are one, two, or three dimensional.

[Claim 7]

The element according to any one of Claims 1 to 6, wherein the plurality of nanostructural features have a periodicity in the material, and said periodicity may be in one, two, or three dimensions.

[Claim 8]

The element according to any one of Claims 1 to 7, wherein the plurality of nanostructural features are arranged in one of the following: semi-periodic, aperiodic, graded, partially graded, symmetric, fractal, gyroid, swiss roll, non-planar, segments, repeated unit, forming a pattern, or randomly or semi random order in the material.

[Claim 9]

The light exposure system according to any one of Claims 1 to 8, wherein the plurality of nanostructural features comprise one or more of the following: metal, dielectric, gas, liquid, compound, semiconductor, polymer, organic material, biological material, monatomic material, air, carbon, molybdenum, beryllium, lanthanum, boron carbide, silicon, SiO_2, TiO_2, ruthenium, niobium, rhodium, gold, silver, copper, platinum, palladium, germanium, DNA, proteins, graphene, graphite, carbon nanotubes, MoS, O_2, N_2, He, H_2, Ar, and CO_2.

[Claim 10]

The element according to any one of Claims 1 to 9, wherein the element comprises a substrate, a mirror, a lens, a surface, a window, a facet, a filter, a covering element, a capping layer, a protective layer, a barrier layer, a thin film, a collector, a droplet generator, a panel, a waveguide, cavity, a fiber, a reflective element, a transmissive element, a detector, a wavelength monitor, a bandwidth or power motor, sensors, a photo mask, a photo resist, a cooling mechanism, a heat management mechanism, a light source, a lamp, a laser, an optical element, a mask aligner, an integrator, an optical device, or an electronic device.

[Claim 11]

The element according to any one of Claims 1 to 10, wherein the plurality of nanostructural features have shapes containing layers, films, spheres, blocks, pyramids, rings, cylinders, shells, hemispheres, or segments."

(2) "[Technical Field]

[0001]

Related application

The present application is a non-provisional version of U.S. Provisional Application No. 61/588601, filed on January 19, 2012, entitled "Materials, Components, and Methods for Use with Extreme Ultraviolet Radiation in Lithography & Other Applications," the disclosure of which is hereby incorporated by reference in its entirety."

(3) "[Background Art]

[0002]

Background

Optical lithography systems are commonly used for fabrication of, for example, devices. The resolving power of such a system is proportional to the exposure wavelength. Thus, shorter wavelengths can improve resolution in fabrication. Extreme ultraviolet lithography (EUVL) uses electromagnetic radiation at extreme ultraviolet (EUV) wavelength (approximately 120 nanometers to 0.1 nanometers). Accordingly, photons at these wavelengths have energies in the range of approximately 10 electron volts (eV) to 12.4 keV (corresponding to 124 nm and 0.1 nm, respectively). Extreme ultraviolet wavelengths may be generated artificially by devices such as plasma and synchrotron light sources. Using EUV wavelengths for lithography has potential advantages of reducing feature sizes in devices such as semiconductor chips as well as in other applications such as polymer electronics, solar cells, biotech, medical technologies. At EUV wavelengths, the materials used to form the components of the lithography system, for example, mirrors, lenses, photoresist, etc. become important. Most materials, however, have a high absorption rate for radiation at EUV wavelengths. Higher absorption in these materials at EUV wavelengths decreases the performance of EUV lithography systems. For example, EUV lithography systems may need a higher power source to overcome this absorption.

(4) "[Summary of Invention]

[0003]

This disclosure relates generally to materials, devices, apparatus, and methods for use with ultraviolet (UV), extreme ultraviolet (EUV), and soft X-ray radiation, such as in lithography (EUVL) or other applications. More specifically, but not exclusively, the disclosure relates to materials and components for use in UV, EUV, and soft X-ray applications, as well as methods of fabrication and use of such materials and components in apparatus, devices, and systems using EUV radiation.

[0004]

In certain embodiments, the disclosure relates to an element that can be used in a light exposure system, wherein the system or subsystem includes a light source to transmit light having a wavelength. The element can include a material having a plurality of structural features. The plurality of structural features can improve the reflectivity of the element to greater than 70% for a selected wavelength.

[0005]

In another embodiment, the disclosure relates to an element that can be used in a light exposure system. The system or subsystem can include a light source to transmit light having a wavelength. The element can include a material having a plurality of structural features. The plurality of structural features can improve the transmission of the element to greater than 4% for a selected wavelength.

[0006]

In another embodiment, the disclosure relates to an element that can be used in a light exposure system. The system or subsystem can include a light source to transmit light having a wavelength. The element can include a material having a plurality of structural features. The plurality of structural features can control the electromagnetic radiation absorption for a selected wavelength.

[0007]

In some embodiments, the light exposure system can include a photolithography tool, a scanning or imaging system, an astronomical system, a material processing system, or a printing system.

[0008]

In one embodiment, the wavelength is less than or equal to 250 nm. The plurality of structural features can have a first size, where the first size substantially correlates with the wavelength. In one embodiment, the plurality of structural features have a first size between 250 nm and 0.01 nm. The plurality of structural features can be one, two, or three dimensional. The plurality of structural features can have a periodicity in the material. The periodicity may be in one, two, or three dimensions. The plurality of structural features can be arranged in one of the following: semi-periodic, aperiodic, quasi-periodic, graded, partially graded, symmetric, fractal, gyroid, swiss roll, non-planar, segments, repeated unit, forming a pattern, or randomly or in semi random order in the material. The material can include one or more of the following: metal, dielectric, gas, liquid, compound, semiconductor, polymer, organic material, biological material, monatomic material, air, carbon, molybdenum, beryllium, lanthanum, boron carbide, silicon, SiO_2, TiO_2, ruthenium, niobium, rhodium, gold, silver, copper, platinum, palladium, germanium, DNA, proteins, graphene, graphite, carbon nanotubes, MoS, O_2, N_2, He, H_2, Ar, CO_2. The sutructural features can include one or more of the following: metal, dielectric, gas, liquid, compound, semiconductor, polymer, organic material, biological material, monatomic material, air, carbon, molybdenum, beryllium, lanthanum, boron carbide, silicon, SiO_2, TiO_2, ruthenium, niobium, rhodium, gold, silver, copper, platinum, palladium, germanium, DNA, proteins, graphene, graphite, carbon nanotubes, MoS, O_2, N_2, He, H_2, Ar, CO_2, vacuum, or voids. The plurality of structural features can have shapes or dimensions containing layers, films, spheres, blocks, pyramids, rings, porous structures, cylinders, linked shapes, shells, freeform shapes, chiral structures, hemispheres, or segments.

[0009]

In some embodiments, the element can be a substrate, mirror, lens, surface, window, facet, filter, covering element, capping layer, protective layer, barrier layer, thin film, coating, internal surface area, collector, droplet generator, interdispersed material, panel, waveguide, cavity, fiber, structural component, reflective element, transmissive element, a detector, a wavelength monitor, bandwidth or power monitor, sensors, a photomask, photoresist, a cooling mechanism, a heat management mechanism, light source, lamp, laser, optical element, mask aligner, integrator, structural component, optical device, or electronic device.

[0010]

In some embodiments, the material or structural features can be cleaned or preprocessed by one of the following methods of processing: chemical etching, laser radiation, or heating.

[0011]

In one embodiment, the material or subset of the material or aspect of the material can be fabricated by one of the following methods of processing: self-assembly, direct assembly, soft templating, electroforming, electroplating, sacrificial or scaffolding materials, block co-polymers, bottom-up techniques, EUV or XUV lithography, focused electron or ion beams, nanoimprinting, atomic force or scanning probe microscopy, two or more photon lithography, laser irradiation, dealloying, chemical etching, chemical surfactants, surface treatments.

[0012]

In certain embodiments, the disclosure provides a method of fabricating a material that can have a reflectivity of more than 70% at a wavelength. The method can include the step of polishing a host layer. In some embodiments, the method can further include the step of assembling a polymeric or scaffolding structure. Moreover, the method can include growing a main layer over the scaffolding structure. The method can also include polishing the surface of the main layer. Furthermore, the method can include the step of removing the polymeric or scaffolding structure so that the reflectivity of the material is greater than 70% at a wavelength between 0.1 nm and 250 nm. In some embodiments, the method can include the step of smoothing one or more layers through laser irradiation or chemical etching. The polymeric or scaffolding structure can be one or more block copolymers. In one embodiment, the method can further include the step of applying a capping or substrate."

(5) "[Brief Description of Drawings]

[0013]

The present disclosure may be more fully appreciated in connection with the following detailed description taken in conjunction with the accompanying drawings, wherein:

[Figure 1]

Figure 1 illustrates details of reflectivity characteristics of a Mo/Si multilayer stack at the EUV wavelengths compared to a structure of a material described herein.

[Figure 2]

Figure 2 illustrates an embodiment of a three-dimensional structure containing structural features and an example reflectance profile from a structure containing voids at EUV wavelengths.

[Figure 3]

Figure 3 illustrates an embodiment of a photolithography mask with a material described herein.

[Figure 4]

Figure 4 shows an embodiment of a photoresist with a material described herein.

[Figure 5]

Figure 5 shows an embodiment of an optical element or surface with a material described herein.

[Figure 6]

Figure 6 shows an embodiment of a fabrication process to make a material described herein using a polymeric template."

(6) "[Description of Embodiments]

[0014]

Lithography using extreme ultraviolet radiation may enable fabrication of devices with smaller feature sizes. However, most materials have a high absorption for electromagnetic radiation in the EUV spectrum. The choice of natural materials with a low absorption rate in the EUV spectrum is limited. Accordingly, the high absorption of most materials affects the performance of EUV lithography (EUVL) systems. For example, high levels of optical power might be required to operate a EUVL system. The system might also require an extensive heat management system because of the increased optical power.

[0015]

This disclosure describes materials that can improve performance of EUVL systems. The disclosure further describes fabrication of these materials and using these materials in components, apparatus, and devices of a EUVL system. The materials, methods, and systems described here can also be used in systems where the electromagnetic radiation is in the extreme ultraviolet and the soft X-ray wavelengths.

[0016]

The material can further improve performance in non-lithography systems which may use UV, EUV, or soft X-ray wavelengths. Examples include lamps and light sources, biological (e.g., biological assay and array development), botanical systems, imaging and microscopy systems, sensor activation, fluorescence, quantum dots, astronomy systems, material processing systems, and atomic, nuclear and particle emission radiation, acceleration systems, space systems.

[0017]

As used herein, UV radiation is electromagnetic radiation in the wavelength range of approximately 400 nanometers to 120 nanometers, EUV radiation is electromagnetic radiation in the wavelength range of approximately 120 nanometers to 1 nanometer, and soft X-ray is electromagnetic radiation in the wavelength range of approximately 1 nanometer to 0.01 nanometers. The selected wavelength range may be part of a two or more photon process which may be equivalent to an excitation in the UV, EUV, or X-ray range. Some differences in definition may exist in the general literature, but the intended region is approximately the same. In addition, the intended range intends to encompass radiation defined as XUV radiation.

[0018]

This disclosure also describes systems, apparatus, and methods which employ UV, EUV, XUV, or soft X-ray radiation for applications in biomaterial development, printing and patterning, microscopy, material processing, astronomical systems, light exposure, imaging and scanning systems. More specifically, the applications can include 3D printing, selective biomaterial patterning, biosensor activation, DNA/peptide patterning, quantum dot activation, fluorescence microscopy, selective biomaterial activation.

[0019]

The disclosure describes materials that can be used in extreme ultraviolet wavelength applications. The material may include features that can be used in applications that require operation at one or more electromagnetic wavelength ranges. In one embodiment, the dimension of structural features is approximately in the same order as the wavelengths used in extreme ultraviolet applications. For example, the structural features can have a dimension of approximately 13.5 nm. In some embodiments, the features may be structural features having dimensions on the order of 10 to 20 nm. In another embodiment, the material can have structural features in the range of 0.001 nm to 10 nm. In yet another embodiment, the material can have structural features in the range of 10 nm to 250 nm. These features can be referred to as nanoscale features. The nanoscale features may be one dimensional, two dimensional, or three dimensional. The structural features can reduce the bulk electromagnetic absorption of the material. For example, in some applications, the nanoscale features can approximately correlate with the wavelength of the radiation used in that application. The material may include sub-wavelength features.

[0020]

The materials can also be designed to reduce absorption in applications that use ultraviolet (UV) wavelength range. For example, the dimensions of the structural features can correlate to the UV wavelengths. In another embodiment, the dimensions of the structural features can correlate to the soft X-ray wavelength range. The selected wavelength range may be part of two or more photons (multiphotons) which replace the UV, EUV, or X-ray range.

[0021]

The nanoscale features may include, for example, a periodic or semi-periodic, quasi-periodic, or aperiodic structure or a repeating or repeated element. The periodic structure may be a one, two or three dimensional structure. The structure may be a part of a layered structure, or on a substrate. The substrate may be planar, non-planar, or freeform. Examples of a periodic structure include a 2D or 3D array of nanoparticles, a gyroidal structure, a swiss-roll structure. The nanoscale features can be of any shape in any dimension, for example, but not limited to, layers, films, spheres, blocks, pyramids, rings, porous structures, cylinders, linked shapes, shells, freeform shapes, chiral structures, hemispheres, segments, or any combination thereof.

[0022]

The material may include, for example, a graded structure. For example, a layered structure in any dimension where some layers within the material have lengths, depths, thicknesses, periods or repeating units, that increase or decrease from the previous layer. In one embodiment if the layers are arranged in such a way to produce a graded refractive index, then a customized optical response is produced for a broader range of wavelengths or angles. The structure may be part of a layered structure, or on a substrate. The substrate may be planar or non-planar or freeform.

[0023]

Figure 2 illustrates an embodiment of 3D array with voids. The material may include gaps or voids 220 of any shape. The gaps or voids may be distributed throughout the material in any dimension and can have sizes ranging from 0.01 nm to micron sizes. The gaps or voids may be filled with a fluid, a liquid gas, monatomic material, organic material, polymer, or vacuum. The material may include membranes, free standing structures or elements, or partially supported structures or features, or supporting structure 210. The feature may be supported by structures or components. The gaps may be periodic or random in distribution. The gas may include O_2, H_2, He, N_2, Ar, CO_2, or other gases including inert gases. An example is a 3D periodic array of metallic spheres with air gaps. If the system is under vacuum, then the voids may also include vacuum. Figure 2 also illustrates a reflectance profile from a material that may include voids. As shown in Figure 2, the reflectance is more than 70% at a wavelength of approximately 13.5 nm.

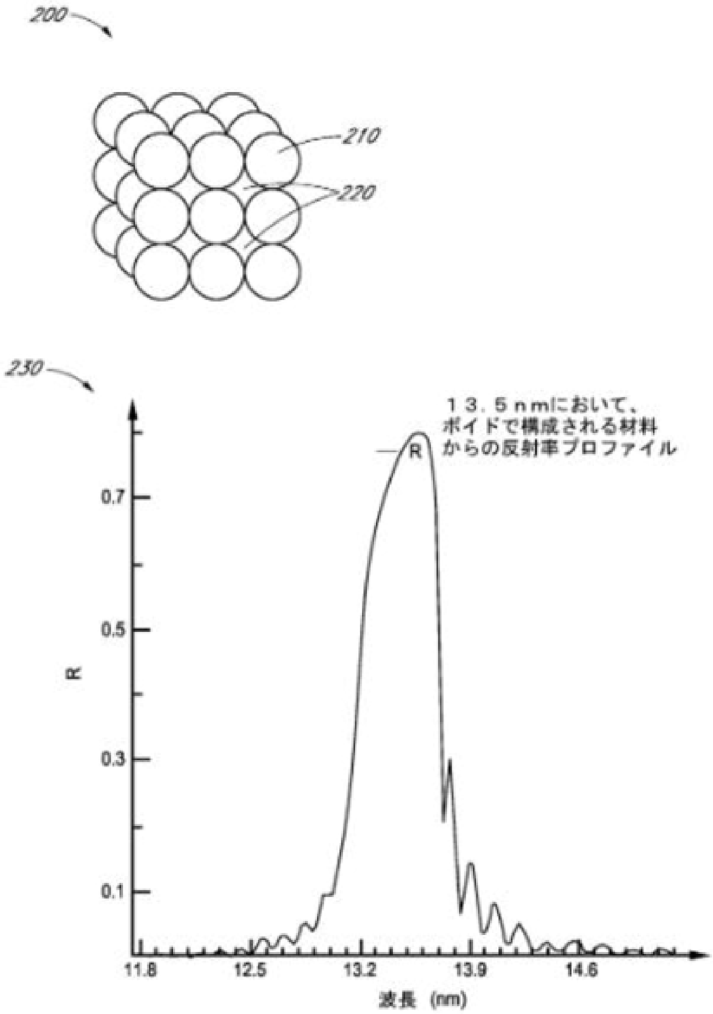

FIG. 2

１３．５ｎｍにおいて、ポイドで構成される材料からの反射率プロファイル
Reflectance profile from a material configured with voids at 13.5 nm

波長 (nm)　　Wavelength (nm)

[0024]

The material may further comprise a micro or nano structure of the monatomic material. Some examples of the monatomic materials include graphene, graphite, molybdenum sulfide, and carbon nanotubes. The monatomic material may serve as an optical element, or a heat management or cooling mechanism element. The monatomic material may be used in combination with other materials e.g., a metal, dielectric, semiconductor. It may form part of a layered structure, periodic structure, multidimensional or freeform structure, or may be on a substrate.

[0025]

The material may be an organic material or a biomaterial. The material may further comprise micro or nano structural features of the organic or bio material. Examples of organic materials or biomaterials include DNA, proteins, or other molecular or genomic material which have lower absorption in the wavelengths. The organic material or biomaterial may also be a sacrificial material, or a soft templating or scaffolding structure. The organic or bio material may be encapsulated in other material, which include, but not exclusively, polymers or dielectrics or semiconductors. The organic or bio material may serve as an optical element or heat management or cooling mechanism element. The organic or bio material may be used in combination with other materials e.g., a metal, dielectric, semiconductor. It may form part of a layered structure, periodic structure, multidimensional or freeform structure, or may be on a substrate.

[0026]

The material can also include a polymer. The material may further comprise micro or nano structural features of the polymer. The polymer may also be a sacrificial material, or a soft templating or scaffolding structure. In some embodiment, the polymer may be removed, leaving gaps or voids in the material. These gaps or voids may form structural features in the material. In other embodiments, the polymer can remain in the material. The polymer may be photoresist. The polymer may also be irradiated and exposed by a laser or a two or more photon laser process.

[0027]

The material may include nanoscale features that are made using metals, semiconductors, alloys, dielectrics, compounds, gases, liquids, or combinations of these. These nanoscale structures can be engineered to reduce absorption by the material at one or more band of wavelengths. The metal may include for example gold, silver, platinum, molybdenum, beryllium, ruthenium rhodium, niobium, palladium, copper, or lanthanum. The combined material may include for example silicon, silicon dioxide, boron carbide, carbon, organic, biomaterial, germanium, polymers or monatomic materials, liquids or gases or other element, alloy or compound, or vacuum. In this case, either material can have a small amount of absorption as described by the imaginary part of the refractive index, where one material has more than the other.

[0028]

The material may have nanosized structures and features which form an array or are periodic in one, two or three dimensions, for example, but not limited to, a photonic crystal, plasmonic crystal, metamaterial, chiralic structure, or subwavelength structure. Features of the array may be tuned to optimize the wavelength, spectral bandwidth, photonic bandgap angular acceptance, reflectance including average reflectance (when averaged over the spectral range), transmission, absorption, scattering and electromagnetic enhancement factor, resonance, or interaction modes. The structure may provide a cavity which slows the group velocity of light to increase electromagnetic interaction or form a waveguide or cavity where certain electromagnetic nodes are enhanced and certain nodes are forbidden. In the case of forbidden modes of propagation, this may be used to form a selective or omnidirectional mirror with tunable peak wavelength and spectral bandwidth properties. The cavity can also be used to enhance the conversion of light from infrared to EUV, as may be needed in a two or more photon process, or a light source emitting EUV radiation from infrared excitation.

[0029]

The nanoscale features of the material may, for example, be configured as a 3D hexagonally packed array. The 3D hexagonally packed array may include a metal. The metal may be, for example, gold, silver, ruthenium, molybdenum, silicon, germanium, platinum, palladium, or other metal. See Figure 2.

[0030]

The nanoscale features of the material may, for example, include a gyroid structure. The gyroid structure can be a metal, for example, gold, silver, ruthenium, molybdenum, silicon, germanium, or platinum.

[0031]

The nanoscale features of the material may, for example, be made using graphene or molybdenum graphene (Mo-Graphene). The nanoscale features may include a graphene double gyroid structure.

[0032]

Nanophotonics material may include a periodic one, two or three dimensional structure engineered to have a low bulk absorption of electromagnetic radiation at selected wavelengths, such as at UV, EUV, or soft X-ray wavelengths.

[0033]

This disclosure further describes methods, apparatus, and techniques used to fabricate the material. The EUV materials can be fabricated using top-down fabrication procedures, where materials are deposited onto a flat substrate via electrodeposition in a controlled vacuum environment. The deposited material can have a thickness of approximately 5 nm or less and a roughness factor less than λ/20. A low roughness factor may be preferred due to the Mie scattering from anomalies which reduce the overall reflectance or transmission of the material. Depositing ultraflat materials with sufficiently low roughness can be challenging. When multiple materials or a layered structure is used, each material and layer can be individually smoothed or polished.

[0034]

In some embodiments, the EUV material can be fabricated using a bottom-up approach. In the bottom-up fabrication approach, the bulk material can be gradually grown by inserting matter from the bottom end of the structure, thereby only requiring one surface (the topmost outer layer) for smoothing. The bottom-up approach can be used to fabricate lithography-based materials for use in the UV, EUV, and soft X-ray ranges of wavelengths.

[0035]

In one embodiment, the material optimized for a particular wavelength can be fabricated using a soft templating approach. In the soft templating approach, certain polymers, sacrificial or temporary materials, but not exclusively, may be temporarily used in conjunction with electrodeposition and other material deposition techniques. The sacrificial materials or polymers from a soft template or scaffolding structure, which may later be removed once the actual material is in place. The sacrificial or temporary material may be removed by chemical etching or other methods. An example of a sacrificial material may be photoresist. Another example of a temporary material is a nanosphere. The soft templating approach can be used to fabricate lithography-based materials optimized to reduce absorption for one or more of the wavelengths or range of wavelengths in the UV, EUV, and the soft X-ray range. These EUV materials can be further used to manufacture elements for lithography systems. Figure 6 illustrates an embodiment of a method for fabrication of materials described herein using a polymer based soft templating approach. The method 500 can include the step of polishing a host layer. In some embodiments, the method can further include the step of assembling a polymeric or scaffolding structure. Moreover, the method can include growing a main layer over the scaffolding structure. The method can also include polishing the surface of the main layer. Furthermore, the method can include the step of removing the polymeric or scaffolding structure so that the reflectivity of the material is greater than 70% at a wavelength between 0.1 nm and 250 nm. In some embodiments, the method can include the step of smoothing one or more layers through laser irradiation or chemical etching. The polymeric or scaffolding structure can be one or more block co-polymers. In one embodiment, the method can further include the step of applying a capping or substrate.

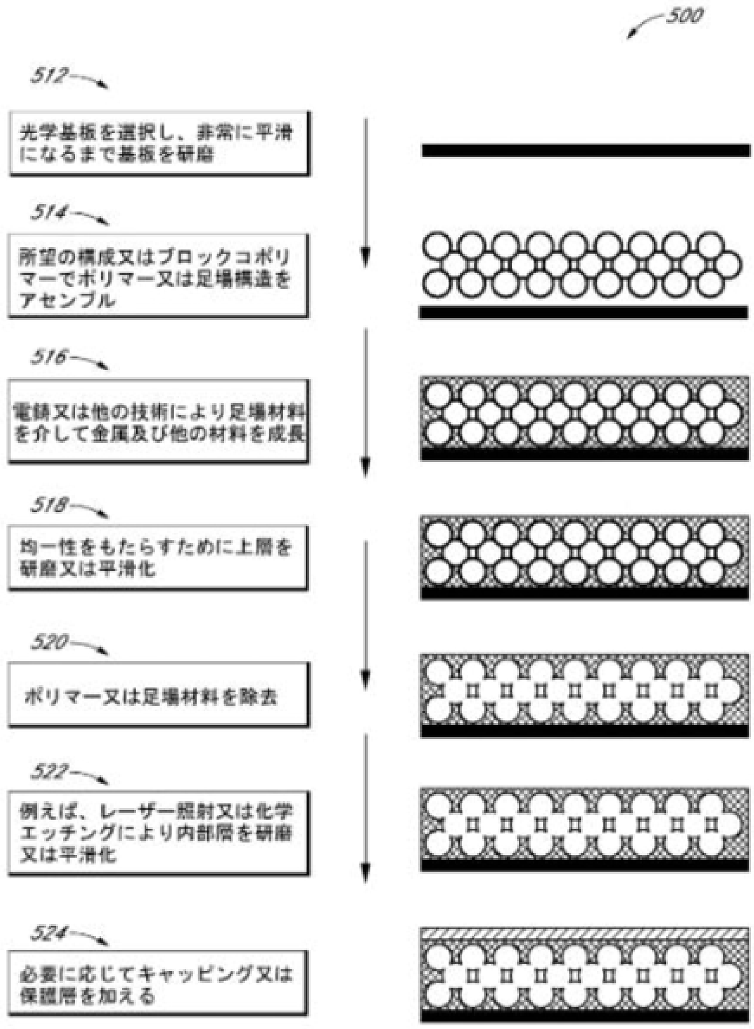

FIG. 6

光学基板を選択し、非常に平滑になるまで基板を研磨 Select optical substrate and polish until ultrasmooth

所望の構成又はブロックコポリマーでポリマー又は足場構造をアセンブル Assemble polymeric or scaffolding structure in desired configuration, or block co-polymers

電鋳又は他の技術により足場材料を介して金属及び他の材料を成長　Grow metal or other material through the scaffolding material via electroformation, or other technique

均一性をもたらすために上層を研磨又は平滑化　Polish or smooth top layer to achieve uniformity

ポリマー又は足場材料を除去　Remove polymeric or scaffolding material

例えば、レーザー照射又は化学エッチングにより内部層を研磨又は平滑化　Polish or smooth internal layers e.g., by laser irradiation, or chemical etching

必要に応じてキャッピング又は保護層を加える　Apply capping or protection layer if necessary

[0036]

The EUV material can also be fabricated using an electroformation or other similar process. In electroformation of a material, e.g., a metal, is grown through another material by chemical, electrical, or magnetic means. This method can be used in the electroformation of the metal molybdenum and ruthenium, which are not commonly electroformed metals. The electroforming process can be used in the fabrication of lithography-based materials at UV, EUV, and soft X-ray ranges.

[0037]

The EUV materials can be further fabricated using a self-assembly or other similar process. In self-assembly, certain aspects of the material, e.g., nanoscale features are assembled together to form the overall bulk structure. The assembly formation may either be self-assembly or a direct assembly. In one embodiment, the features may retain a given rigid structure through chemical or electrical or magnetic means. An example of this is a chemically polarized material. In another embodiment, the substrate of the material may be pre-patterned to ensure a preferential structure or embodiment of the bulk material disposed on top of it. In another embodiment, the substrate may be surface treated with an organic or biomaterial or chemically treated to ensure a preferential or selective structure or embodiment of the bulk material disposed on top of it. The self-assembly approach can be used to fabricate lithography-based materials for use in the UV, EUV, and soft X-ray ranges of wavelengths.

[0038]

The material can also be fabricated using a folding process. In the folding process the material or a subset of the material may be folded, or bent or hinged, to add a higher dimension to the overall material structure. For example, but not limited to, a metallo-dielectric 2D array may be folded to form 3D hierarchical object where the overall bulk material reveals a stacked structure of multiple units of the original material.

[0039]

The material may also be fabricated using a building block process. In the building block process, the material or a subset of the material may be assembled or stacked to create an overall bulk material structure. For example, but not limited to, a metal semiconductor 3D array may be stacked in any configuration to form a 3D bulk material object where the overall bulk material reveals a stacked structure of multiple units of the original material.

[0040]

The material may, for example, be fabricated by a chemical etching process. Chemical etchants (e.g., acids) may also be used to selectively remove material in semiconductors or polymers or metals.

[0041]

In some embodiments, the material may be fabricated using a dealloying process. In this method, the material may include a metal. The metal may be mixed with another auxiliary metal e.g., via a heating/melting process to form an ingot. An acid which may be corrosive can be used to then selectively remove the auxiliary metal e.g., gold or silver, to leave a porous structure of the original material. The remaining structure may form a uniform and smooth surface at the atomic level.

[0042]

The EUV material or any subset or element of the material can be further polished or smoothed using a laser. The laser may have a pulse duration in the femtosecond or picosecond range. The laser may be used prior, during, or after the fabrication. The laser may also be used to irradiate the material post fabrication to efface, remove, clean, or dislodge any defects, anomalies, or non-uniformities. This includes removal of defects which are not directly involved in the fabrication process. For example, an embodiment of the material for a photomask falls under the case. The photomask may receive a defective particle from another part of its fabrication process, or a defective particle from a stray ion/element in the lithography or light source system. The photomask can subsequently be cleaned by a laser irradiation process.

[0043]

In some embodiments, a nanoscale structural feature or building block or element of the material may further be manufactured by laser. The laser may be used prior, during, or after the fabrication. The laser approach may be part of a two or more photon process.

[0044]

The material or any subset or element of the material may further be polished or smoothed using a chemical etchant with a controlled concentration. In one embodiment, the material or any subset or element of the material can be further smoothed using a surfactant, or chemically treated surface, during the formation of the material. The surfactant may be removed later. The chemical surfactant approach can be used to fabricate photonic structure formations for use in the UV, EUV, and soft X-ray ranges.

[0045]

The material or any subset or element of the material, or nanoscale features may also be manufactured by a lithography or printing or patterning process. The lithography or printing process may include, for example, e-beam lithography, nano-imprint lithography, UV, EUV or X-ray lithography, 2D or 3D lithography, stereolithography, focused electron or ion beams, scanning tunneling microscopy, scanning probe lithography, atomic force microscopy, sol-gel nanofabrication, two or more photon lithography, dip pen lithography, near field lithography, laser assisted imprinting, temperature-based patterning, laser-based patterning. In addition, an etching or deposition or temperature process may be used in combination with the lithography or printing process. The lithography or printing approach can be used to fabricate lithography-based materials at UV, EUV, and soft X-ray ranges and used in lithography devices, systems, or apparatus.

[0046]

In another aspect, the disclosure relates to a method of making a material including nanoscale features for use at a selected electromagnetic wavelength range. The material may be a material as described herein for elements or devices used for lithography or other optical applications. The material can also be fabricated using a block copolymer scaffold process. The method may include, for example, fabricating a block copolymer structure having at least a first block and a second block. The method may further include removing the first block, and replacing at least a portion of a volume of the structure occupied by the first block with a metal or semiconductor or polymer, dielectric, or monatomic material. The block co-polymer approach can be used to fabricate lithography-based materials for use in the UV, EUV, and soft X-ray ranges of wavelengths.

[0047]

The first block may be, for example, a selectively degradable block. The method may further include removing the second block and/or removing any additional blocks, in whole or in part. The second block and/or any additional blocks may be removed using a process such as plasma etching.

[0048]

Replacement of at least a portion of the volume may include, for example, electrochemically depositing the metal or semiconductor. Replacement of at least a portion of the volume may include electrodeposition or electroformation of the metal or semiconductor.

[0049]

In another embodiment, the material can be fabricated using a swiss roll or a laminate process. In the swiss roll process, the material or a subset of the material may be rolled from one end to add a higher dimension to the overall material structure, and a cross section of the overall material appears as multiple formations of the material. For example, but not limited to, a metallo-dielectric 2D array may be rolled from one end to form a 3D cylindrical object where the cross-section of the cylindrical object, perpendicular to the axis, can reveal a stacked structure of multiple units of the original material.

[0050]

In another aspect, the disclosure relates to an element of a system or subsystem. The element may include a material having nanoscale features designed to be at least partially reflective or transmissive to electromagnetic radiation, or electromagnetic interaction enhancement, in a selected electromagnetic wavelength range. The material may be a material such as described previously or subsequently herein. The material may be disposed on an element, or embedded within the element, or embedded within a radiation emitting system or element within a radiation emitting system, or a radiation monitoring device at the selected wavelength range.

[0051]

In one embodiment, the system or subsystem is a lithography system. The elements may be one of the components of the lithography system. For example, elements can include, but are not limited to, a photomask, a detector, a wavelength monitor, a bandwidth or power monitor, sensors, a photoresist, a substrate, a cooling mechanism, a heat management mechanism, light source, lamp, laser, optical element, mask aligner, integrator, structural component, electronical device, optical device, or any other component contained within the system. The system or subsystem may also include a semiconductor manufacturing device or apparatus. Figure 3 illustrates an element 300 (photomask, in this example) that can include a material 316. The mask 300 can receive radiation 320 of a selected wavelength. In one embodiment, the material 316 can be a 3D array as described with respect to Figure 2. In other embodiments, the material 316 can be any of the materials described herein that can increase reflectance of the element 300. In some embodiments, the reflectivity of the element 300 can be increased to more than 70% for a selected wavelength. The wavelength can be between 0.1 nm and 250 nm. The material 316 can be integrated in the mask 300 as illustrated in Figure 3. In one embodiment, the material is sandwiched between the top and bottom layers of the mask 300. Other method of affixing the material 316 can also be used.

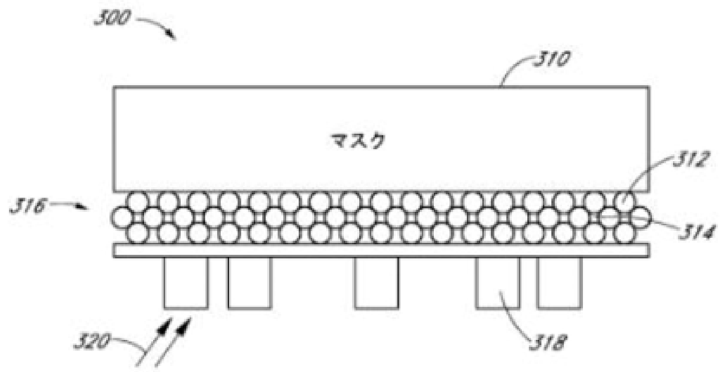

FIG. 3

マスク　Mask

[0052]

It should be noted that in addition to lithography systems, the materials described above can also be used in a biotech system, a 2D or 3D printing or patterning system, or a material processing system. These systems can also include elements that can use EUV materials to improve performance. Elements can include, for example, a photomask, a detector, a wavelength monitor, a bandwidth or power monitor, sensors, photoresist, a substrate, a cooling mechanism, a heat management mechanism, light source, lamp, laser, optical element, mask aligner, integrator, structural component, or any other element or component contained within the system. In some embodiments, the EUV materials can be used in a projection lens system. For example, in this system, instrumentation may include multiple optical elements at the selected wavelength range e.g., a telescope or a satellite.

[0053]

Another example of a system where EUV materials can be used is a system that involves detection at the selected electromagnetic wavelength range, for example, X-ray detection, imaging and scanning systems, radiation from nucleic particles, accelerator systems, biotechnology systems. EUV materials can also be used in scanning and imaging systems. EUV materials can also be used in systems that require reduced absorption in one or more ranges of operating wavelengths.

[0054]

In one embodiment, the element is an optical element. The optical element may include an optical substrate, mirror, lens, surface, window, facet, filter, covering element, capping layer, barrier layer, thin film, coating, internal surface area, collector, droplet generator, interdispersed material, panel, waveguide, cavity, fiber, structural component, reflective element, transparent element, a detector, a wavelength monitor, bandwidth or power monitor, sensors, a photo mask, a photo resist, a cooling mechanism, a heat management mechanism, a light source, a lamp, a laser, an optical element, a mask aligner, an integrator, a structural component, an electronical device or optical device, or any other optical elements that may be used in systems described above. The optical substrate can be fused silica, or calcium fluoride, or magnesium fluoride. The optical element may also be neither transmissive nor reflective, but serves to increase the electromagnetic interaction with a certain region. For example, it may enhance a certain electromagnetic mode such as radiation, form a cavity, or increase internal surface area available for interaction. Figure 5 illustrates an embodiment of an optical element 500 where a material 510 is disposed on top of the surface 520 of the optical element 500. The material can be affixed with the optical element 500 using other methods not shown here. The optical element 500 can receive radiation 530 of a selected wavelength. In one embodiment, the material 510 can be a 3D array as described with respect to Figure 2. In other embodiments, the material 510 can be any of the materials described herein that can increase reflectance of the optical element 500. In some embodiments, the reflectivity of the optical element 500 can be increased to more than 70% for a selected wavelength. The wavelength can be between 0.1 nm and 250 nm. The optical element can be used with any of the systems described herein.

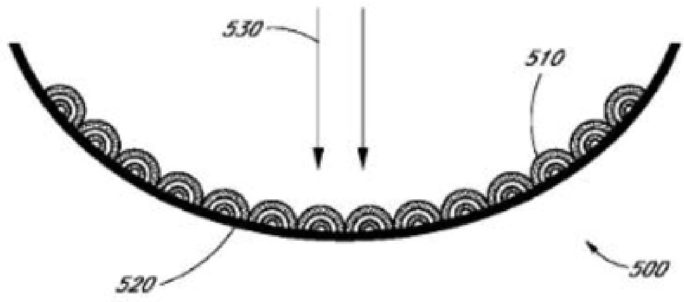

FIG. 5

[0055]

Figure 4 illustrates an embodiment of a material-photoresist composite 400. The material 410 can be embedded or interdispersed in a host material, e.g., photoresist 420. The material can improve the performance of the host material 420. In the case of photoresist, the increase in electromagnetic interaction; i.e., scattering and absorption with the polymer or organic material can increase the sensitivity of the photoresist.

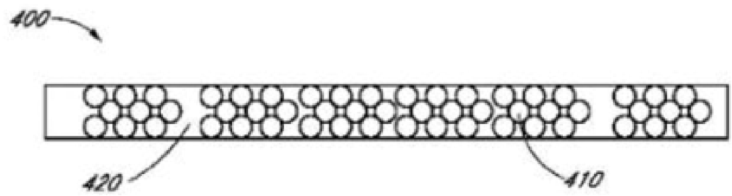

FIG. 4

[0056]

In another aspect, the disclosure relates to a reflective element. The reflective element may include a material having nanoscale features configured to be at least partially reflective to electromagnetic radiation in a selected electromagnetic wavelength range. The material may be a material such as described previously or subsequently herein.

[0057]

The reflective element may be, for example, an optic or a component of an optic. The optic may be, for example, a mirror, lens, optical window, filter or coating, thin film, membrane, or substrate or other optical element. Alternatively, the reflective element may be a component of a mask or a coating or layer of material of the mask. The mask may be a photolithography mask. Alternatively, the reflective element may be a photoresist or an element of a photoresist. The photoresist may be a photolithography photoresist. The reflective element may be, for example, a component or element of a lithography device or system, such as an EUVL system, or a soft X-ray system.

[0058]

The reflective element may be, for example, a coating or layer of material disposed on or in an optic, photoresist, mask, or other component or device. The optic may be a fused silica or calcium fluoride optic.

[0059]

The reflective element may be, for example, configured as a component of a photolithography device. The reflective element may be configured as a component of an electromagnetic radiation source device. The reflective element may be configured as a semiconductor manufacturing device or other device using UV, EUV, or soft X-ray electromagnetic radiation. The reflective element may be a component of a UV, EUV, or X-ray light source.

[0060]

The reflective element may include a material having nanoscale features configured to be partially reflective in the selected electromagnetic wavelength range. Alternatively, or in addition, the reflective element may include material having nanoscale features configured to be substantially fully reflective in the selected electromagnetic wavelength range. In some embodiments, the reflective element may include material having structural features configured to have a reflectivity of greater than or equal to 70%.

[0061]

The reflective element may include a material having nanoscale features configured to be reflective in the selected electromagnetic wavelength range where the material can be consistently fabricated to have a reflectivity greater than or equal to 70%.

[0062]

The reflective element may include a material having nanoscale features configured to increase spectral bandwidth in the electromagnetic wavelength range. An example of this would be a grade structure.

[0063]

The reflective element may include a material having nanoscale features configured to increase angular acceptance in the electromagnetic wavelength range. An example of this would be a 2D or 3D symmetric structure.

[0064]

The reflective element may include a material having nanoscale features configured to increase average reflectance (integrated or averaged over the spectral range) in the electromagnetic wavelength range.

[0065]

In another aspect, the disclosure relates to a transmissive/transparent element. The transparent element may include a material having nanoscale features configured to be at least partially transmissive (greater than or equal to 4%) to electromagnetic radiation in a selected electromagnetic wavelength range. The material may be a material such as described previously or subsequently herein. The transparent element may be, for example, a component or element of a lithography device or system, such as an EUVL system or a soft X-ray system or a biotechnology or material processing system.

[0066]

The transparent element may be, for example, an optic or a component of an optic. The optic may be, for example, a mirror, lens, optical window, or other optical element. Alternatively, the transparent element may be a component of a mask or a coating or layer of material of the mask. The mask may be a photolithography mask. Alternatively, the transparent element may be a photoresist or an element of a photoresist. The photoresist may be a photolithography photoresist.

[0067]

The transparent element may be, for example, a coating or layer of material disposed on or in an optic, photoresist, mask, or other component or device. The optic may be a fused silica or calcium fluoride optic.

[0068]

The transparent element may be a component of a photolithography device. In some embodiments, the transparent element can be a component of an electromagnetic radiation source device. The transparent element may also be configured as a component of a semiconductor manufacturing device or other device using UV, EUV, or soft X-ray electromagnetic radiation. The transparent element may also be configured as a component of UV, EUV, or soft X-ray light source. The transparent element may be a component of an optical window or a coating or a layer of material disposed on or in the optical window.

[0069]

In another aspect, the disclosure relates to means for fabricating and using the above-described nanophotonics materials and related methods, in whole or in part.

[0070]

In another aspect, the disclosure relates to methods of using such nanophotonics materials in systems such as extreme ultraviolet lithography (EUVL) or soft X-ray lithography systems or other systems.

[0071]

In another aspect, the disclosure relates to components, devices, and systems including the above-described nanophotonics materials, in whole or in part.

[0072]

Various additional aspects, features, and functionality are further described below in conjunction with the appended Drawings.

[0073]

The exemplary embodiments described herein are provided for the purpose of illustrating examples of various aspects, details, and functions of apparatus, methods, and systems for inspecting the interior of pipes, conduits, and other voids; however, the described embodiments are not intended to be in any way limiting. It will be apparent to one of ordinary skill in the art that various aspects may be implemented in other embodiments within the spirit and scope of the present disclosure.

[0074]

It is noted that as used herein, the term, "exemplary" means "serving as an example, instance, or illustration." Any aspect, detail, function, implementation, and/or embodiment described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other aspects and/or embodiments.

[0075]

Extreme Ultraviolet Lithography is a significant departure from other types of ultraviolet (UV) lithography, such as the deep ultraviolet lithography technology in general use today. EUV radiation is highly absorbed by all materials, and therefore EUV lithography typically takes place in a vacuum. Optical elements in such systems should be configured to minimize absorption of EUV radiation; however, this is difficult to implement. For example, components such as mirrors will typically absorb around 35-40% of the incident light.

[0076]

Typical pre-production EUVL systems built to date contain at least two condenser multilayer mirrors, six projection multilayer mirrors, and a multilayer object (mask). Since the optics already absorb approximately 96% of the available EUV light, an appropriate EUV light source will need to be sufficiently bright to overcome this loss of radiation. EUV source development has focused on plasmas generated by laser or discharge pulses. The mirror responsible for collecting the light is directly exposed to the plasma and is therefore vulnerable to thermal damage and damage from the high-energy ions and other debris. This damage associated with the high-energy process of generating EUV radiation has limited implementation of EUV light sources for lithography.

[0077]

Consequently, existing EUV lithography scanner units have poor efficiency because of these absorption properties of EUV lithography using traditional materials for elements such as optics, mirrors, optical windows, masks, photoresists, and other elements or components.

[0078]

While one-dimensional structures may present some potential advantages, they also include limitations. For example, initial simulation analysis of a molybdenum/silicon multilayer stack configuration indicates that the maximum reflectivity obtainable from a one-dimensional molybdenum/silicon multilayer stack at 90 nanometers with 50 layers of periodicity is a theoretical maximum of 70.6% at zero degrees incident angle, as shown in Figure 1. In practice the reflectivity is lower due to defects in fabrication process and Mie Scattering.

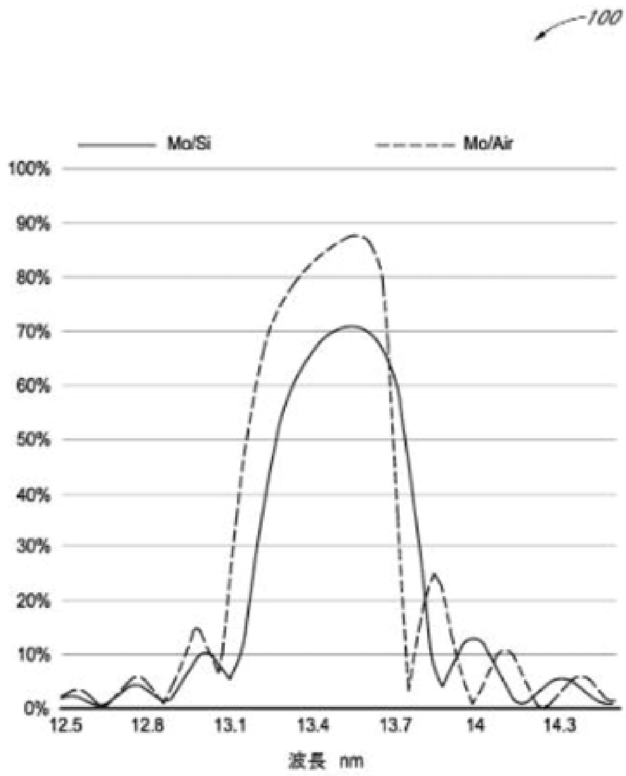

FIG. 1

波長 Wavelength

[0079]

Accordingly, in some embodiments, an EUV reflective element (and associated devices) having a two or three dimensional nanoscale structure, for operating in wavelength ranges of approximately 13.5 nm and having a reflectivity of approximately 80% or higher, may be fabricated and used in applications such as EUVL, using techniques such as those described here. In addition, materials with similarly transmissive properties (e.g., EUV transparent materials and associated components and devices) may be similarly fabricated using techniques such as those described herein.

[0080]

In another aspect, nanostructured (nanophotonics) two or three dimensional materials such as those described herein or similar or equivalent materials may be used in components and devices such as, for example, lasers and laser systems, light sources, scanners, masks, and resist materials, or other devices or systems for use in manufacturing semiconductors or other devices.

[0081]

Other applications may include plasma sources or synchrotron radiation sources or other electromagnetic radiation sources. Still other applications may include excimer or other lasers, such as industrial lasers as well as X-ray electromagnetic radiation devices or other devices for generating or using electromagnetic radiation in wavelength ranges such as infrared, visual, UV, EUV, or X-ray wavelengths. Components and devices using nanophotonic materials may also be used in other applications such as biomedical devices or other devices or systems.

[0082]

In some embodiments, a three dimensional graphene photonic crystal may be used as a nanophotonics material for devices and systems operating at UV, EUV, and X-ray wavelengths. Graphene is a recently developed material that has high thermal conductivity and can be configured to be transparent or, through use of stacking, layering, or other composite configurations, made reflective or absorptive. Similarly, in some embodiments, carbon nanotubes, which have similar properties to graphene, may be used to make transparent or reflective nanophotonics materials. For example, graphene or carbon nanotube materials may be used in lithography devices as, for example, a coating or layered material. High thermal conductivity of these materials makes them advantageous for applications where transparency or reflectivity are required (e.g., at UV, EUV, and/or soft X-ray wavelengths) along with a need for high conduction generating heat (e.g., high thermal dissipation in devices such as light scanning tools, machines for wafer patterning, two-photon devices, or other devices or systems where UV, EUV, and/or soft X-ray radiation is used, such as to pattern a photoresist).

[0083]

In another embodiment, a nanostructured material may be fabricated in a double gyroid structure. The double gyroid structure may comprise, for example, gold (Au), and/or molybdenum (Mo). The double gyroid structure may be fabricated using a block copolymer technique, such as described previously herein. Such a material may have a low metallic density with ambient air in the interstices. For example, the metallic density may be less than corresponding bulk material by, for example, a factor of 10 or greater.

[0084]

Other embodiments and modifications of this disclosure may occur readily to a person skill in the art in view of these teachings. Therefore, the protection afforded this disclosure is to be limited only by the following claims, which include all such embodiments and modifications when viewed in conjunction with the above specification and accompanying drawings.

[0085]

It is understood that the specific order or hierarchy of steps or stages in the processes and methods disclosed herein are examples of exemplary approaches. Based upon design preference, it is understood that the specific order or hierarchy of steps and stages in the processes and methods may be rearranged while remaining within the scope of the present disclosure unless noted otherwise.

[0086]

The previous description of the disclosed embodiments is provided to enable a person skilled in the art to make or use the present disclosure. Various modifications to these embodiments will be readily apparent to a person skilled in the art, and the generic principles defined herein may be applied to other embodiments without departing from the spirit or scope of the disclosure. Thus, the present disclosure is not intended to be limited to the embodiments shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

[0087]

The disclosure is not intended to be limited to the aspects shown herein, but is to be accorded the full scope consistent with the detailed description of the invention and drawings, wherein reference to an element in the singular is not intended to mean "one and only one" unless specifically so stated, but rather "one or more." Unless specifically stated otherwise, the term "some" refers to one or more. A phrase referring to "at least one of" a list of items refers to any combination of those items, including single members. As an example, "at least one of a, b, and c" is intended to cover: a; b; c; a and b; a and c; b and c; and a, b and c.

[0088]

The previous description of the disclosed aspects is provided to enable a person skilled in the art to make or use the present disclosure. Various modifications to these aspects will be readily apparent to a person skilled in the art, and the generic principles defined herein may be applied to other aspects without departing from the spirit or scope of the disclosure. Thus, the disclosure is not intended to be limited to the aspects shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

[0089]

Conditional language used herein, such as, among others, "can," "might," "may," "e.g.," and the like, unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey that certain embodiments include, while other embodiments do not include, certain features, elements, and/or states. Thus, such conditional language is not generally intended to imply that features, elements, and/or states are in any way required for one or more embodiments or that one or more embodiments necessarily include logic for deciding, with or without author input or prompting, whether these features, elements, and/or states are included or are to be performed in any particular embodiment. The terms "comprising," "including," "having," and the like are synonymous and are used inclusively, in an open-ended fashion, and do not exclude additional elements, features, acts, operations, and so forth. Also, the term "or" is used in its inclusive sense (and not in its exclusive sense) so that when used, for example, to connect a list of elements, the term "or" means one, some, or all of the elements in the list. In addition, the article "a" and "an" are to be construed to mean "one or more" or "at least one" unless specified otherwise.

[0090]

Conjunctive language such as the phrase "at least one of X, Y, and Z," unless specifically stated otherwise, is otherwise understood with the context as used in general to convey that an item, term, etc. may be any one of X, Y, and Z. Thus, such conjunctive language is not generally intended to imply that certain embodiments require at least one of X, at least one of Y, and at least one of Z to each be present.

[0091]

While the above detailed description has shown, described, and pointed out novel features as applied to various embodiments, it will be understood that various omissions, substitutions, and changes in the form and details of the devices or algorithms illustrated can be made without departing from the spirit of the disclosure. Thus, nothing in the foregoing description is intended to imply that any particular feature, characteristic, step, module, or block is necessary or indispensable. As will be recognized, the processes described herein can be embedded within a form that does not provide all of the features and benefits set forth herein. The protection of the present invention is defined by the appended claims rather than by the foregoing description."

2. Judgment on compatibility to the supporting requirement

(1) Whether descriptions in the scope of claims comply with the supporting requirement should be judged, by examining, through comparison between the descriptions in the scope of claims and descriptions in the detailed description of the invention, whether the inventions described in the scope of claims coincide with the inventions described in the detailed description of the invention and whether a person skilled in the art recognizes

that the problem to be solved can be solved by the invention with the descriptions in the detailed description of the invention, or whether a person skilled in the art recognizes that the problem to be solved can be solved by the invention in the light of common technical knowledge as of the time of filing the application even without such descriptions or suggestions.

(2) According to descriptions in the specification, etc. of the present application as found in above 1, it is acknowledged that the specification, etc. of the present application describe the following technical matters.

A The disclosure relates generally to materials, devices, apparatus, and methods for use in lithography (EUVL) and other applications with ultraviolet (UV), extreme ultraviolet (EUV), and soft X-ray ([0003]).

B Extreme ultraviolet lithography (EUVL) uses electromagnetic radiation at extreme ultraviolet (EUV) wavelength (approximately 120 nanometers to 0.1 nanometers). Use of EUV wavelength for lithography has a potential advantage of devices with smaller feature sizes ([0002], [0014]).

C At the EUV wavelengths, the material used to form the components of the lithography such as mirror, lens, photoresist, etc. becomes important. Most materials, however, have a high absorption rate for radiation at the EUV wavelengths. Higher absorption in these materials at the EUV wavelengths decreases the performance of an EUV lithography system ([0002], [0014]).

D In certain embodiment, the disclosure relates to an element that can be used in a light exposure system, and the element can include a material having a plurality of structural features. The plurality of structural features can improve the reflectivity of the element to greater than 70% for a selected wavelength ([0004]).

In another embodiment, the plurality of structural features can improve the transmission of the element to greater than 4% for a selected wavelength ([0005]).

In another embodiment, the plurality of structural features can control the electromagnetic radiation absorption for a selected wavelength ([0006]).

E The plurality of structural features may be provided with one or more of the following; metal, dielectric, gas, liquid, compound, semiconductor, polymer, organic material, biological material, monatomic material, air, carbon, molybdenum, beryllium, lanthanum, boron carbide, silicon, SiO_2, TiO_2, ruthenium, niobium, rhodium, gold, silver, copper, platinum, palladium, germanium, DNA, protein, graphene, graphite, carbon nanotube, MoS, O_2, N_2, He, H_2, Ar, CO_2, vacuum, or voids ([0008]).

The material can also include a polymer, and, in some embodiments, the polymer may be removed, leaving gaps or voids in the material. These gaps or voids may form structural features in the material ([0026]).

F In one embodiment, the wavelength is 250 nm or less. The plurality of structural features can have a first size, where the first size substantially correlates with the wavelength ([0008]).

In one embodiment, the dimension of structural features is approximately in the same order as the wavelengths used in extreme ultraviolet applications. The structural features can reduce the bulk electromagnetic absorption of the material. For example, in some applications, the nanoscale features can approximately correlate with the wavelength of the radiation used in that application. The material may include subwavelength features ([0019]).

The material can also be designed to reduce absorption in applications that use ultraviolet (UV) wavelength range. For example, the dimension of the structural features can correlate to the UV wavelength. In other embodiments, the dimensions of the structural features can correlate to the soft X-ray wavelength range. The selected wavelength range may be part of two or more photons (multiphoton) which replaces the UV, EUV, or X-ray range ([0020]).

The material may have nanosized structures and features which form an array or are periodic in one, two, or three dimensions, for example, but not limited to, a photonic crystal, plasmonic crystal, metamaterial, chiralic structure, or subwavelength structure. Features of the array may be tuned to optimize the wavelength, spectral bandwidth, photonic bandgap angular acceptance, reflectance including average reflectance (when averaged over the spectral range), transmission, absorption, scattering and electromagnetic enhancement factor, resonance, or interaction modes. The structure may provide a cavity which slows the group velocity of light to increase electromagnetic interaction, or may form a waveguide or cavity where certain electromagnetic nodes are enhanced and certain nodes are forbidden. In the case of forbidden modes of propagation, this may be used to form a selective or omnidirectional mirror with tunable peak wavelength and spectral bandwidth properties. The cavity can also be used to enhance the conversion of light from infrared to EUV, as may be needed in a two or more photon process, or a light source emitting EUV radiation from infrared excitation ([0028]).

G Figure 2 illustrates an embodiment of 3D array that has voids. The material may contain gaps or voids 220 in any shape. The gaps or voids may be distributed throughout the whole material with any dimension and may have a size within the range of 0.01 nm to micron size. The gaps or voids may be filled with a fluid, a liquid gas, monatomic material, organic material, polymer, or vacuum. The material may include membranes, free standing structures or elements, or partially supported structures or features, or supporting structure 210. The features may be supported by structures or components. The gaps may be periodic or random in distribution. The gaps may include O_2, H_2, He, N_2, Ar, CO_2 or other gases, including inert gases. An example is a 3D periodic array of metallic spheres with air gaps. If the system is under vacuum, then the voids may also include vacuum. Figure 2 also illustrates a reflectance profile from a material that may include voids. As shown in Figure 2, the reflectance is more than 70% at a wavelength of approximately 13.5 nm ([0023]).

(3) Examination

A According to above 2), C, it is acknowledged that the problems to be solved by the invention described in the specification, etc. of the present application (hereinafter, referred to as "the problem to be solved by the present inventions") are such that the materials used for forming components for lithography have a high absorption rate for radiation at the EUV wavelengths.

According to scope of claims, it is acknowledged that independent Claims 1 to 3 describe the following contents as means for solving the problem to be solved by the present inventions (herein after, referred to as "the means for solving the problem to be solved by the present invention"); namely,

Claim 1 describes an element comprising "a material having a plurality of nanostructural features that form voids or gaps, said plurality of nanostructural features having a first size between 250 nm and 0.01 nm; wherein the plurality of nanostructural features are configured so that the reflectivity of the element is greater than 70% for a single target wavelength selected to be a single wavelength between 0.1 nm and 250 nm,"

Claim 2 describes an element comprising "a material having a plurality of nanostructural features that form voids or gaps, said plurality of nanostructural features having a first size between 250 nm and 0.01 nm; wherein the plurality of nanostructural features are configured so that the transmission of the element is greater than 4% for a single target wavelength selected to be a single wavelength between 0.1 nm and 250 nm," and

Claim 3 describes an element comprising "a material having a plurality of nanostructural features that form voids or gaps, said plurality of nanostructural features having a first size between 250 nm and 0.01 nm; wherein the plurality of nanostructural features is configured to control the electromagnetic radiation absorption for a single target wavelength selected to be a single wavelength between 0.1 nm and 250 nm."

B According to above A, it is understood that inventions recited in Claims 1 to 3 try to solve the problem to be solved by the present inventions by obtaining a material at least of which absorption rate at the EUV wavelength is reduced. From the description in the specification, etc. of the present application, however, as explained below, any principle that can solve the problem to be solved by the present inventions with the means for solving the problem to be solved by the present invention (hereinafter, referred to as "the principle for solving the problem to be solved by the present inventions") can not be understood.

(A) First, the means for solving the problem to be solved by the present inventions is specified as "the plurality of nanostructural features" "configured so that the reflectivity of the element is greater than 70% for a single target wavelength selected to be a single wavelength ..." (Claim 1), "configured so that the transmission of the element is greater than 4% for a single target wavelength ..." (Claim 2), and "configured to control the electromagnetic radiation absorption for a single target wavelength ..." (Claim 3). However, these specifications are results per se which should be achieved, and they do not indicate clearly what concrete structure should be adopted to obtain the results. In addition, even if any concrete structure could exist, it is not clear why the structure can provide any material in which absorption rate at the EUV wavelength is reduced.

In addition, it is difficult to believe that a material having "a plurality of nanostructural features having a first size between 250 nm and 0.01 nm" leads to providing a material in which absorption rate at the EUV wavelength is reduced.

Therefore, it cannot be deemed that a person skilled in the art can understand the principle of solving the problem to be solved by the present inventions, directly from the means for solving the problem to be solved by the present invention.

(B) In [0008], it is described that the wavelength is less than or equal to 250 nm, and that the plurality of structural features can have a first size where the first size substantially correlates with the wavelength. In [0019], it is described that the dimension of structural features is approximately in the same order as the wavelengths used in extreme ultraviolet application, and the structural features can reduce the bulk electromagnetic absorption of the material. Although technical matters such as "the plurality of structural features have a first size where a first size substantially correlating with the wavelength" and "the dimension of structural features is approximately in the same order as the wavelengths used in extreme ultraviolet application" are not explicitly described in the means for solving the problem to be solved by the present inventions, regarding Claim 5, a dependent claim which specifies that the plurality of nanostructural features have a first size, and the first size substantially correlates with the target wavelength, it can be understood that above mentioned technical matters may be included in the means for solving the problem to be solved by the present inventions.

However, it is difficult to believe that these technical matters lead to providing a material in which the absorption rate at the EUV wavelength is reduced.

(C) In [0023], it is described that the material may include gaps or voids of any shape and that the gaps or voids may be distributed throughout the material in any dimension and can have sizes ranging from 0.01 nm to micron sizes, and also in [0008] and [0026], it is described that that the plurality of structural features can have voids.

According to [0023], however, it is described that the "gaps or voids" may be filled with vacuum, or may be filled with monatomic material, organic material, polymer etc. As just mentioned, in the specification, etc. of the present application, "gaps or voids" may have sizes from a wide range and at the same time, may be filled with various substances. Accordingly, it is difficult to believe that specifying such "gaps or voids" as the means for solving the problem to be solved by the present invention may lead to providing a material in which absorption rate is reduced at the EUV wavelength.

(D) In [0028], it is described that the material may be, for example, photonic crystal, plasmonic crystal, metamaterial, chiralic structure, or subwavelength structure.

However, in [0028] it is described that the material is not limited to such materials, nor the means for solving the problem to be solved by the present inventions is not restricted to these structures. In addition, apart from limitation or restriction, these structures are different from each other, and it is difficult to believe that the means for solving the problem to be solved by the present inventions that covers such different structures leads to providing of a material in which absorption rate at the EUV wavelength is reduced. Accordingly, considering these descriptions, it is difficult to believe that the means for solving the problem to be solved by the present inventions enables to obtain a material in which absorption rate at the EUV wavelength is reduced.

(E) Furthermore, in the invention recited in Claim 1, the means for solving the problem to be solved by the present invention is arranged so that "a plurality of nanostructural features are configured ... the reflectivity of the element is greater than 70% for a single target wavelength," and while satisfying such conditions, it is necessary to reduce the absorption rate at the EUV wavelength.

In the invention recited in Claim 3, the means for solving the problem to be solved by the present inventions is "the plurality of nanostructural features are configured to control the electromagnetic radiation absorption for a single target wavelength," and while satisfying such conditions, it is necessary to decrease the absorption rate at the EUV wavelength.

As just described, the invention recited in Claim 1 or 3, since it is required not only to decrease the absorption rate at the EUV wavelength, but also to satisfy other conditions, it becomes further difficult to understand the principle of solving the problem to be solved by the present inventions.

(F) Taking other descriptions in the specification, etc. of the present application and common technical knowledge into consideration, it cannot be understood that a material in which absorption rate at the EUV wavelength is reduced can be obtained with the means for solving the problem to be solved by the present inventions.

(G) Accordingly, in the light of descriptions in the specification, etc. of the present application and common technical knowledge, a person skilled in the art cannot understand any principle that can solve the problem to be solved by the present inventions with the means for solving the problem to be solved by the present inventions.

C Nevertheless, the specification, etc. of the present application do not disclose any concrete structure such as working examples, etc.

In this regard, Figures 1 and 2 show graphs that indicate reflectivity to the wavelength of the material, but explanations of the structures of the material are limited to the terms "Mo/Air" in Figure 1 and "a material configured with voids at 13.5 nm" in Figure 2. Accordingly, it cannot be understood what structure both of the terms concretely mean. Particularly in Figure 2, it cannot be understood what substance configures the structure. Leaving these points behind, even if concrete substances and structures per se could be understood from above mentioned descriptions, it is unclear how it could be made sure that an obtained element actually comprises such structure. Therefore, Figures 1 and 2 cannot be accepted as concretely supported.

D As explained in above B and C, a person skilled in the art cannot understand any principle of solving the problem to be solved by the present inventions, in the light of descriptions in the specification, etc. of the present application and common technical knowledge, with the means for solving the problem to be solved by the present inventions. Nevertheless, no concrete structure such as a working example has been disclosed in the specification, etc. of the present application.

Accordingly, it cannot be deemed that a person skilled in the art can recognize that, regarding inventions recited in Claims 1 to 3, the problems to be solved by the inventions can be solved in light of the description in the detailed description of the invention and common technical knowledge.

E The Appellant alleges as shown below, but none of Appellant's allegations can be accepted.

(A) a The Appellant alleges that, according to [0028], inventions recited in Claims 1 to 3 aim to increase reflectivity or transmission, or to control electromagnetic radiation absorption by defining and establishing the structure of the cavities, namely voids or gaps, so that the electromagnetic interaction at the target wavelength increases.

However, it is not described in the specification, etc. of the present application that the "cavities" described in [0028] means "voids or gaps" in the means for solving the problem to be solved by the present invention. In addition, leaving it behind, the principle is not clear why arranging the structure of the voids or gaps as defined by the means for solving the problem to be solved by the present inventions can lead to increase reflectivity or transmission, or to control electromagnetic radiation absorption.

b The Appellant alleges further, that inventions recited in Claims 1 to 3 are based on a principle that electromagnetic radiation has subwavelength interaction with the substrate.

The term "subwavelength interaction" is not described in the specification, etc. of the present application. In this regard, a term "subwavelength structure" is described in the specification, etc. of the present application. However, as explained in B, (D) above, the means for solving the problem to be solved by the present inventions does not have any limitation that it comprises a subwavelength structure, but it may rather be any structures other than that.

Accordingly, the Appellant's allegation is not based on any description in the specification, etc. of the present application.

(B) The Appellant alleges that inventions recited in Claims 1 to 3, based on the principle as mentioned in above (A), b, induce improved electromagnetic interaction and control and improve reflection, transmission, or absorbing characteristics of the material due to the structure of the voids or gaps, and that it was found by a simulation using Maxwell's equations. In addition, with respect to the 3D structure illustrated in Figure 2, the appellant alleges that it is configured and formed with spheres, having diameters defined in Claims 1 to 3, and that the spheres have 3D periodicity, wherein each sphere tangentially contacts with other spheres both in row and column directions, and the gaps or voids 220 are filled with atmospheric air. The Appellant alleges that the chart 230 illustrated in Figure 2 is prepared using the above simulation.

However, as shown in above (A), b, it is not based on the description in the specification, etc. of the present application that the electromagnetic radiation operates based on the principle that it has subwavelength interaction with the substrate. In addition, it is not described in the specification, etc. of the present application that the interaction alleged by the Appellant was found by the simulation using Maxwell's equations, and that the chart 230 illustrated in Figure 2 was prepared using the above simulation. Accordingly, the Appellant's allegations are not based on any description in the specification, etc. of the present application.

Even if it can be understood from the description in the specification, etc. of the present application that the interaction alleged by the Appellant can be found by a simulation using Maxwell's equations, it is not described in the specification, etc. of the present application what kind of simulation was actually carried out for what kind of concrete structure. In this regard, as far as Figure 2 is a mere schematic diagram and it is not described in the specification, etc. of the present application with what concrete substance and structure (dimensions, etc.) it is composed, the above finding that the simulation has not been concretely disclosed is not affected. Examining as shown above, it is not clear whether or not the structure according to the simulation corresponds to the means for solving the problem to be solved by the present inventions. Even if this point is left behind, the simulation cannot be replicated by any third party, and cannot be deemed to be reliable.

Furthermore, even if Figure 2 has been obtained through a simulation using

Maxwell's equations and concrete substances and structures could be understood from the description in the specification, etc. of the present application, and furthermore, the result of the simulation could be reliable, in the situation that the principle of solving the problem to be solved by the present inventions cannot be understood as explained in B above, the judgment as described in D above is not affected by the result of a single simulation. Even if Figure 1 is taken into consideration together, the judgment is not affected.

In addition, even if it could be found through a simulation using Maxwell's equations that with the structure of the voids or gaps, improved electromagnetic interaction can be induced and it enables to control and improve reflection, transmission, or absorbing characteristics of the material, it cannot be deemed that a structure according to the means for solving the problem to be solved by the present inventions, for which fineness and high preciseness should be required, can actually be obtained as in the simulation. Accordingly, it cannot be deemed that providing the interaction alleged by the Appellant is supported merely by the simulation.

Accordingly, the Appellant's allegation cannot be accepted.

(C) The Appellant alleges that the specification, etc. of the present application describe the size, arrangement, material, and concrete shape of the structural feature 210, and therefore, the configuration of the voids or gaps is clear.

However, since descriptions in each paragraph presented by the Appellant are general outlines or abstractive, they do not reveal any concrete structure such as working examples etc., or any principle of solving the problem to be solved by the present inventions. Therefore, the judgment shown in above D is not affected by the Appellant's allegation.

(4) Interim summary of judgment on compatibility with the supporting requirement

According to the above, inventions recited in Claims 1 to 3 are not identical with the inventions described in the detailed description of the invention.

3 Judgment on compatibility with the enablement requirement

(1) Examination

A As described in 2 above, in the light of descriptions in the specification, etc. of the present application and common technical knowledge, a person skilled in the art cannot understand any principle of solving the problem to be solved by the present inventions, with the means for solving the problem to be solved by the present invention.

Nevertheless, no concrete structure such as a working example has been disclosed in the specification, etc. of the present application.

Furthermore, referring to the specification, etc. of the present application is read, it cannot be understood how the elements of the inventions recited in Claims 1 to 3 can be concretely manufactured. With respect to the manufacturing method for the element, the specification, etc. of the present application describe top-down fabrication procedures ([0033]), bottom-up approach ([0034]), a soft templating approach ([0035], Figure 6), an electroformation or other similar process ([0036]), a self-assembly or other similar process ([0037]), a folding process ([0038]), a building block process ([0039]), a chemical etching process ([0040]), a dealloying process ([0041]), manufacture by a laser ([0043]), a lithography or printing or patterning process ([0045]), a block co-polymer scaffolding process ([0046] to [0048]), a swiss roll or laminate process ([0049]), etc. However, all of them are described generally and abstractly, and it is not clear concretely by processing what substance, under what conditions, by what kind of procedures, the elements recited in Claims 1 to 3 can be obtained.

It is understood that the elements recited Claims 1 to 3, "having a plurality of nanostructural features that form voids or gaps, said plurality of nanostructural features having a first size between 250 nm and 0.01 nm", should have extremely fine and precise structures

As just described, while none of the principle of solving the problem to be solved by the present inventions, concrete working examples, and concrete manufacturing method can be understood from the specification, etc. of the present application, the elements recited in Claims 1 to 3 have extremely fine and precise structures, and it cannot be deemed that there is common technical knowledge indicating such structures can be easily realized.

Thus, it cannot be deemed that a person skilled in the art can fabricate any product according to the element recited in Claims 1 to 3, based on descriptions in the specification, etc. of the present application and common technical knowledge, without excessive trial and error.

B The Appellant alleges as shown below, but none of the Appellant's allegations can be accepted.

(A) With respect to the structure according to Figure 2, same as in the allegation in above 2, (3), E, (B), the Appellant alleges that it is configured and formed with spheres, and the spheres have diameters defined in Claims 1 to 3, 3D periodicity, and each sphere contacts with other spheres tangentially both in row and column directions, and gaps or voids 220 are filled with atmospheric air.

As found in above sections, however, Figure 2 is a mere schematic diagram and it is not described in the specification, etc. of the present application with what concrete substance and structure it is composed. Even if it can be understood with what concrete substance and structure the structure in Figure 2 is composed, it is not clear how the structure can concretely be manufactured.

(B) The Appellant alleges that it has been confirmed that an actual mirror device works according to the result of the simulation.

However, the concrete structure and the manufacturing process of the "actual mirror device" alleged by the Appellant are not clear. Even if they could be made clear, as far as they are not described in the specification, etc. of the present application, the Appellant's allegation cannot be taken into consideration.

(2) Interim summary of judgment on compatibility with the enablement requirement

According to the above, the description in the detailed description of the invention of the present application is not described clearly and sufficiently as to enable a person skilled in the art to work the inventions recited in Claims 1 to 3.

4. Judgment on inventive step

If the problem to be solved by the present inventions that the structure has a high absorption rate because of radiation at the EUV wavelength could be solved by "having a plurality of nanostructural features that form voids or gaps, said plurality of nanostructural features having a first size between 250 nm and 0.01 nm," according to mere common technical knowledge, and such extremely fine and precise structure as recited in Claims 1 to 3 as "having a plurality of nanostructural features that form voids or gaps, said plurality of nanostructural features having a first size between 250 nm and 0.01 nm" could be fabricated based on common technical knowledge, the present application complies with both of the supporting requirement and the enablement requirement. But, under such assumptions, inventions recited in Claims 1 to 3 lack inventive step for following reason.

(1) Finding on the Inventions of Present Application

Inventions according to Claims 1 to 3 of the present application (hereinafter, respectively referred to as the "Invention 1" to the "Invention 3"), as recited in claims after the amendments 1 to 3, shown in above 1, (1), are as following.

A The Invention 1

"An element configured to be used in a light exposure system, wherein the light exposure system comprises a light source configured to transmit light having a wavelength, the element comprising:

a material having a plurality of nanostructural features that form voids or gaps, said plurality of nanostructural features having a first size between 250 nm and 0.01 nm;

wherein the plurality of nanostructural features is configured so that the reflectivity of the element is greater than 70% for a single target wavelength selected to be a single wavelength between 0.1 nm and 250 nm."

B Invention 2

"An element configured to be used in a light exposure system, wherein the light exposure system comprises a light source configured to transmit light having a wavelength, the element comprising:

a material having a plurality of nanostructural features that form voids or gaps, said plurality of nanostructural features having a first size between 250 nm and 0.01 nm;

wherein the plurality of nanostructural features are configured so that the transmission of the element is greater than 4% for a single target wavelength selected to be a single wavelength between 0.1 nm and 250 nm."

C Invention 3

" An element configured to be used in a light exposure system, wherein the light exposure system comprises a light source configured to transmit light having a wavelength, the element comprising:

a material having a plurality of nanostructural features that form voids or gaps, said plurality of nanostructural features having a first size between 250 nm and 0.01 nm;

wherein the plurality of nanostructural features are configured to control the electromagnetic radiation absorption for a single target wavelength selected to be a single wavelength between 0.1 nm and 250 nm."

(2) Finding on the Cited Invention

A The Cited Document (Japanese Unexamined Patent Application Publication No. 2003-318094) mentioned in above No. 2, 3 cited in the notice of reasons for refusal dated August 2, 2019 by the body, that was distributed or made publicly available through an electric telecommunication line prior to the priority date of the present application, has the following descriptions (underlines added by the body).

(A) "[Scope of Claims] ",

"[Claim 1] A reflecting mirror for light exposure apparatus used as a multi-layered-film reflecting mirror for at least either one of a mask pattern layer, a lighting optical system and a projection optical system composing a light exposure apparatus which irradiates a first base having a mask pattern layer which serves as a mask pattern formed thereon with exposure light obtained from a light source, through the lighting optical system, to thereby transfer an image of the mask pattern through a projection optical system onto a second base in a shrunk manner,
and having a stack comprising a plurality of periodic structural bodies in which two or more types of media differing in refractive index to the exposure light are periodically arranged, as being formed on a base, and the periodic structural bodies are adjusted in the thickness of a single period so as to show a behavior as a 1D photonic crystal to the exposure light.",
"[Claim 4] The reflecting mirror for light exposure apparatus as claimed in any one of Claims 1 to 3, wherein the stack comprises a single periodic structural body stacked on the base.",
"[Claim 6] The reflecting mirror for light exposure apparatus as claimed in any one of Claims 1 to 5, wherein wavelength of the exposure light is at least 500 nm or shorter ."

(B) "[0010] [Means for solving the problem and function and effect] A reflecting mirror for light exposure apparatus of the invention conceived to solve the aforementioned subject is such as being used as a multi-layered-film reflecting mirror for at least either one of a mask pattern layer, a lighting optical system and a projection optical system composing a light exposure apparatus which irradiates a first base having a mask pattern layer which serves as a mask pattern formed thereon with exposure light obtained from a light source, through the lighting optical system, to thereby transfer an image of the mask pattern through a projection optical system onto a second base in a shrunk manner, and having a stack comprising a plurality of periodic structural bodies in which two or more types of media differing in refractive index to the exposure light are periodically arranged, as being formed on a base, and the periodic structural bodies are adjusted in the thickness of a single period so as to show a behavior as a 1D photonic crystal to the exposure light.
[0011] The reflecting mirror for light exposure apparatus of this invention is configured as a multi-layered-film reflecting mirror for at least either one of a mask pattern layer, a lighting optical system and a projection optical system composing a light exposure apparatus of shrink projection type. The conventional multi-layered-film reflecting mirror used for these applications have been configured so that two species of media

differing in the refractive index to the exposure light are alternately stacked on the base, and so that thicknesses of the layers composed of the individual media are adjusted so as to allow the exposure light to cause multiple-reflection on the surface of the multi-layered-film reflecting mirror. The multi-layered-film reflecting mirror using multiple reflection was advantageous in raising reflectivity to the exposure light as compared with that of a mirror simply having a single metal thin film formed on a base. However in recent trends towards shorter wavelength of the exposure light as short as the near-ultraviolet region (500 nm or around) or below, the reflectivity based on multiple reflection, however, sharply decreases due to lowered reflectivity to the exposure light etc. of the individual media composing the multi-layered-film reflecting mirror .

[0012] In view of raising the reflectivity to the exposure light, in particular to the exposure light in the near-ultraviolet wavelength region or shorter, as compared with the conventional multi-layered-film reflecting mirror based on multiple reflection, the reflecting mirror for light exposure apparatus of this invention has the following constituent features. First, the visible light reflecting member of this invention has a stack comprising a plurality of periodic structural bodies in which two or more types of media differing in refractive index to the visible light are periodically arranged, as being formed on a base. Second, the periodic structural bodies are adjusted in the thickness of a single period so as to show a behavior as a 1D photonic crystal to the exposure light .

[0013] An example of the periodic structural body which the reflecting mirror for light exposure apparatus of this invention has is shown in Figure 5. A periodic structural body 100 in Figure 5 corresponds to a case in which two types of media differ in the refractive index to the exposure light are stacked so as to alternately and periodically arranged therein. This mode of stacking allows the high refractive index layer 10 and the low refractive index layer 11 to be periodically stacked, wherein the a pair of the high refractive index layer 10 and the low refractive index layer 11 corresponds to a single period. Thickness of the single period is adjusted so as to correspond to an integral multiple of a half-wavelength ($\lambda a/2$) of an in-medium average wavelength λa obtained by averaging an in-medium wavelength in each of the high refractive index layer 10 and the low refractive index layer 11 to the exposure light.

[0014] In thus configured periodic structural body 100, as schematically shown in Figure 4, the refractive index periodically varies in the direction of stacking. If the length of a single period in the periodic variation of the refractive index corresponds to an integral multiple of a half-wavelength of a propagating light, or a half-wavelength ($\lambda a/2$) of the in-medium average wavelength, which is going to propagate through the periodic structural body 100 in the direction of stacking thereof, such propagating light cannot propagate through the periodic structural body 100, and is reflected instead in a form almost equivalent to perfect reflection (reflectivity is 1). The behavior characterized by reflection of light in a specific wavelength region is generally referred to as photonic band gap, because it is conceptually same as band gap explained based on dispersion of electron in a solid crystal such as semiconductor. In particular, those having the photonic band gap only for the light propagating in the direction of stacking, such as the periodic structural body 100, are referred to as 1D photonic crystal.

[0015] Figure 5 showed an exemplary case using two types of media differing in the refractive index to the exposure light, but it is also allowable to periodically stack three or more types of media differing in the refractive index to the exposure light to thereby make the periodic structural body as the 1D photonic crystal to the exposure light. As one example, the periodic structural body 100 shown in Figure 7 uses three types of media differing in the refractive index to the exposure light. A group of the high refractive index layer 10, the middle refractive index layer 12, and the low refractive index layer 11 forms a single period, and the thickness of the single period is adjusted so as to correspond to an integral multiple of a half-wavelength ($\lambda a/2$) of an in-medium average wavelength λa obtained by averaging an in-medium wavelength of the exposure light in each of the high refractive index layer 10, the middle refractive index layer 12, and the low refractive index layer 11 of the exposure light. This configuration allows the refractive index to vary periodically in the direction of stacking as shown in Figure 6, and the length of one period corresponds to an integral multiple of a half-wavelength of the in-medium wavelength λa. This consequently makes the periodic structural body 100 shown in Figure 7 as the 1D photonic crystal to the exposure light .

[0016] As described in the above, the periodic structural body owned by the reflecting mirror for light exposure apparatus of this invention is configured as a 1D photonic crystal so that the wavelength region possibly reflected by the photonic band gap is corresponded to a region including wavelength region in the exposure light. The reflecting mirror for light exposure apparatus of this invention is consequently successful in increasing the reflectivity to the exposure light to a considerable degree as compared with the conventional multi-layered-film reflecting mirror based on multiple reflection. Thickness of one period in the periodic structural body may be adjusted so as to correspond to an integral multiple of a half-wavelength of the in-medium average wavelength, where a larger thickness of one period results in a larger attenuation ratio of light. It is, therefore, possible to improve the reflectivity of the reflecting mirror for light exposure apparatus of this invention to the exposure light, particularly by adjusting the thickness of one period in the periodic structural body so as to correspond to a single wavelength or a half-wavelength of the in-medium average wavelength. From this point of view, it is made possible to most effectively improve the reflectivity of the reflecting mirror for light exposure apparatus of this invention to the exposure light, when the thickness of single period in the periodic structural body is adjusted so as to correspond to a half-wavelength of the in-medium average wavelength. ",

"[0019] Next, the wavelength width of the exposure light to be reflected by the reflecting mirror of the light exposure apparatus of this invention is discussed below. The wavelength width depends on the refractive indices of the individual media composing a single period of the periodic structural body. More specifically, it depends on difference in the refractive index Δn given by a medium having the largest refractive index to the exposure light and a medium having the smallest refractive index, among the individual media composing one period. As Δn becomes larger, the wavelength width of the exposure light to be reflected, or the wavelength region of the exposure light to be reflected increases. For the purpose of reflecting the exposure light in a specific wavelength region, it is allowable to use a plurality of periodic structural bodies, or to use a single periodic structural body. As an example of using a plurality of periodic structural bodies, a schematic drawing of Figure 8 shows a case where two periodic structural bodies are combined. A first periodic structural body 101 and a second periodic structural body 102 are adjusted so as to be differ in the wavelength region of the exposure light to be reflected, wherein thickness of a single period of the one is adjusted so as to cause reflection of the exposure light having a center wavelength of λ1, and thickness of the other is adjusted so as to cause reflection of the exposure light having a center wavelength of λ2. By combining two periodic structural bodies as described in the above, wavelength width Δλ of the exposure light to be reflected as a whole is equivalent to the total of the wavelength widths Δλ1 and Δλ2 of the exposure light reflected by the first periodic structural body 101 and second periodic structural body 102, respectively. On the other hand, it is also possible to reflect the exposure light in the wavelength region having the same wavelength width Δλ with a single periodic structural body. In this case, materials for the individual media composing a single period can appropriately be selected so as to adjust difference in the refractive index Δn in the single period of the periodic structural body to as large as a sum of the individual differences in the refractive index Δn within a single period of the first periodic structural body 101 and second periodic structural body 102 in Figure 8.

[0020] As described in the above, the reflecting mirror for light exposure apparatus of this invention can reflect the exposure light effectively in a specific wavelength region equally in both cases of using a single periodic structural body and a plurality of periodic structural bodies. The difference in the refractive index within a single period of the periodic structural body is, however, sometimes becoming more difficult to be enlarged in recent trends towards shorter wavelength of the exposure light. In this case, use of a plurality of periodic structural bodies so as to expand the wavelength region to be reflected is said to be an effective mean. On the other hand, for the case where only a single periodic structural body is sufficient for fully reflecting the exposure light, it is particularly preferable to use a single periodic structural body. The single periodic structural body is advantageous in that requiring only a less total number of stacking as compared with a plurality of periodic structural bodies. The reduction in the number of stacking is successful in suppressing attenuation ratio of the exposure light propagating in the periodic structural body. As a consequence, the reflecting mirror for light exposure apparatus configured as having a single periodic structural body makes it possible to further improve the reflectivity to the exposure light. Because the periodic structural body is stacked on the base, a configuration having a single structural body is successful in reducing stress, such as distortion stress concentrated on the base. This consequently makes it possible to reduce deformation possibly occurs in the base or periodic structural body. "

"[0032] The foregoing paragraphs have described the constituent features for improving the reflectivity to the exposure light of the reflecting mirror for light exposure apparatus of this invention, as compared with that of the conventional multi-layered-film reflecting mirror. In this sort of reflecting mirror for light exposure apparatus, the wavelength region of the exposure light to be targeted is not specifically limited. However, to catch up with recent micronization of the element pattern of semiconductor devices, there is a demand for the multi-layered-film reflecting mirror possibly improved in the reflectivity to the exposure light in the near-ultraviolet wavelength region of shorter. Use of the reflecting mirror for light exposure apparatus of this invention particularly raises its efficacy when it is used for the exposure light in the near-ultraviolet wavelength region of 500 nm or shorter. The lower limit of the wavelength of the exposure light, which is in the near-ultraviolet wavelength region of 500 nm or shorter, depends on available light sources for the exposure light, and is typically set to 10 nm or around when a light source in the soft-X-ray wavelength region, such as a laser plasma X-ray source or the like, is used."

B According to the above A, it is acknowledged that the Cited Document describes the following invention (hereinafter, referred to as "the Cited Invention"). Paragraph numbers used for the finding of the Cited Invention are shown in brackets for reference:

" A reflecting mirror for light exposure apparatus used as a multi-layered-film reflecting mirror for at least either one of a mask pattern layer, a lighting optical system and a projection optical system composing a light exposure apparatus which irradiates a first base having a mask pattern layer which serves as a mask pattern formed thereon with exposure light obtained from a light source, through the lighting optical system, to thereby transfer an image of the mask pattern through a projection optical system onto a second base in a shrunk manner,

the reflecting mirror for light exposure apparatus having a stack comprising a plurality of periodic structural bodies in which two or more types of media differing in refractive index to the exposure light are periodically arranged, as being formed on a base, and the periodic structural bodies are adjusted in the thickness of a single period so as to show a behavior as a 1D photonic crystal to the exposure light ([Claim 1]),

wherein the stack comprises a single periodic structural body stacked on the base ([Claim 4]),

the wavelength of the exposure light is at least 500 nm or shorter ([Claim 6]),

the lower limit of the wavelength of the exposure light, which depends on available light sources for the exposure light, is typically set to 10 nm or around when a light source in the soft-X-ray wavelength region, such as a laser plasma X-ray source or the like, is used ([0032]),

and it is possible to improve the reflectivity of the reflecting mirror to the exposure light, particularly by adjusting the thickness of one period in the periodic structural body so as to correspond to a single wavelength or a half-wavelength of the in-medium average wavelength ([0016])."

(3) Regarding Invention 1

A Comparison

(A) Concerning the matter specifying Invention 1, "An element configured to be used in a light exposure system"

a "A reflecting mirror for light exposure apparatus" of the Cited Invention corresponds to "An element configured to be used in a light exposure system" in Invention 1."

b Therefore, the Cited Invention has the above matter specifying Invention 1.

(B) Concerning the matter specifying Invention 1, "the light exposure system comprises a light source configured to transmit light having a wavelength"

Since in the Cited Invention " irradiates a first base having a mask pattern layer which serves as a mask pattern formed thereon with exposure light obtained from a light source, through the lighting optical system," the Cited Invention has the matter specifying Invention 1, "the light exposure system comprises a light source configured to transmit light having a wavelength."

(C) Concerning the matter specifying Invention 1, "the element comprising: a material having a plurality of nanostructural features that form voids or gaps, said plurality of nanostructural features having a first size between 250 nm and 0.01 nm"
a "A reflecting mirror for light exposure apparatus " of the Cited Invention is specified as "having a stack comprising a plurality of periodic structural bodies in which two or more types of media differing in refractive index to the exposure light are periodically arranged, as being formed on a base, and the periodic structural bodies are adjusted in the thickness of a single period so as to show a behavior as a 1D photonic crystal to the exposure light ", "the stack comprises a single periodic structural body stacked on the base", wherein "the wavelength of the exposure light is at least 500 nm or shorter," "the lower limit of the wavelength of the exposure light, which depends on available light sources for the exposure light, is typically set to 10 nm or around when a light source in the soft-X-ray wavelength region, such as a laser plasma X-ray source or the like, is used," and "it is possible to improve the reflectivity of the reflecting mirror to the exposure light, particularly by adjusting the thickness of one period in the periodic structural body so as to correspond to a single wavelength or a half-wavelength of the in-medium average wavelength". Rearranging these technical matters of the Cited Invention from the viewpoint of "periodic structural bodies", concerning "periodic structural bodies," it is specified that "by adjusting the thickness of one period in the periodic structural body so as to correspond to a single wavelength or a half-wavelength of the in-medium average wavelength," "the wavelength of the exposure light is at least 500 nm or shorter," and "the wavelength of the exposure light .... is typically set to 10 nm or around when a light source in the soft-X-ray wavelength region, such as a laser plasma X-ray source or the like, is used." Then, it can be deemed that the "periodic structural bodies" of the Cited Invention corresponds to "a plurality of nanostructural features" "having a first size between 250 nm and 0.01 nm" of Invention 1.

b Accordingly, the Cited Invention and Invention 1 have common matters for specifying invention, "the element comprising: a material having a plurality of nanostructural features," "said plurality of nanostructural features having a first size between 250 nm and 0.01 nm.".

However, in the Cited Invention, "plurality of nanostructural features" do not "form voids or gaps."

(D) Concerning the matter specifying Invention 1, "the plurality of nanostructural features are configured so that the reflectivity of the element is greater than 70% for a single target wavelength selected to be a single wavelength between 0.1 nm to 250 nm"

Since the Cited Invention is specified as " the wavelength of the exposure light is at least 500 nm or shorter," "the lower limit of the wavelength of the exposure light, which depends on available light sources for the exposure light, is typically set to 10 nm or around when a light source in the soft-X-ray wavelength region, such as a laser plasma X-ray source or the like, is used," and "it is possible to improve the reflectivity of the reflecting mirror to the exposure light, particularly by adjusting the thickness of one period in the periodic structural body so as to correspond to a single wavelength or a half-wavelength of the in-medium average wavelength," the Cited Invention is commonn with Invention 1 in that "the plurality of nanostructural features are configured so that" "the reflectivity of the element" is certain value "for a single target wavelength selected to be a single wavelength between 0.1 nm to 250 nm."

However, it is not clear whether the certain value of the reflectivity in the Cited Invention is "greater than 70%."

(E) Concerning the matter specifying Invention 1, "element,"

As shown in above (A), the Cited Invention has the above matter specifying Invention 1.

B Finding on Common Features and Different Features

According to above A, Invention 1 and the Cited Invention coincide with each other in that;

"An element configured to be used in a light exposure system, wherein the light exposure system comprises a light source configured to transmit light having a wavelength, the element comprising:

a material having a plurality of nanostructural feature having a first size between 250 nm and 0.01 nm, wherein the plurality of nanostructural features are configured so that the reflectivity of the element is certain value for a single target wavelength between 0.1 nm to 250 nm."

And they differ from each other in the following points.

[Different Feature 1] Concerning "a plurality of nanostructural features" "having a first size between 250 nm and 0.01 nm", while they "form voids or gaps" in Invention 1, the Cited Invention does not have such feature.
[Different Feature 2] Concerning certain value of reflectivity, while it is "greater than 70%" in Invention 1, the value is not clear in the Cited Invention.

C Judgment on Different Feature 1
(A) First, considering that what change to the Cited Invention makes to arrive at the configuration of Different Feature 1; it suffices if a plurality of periodic structural bodies of the Cited Invention which "are adjusted in the thickness of a single period so as to show a behavior as a 1D photonic crystal to the exposure light," are changed to such that "having a plurality of nanostructural features that form voids or gaps, said plurality of nanostructural features having a first size between 250 nm and 0.01 nm."

(B) In the Cited Document, in [0014], it is described that "The behavior characterized by reflection of light in a specific wavelength region is generally referred to as photonic band gap, because it is conceptually same as band gap explained based on dispersion of electron in a solid crystal such as semiconductor. In particular, those having the photonic band gap only for the light propagating in the direction of stacking, such as the periodic structural body 100, are referred to as 1D photonic crystal."

The above description explains the physical principle, from the viewpoint of photonic bandgap, through which the Cited Invention functions as a reflecting mirror. Rearranging this physical principle from the viewpoint of photonic bandgap, the Cited Invention can reflex light of a certain wavelength domain, with photonic bandgap as a 1D photonic crystal, while having the photonic band gap only for the light propagating in the direction of stacking, it can be deemed to function as such a reflecting mirror only for that direction.

(C) In the field of photonic crystal, 1D photonic crystal and 3D photonic crystal are well known without exemplifying, and they are understood to be equally positioned in the concept of "photonic crystal." In addition, 3D photonic crystal comprising a plurality of nanostructural features that form voids or gaps, wherein bandgaps exist for light propagating in any direction, is well known in the technical field (for example, Figures 2 and 3 on page 57 in Susumu Noda, "Photonic crystal," Optical Review (KOGAKU), 2001, volume 30, No. 1, pages 56 to 64 (well-known example mentioned in above No. 2, 3) may be referred; as shown below).

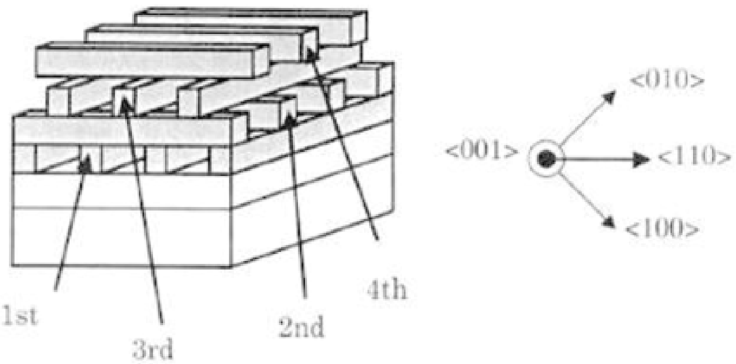

図2　3次元フォトニック結晶の例．屈折率の分布が3次元的になるとき，光がどの方向に伝搬する場合でもバンドギャップが存在するようになる．

図２　３次元フォトニック結晶の例，屈折率の分布が３次元になるとき，光がどの方向に伝搬する場合でもバンドギャップが存在するようになる。　Figure 2: Example of 3D photonic crystal.　When the distribution of reflective index becomes three-dimensional, bandgaps becomes to exist for light propagating in any direction.

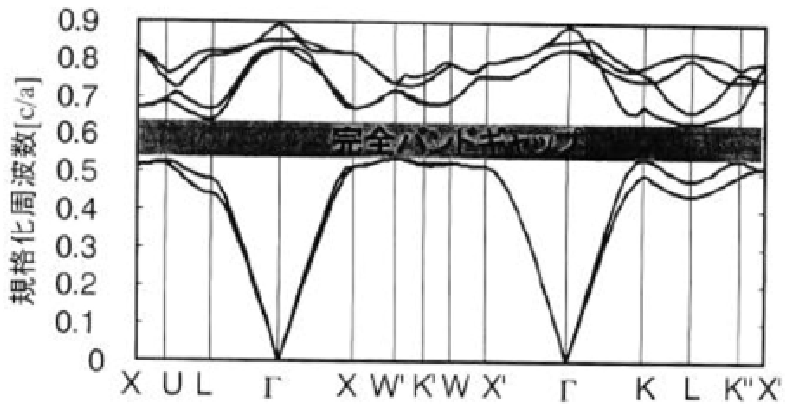

図3　図2の3次元結晶のバンド構造．横軸はさまざまな光の伝搬方向を表し，縦軸は，光の周波数（波長）を表す．

規格化周波数　　Normalized frequency

図 3　図 2 の 3 次元結晶のバンド構造，横軸はさまざまな光の伝搬方向を表し，縦軸は，光の周波数（波長）を表す。　　Figure 3: Band structure of 3D crystal of Figure 2; the horizontal axis represents various propagating direction of light, and the vertical axis represents frequency (wavelength) of light

(D) a　With respect to the 3D photonic crystal described in the well-known example, there are descriptions in the well-known example which show the wavelength is in mid-infrared and optical communication bands; from page 57, right column, last line to page

58, left column, line 2 etc.

However, it is understood that the technical matter described in Figures 2 and 3 of the well-known example (above mentioned (C)) is not affected by the wavelength. In addition, the present reason is examined under assumption that a person skilled in the art can fabricate, based on common technical knowledge, the extremely fine and precise structure such as "having a plurality of nanostructural features that form voids or gaps, said plurality of nanostructural features having a first size between 250 nm and 0.01 nm," as recited in Claims 1 to 3.

Then, the above descriptions do not mean there is a disincentive for applicating the 3D photonic crystal described in the well-known example, to the reflecting mirror light exposure apparatus of the Cited Invention.

b The well-known example does not clearly describe that the 3D photonic crystal described in its Figures 2 and 3 (above (C)) is a means for reflecting.

However, the existence of bandgaps is clearly shown in Figure 2 and Figure 3 of the well-known example, while the Cited Invention, as discussed in above (B), can reflect light of a certain wavelength domain by having photonic bandgap as 1D photonic crystal.

Then, a person skilled in the art, who read the Cited Document, can recognize that the 3D photonic crystal described in Figures 2 and 3 of the well-known example can be a means for reflection.

(E) Since the reflecting mirror for light exposure apparatus of the Cited Invention can be deemed to function as a reflecting mirror only for the light propagating in the direction of stacking (above (B)), it is naturally desired to make it possible to reflect propagating light from a wider direction (wider angle).

Then, in the Cited Invention, intending wider angle reflection, a person skilled in the art could have easily conceived to replace the structure, comprising 1D photonic crystal, with the following structure; namely the above mentioned well-known 3D photonic crystal, comprising a plurality of nanostructural features which form voids or gaps. And regarding the wavelength of the exposure light used in the Cited Invention, it can be deemed that by above mentioned replacement, a person skilled in the art can arrive at the configuration according to Different Feature 1.

D Judgment on Different Feature 2

Since it is obvious that sufficient reflectivity can be ensured in structures having photonic bandgap, it is not particularly remarkable with the structure, in which the well-known art is applied to the Cited Invention, to arrive at the value of "reflectivity of the element" as in Different Feature 2.

E　Effect of Invention 1

Taking into consideration that the present reason is examined under assumption, as indicated at the beginning of the reason, that by "having a plurality of nanostructural features that form voids or gaps, said plurality of nanostructural features having a first size between 250 nm and 0.01 nm," the problem to be solved by the Inventions that the structure has a high absorption rate because of radiation at the EUV wavelength can be solved according to mere common technical knowledge, the effect of Invention 1 could be predicted by a person skilled in the art.

F　Interim summary of the judgment on Invention 1

As explained above, Invention 1 of the present application could have been easily invented by a person skilled in the art, based on the Cited Invention, the descriptions in the Cited Document, and the well-known art.

(4) Invention 2

A　Comparison, and findings on Common Features and Different Features

Comparing Invention 2 and the Cited Invention, as same as in above (3)A, it is acknowledged that they coincide with each other in that;

"An element configured to be used in a light exposure system, wherein the light exposure system comprises a light source configured to transmit light having a wavelength, the element comprising:

a material having a plurality of nanostructural features having a first size between 250 nm and 0.01 nm, wherein the plurality of nanostructural features are configured so that the transmission of the element is certain value for a single target wavelength between 0.1 nm to 250 nm."

And they differ from each other in the following points.

[Different Feature 3] Concerning "a plurality of nanostructural features" "having a first size between 250 nm and 0.01 nm", while they "form voids or gaps" in Invention 2, the Cited Invention does not have such a feature.

[Different Feature 4] Concerning certain value of transmission, while it is "greater than 4%" in Invention 2, the value is not clear in the Cited Invention.

B Judgment on Different Feature 3

Judgment on Different Feature 3 is same as judgment on Different Feature 1.

C Judgment on Different Feature 4

Taking into consideration that the value of transmission in Invention 2 is not so large, the probability that the configuration according to Different Feature 4 is satisfied also with a structure, in which the well-known art is applied to the Cited Invention, is high. Putting this aside, taking into consideration that the present reason is examined under assumption, as indicated at the beginning of the reason, that by "having a plurality of nanostructural features that form voids or gaps, said plurality of nanostructural features having a first size between 250 nm and 0.01 nm," the problem to be solved by the Inventions that the structure has a high absorption rate because of radiation at the EUV wavelength can be solved according to mere common technical knowledge, it would be possible for a person skilled in the art to set the value appropriately, as in Different Feature 4.

D Effect of Invention 2

Taking into consideration that the present reason is examined under assumption, as indicated at the beginning of the reason, that by "having a plurality of nanostructural features that form voids or gaps, said plurality of nanostructural features having a first size between 250 nm and 0.01 nm," the problem to be solved by the Inventions that the structure has a high absorption rate because of radiation at the EUV wavelength can be solved according to mere common technical knowledge, the effect of Invention 2 could be predicted by a person skilled in the art.

E Interim summary of the judgment on Invention 2

According to the above, the Invention 2 could have been easily invented by a person skilled in the art, based on the Cited Invention, the descriptions in the Cited Document, and the well-known art.

(5) Regarding Invention 3

A Comparison, and findings on Common Features, and Different Feature

Comparing Invention 3 and the Cited Invention, as same as in above (3)A, it is acknowledged that they coincide with each other in that:

"An element configured to be used in a light exposure system, wherein the light exposure system comprises a light source configured to transmit a light having a wavelength, the element comprising:

a material having a plurality of nanostructural features having a first size between 250 nm to 0.01 nm."

And they differ from each other in the following points.

[Different Feature 5] Concerning "a plurality of nanostructural features" "having a first size between 250 nm and 0.01 nm", while they " form voids or gaps" in Invention 3, the Cited Invention does not have such feature.

[Different Feature 6] While "the plurality of nanostructural features is configured to control the electromagnetic radiation absorption for a single target wavelength selected to be a single wavelength between 0.1 nm and 250 nm" in Invention 3, the Cited Invention does not have such feature.

B Judgment on Different Feature 5

Judgment on Different Feature 5 is same as judgment on Different Feature 1.

C Judgment on Different Feature 6

Concerning the meaning of the configuration according to Different Feature 6, "the plurality of nanostructural features is configured to control the electromagnetic radiation absorption for a single target wavelength selected to be a single wavelength between 0.1 nm and 250 nm," the subject of Invention 3 is an "element", and relating to "control," the specification, etc. of the present application do not describe anything about what is called dynamic control. Accordingly, it is understood that the configuration according to Different Feature 6 merely specifies that an element having a plurality of nanostructural features has a certain absorption rate to a single target wavelength selected to become a single wavelength between 0.1 nm and 250 nm.

It is obvious that the structure, obtained by applying the well-known art to the Cited Invention, has a certain absorption rate.

Thus, Different Feature 6 is not remarkable, without assumption that by "having a plurality of nanostructural features that form voids or gaps, said plurality of nanostructural features having a first size between 250 nm and 0.01 nm," the problem to be solved by the Inventions that the structure has a high absorption rate because of radiation at the EUV wavelength can be solved according to mere common technical knowledge.

D　Effects of Invention 3

The effect of Invention 3 could be predicted by a person skilled in the art, without assumption that by "having a plurality of nanostructural features that form voids or gaps, said plurality of nanostructural features having a first size between 250 nm and 0.01 nm," the problem to be solved by the Inventions that the structure has a high absorption rate because of radiation at the EUV wavelength can be solved according to mere common technical knowledge.

E　Interim summary of judgment on Invention 3

According to the above, the Invention 3 could have been easily invented by a person skilled in the art, based on the Cited Invention, the descriptions in the Cited Document, and the well-known art.

(6) Interim summary of judgment on inventive step

As explained above, Inventions 1 to 3 could have been easily invented by a person skilled in the art based on the Cited Invention, the descriptions in the Cited Document, and the well-known art.

5. Closing

As explained above, since inventions recited in Claims 1 to 3 of the present application do not coincide with the inventions described in the detailed description of the invention, the present application does not comply with the requirement set forth in Article 36(6)(i) of the Patent Act, and the detailed description of the invention of the present application is not described clearly and sufficiently as to enable a person skilled in the art to work the inventions recited in Claims 1 to 3 of the present application, the present application does not comply with the requirement set forth in Article 36(4)(i) of the Patent Act, and, since Inventions 1 to 3 could have been easily invented by a person skilled in the art based on the Cited Invention, the descriptions in the Cited Document, and the well-known art, a patent should not be granted for the Inventions 1 to 3 under the provisions of Article 29(2) of the Patent Act.

Accordingly, the present application should be rejected without examining the inventions according to the other claims.

Therefore, the appeal decision shall be made as described in the conclusion.

July 22, 2020

Chief administrative judge:	SEGAWA, Katsuhisa
Administrative judge:	YAMAMURA, Hiroshi
Administrative judge:	KONDO, Yukihiro