Claims:

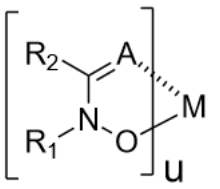
1. A lithography method comprising:

i) applying an organometallic compound represented by Formula (I) or Formula (II), or

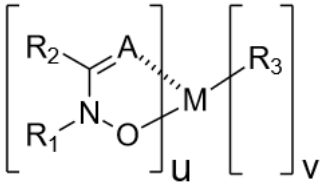
a polymer obtained by subjecting one or more compounds represented by Formula (I) and/or Formula (II) to conditions of polymerization, optionally in the presence of oxygen, or

a composition comprising the organometallic compound represented by Formula (I) or Formula (II), and/or the polymer,

for a resist on a substrate,



(I)



(II) wherein

M is an ion and is selected from the group of transition metals, or from the group of metals and metalloids of groups 1 to 15, or 3 to 15;

R_1 stands for hydrogen or an optionally substituted hydrocarbyl residue;

R_2 stands for hydrogen, a hydrocarbyl residue of a saturated or unsaturated, linear, branched or cyclic hydrocarbon, optionally substituted with one or more reactive or non-reactive groups optionally containing heteroatoms;

R_3 stands for an alkenyl group with 2 to 10 carbon atoms, said alkenyl being optionally substituted with one or more alkyl groups having 1 to 10 carbon atoms; or an acrylate, methacrylate, carbamate, thiocarbamate, thiacarbamate or acetate, or

R_3 represents a residue corresponding to the structure placed within the left-hand side brackets of Formula (II), whereby R_1 stands for hydrogen or an optionally substituted hydrocarbyl residue and R_2 stands for hydrogen, a hydrocarbyl residue or a saturated or unsaturated, linear, branched or cyclic hydrocarbon, optionally substituted with one or more reactive or non-reactive groups optionally containing heteroatoms, at least one of said substituents R_1 and R_2 in the meaning of R_3 being different from the corresponding

substituents of the structure placed within the left-hand side brackets of Formula (II);

A stands for a heteroatom selected from oxygen, and sulphur; and

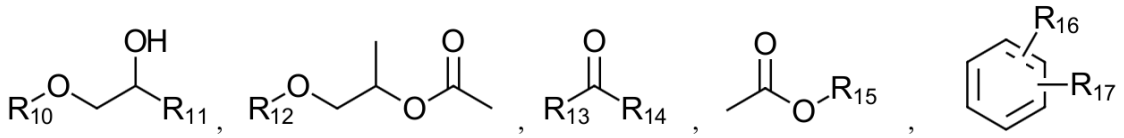
u and v are independently selected from integers having a value in the range from 1 to 10;

thereby forming a resist film on the substrate;

ii) exposing the formed resist film to light or electron beam radiation, thereby forming an exposed resist film on the substrate; and

iii) developing the formed exposed resist film with one or more developers, thereby forming a patterned resist film on the substrate; wherein

the one or more developers are each independently selected from the group of compounds represented by Formula (VIII), Formula (IX), Formula (X), Formula (XI), and Formula (XII),



(VIII) (IX) (X) (XI) (XII),

wherein R_{10}, R_{11}, R_{12}, R_{13}, R_{14}, and R_{15} are each independently selected from linear and branched hydrocarbon groups having 1 to 10 carbon atoms; and R_{16} and R_{17} are each independently selected from H, linear and branched hydrocarbon groups having 1 to 10 carbon atoms, linear and branched alkoxy groups having 1 to 10 carbon atoms, and halogen.

2. The lithography method as claimed in claim 1, wherein at least one of the one or more developers has a Hansen solubility parameter (δh) between 3 to 12.

3. The lithography method as claimed in any of claims 1 – 2, wherein at least one of the one or more developers is each independently selected from the group of compounds represented by Formula (VIII), wherein R_{10} and R_{11} are each independently selected from methyl, ethyl, propyl, isopropyl, butyl, pentyl, neo-pentyl and neo-propyl; or

wherein at least one of the one or more developers is each independently selected from the group of compounds represented by Formula (IX), wherein R_{12} is methyl, ethyl, propyl, or butyl.

4. The lithography method as claimed in any of claims 1 – 2, wherein at least one of the one or more developers is each independently selected from the group of compounds represented by Formula (X), wherein R_{13} and R_{14} are each independently selected from methyl, ethyl, isobutyl, hexyl, heptyl, nonyl, and decyl.

5. The lithography method as claimed in any of claims 1 – 2, wherein at least one of the one or more developers is each independently selected from the group of compounds represented by Formula (XI), wherein R_{15} is ethyl, propyl, isopropyl, pentyl, neo-pentyl, neo-propyl, butyl, pentyl, or hexyl, preferably propyl or butyl, more preferably iso-propyl, sec-butyl or tert-butyl, even more preferably sec-betyl or tert-butyl.

6. The lithography method as claimed in any of claims 1 – 2, wherein at least one of the one or more developers is each independently selected from the group of compounds represented by Formula (XII), wherein R_{16} and R_{17} are each independently selected from H, methyl, methoxy, and chloro, preferably R_{16} is H and R_{17} is methyl, methoxy, or chloro, more preferably R_{16} is H and R_{17} is methoxy; or wherein the one or more developers are selected from sec-butyl acetate, tert-butyl acetate, iso-propyl acetate, and anisol.

7. The lithography method as claimed in any of claims 1 – 2, wherein the one or more developers are two developers selected from NBA and PGMEA; NBA and 2-heptanone; PGMEA and 2-heptanone; and toluene and PGME.

8. The lithography method as claimed in any of claims 1 – 7, wherein the exposing the formed resist film to light or electron beam radiation is exposing the formed resist film to light of a wavelength selected from 13.5 nm, 193 nm, 248 nm and 365 nm, or combinations thereof.

9. The lithography method as claimed in any of claims 1 – 8, wherein, in ii), exposing the formed resist film to electron beam radiation (EBEAM).

10. The lithography method as claimed in any of claims 1 – 9, wherein the one or more developers are toluene and PGME, and the content of PGME is at least 1% by weight based on the total weight of toluene and PGME.

11. The lithography method as claimed in any of claims 1 – 10, wherein the substrate is a semiconductor substrate.

12. The lithography method as claimed in any of claims 1 – 11 for producing a semiconductor device, wherein the method comprising:

- applying the compound, the polymer or the composition as defined in any of claims 1 – 11 for forming a film onto a semiconductor substrate and baking the compound, the polymer or the composition to form a underlayer film on the substrate;
- applying a resist onto the formed underlayer film to form a resist film;
- exposing the formed resist film to light or to electron beam radiation to form an exposed resist film;
- developing the formed exposed resist film with the one or more developers, thereby forming a patterned resist film on the substrate;
- etching the underlayer film according to the pattern of the patterned resist film; and
- processing the semiconductor substrate according to the pattern of the resist film and the resist underlayer film.

13. The lithography method as claimed in any of claims 1 – 11 for producing a semiconductor device, the method comprising:

- applying an organic underlayer film composition on a surface of a semiconductor substrate and baking the organic underlayer film composition to form an organic underlayer film;
- applying the compound, the polymer or the composition as defined in any of claims 1 – 11 for forming a resist film onto the formed organic underlayer film and baking the compound, the polymer or the composition to form a resist film;
- exposing the formed resist film to light or to electron beam radiation;

- developing the formed exposed resist film with the one or more developers, thereby forming a patterned resist film;
- etching the resist underlayer film according to the pattern of the patterned resist film;
- etching the organic underlayer film according to the pattern of the patterned resist underlayer film; and
- processing the semiconductor substrate according to the pattern of the patterned organic underlayer film.

14. The lithography method as claimed in any of claims 1 – 11 for producing an optical or semiconductor device, the method comprising:

- applying a spin on carbon (SOC), e.g. high temperature (350–400 °C) SOC, or α-carbon layer obtained by CVD on a surface of a substrate;
- applying a layer of a composition of high silicon content or silicon oxynitride or metal oxide layer on the SOC or the α-carbon layer;
- applying a functional coating layer comprising the compound, the polymer or the composition as defined in any of claims 1 – 11 on the layer of a composition of high silicon content or silicon oxynitride or metal oxide layer on the SOC or the α-carbon layer to form a resist underlayer functional layer;
- applying a resist onto the resist underlayer functional layer to form a resist film;
- exposing the formed resist film to light or to electron beam radiation to form an exposed resist film;
- developing the formed exposed resist film with the one or more developers, thereby forming a patterned resist film;
- etching the resist underlayer functional layer according to the pattern of the patterned resist film; and
- processing the substrate according to the pattern of the resist film and the resist underlayer functional layer.

15. The lithography method as claimed in any of claims 1 – 11 for producing an optical element or an optically active device, the method comprising:

- applying the compound, the polymer or the composition as defined in any of claims 1 – 11 for forming a resist underlayer film onto a surface of a substrate and baking the compound, the polymer or the composition to form a resist underlayer film;
- exposing the formed resist underlayer film to light or to electron beam radiation;
- developing the formed exposed resist film with the one or more developers, thereby forming a patterned resist film;
- etching the resist underlayer film according to the pattern of the patterned resist film; and
- processing the substrate according to the pattern of the resist film and the resist underlayer film.

16. The lithography method as claimed in any of claims 1 – 15, wherein the substrate is made of TiO_2, Si, or GaAs.

17. The lithography method as claimed in claim 16 for patterning a semiconductor substrate, the method comprising:

- forming an organic underlayer film on a surface of a semiconductor substrate;
- forming an inorganic oxide containing middle layer film on the formed organic underlayer film;
- applying the compound, the polymer or the composition as defined in any of claims 1 – 11 for forming a resist film onto the formed inorganic oxide containing middle layer film and baking the compound, the polymer or the composition to form a resist film;
- exposing the formed resist film to light or to electron beam radiation:
- developing the formed exposed resist film with the one or more developers, thereby forming a patterned resist film;
- etching the resist film according to the pattern of the patterned resist film;
- etching the inorganic oxide containing middle layer film according to the pattern of the patterned resist film;
- etching the organic underlayer film according to the pattern of the pattered resist film; and

- processing the semiconductor substrate according to the pattern of the patterned organic underlayer film.

18. An optical element, optically active device or optical or semiconductor device obtainable by a method as defined in any of claims 12 – 15 and 17, or an optical element, optically active device or optical or semiconductor device obtainable by a method as defined in any of claims 12 – 15 and 17, wherein the substrate is made of TiO_2, Si, or GaAs.