## CLAIMS

1. A method of processing a semiconductor substrate, comprising:

providing in a process chamber a photopatterned organo-metal-oxide-containing EUV resist comprising an unexposed organo-metal-oxide-containing portion and an EUV-exposed metal-oxide-containing portion on a substrate layer of a semiconductor substrate; and

dry developing the photopatterned organo-metal-oxide-containing EUV resist by selectively removing a portion of the photopatterned organo-metal-oxide-containing EUV resist by exposure to a dry development chemistry to form a resist mask,

wherein the dry development chemistry selectively removes the unexposed organo-metal-oxide-containing portion relative to the EUV-exposed metal-oxide-containing portion to form the resist mark, wherein the dry development chemistry comprises a hydrogen halide or hydrogen gas and halogen gas.

2. The method of claim 1, wherein the dry development chemistry selectively breaks metal-oxide bonds in organo-metal-oxide networks in the unexposed organo-metal-oxide-containing portion to form one or more volatile byproducts, while leaving metal-oxide bonds intact in metal-oxide networks in the EUV-exposed metal-oxide-containing portion to form the resist mask

3. The method of claim 1, further comprising:

removing the unexposed organo-metal-oxide-containing portion and the EUV-exposed metal-oxide-containing portion of the photopatterned organo-metal-oxide-containing EUV resist without removing the substrate layer.

4. The method of claim 1, wherein the dry development chemistry comprises hydrogen fluoride (HF), hydrogen chloride (HCl), hydrogen bromide (HBr), or hydrogen iodide (HI).

5. The method of claim 1, wherein the dry development chemistry comprises hydrogen gas ($H_2$) and fluorine gas ($F_2$), chlorine gas ($Cl_2$), bromine gas ($Br_2$), or iodine gas ($I_2$).

6. The method of claim 1, wherein the dry development chemistry is flowed with a carrier gas into the process chamber, the carrier gas including helium (He), neon (Ne), argon (Ar), xenon (Xe), or nitrogen ($N_2$).

7. The method of claim 1, wherein dry developing the photopatterned organo-metal-oxide-containing EUV resist comprises applying a remote plasma including radicals of the dry development chemistry to the photopatterned metal-containing resist.

8. The method of claim 1, wherein dry developing the photopatterned organo-metal-oxide-containing EUV resist comprises exposure to at least the dry development chemistry in a plasma-free thermal process.

9. The method of claim 1, wherein dry developing the photopatterned organo-metal-oxide-containing EUV resist occurs at a temperature between -60°C and 120°C, at a chamber pressure between 0.1 mTorr and 760 Torr, at a gas flow rate of the dry development chemistry between 100 sccm and 2000 sccm, an etch selectivity of the resist mask being tunable based at least in part on the temperature, the chamber pressure, the gas flow rate, or combinations thereof

10. The method of claim 9, wherein the temperature is between -20°C and 20°C.

11. The method of claim 9, wherein a profile of the resist mask is controllable based at least in part on the temperature, the chamber pressure, the gas flow rate, or combinations thereof.

12. The method of claim 1, wherein the photopatterned organo-metal-oxide-containing EUV resist comprises an organotin oxide.

13. The method of any one of claims 1–12, wherein the photopatterned organo-metal-oxide-containing EUV resist comprises an element selected from the group consisting of: tin, hafnium, tellurium, bismuth, indium, antimony, iodine, and germanium.

14. The method of any one of claims 1–12, wherein providing the photopatterned organo-metal-oxide-containing EUV resist comprises vapor depositing a metal-containing resist film on the substrate layer.

15. The method of any one of claims 1–12, wherein providing the photopatterned organo-metal-oxide-containing EUV resist comprises spin-coating an organo-metal-oxide-containing EUV resist film on the substrate layer.

16. The method of any one of claims 1–12, wherein a thickness of the photopatterned organo-metal-oxide-containing EUV resist is between 10 nm and 50 nm.

17. The method of any one of claims 1–12, further comprising:

exposing, after dry developing the photopatterned organo-metal-oxide-containing EUV resist, the photopatterned organo-metal-oxide-containing EUV resist to an inert gas plasma.

18. The method of claim 17, further comprising:

repeating operations of dry developing the photopatterned organo-metal-oxide-containing EUV resist and exposing the photopatterned organo-metal-oxide-containing EUV resist to the inert gas plasma.

19. The method of any one of claims 1–12, further comprising:

baking, prior to dry developing the photopatterned organo-metal-oxide-containing EUV resist, the photopatterned organo-metal-oxide-containing EUV resist at a temperature between 100°C and 300°C.

20. An apparatus for conducting development of resist, the apparatus comprising:

a process chamber with a substrate support;

a vacuum line coupled to the process chamber;

a development chemistry line coupled to the process chamber; and

a controller configured with instructions for processing a semiconductor

substrate, the instructions comprising code for:

providing in the process chamber a photopatterned organo-metal-oxide-containing EUV resist comprising an unexposed organo-metal-oxide-containing portion and an EUV-exposed metal-oxide-containing portion on a substrate layer of the semiconductor substrate; and

dry developing the photopatterned organo-metal-oxide-containing EUV resist by selectively removing a portion of the photopatterned organo-metal-oxide-containing EUV resist by exposure to a dry development chemistry to form a resist mask,

wherein the dry development chemistry selectively removes the unexposed organo-metal-oxide-containing portion relative to the EUV-exposed metal-oxide-containing portion to form the resist mask, wherein the dry development chemistry comprises a hydrogen halide or hydrogen gas and halogen gas.

21. The apparatus of claim 20, wherein the dry development chemistry selectively breaks metal-oxide bonds in organo-metal-oxide networks in the unexposed organo-metal-oxide-containing portion to form one or more volatile byproducts, while leaving metal-oxide bonds intact in metal-oxide networks in the EUV-exposed metal-oxide-containing portion to form the resist mask.

22. The apparatus of claim 20, further comprising:

one or more heaters coupled to the substrate support, wherein the one or more heaters include a plurality of independently controllable temperature control zones.

23. The apparatus of claim 20, wherein an interior of the process chamber is coated with a corrosion inhibitor.

24. The apparatus of claim 20, further comprising:

a cold trap coupled to the process chamber, wherein the cold trap is configured to remove water from the process chamber.

25. The apparatus of any one of claims 20-24, wherein the process chamber comprises a plastic material.

26. The apparatus of any one of claims 20-24, further comprising:

a UV lamp or IR lamp coupled to the process chamber, wherein the UV lamp or IR lamp is configured to cure the photopatterned organo-metal-oxide-containing EUV resist or remove excess halide from the process chamber.

27. A method of processing a semiconductor substrate, the method comprising:

providing in a process chamber a dry-deposited photopatterned organo-metal oxide EUV resist comprising an unexposed organo-metal-oxide-containing portion and an EUV-exposed metal-oxide-containing portion on a substrate layer of a semiconductor substrate; and

dry developing the photopatterned organo-metal oxide EUV resist by selectively removing a portion of the photopatterned organo-metal-containing EUV resist by exposure to a dry development chemistry comprising HCl and/or HBr to form a resist mask, wherein the HCl and/or HBr selectively removes the unexposed organo-metal-oxide-containing portion relative to the EUV-exposed metal-oxide-containing portion to form the resist mask.

28. The method of claim 27, wherein the photopatterned organo-metal oxide EUV resist includes an organotin oxide.

29. A method of processing a semiconductor substrate, comprising:

providing in a process chamber a photopatterned organo-metal-oxide-containing EUV resist comprising an unexposed organo-metal-oxide-containing portion and an EUV-exposed metal-oxide-containing portion on a substrate layer of a semiconductor substrate; and

dry developing the photopatterned organo-metal-oxide-containing EUV resist by selectively removing a portion of the photopatterned organo-metal-oxide-containing EUV resist by exposure to a dry development chemistry comprising a halide to form a resist mask, wherein dry developing the photopatterned organo-metal-oxide-containing EUV resist comprises applying a remote plasma including radicals of the halide to the

photopatterned metal-containing resist.

30. A method of processing a semiconductor substrate, comprising:

providing in a process chamber a photopatterned organo-metal-oxide-containing EUV resist comprising an unexposed organo-metal-oxide-containing portion and an EUV-exposed metal-oxide-containing portion on a substrate layer of a semiconductor substrate, wherein providing the photopatterned organo-metal-oxide-containing EUV resist comprises spin-coating an organo-metal-oxide-containing EUV resist film on the substrate layer; and

dry developing the photopatterned organo-metal-oxide-containing EUV resist by selectively removing a portion of the photopatterned organo-metal-oxide-containing EUV resist by exposure to a dry development chemistry comprising a halide to form a resist mask.

31. A method of processinga semiconductor substrate, comprising:

providing in a process chamber a photopatterned organo-metal-oxide-containing EUV resist comprising an unexposed organo-metal-oxide-containing portion and an EUV-exposed metal-oxide-containing portion on a substrate layer of a semiconductor substrate;

dry developing the photopatterned organo-metal-oxide-containing EUV resist by selectively removing a portion of the photopatterned organo-metal-oxide-containing EUV resist by exposure to a dry development chemistry comprising a halide to form a resist mask; and

exposing, after dry developing the photopatterned organo-metal-oxide-containing EUV resist, the photopatterned organo-metal-oxide-containing EUV resist to an inert gas plasma.

32. The method of claim 33, further comprising:

repeating operations of dry developing the photopatterned organo-metal-oxide-containing EUV resist and exposing the photopatterned organo-metal-oxide-containing EUV resist to the inert gas plasma.

33. A method of processing a semiconductor substrate, comprising:

providing in a process chamber a photopatterned organo-metal-oxide-containing EUV resist comprising an unexposed organo-metal-oxide-containing portion and an EUV-exposed metal-oxide-containing portion on a substrate layer of a semiconductor substrate;

dry developing the photopatterned organo-metal-oxide-containing EUV resist by selectively removing a portion of the photopatterned organo-metal-oxide-containing EUV resist by exposure to a dry development chemistry comprising a halide to form a resist mask; and

removing the unexposed organo-metal-oxide-containing portion and the EUV-exposed metal-oxide-containing portion of the photopatterned organo-metal-oxide-containing EUV resist without removing the substrate layer.