CLAIMS

1. A field-effect transistor comprising:

a gate electrode;

a source electrode and a drain electrode;

an active layer, which is formed between the source electrode and the drain electrode; and

a gate insulating layer, which is formed between the gate electrode and the active layer,

wherein the active layer includes at least two kinds of oxide layers including layer A and layer B,

wherein the active layer is an ABA stacked structure of three layers that are the layer A, the layer B, and the layer A stacked in this order, one of the layers A being in contact with the gate insulating layer and other of the layers A being in contact with the source electrode and the drain electrode, and

wherein the layer B includes a substitution dopant.

2. A field-effect transistor comprising:

a gate electrode;

a source electrode and a drain electrode;

an active layer, which is formed between the source electrode and the drain electrode; and

a gate insulating layer, which is formed between the gate electrode and the active layer,

wherein the active layer includes at least two kinds of oxide layers including layer A and layer B,

wherein the layer A is an oxide layer including a Group A element, which is at least one selected from the group consisting of zinc, cadmium, gallium, indium, thallium, tin, lead, bismuth, titanium, niobium, tantalum, molybdenum, and tungsten,

wherein the layer B is free of the Group A element,

wherein the layer B includes a substitution dopant, and

wherein the active layer satisfies condition (1) below:

condition (1): the active layer includes 3 or more oxide layers including 2 or more of the layer A.

3. The field-effect transistor according to claim 1 or 2, wherein carrier concentration NA of the layer A is higher than carrier concentration NB of the layer B.

4. The field-effect transistor according to any one of claims 1 to 3, wherein activation energy ΔEA of electric conduction of the layer A is lower than activation energy ΔEB of electric conduction of the layer B.

5. The field-effect transistor according to any one of claims 1 to 4, wherein bandgap EAg of the layer A is lower than bandgap EBg of the layer B.

6. A field-effect transistor comprising:

a gate electrode;

a source electrode and a drain electrode;

an active layer, which is formed between the source electrode and the drain electrode; and

a gate insulating layer, which is formed between the gate electrode and the active layer,

wherein the active layer includes at least two kinds of oxide layers including layer A and layer B,

wherein carrier concentration NA of the layer A is higher than carrier concentration NB of the layer B, and

wherein the active layer is an ABA stacked structure of three layers that are the layer A, the layer B, and the layer A stacked in this order, one of the layers A being in contact with the gate insulating layer and other of the layers A being in contact with the source electrode and the drain electrode.7. The field-effect transistor according to claim 6, wherein in the layer A is an oxide layer including a Group A element, which is at least one selected from the group consisting of zinc, cadmium, gallium, indium, thallium, tin, lead, bismuth, titanium, niobium, tantalum, molybdenum, and tungsten, and wherein the layer B is free of the Group A element.

8. A field-effect transistor comprising:

a gate electrode;

a source electrode and a drain electrode;

an active layer, which is formed between the source electrode and the drain electrode; and

a gate insulating layer, which is formed between the gate electrode and the active layer,

wherein the active layer includes at least two kinds of oxide layers including layer A and layer B,

wherein carrier concentration NA of the layer A is higher than carrier concentration NB of the layer B, and

wherein the layer A is an oxide layer including a Group A element, which is at least one selected from the group consisting of zinc, cadmium, gallium, indium, thallium, tin, lead, bismuth, titanium, niobium, tantalum, molybdenum, and tungsten.

9. The field-effect transistor according to claim 8, wherein the active layer is an ABA stacked structure of three layers that are the layer A, the layer B, and the layer A stacked in this order, one of the layers A being in contact with the gate insulating layer and other of the layers A being in contact with the source electrode and the drain electrode.

10. The field-effect transistor according to any one of claims 6 to 9, wherein activation energy ΔEA of electric conduction of the layer A is lower than activation energy ΔEB of electric conduction of the layer B.

11. A field-effect transistor comprising:

a gate electrode;

a source electrode and a drain electrode;

an active layer, which is formed between the source electrode and the drain electrode; and

a gate insulating layer, which is formed between the gate electrode and the active layer,

wherein the active layer includes at least two kinds of oxide layers including layer A and layer B,

wherein activation energy ΔEA of electric conduction of the layer A is lower than activation energy ΔEB of electric conduction of the layer B, and

wherein the active layer is an ABA stacked structure of three layers that are the layer A, the layer B, and the layer A stacked in this order, one of

the layers A being in contact with the gate insulating layer and other of the layers A being in contact with the source electrode and the drain electrode.

12. The field-effect transistor according to claim 11, wherein the layer A is an oxide layer including a Group A element, which is at least one selected from the group consisting of zinc, cadmium, gallium, indium, thallium, tin, lead, bismuth, titanium, niobium, tantalum, molybdenum, and tungsten, wherein the layer B is free of the Group A element.

13. A field-effect transistor comprising:

a gate electrode;

a source electrode and a drain electrode;

an active layer, which is formed between the source electrode and the drain electrode; and

a gate insulating layer, which is formed between the gate electrode and the active layer,

wherein the active layer includes at least two kinds of oxide layers including layer A and layer B,

wherein activation energy ΔEA of electric conduction of the layer A is lower than activation energy ΔEB of electric conduction of the layer B,

wherein the layer A is an oxide layer including a Group A element, which is at least one selected from the group consisting of zinc, cadmium, gallium, indium, thallium, tin, lead, bismuth, titanium, niobium, tantalum, molybdenum, and tungsten,

wherein the layer B is free of the Group A element, and

wherein the active layer satisfies condition (1) below:

condition (1): the active layer includes 3 or more oxide layers including 2 or more of the layer A.

14. The field-effect transistor according to claim 13, wherein the active layer is an ABA stacked structure of three layers that are the layer A, the layer B, and the layer A stacked in this order, one of the layers A being in contact with the gate insulating layer and other of the layers A being in contact with the source electrode and the drain electrode.

15. The field-effect transistor according to any one of claims 11 to 14, wherein the carrier concentration NA of the layer A is higher than the carrier concentration NB of the layer B.

16. The field-effect transistor according to any one of claims 6 to 15, wherein bandgap EAg of the layer A is lower than bandgap EBg of the layer B.

17. The field-effect transistor according to any one of claims 6 to 16, wherein the layer B is an oxide layer including a Group B element, which is at least one selected from the group consisting of a Group 2A element, a Group 3A element, zirconium, hafnium, boron, aluminium, silicon, germanium, phosphorus, antimony, and tellurium.

18. The field-effect transistor according to any one of claims 6 to 17, wherein the layer B includes a substitution dopant.

19. The field-effect transistor according to claim 8 or 13 wherein at least one of the 2 or more of the layer A is in contact with the source electrode and the drain electrode.

20. The field-effect transistor according to claim 8 or 13 wherein at least one of the 2 or more of the layer A is in contact with the gate

insulating layer.

21 A field-effect transistor comprising:

a gate electrode;

a source electrode and a drain electrode;

an active layer, which is formed between the source electrode and the drain electrode; and

a gate insulating layer, which is formed between the gate electrode and the active layer,

wherein the active layer includes at least two kinds of oxide layers including layer A and layer B, and wherein the active layer satisfies condition (2) below:

condition (2): a band-gap of the layer A is lower than a band-gap of the layer B and an oxygen affinity of the layer A is equal to or higher than an oxygen affinity of the layer B.

22. The field-effect transistor according to claim 21, wherein the layer B includes a substitution dopant.

23. The field-effect transistor according to claim 21 or 22, wherein, the layer A includes at least one selected from the group consisting of zinc, cadmium, gallium, indium, thallium, tin, lead, bismuth, titanium, niobium, tantalum, molybdenum, and tungsten as A1 element, and wherein the layer A includes at least one selected from the group consisting of magnesium, calcium, strontium, barium, scandium, yttrium, lanthanoids, zirconium, hafnium, aluminium, silicon, and germanium as A2 element.

24. The field-effect transistor according to any one of claims 21 to 23,

the layer B includes at least one selected from the group consisting of zinc, cadmium, gallium, indium, thallium, tin, lead, bismuth, titanium, niobium, tantalum, molybdenum, and tungsten as element B1,

wherein the layer B includes at least one selected from the group consisting of aluminium, gallium, indium, thallium, germanium, tin, lead, antimony, bismuth, titanium, niobium, tantalum, molybdenum, tungsten, rhenium, and osmium as element B3, and

wherein a Group number of the B3 element in a periodic table is larger than a Group number of the B1 element in the periodic table.

25. The field-effect transistor according to any one of claims 21 and 24, the layer B includes at least one selected from the group consisting of magnesium, calcium, strontium, barium, scandium, yttrium, lanthanoids, zirconium, hafnium, aluminium, silicon, and germanium as B2 element.

26. A display element comprising:

a light control element configured to control light output according to a driving signal; and

a driving circuit containing the field-effect transistor according to any one of claims 1 to 25 and configured to drive the light control element.

27. The display device according to claim 26,

wherein the light control element includes an organic electroluminescent element, an electrochromic element, a liquid crystal element, an electrophoretic element, or an electrowetting element.

28. An image display device configured to display an image corresponding to image data, the image display device comprising:

a plurality of display elements arranged in a form of matrix, each of the plurality of display elements being the display element according to claim 26 or 27;

a plurality of wired lines configured to individually apply gate voltage and signal voltage to the field-effect transistors in the plurality of display elements; and

a display control device configured to individually control the gate voltage and the signal voltage of the field-effect transistors via the plurality of wired lines correspondingly to the image data.

29. A system comprising:

the image display device according to claim 28; and

an image-data-generating device configured to generate image data based on image information to be displayed and to output the image data to the image display device.