TRANSISTORS HAVING SELF-ALIGNED BODY TIE

CROSS-REFERENCE TO RELATED APPLICATION(S)

[0001] This application claims priority to U.S. Provisional Application No. 63/168,887 filed March 31, 2021, entitled TRANSISTORS HAVING SELF-ALIGNED BODY TIE, the disclosure of which is hereby expressly incorporated by reference herein in its respective entirety.

BACKGROUND

Field

[0002] The present disclosure relates to transistors having self-aligned body tie.

Description of the Related Art

[0003] In metal–oxide–semiconductor field-effect transistors (MOSFETs) such as silicon-on-insulator transistors, a floating-body configuration can provide lower parasitic effects than a body-connected configuration. Thus, floating-body silicon-on-insulator transistors tend to provide better performance than body-connected silicon-on-insulator transistors. However, floating-body effect can limit practical applications of floating-body silicon-on-insulator transistors.

SUMMARY

[0004] In accordance with an aspect, the present disclosure relates to a transistor includes a source and a drain each implemented in a first type active region, a gate implemented relative to the source and the drain, and a body implemented in the first type active region and substantially covered by the gate. The transistor further includes a body tie implemented in a second type active region and including a connecting portion substantially covered by the gate and engaging the body, with the body and body tie corresponding to the first and second active region are dimensioned to provide a gap therebetween on each side of the gate.

[0005] In some examples, the first type active region can include an N+ active region, and the second type active region can include a P+ active region. In some examples, the gate can have a symmetric shape about a line

along a width direction of the gate. In some examples, the gate can have an I shape that covers the body and the connecting portion of the body tie.

[0006] In some examples, the connecting portion of the body tie can be aligned with the body based on a shape of the gate. In some examples, the aligned configuration of the connecting portion of the body tie and the body can result from formation of the gap between the first and second active region on each side of the gate. In some examples, the aligned engagement between the connecting portion of the body tie and the body can be the only engagement between the body tie and the body.

[0007] In an aspect, the present disclosure relates to a method for fabricating a transistor. The method includes forming or providing a first type active region and a second type active region, implementing a source and a drain with the first type active region, forming a body tie with the second type active region, and forming a gate relative to the source and the drain. The method further includes dimensioning either or both of the first and second type active regions to provide a gap between the first and second type active regions on each side of the gate, such that a connecting portion of the body tie engaging the body implemented in the first type active region is substantially covered by the gate, wherein the dimensioning includes removing portions of the first type active region to provide the gaps on both sides of the gate with a mask protecting the gate during the removing step.

[0008] In some examples, the first type active region can include an N+ active region, and the second type active region can include a P+ active region. In some examples, the forming of the gate can include forming a symmetric shaped gate about a line along a width direction of the gate. In some examples, the gate can have an I shape that covers the body and the connecting portion of the body tie.

[0009] In some examples, the dimensioning can include removing portions of the first type active region to provide the gaps on both sides of the gate with a mask protecting the gate during the removing step. In some examples, the forming of the gaps with the mask protecting the gate can result in a body under the gate and the connecting portion of the body tie under the gate being aligned with each other based on a shape of the gate. In some examples, the aligned engagement between the connecting portion of the body tie and the body can be the only engagement between the body tie and the body.

[0010] According to an aspect, the present disclosure relates to a semiconductor die that includes a substrate and one or more transistors implemented on the substrate. Each transistor includes a source and a drain each implemented as a first type active region, and a gate implemented relative to the source and the drain such that application of a voltage to the gate results in formation of a conductive channel between the source and the drain. The transistor further includes a body configured to provide the conductive channel upon the application of the voltage to the gate. The body is implemented in the first type active region and substantially covered by the gate. The transistor further includes a body tie implemented as a second type active region and including a connecting portion substantially covered by the gate and engaging the body, wherein the body and body tie corresponding to the first and second active region are dimensioned to provide a gap therebetween on each side of the gate.

[0011] In some examples, the substrate can include a silicon-on-insulator substrate. In some examples, each transistor can be configured as a radio-frequency transistor. In some examples, each transistor can be configured as a digital cell transistor or a switching transistor.

[0012] In an aspect, the present disclosure relates to a packaged module that includes a packaging substrate and a semiconductor die mounted on the packaging substrate. The semiconductor die includes one or more transistors. Each transistor includes a source and a drain each implemented as a first type active region, and a gate implemented relative to the source and the drain such that application of a voltage to the gate results in formation of a conductive channel between the source and the drain. The transistor further includes a body configured to provide the conductive channel upon the application of the voltage to the gate. The body is implemented in the first type active region and substantially covered by the gate. The transistor further includes a body tie implemented as a second type active region and including a connecting portion substantially covered by the gate and engaging the body, wherein the boy and body tie corresponding to the first and second active region are dimensioned to provide a gap therebetween on each side of the gate.

[0013] In an aspect, the present disclosure relates to an electronic device that includes a power source and an integrated circuit implemented on a semiconductor die and powered by the power source. The

integrated circuit includes one or more transistors. Each transistor includes a source and a drain each implemented as a first type active region, and a gate implemented relative to the source and the drain such that application of a voltage to the gate results in formation of a conductive channel between the source and the drain. The transistor further includes a body configured to provide the conductive channel upon the application of the voltage to the gate. The body is implemented in the first type active region and substantially covered by the gate. The transistor further includes a body tie implemented as a second type active region and including a connecting portion substantially covered by the gate and engaging the body, wherein the body and body tie corresponding to the first and second active region are dimensioned to provide a gap therebetween on each side of the gate.

[0014] In some examples, the integrated circuit can include a switching circuit, and each of the one or more transistors can be implemented as a switching transistor. In some examples, the electronic device can be a wireless device.

[0015] In some examples, each of the one or more transistors can be implemented as digital cell.

[0016] For purposes of summarizing the disclosure, certain examples, advantages and novel features of the inventions have been described herein. It is to be understood that not necessarily all such advantages may be achieved in accordance with any particular example of the invention. Thus, the invention may be embodied or carried out in a manner that achieves or optimizes one advantage or group of advantages as taught herein without necessarily achieving other advantages as may be taught or suggested herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] Figure 1 depicts a transistor having one or more features as described herein.

[0018] Figure 2 shows that in some embodiments, the transistor of Figure 1 can be implemented in a circuit and/or a device.

[0019] Figure 3 shows an example of a silicon-on-insulator (SOI) transistor having a T-shaped gate and a conventional body tie configuration.

[0020] Figures 4A and 4B show sectional views as indicated in Figure 3.

WHAT IS CLAIMED IS:

1. A transistor comprising:

a source and a drain each implemented in a first type active region;

a gate implemented relative to the source and the drain;

a body implemented in the first type active region and substantially covered by the gate; and

a body tie implemented in a second type active region and including a connecting portion substantially covered by the gate and engaging the body, wherein the body and body tie corresponding to the first and second active region are dimensioned to provide a gap therebetween on each side of the gate.

2. The transistor of claim 1 wherein the first type active region includes an N+ active region, and the second type active region includes a P+ active region.

3. The transistor of claim 2 wherein the gate has a symmetric shape about a line along a width direction of the gate.

4. The transistor of claim 3 wherein the gate has an I shape that covers the body and the connecting portion of the body tie.

5. The transistor of claim 1 wherein the connecting portion of the body tie is aligned with the body based on a shape of the gate.

6. The transistor of claim 5 wherein the aligned configuration of the connecting portion of the body tie and the body results from formation of the gap between the first and second active region on each side of the gate.

7. The transistor of claim 6 wherein the engagement between the connecting portion of the body tie and the body is the only aligned engagement between the body tie and the body.

8. A method for fabricating a transistor, the method comprising:

forming or providing a first type active region and a second type active region;

implementing a source and a drain with the first type active region;

forming a body tie with the second type active region;

forming a gate relative to the source and the drain; and

dimensioning either or both of the first and second type active regions to provide a gap between the first and second type active regions on each side of the gate, such that a connecting portion of the body tie engaging the body implemented in the first type active region is substantially covered by the gate;

wherein the dimensioning includes removing portions of the first type active region to provide the gaps on both sides of the gate with a mask protecting the gate during the removing step.

9. The method of claim 8 wherein the first type active region includes an N+ active region, and the second type active region includes a P+ active region.

10. The method of claim 9 wherein the forming of the gate includes forming a symmetric shaped gate about a line along a width direction of the gate.

11. The method of claim 10 wherein the gate has an I shape that covers the body and the connecting portion of the body tie.

12. The method of claim 8 wherein the forming of the gaps with the mask protecting the gate results in a body under the gate and the connecting portion of the body tie under the gate being aligned with each other based on a shape of the gate.

13. The method of claim 12 wherein the engagement between the connecting portion of the body tie and the body is the only aligned engagement between the body tie and the body.

14. A semiconductor die comprising:

a substrate; and

one or more transistors implemented on the substrate, each transistor including a source and a drain each implemented as a first type active region, and a gate implemented relative to the source and the drain such that application of a voltage to the gate results in formation of a conductive channel between the source and the drain, the transistor further including a body configured to provide the conductive channel upon the application of the voltage to the gate, the body implemented in the first type active region and substantially covered by the gate, the transistor further including a body tie implemented as a second type active region and including a connecting portion substantially covered by the gate and engaging the body, wherein the body and body tie corresponding to the first and second active region are dimensioned to provide a gap therebetween on each side of the gate.

15. The semiconductor die of claim 14 wherein the substrate includes a silicon-on-insulator substrate.

16. The semiconductor die of claim 14 wherein each transistor is configured as a radio-frequency transistor.

17. The semiconductor die of claim 14 wherein each transistor is configured as a digital cell transistor or a switching transistor.

18. A packaged module comprising:

a packaging substrate; and

a semiconductor die mounted on the packaging substrate and including one or more transistors, each transistor including a source and a drain each implemented as a first type active region, and a gate implemented relative to the source and the drain such that application of a voltage to the gate results in formation of a conductive channel between the source and the drain, the transistor further including a body configured to provide the conductive channel upon the application of the voltage to the gate, the body implemented

in the first type active region and substantially covered by the gate, the transistor further including a body tie implemented as a second type active region and including a connecting portion substantially covered by the gate and engaging the body, wherein the body and body tie corresponding to the first and second active region are dimensioned to provide a gap therebetween on each side of the gate.

19. An electronic device comprising:

a power source; and

an integrated circuit implemented on a semiconductor die and powered by the power source, the integrated circuit including one or more transistors, each transistor including a source and a drain each implemented as a first type active region, and a gate implemented relative to the source and the drain such that application of a voltage to the gate results in formation of a conductive channel between the source and the drain, the transistor further including a body configured to provide the conductive channel upon the application of the voltage to the gate, the body implemented in the first type active region and substantially covered by the gate, the transistor further including a body tie implemented as a second type active region and including a connecting portion substantially covered by the gate and engaging the body, wherein the body and body tie corresponding to the first and second active region are dimensioned to provide a gap therebetween on each side of the gate.

20. The electronic device of claim 19 wherein the integrated circuit includes a switching circuit, and each of the one or more transistors is implemented as a switching transistor.

21. The electronic device of claim 20 wherein the electronic device is a wireless device.

22. The electronic device of claim 19 wherein each of the one or more transistors is implemented as digital cells.