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Semiconductor device including transistors sharing gates with structures having reduced parasitic circuit

Abstract

A semiconductor device includes a first to sixth regions, a first gate, a first metal contact and a second metal contact. The second region is disposed opposite to the first region with respect to the first gate. The first metal contact couples the first region to the second region. The fourth region is disposed opposite to the third region with respect to the first gate. The second metal contact is coupling the third region to the fourth region. The fifth region is disposed between the first gate and the second region, and is disconnected from the first metal contact and the second metal contact. The sixth region is disposed between the first gate and the first region, and is disconnected from the first metal contact and the second metal contact.

Inventors: Chang; Yi-Feng (New Taipei, TW), Peng; Po-Lin (Taoyuan, TW), Lee; Jam-Wem (Hsinchu, TW)

Applicant: TAIWAN SEMICONDUCTOR MANUFACTURING CO., LTD. (Hsinchu, TW)

Family ID: 1000008763015

Assignee: TAIWAN SEMICONDUCTOR MANUFACTURING CO., LTD. (Hsinchu, TW)

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Primary Examiner: Jahan; Bilkis

Attorney, Agent or Firm: Maschoff Brennan

Background/Summary

RELATED APPLICATION (1) This application is a continuation Application of U.S. application Ser. No. 17/570,872, filed Jan. 7, 2022, which is a continuation Application of U.S. application Ser. No. 16/525,275, filed Jul. 29, 2019, now U.S. Pat. No. 11,222,893, issued Jan. 11, 2022, which is a divisional application of the U.S. application Ser. No. 15/691,725, filed Aug. 30, 2017, now U.S. Pat. No. 10,366,992, issued Jul. 30, 2019, all of which are herein incorporated by reference.

BACKGROUND

(1) Latchup is a phenomenon of parasitic SCR paths triggered by internal or external noise in a CMOS circuit, which causes malfunction or electrical failure. Meanwhile, single event latchup caused by particle striking or electromagnetic radiation prevents the CMOS circuit from applications of aerospace, outer space, server and automobile, etc.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) Aspects of the present disclosure are best understood from the following detailed description when read with the accompanying figures. It is noted that, in accordance with the standard practice in the industry, various features are not drawn to scale. In fact, the dimensions of the various features may be arbitrarily increased or reduced for clarity of discussion.

(2) FIG. 1 is a diagram of a semiconductor device, in accordance with various embodiments.

(3) FIG. 2 is a cross-sectional view of the semiconductor device in FIG. 1, in accordance with various embodiments.

(4) FIG. 3 is an equivalent circuit of the semiconductor device in FIG. 1, in accordance with various embodiments.

(5) FIG. 4 is a flow chart of a method for fabricating the semiconductor device in FIG. 1, in accordance with various embodiments.

(6) FIG. 5 is a diagram of a semiconductor device, in accordance with various embodiments.

(7) FIG. 6 is an equivalent circuit of the semiconductor device in FIG. 5, in accordance with various embodiments.

DETAILED DESCRIPTION

(8) The following disclosure provides many different embodiments, or examples, for implementing different features of the provided subject matter. Specific examples of components and arrangements are described below to simplify the present disclosure. These are, of course, merely examples and are not intended to be limiting. For example, the formation of a first feature over or on a second feature in the description that follows may include embodiments in which the first and second features are formed in direct contact, and may also include embodiments in which additional features may be formed between the first and second features, such that the first and second features may not be in direct contact. In addition, the present disclosure may repeat reference numerals and/or letters in the various examples. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various embodiments and/or configurations discussed.

(9) Further, spatially relative terms, such as “beneath,” “below,” “lower,” “above,” “upper” and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. The spatially relative terms are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. The apparatus may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein may likewise be interpreted accordingly.

(10) Reference is now made to FIG. 1. FIG. 1 is a diagram of a semiconductor device **100**, in accordance with various embodiments. As illustrated in FIG. 1, the semiconductor device **100** includes a first active area **110** of a first type, a second active area **120** of a second type, and a plurality of gates **131~139**. The gates **131~139** are arranged above and across the first active area **110** and the second active area **120**. In various embodiments, the first type is a P-type and the second type is an N-type. However, the scope of the disclosure is not intended to be limited in the above-mentioned types, and other suitable arrangement of types of the first type and the second type are within the contemplated scope of the present disclosure.

(11) As illustrated in FIG. 1, a first region **111** of the first active area **110** and a first region **121** of the second active area **120** are disposed at a first side of a first gate **131** of the plurality of gates **131~139**. A second region **112** of the first active area **110** and a second region **122** of the second active area **120** are disposed at a second side of the first gate **131**. Explain in a different way, the first region **111** of the first active area **110** and the first region **121** of the second active area **120** are disposed at the left side of the first gate **131** of the plurality of gates **131~139**. The second region **112** of the first active area **110** and the second region **122** of the second active area **120** are disposed at the right side of the first gate **131**.

(12) In various embodiments, the first region **111** and the third region **113** of the first active area **110** are coupled to a metal contact **152**, and the first region **121** and the third region **123** of the second active area **120** are coupled to a metal contact **154**.

(13) In some embodiments, there are fourth region **114**, fifth region **115**, sixth region **116**, and seventh region **117** of the first active area **110** and fourth region **124**, fifth region **125**, sixth region **126**, and seventh region **127** of the second active area **120** in FIG. 1. The pattern is that the first regions **111**, **121**, the third regions **113**, **123**, and the fifth regions **115**, **125** are coupled to the metal contact **152** or the metal contact **154**, and the second regions **112**, **122**, the fourth regions **114**, **124** are not coupled to the metal contact **152** or the metal contact **154**. However, the scope of the disclosure is not intended to be limited in the above-mentioned configuration. As illustrated in FIG. 1, there are sixth regions **116**, **126** and seventh regions **117**, **127** that are not coupled to the metal contact **152** or the metal contact **154**, and other suitable configuration are within the contemplated scope of the present disclosure. In various embodiments, the regions that are not coupled to the metal contact **152** or the metal contact **154** are configured as fillers.

(14) In some embodiments, a region **162** and a region **164** are configured as body. The region **162** is coupled to the metal contact **152**, and the region **164** is coupled to the metal contact **154**. In various embodiments, the region **162** is the second type, and the region **164** is the first type.

(15) Reference is now made to FIG. 2. FIG. 2 is a cross-sectional view of the semiconductor device in FIG. 1, in accordance with various embodiments. It is noted that the cross-sectional view of the semiconductor device **100** in FIG. 2 is for explanation purpose for understanding the SCR circuits **142**, **144**, **146** in the semiconductor device **100**, and it is not illustrated by actual cross-sectional structure of FIG. 1, which is described in detailed as below.

(16) As illustrated in the left side of FIG. 2, it is a cross-sectional view of the semiconductor device **100** across line AA' in FIG. 1. It is noted that the direction of the line AA' in FIG. 1 is from the left side to the right side. The semiconductor device **100** further includes a substrate **170**, and a first well **180** of the second type. The first well **180** of the second type is formed on the substrate **170**. The first region **111** and the second region **112** of the first active area **110** are formed in the first

well **180**. The gate **131** is formed on the first well **180**. The first region **111** of the first active area **110** is configured as a source region of a transistor **M1**, and the second region **112** of the first active area **110** is configured as a drain region of the transistor **M1**.

(17) Reference is now made to the right side of FIG. **2**. It is a cross-sectional view of the semiconductor device **100** across line BB' in FIG. **1**. It is noted that the direction of the line BB' in FIG. **1** is from the right side to the left side, which is opposite to the direction of the line AA'. The semiconductor device **100** further includes a second well **190** of the first type. The second well **190** of the first type is formed on the substrate **170**. The first region **121** and the second region **122** of the second active area **120** are formed in the second well **190**. The gate **131** is formed on the second well **190**. The first region **121** of the second active area **120** is configured as a source region of a transistor **M2**, and the second region **122** of the second active area **120** is configured as a drain region of the transistor **M2**.

(18) In various embodiments, the first region **111** of the first active area **110**, the first well **180**, the second well **190**, and the first region **121** of the second active area **120** are configured to operate as the equivalent SCR circuit **142**. In some embodiments, the equivalent SCR circuit **142** is formed by a transistor **T1** and a transistor **T2**. The emitter of the transistor **T1** is coupled to the first region **111** of the first active area **110**, the base of the transistor **T1** is coupled to the body region **162** and the collector of the transistor **T2**, and the collector of the transistor **T1** is coupled to the base of the transistor **T2**. The emitter of the transistor **T2** is coupled to the first region **121** of the second active area **120**, and the base of the transistor **T2** is coupled to the body region **164**.

(19) For further understanding the original circuit and the parasitic circuit in the semiconductor device **100**, reference is now made to FIG. **3**. FIG. **3** is an equivalent circuit of the semiconductor device **100** in FIG. **1**, in accordance with various embodiments. As shown in FIG. **3**, there are complementary metal oxide semiconductors (CMOS) and the equivalent SCR circuit **142**. The CMOS is composed of a metal oxide semiconductor field effect transistor (MOSFET) **M1** and a MOSFET **M2**. Reference is now made to both FIG. **2** and FIG. **3**, the first region **111** of the first active area **110** is configured as a source region of the MOSFET **M1**, and the second region **112** of the first active area **110** is configured as a drain region of the MOSFET **M1**. In addition, the first region **121** of the second active area **120** is configured as a source region of the MOSFET **M1**, and the second region **122** of the second active area **120** is configured as a drain region of the MOSFET **M2**. The first region **111** of the first active area **110**, the first well **180**, the second well **190**, and the first region **121** of the second active area **120** in FIG. **2** are configured to operate as the equivalent SCR circuit **142** in FIG. **3**.

(20) As illustrated in FIG. **3**, if noises occur in the semiconductor device **100** and the base of the transistor **T1** is pulled low, the transistor **T1** is turned on and a power source **800** provides the first voltage **VDD** through the transistor **T1** to the base of the transistor **T2**. Subsequently, the transistor **T2** is turned on due to the first voltage **VDD**, and a short path is therefore formed in the semiconductor device **100**, such that a high current leakage from the power source **800** to the ground **900** occurs. However, the configuration of the semiconductor device **100** in FIG. **1** may improve the above-mentioned phenomenon. The following description explains how to improve the above-mentioned phenomenon together with a flow chart of a method **400**.

(21) Reference is now made to FIG. **4**. FIG. **4** is a flow chart of a method **400** for fabricating the semiconductor device **100** in FIG. **1**, in accordance with various embodiments. For illustration, the fabricating process of the semiconductor device **100** in FIG. **1** is described by the method **400**.

(22) With reference to the method **400** in FIG. **4** in operation **410**, the first region **111** of the first active area **110** is configured to receive a first voltage **VDD**. In some embodiments, referring to FIG. **1**, FIG. **2** and FIG. **3**, the metal contact **152** is coupled to the power source as shown in FIG. **3**, and therefore, the first region **111** of the first active area **110** is configured to receive the first voltage **VDD** provided by the power source **800** through the metal contact **152**.

(23) In operation **420**, the first region **121** of the second active area **120** is configured to receive a

second voltage VSS. In some embodiments, referring to FIG. 1, FIG. 2 and FIG. 3, the metal contact **154** is coupled to ground **900**, and therefore, the first region **121** of the second active area **120** is configured to receive the second voltage VSS introduced by the ground **800** through the metal contact **154**. In various embodiments, the first voltage VDD is a power supply voltage or a high level voltage, and the second voltage VSS is ground voltage or a low level voltage. However, the scope of the disclosure is not intended to be limited in such kinds of the voltages, and other suitable kinds of the voltages are within the contemplated scope of the present disclosure.

(24) In operation **430**, the second region **112** of the first active area **110** is disconnected from the first voltage VDD. In some embodiments, referring to FIG. 1, FIG. 2, and FIG. 3, the second region **112** of the first active area **110** is not coupled to the metal contact **152**, and therefore, the second region **112** of the first active area **110** is disconnected from the first voltage VDD provided by the power source **800**.

(25) In operation **440**, the second region **122** of the second active area **120** is disconnected from the second voltage VSS. In some embodiments, referring to FIG. 1, FIG. 2, and FIG. 3, the second region **122** of the second active area **120** is not coupled to the metal contact **154**, and therefore, the second region **122** of the second active area **120** is disconnected from the second voltage VSS introduced by the ground **900**.

(26) As illustrated in FIG. 1, a second gate **132** of the plurality of gates **131~139** is disposed adjacent to the first gate **131**, the second region **112** of the first active area **110** and the second region **122** of the second active area **120** are arranged at a first side of the second gate **132**, and a third region **113** of the first active area **110** and a third region **123** of the second active area **120** are arranged at a second side of the second gate **132**. Explain in a different way, the second region **112** of the first active area **110** and the second region **122** of the second active area **120** are arranged at the left side of the second gate **132**, and the third region **113** of the first active area **110** and the third region **123** of the second active area **120** are arranged at the right side of the second gate **132**.

(27) In some embodiments, the third region **113** of the first active area **110** is coupled to the metal contact **152**, and the third region **123** of the second active area **120** is coupled to the metal contact **154**.

(28) With reference to the method **400** in FIG. 4, in operation **450**, the third region **113** of the first active area **110** is configured to receive the first voltage VDD. In some embodiments, referring to FIG. 1, FIG. 2 and FIG. 3, the third region **113** of the first active area **110** is configured to receive the first voltage VDD provided by the power source **800** through the metal contact **152**.

(29) In operation **460**, the third region **123** of the second active area **120** is configured to receive the second voltage VSS. In some embodiments, referring to FIG. 1, FIG. 2 and FIG. 3, the third region **123** of the second active area **120** is configured to receive the second voltage VSS introduced by the ground **900** through the metal contact **154**.

(30) The above description of the method **400** includes exemplary operations, but the operations of the method **400** are not necessarily performed in the order described. The order of the operations of the method **400** disclosed in the present disclosure are able to be changed, or the operations are able to be executed simultaneously or partially simultaneously as appropriate, in accordance with the spirit and scope of some embodiments of the present disclosure. In addition, the operations may be added, replaced, changed order, and/or eliminated as appropriate, in accordance with the spirit and scope of some embodiments of the present disclosure.

(31) In some embodiments, referring to FIG. 1, the second region **112** of the first active area **110** and the second region **122** of the second active area **120** are floating. In various embodiments, the fourth region **114** of the first active area **110** and the fourth region **124** of the second active area **120** are floating. In some embodiments, referring to FIG. 1, the sixth regions **116**, **126** and the seventh regions **117**, **127** of the first active area **110** and the second active area **120** are floating.

(32) As illustrated in FIG. 1, equivalent silicon controlled rectifier (SCR) circuits **142**, **144**, and **146** are parasitic SCRs occurred in the regions that receive the first voltage VDD and the second

voltage VSS. Due to the configuration in FIG. 1, a portion of the regions receive the first voltage VDD and the second voltage VSS, and therefore, the number of the SCR circuits is reduced, and a high current leakage phenomenon generated by the SCR circuits is improved as well.

(33) Reference is now made to FIG. 5. FIG. 5 is a diagram of a semiconductor device **100A**, in accordance with various embodiments. Compared with the semiconductor device **100** in FIG. 1, a portion of the connections of the semiconductor device **100A** in FIG. 5 is different, which is described in detailed as below. As illustrated in FIG. 5, the first region **111A** of the first active area **110** is still configured to receive the first voltage VDD, the first region **121A** of the second active area **120A** is still configured to receive the second voltage VSS, the second region **112A** of the first active area **110A** is still disconnected from the first voltage VDD, and the second region **122A** of the second active area **120A** is still disconnected from the second voltage VSS. It is noted that the second region **112A** of the first active area **110A** and the second region **122A** of the second active area **120A** are coupled to each other. In various embodiments, the second region **112A** of the first active area **110A** and the second region **122A** of the second active area **120A** are coupled to each other by a metal contact **156A**.

(34) In various embodiments, when there are noises occurred in the semiconductor device **100A** in FIG. 5, the equivalent SCR circuit **142A** is triggered. Meanwhile, a first type current introduced by the first voltage VDD and a second type current introduced by the second voltage VSS tend to flow through the metal contact **156A** between the second region **112A** of the first active area **110A** and the second region **122A** of the second active area **120A** because the resistance of the metal contact **156A** is lower than the resistance of the equivalent SCR circuit **142A**. In view of the above, less current flows through the equivalent SCR circuit **142A**, and the high current leakage phenomenon happened in the equivalent SCR circuit **142A** is therefore improved.

(35) In some embodiments, as illustrated in FIG. 5, the third region **113A** of the first active area **110A** is disconnected from the first voltage VDD, and the third region **123A** of the second active area **120A** is disconnected from the second voltage VSS. Due to the configuration in FIG. 5, part of the regions receive the first voltage VDD and the second voltage VSS, and therefore, the number of the SCR circuits is reduced, and the high current leakage phenomenon generated by the SCR circuits is further improved.

(36) In various embodiments, the third region **113A** of the first active area **110A** and the third region **123A** of the second active area **120A** are coupled to each other. In some embodiments, the third region **113A** of the first active area **110A** and the third region **123A** of the second active area **120A** are coupled to each other by a metal contact **158A**. Due to such configuration, the first type current introduced by the first voltage VDD and the second type current introduced by the second voltage VSS tend to flow through the metal contact **156A** between the second region **112A** and the second region **122A**, and flows through the metal contact **158A** between the third region **113A** and the third region **123A** because the resistance of the metal contact **158A** is lower than the resistance of the equivalent SCR circuit **142A**. Therefore, less and less current flows through the equivalent SCR circuit **142A**, and the high current leakage phenomenon happened in the equivalent SCR circuit **142A** is even more improved.

(37) Furthermore, different types of the currents introduced by the first voltage VDD and the second voltage VSS are neutralized, which is explained in detailed in the following description regarding FIG. 6.

(38) Reference is now made to FIG. 6. FIG. 6 is an equivalent circuit of the semiconductor device **100A** in FIG. 5, in accordance with various embodiments. For facilitating the understanding of FIG. 6, reference is now made to FIG. 2, FIG. 5 and FIG. 6. The first region **111A** of the first active area **110A**, the first well **180**, the second well **190**, and the first region **121A** of the second active area **120A** are configured to operate as the equivalent SCR circuit **142A**. The first region **111A** of the first active area **110A** and the first region **112A** of the first active area **110A** are regard as the parasitic transistor T3 of the parasitic circuit **143A**, and the first region **121A** of the second active

area **120A** and the second region **122A** of the second active area **120A** are regard as the parasitic transistor **T4** of the parasitic circuit **143A**.

(39) As can be seen in FIG. 5 and FIG. 6, when there are noises occurred in the semiconductor device **100A** and the equivalent SCR circuit **142A** is triggered, the first type current introduced by the first voltage **VDD** originally flows through the path **P1** and the second type current introduced by the second voltage **VSS** originally flows through the path **P2**, such that a short path of the equivalent SCR circuit **142A** is formed and the high leakage current flows from the power source **800** to the ground **900**. However, owing to the connection of the parasitic transistors **T3**, **T4** established by the metal contact **156A**, most of the first type current introduced by the first voltage **VDD** tends to flow through the path **P3**, and most of the second type current introduced by the second voltage **VSS** tends to flow through the path **P4** when the equivalent SCR circuit **142A** is triggered by noises.

(40) In some embodiments, the first type current is composed of holes, and the second type current is composed of electrons. When the holes flow through the path **P3** and the electrons flow through the path **P4**, the holes and the electrons neutralized at the connection of the parasitic transistors **T3**, **T4** established by the metal contact **156A**. In view of the above, the original high leakage current generated by the equivalent SCR circuit **142A** not only tends to flow through the parasitic transistors **T3**~**T4**, but the neutralization occurs to reduce the high leakage current. Therefore, the high current leakage phenomenon happened in the equivalent SCR circuit **142A** is even more improved.

(41) In some embodiments, a semiconductor device is disclosed that includes a first region, a first gate, a second region, a first metal contact, a third region, a fourth region, a second metal contact, a fifth region and a sixth region. The second region is disposed opposite to the first region with respect to the first gate. The first metal contact couples the first region to the second region. The fourth region is disposed opposite to the third region with respect to the first gate. The second metal contact couples the third region to the fourth region. The fifth region is disposed between the first gate and the second region, and is disconnected from the first metal contact and the second metal contact. The sixth region is disposed between the first gate and the first region, and disconnected from the first metal contact and the second metal contact.

(42) Also disclosed is a semiconductor device that includes a first metal contact, a second metal contact, a first gate, a second gate and a third metal contact. The first metal contact is configured to have a first voltage level. The second metal contact is configured to have a second voltage level. The first gate is disposed between two terminals of the first metal contact, and is disposed between two terminals of the second metal contact. The second gate is disposed between the first gate and a first terminal of the two terminals of the first metal contact, and is disposed between the first gate and a first terminal of the two terminals of the second metal contact. The third metal contact is disposed between the first gate and the second gate, and is disconnected from the first metal contact and the second metal contact.

(43) Also disclosed is a semiconductor device that includes a first transistor to a fourth transistor. A first terminal of the first transistor is configured to receive a first voltage signal. A first terminal of the second transistor is configured to receive a second voltage signal, a second terminal of the second transistor is coupled to a control terminal of the first transistor, and a control terminal of the second transistor is coupled to a second terminal of the first transistor. A first terminal of the third transistor is configured to receive the first voltage signal. A first terminal of the fourth transistor is configured to receive the second voltage signal, a second terminal of the fourth transistor is coupled to a second terminal of the third transistor, and a control terminal of the fourth transistor is configured to receive the second voltage signal through a first resistor.

(44) The foregoing outlines features of several embodiments so that those skilled in the art may better understand the aspects of the present disclosure. Those skilled in the art should appreciate that they may readily use the present disclosure as a basis for designing or modifying other

processes and structures for carrying out the same purposes and/or achieving the same advantages of the embodiments introduced herein. Those skilled in the art should also realize that such equivalent constructions do not depart from the spirit and scope of the present disclosure, and that they may make various changes, substitutions, and alterations herein without departing from the spirit and scope of the present disclosure.

Claims

1. A device, comprising: a first region, a second region, a third region and a fourth region separated from each other; a first metal contact coupling the first region to the second region; a second metal contact coupling the third region to the fourth region, and isolated from the first metal contact; and a first gate disposed between the first region and the second region, and disposed between the third region and the fourth region.
2. The device of claim 1, further comprising: a second gate disposed between the first region and the first gate, and disposed between the third region and the first gate.
3. The device of claim 1, further comprising: a fifth region disposed between the second region and the first gate, and isolated from the first metal contact, wherein the first region and the fifth region are included in a first active area.
4. The device of claim 3, further comprising: a third metal contact coupled to the fifth region, wherein a part of the third metal contact is interposed between the third region and the fourth region.
5. The device of claim 4, further comprising: a sixth region disposed between the fourth region and the first gate, and electrically isolated from the second metal contact, wherein the third region and the sixth region are included in a second active area.
6. The device of claim 1, further comprising: a third metal contact and a fourth metal contact separated from each other along a direction, wherein the first gate is interposed between the third metal contact and the fourth metal contact along the direction.
7. The device of claim 6, wherein the first metal contact, the second metal contact, the third metal contact and the fourth metal contact are isolated from each other.
8. The device of claim 6, further comprising: a second gate disposed between the first region and the second region, and disposed between the third region and the fourth region, wherein the third metal contact is interposed between the first gate and the second gate.
9. A device, comprising: a first metal contact; a second metal contact separated from the first metal contact; a first gate disposed between a first terminal of the first metal contact and a second terminal of the first metal contact, and disposed between a first terminal of the second metal contact and a second terminal of the second metal contact; and a third metal contact disposed between the first gate and the first terminal of the first metal contact, disposed between the first gate and the first terminal of the second metal contact, and disconnected from each of the first metal contact and the second metal contact.
10. The device of claim 9, further comprising: a fourth metal contact disposed between the third metal contact and the first terminal of the first metal contact, disposed between the third metal contact and the first terminal of the second metal contact, and disconnected from each of the first metal contact, the second metal contact and the third metal contact.
11. The device of claim 10, further comprising: a second gate interposed between the third metal contact and the fourth metal contact.
12. The device of claim 10, further comprising: a first active area coupled to each of the first metal contact, the third metal contact and the fourth metal contact; and a second active area coupled to each of the second metal contact, the third metal contact and the fourth metal contact.
13. The device of claim 12, wherein the first gate crosses over each of the first active area and the second active area.

14. The device of claim 12, wherein a conductive type of the first active area is different from a conductive type of the second active area.

15. A device, comprising: a first transistor, wherein a first terminal of the first transistor is configured to receive a first voltage signal, and a second terminal of the first transistor is configured to receive a second voltage signal through a first resistor; a second transistor, wherein a first terminal of the second transistor is configured to receive the first voltage signal and a control terminal of the second transistor is configured to receive the first voltage signal through a second resistor; and a third transistor, wherein a first terminal of the third transistor is configured to receive the second voltage signal, a second terminal of the third transistor is coupled to a second terminal of the second transistor, and a control terminal of the third transistor is configured to receive the second voltage signal through a third resistor.

16. The device of claim 15, further comprising: a fourth transistor coupled between a control terminal of the first transistor and the first terminal of the third transistor.

17. The device of claim 16, wherein a control terminal of the fourth transistor is coupled to the second terminal of the first transistor.

18. The device of claim 16, wherein a first terminal of the fourth transistor is configured to receive the first voltage signal through a fourth resistor.

19. The device of claim 18, wherein a second terminal of the fourth transistor is configured to receive the second voltage signal.

20. The device of claim 18, wherein the control terminal of the first transistor is configured to receive the first voltage signal through the fourth resistor.
