SEMICONDUCTOR DEVICE

FIELD OF THE INVENTION

[0001] The present invention generally relates to a semiconductor device, and more particularly relates to power connections to transistors in semiconductor devices

BACKGROUND OF THE INVENTION

[0002] As the size of semiconductor devices continues to decrease, the ability to create standard cell library logic devices, such as scan-D flip-flops and multiplexers, becomes more difficult. This is particularly the case at the 20 nm node, where lithographic limitation results in a lack of scaling of standard cell library devices.

[0003] Referring to FIG. 1, typical semiconductor devices **100** include a plurality of transistors **102** formed within a diffusion region **104**. The semiconductor devices **100** utilize power rails **106**, as part of a first metal layer **107**, to deliver a reference voltage and/or ground to the transistors **102**. Specifically, the power rail **106** includes power tabs **108** that extend into the diffusion region **104**. A via **110** then electrically connects the power tab **108** to a source (not shown) or a drain (not shown) of one of the transistors **102**.

[0004] The projection of the power tabs **108** into the diffusion region **104** causes difficulties, as the metal layer **107** is also routinely utilized for local interconnection between the transistors **102** and as cell pins **112**. This leads to a very complicated patterning for the first metal layer **107**, as is shown in FIG. 2, which routinely leads to fabrication difficulties and/or compromises in standard cell design. One solution is to use a second metal layer (not shown) on a different plane from the first metal layer **107**. However, the use of the second metal layer reduces routing efficiency and results in a larger and more expensive implementation of the semiconductor device **100**.

[0005] Accordingly, it is desirable to provide a semiconductor device arrangement with less resource conflict in the metal layer. Furthermore, other desirable features and characteristics of the present invention will become apparent from the subsequent detailed description of the invention and the appended claims, taken in conjunction with the accompanying drawings and this background of the invention.

BRIEF SUMMARY OF THE INVENTION

[0006] A semiconductor device includes a semiconductor substrate having a diffusion region. A transistor is formed within the diffusion region. The transistor includes a source, a drain, and a gate. A power rail is disposed outside the diffusion region. The device further includes a contact layer disposed above the substrate and below the power rail. A via is disposed between the contact layer and the power rail to electrically connect the contact layer to the power rail. The contact layer includes a first length disposed outside the diffusion region and a second length extending from the first length into the diffusion region and electrically connected to the transistor.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The present invention will hereinafter be described in conjunction with the following drawing figures, wherein like numerals denote like elements, and

[0008] FIG. 1 is a top view of a portion of a semiconductor device according to the prior art showing power tabs extending from power rails into a diffusion region;

[0009] FIG. 2 is a top view of a metal layer of a semiconductor device according to the prior art including the power tabs and power rails;

[0010] FIG. 3 is a top view of a semiconductor device according to the present invention;

[0011] FIG. 4 is a side view of a portion of the semiconductor device according to the present invention as viewed along a line 4-4 shown in FIG. 3; and

[0012] FIG. 5 is a top view of a metal layer of a semiconductor device according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0013] The following detailed description of the invention is merely exemplary in nature and is not intended to limit the invention or the application and uses of the invention. Furthermore, there is no intention to be bound by any theory presented in the preceding background of the invention or the following detailed description of the invention.

[0014] Referring to the figures, wherein like numerals indicate like parts throughout the several views, a semiconductor device **10** is shown and described herein. The semiconductor device **10** may be part of an integrated circuit (not separately numbered) as is well recognized by those skilled in the art.

[0015] Referring to FIG. 3, the semiconductor device **10** includes a semiconductor substrate **12**. The semiconductor substrate **12** includes at least one diffusion region **14** and at least one transistor **16** formed in the at least one diffusion region **14**. In the illustrated embodiment, a first diffusion region **14a** and a second diffusion region **14b** are shown with a plurality of transistors **16** formed in each region **14a**, **14b**. However, those skilled in the art realize that additional diffusion regions **14a**, **14b** may be implemented.

[0016] In the illustrated embodiment, the transistors **16** are field-effect transistors (FETs) and more specifically, metal-oxide-semiconductor field-effect transistors (MOSFETs). Each of the transistors **16** includes a source **18**, a drain **20**, and a gate **22**. The sources **18**, drains **20**, and gates **22** are formed in and/or on the substrate **12** using techniques that are well known to those skilled in the art. In the illustrated embodiments, the gates **22** are formed primarily of polycrystalline silicon, commonly referred to as polysilicon or simply PolySi, disposed above the substrate **12**.

[0017] As can be seen with reference to FIG. 3, the gates **22** are formed as strips **24** generally parallel to one another. The strips **24** are generally linear in shape as is appreciated by those skilled in the art. Gaps (not shown) may be formed in the strips **24** such that more than one transistor **16** may be disposed along each strip **24**. Such gaps may be formed using cut mask techniques as readily appreciated by those skilled in the art.

[0018] As best realized with reference to FIG. 4, the semiconductor device **10** includes at least one metal layer **25** disposed above the substrate **12**. The at least one metal layer **25** is also disposed above the sources **18**, drains **20**, and gates **22**, of the transistors **16**. The at least one metal layer **25** is formed of copper or some other electrically conductive metal as realized by those skilled in the art. Metal layers **25** are routinely labeled and referred to as Metal1, Metal2, etc. or M1, M2, etc., as is appreciated by those skilled in the art.

[0019] The metal layer **25** of the illustrated embodiment includes at least one power rail **26**. The power rail **26** typically provides a reference voltage or ground as is appreciated by those skilled in the art. Referring again to FIG. 3, the at least one power rail **26** is disposed outside the at least one diffusion region **14**. That is, the at least one power rail **26** does not overlap the at least one diffusion region **14**. Said another way, the at least one power rail **26** does not extend into, over, or under the at least one diffusion region **14**. In the illustrated embodiment, a first power rail **26a** is disposed outside and adjacent to the first diffusion region **14a**. Similarly, a second power rail **26b** is disposed outside and adjacent to the second diffusion region **14b**.

[0020] Also in the illustrated embodiment, at least a section (not numbered) of each power rail **26a**, **26b** is generally linear in shape. That is, at least a section of each power rail **26a**, **26b** extends longitudinally, i.e., along a length. Particularly, the section of each power rail **26a**, **26b** is generally linear adjacent to the respective diffusion region **14a**, **14b**. Of course, the at least one power rail **26** may include additional curves, bends, or other non-linear sections.

[0021] The semiconductor device **10** further includes at least one contact layer **28** for providing electrical connections between the at least one power rail **26** and the at least one transistor **16**. The at least one contact layer **28** is formed of a semiconductor material, e.g., silicon. However, the at least one contact layer **28** may be formed of other semiconductor materials or other suitable materials to provide electrical conductivity as realized by those skilled in the art. The at least one contact layer **28** is disposed above the substrate **12** and below the at least one power rail **26**. Said another way, the at least one contact layer **28** is sandwiched between the substrate **12** and the at least one power rail **26**. More specifically, in the illustrated embodiments, at least a portion of the at least one contact layer **28** is disposed directly on the substrate **12**, as is shown in FIG. 4. Referring again to FIG. 3, the semiconductor device **10** of the illustrated embodiment includes a first contact layer **28a** and a second contact layer **28b**.

[0022] The at least one contact layer **28** includes at least a first length **30** and a second length **32**. The first length **30** of the at least one contact layer **28** is disposed outside the at least one diffusion region **14**. That is, the first length **30** of the at least one contact layer **28** does not overlap the at least one diffusion region **14**. In the illustrated embodiment, each contact layer **28a**, **28b** includes a first length **30a**, **30b** that runs generally congruent with the respective power rail **26a**, **26b**. That is, the first length **30a**, **30b** of each contact layer **28a**, **28b** is disposed directly below the respective power rail **26a**, **26b**. As such, the first length **30a**, **30b** of each contact layer **28a**, **28b** is also generally linear in shape. Furthermore, in the illustrated embodiment, the first length **30a**, **30b** of each contact layer **28a**, **28b** is generally perpendicular to the gates **22** of the transistors **16**.

[0023] At least one via **36** is disposed between the at least one contact layer **28** and the at least one power rail **26**. The at least one via **36** electrically connects the at least one contact layer **28** to the at least one power rail **26**. In the illustrated embodiment, a plurality of vias **36** are disposed between each power rail **26a**, **26b** and the first length **30a**, **30b** of each contact layer **28a**, **28b**. The vias **36** of the illustrated embodiment are spaced from one another to

provide balanced electrical conductivity between the contact layers **28a**, **28b** and the power rails **26a**, **26b**.

[0024] The at least one contact layer **28** includes at least one additional length **32**, **34** extending from the first length **30** into the at least one diffusion region **14**. Each additional length **32**, **34** is electrically connected to at least one of the transistors **16**. In the illustrated embodiment, each additional length **32**, **34** is electrically connected to a source **18** or a drain **20** of a transistor. However, at least one of the additional lengths **32**, **34** may be electrically connected to the gate **22** of one of the transistors **16**.

[0025] Each contact layer **28a**, **28b** of the illustrated embodiment includes a second length, **32a**, **32b** and a third length **34a**, **34b**. In the illustrated embodiment, the second and third lengths **32a**, **32b**, **34a**, **34b** of the contact layers **28a**, **28b** are also generally linear in shape. Furthermore, the second and third lengths **32a**, **32b**, **34a**, **34b** are each generally perpendicular to the respective first lengths **30a**, **30b** of the contact layers **28a**, **28b**. As such, the second and third lengths **32a**, **32b**, **34a**, **34b** are each generally parallel to the gates **22** of the transistors **16**.

[0026] By connecting the at least one transistor **16** to the at least one power rail **26** via the at least one contact layer **28**, there is no need for projections from the at least one power rail **26** into the at least one diffusion region **14**. As such, the metal layer **25** can be more simply and succinctly utilized for interconnections between the transistors **16**, as is shown in FIG. 5.

[0027] Referring again to FIGS. 3 and 4, the metal layer **25** of the semiconductor device **10** may also include a pin layer **38** positioned above the at least one transistor **16**. As realized by those skilled in the art, the pin layer **38** is a standard feature of Complementary metal–oxide–semiconductor ("CMOS") circuits. Specifically, the pin layer 38 is typically used to connected the source or drain of a p-channel transistor to a source or drain of an n-channel transistor. As such, in the illustrated embodiment, the pin layer **38** extends from the diffusion region **14** to outside of the diffusion region **14**. More specifically, the pin layer **38** of the illustrated embodiment extends between the first diffusion region **14a** and the second diffusion region **14b**.

[0028] By connecting the at least one transistor **16** to the at least one power rail **26** via the at least one contact layer **28**, the pin layer **38** can be sized larger, i.e., have a greater length, width, and/or surface area, when compared to prior art devices, as there is no projection of the metal layer **25** from the power rail **26** into the diffusion region **14**. This will improve conductivity between the pin layer **38** and other components (not shown).

[0029] While at least one exemplary embodiment has been presented in the foregoing detailed description of the invention, it should be appreciated that a vast number of variations exist. It should also be appreciated that the exemplary embodiment or exemplary embodiments are only examples, and are not intended to limit the scope, applicability, or configuration of the invention in any way. Rather, the foregoing detailed description will provide those skilled in the art with a convenient road map for implementing an exemplary embodiment of the invention, it being understood that various changes may be made in the function and arrangement of elements described in an exemplary embodiment without departing from the scope of the invention as set forth in the appended claims and their legal equivalents.

CLAIMS

1. A semiconductor device comprising:

a semiconductor substrate having a diffusion region;

a transistor formed within said diffusion region and comprising a source, a drain, and a gate;

a metal layer including

a power rail disposed outside said diffusion region and

a pin layer extending from said diffusion region to outside said diffusion region;

a contact layer disposed above said substrate and below said metal layer; and

a via disposed between said contact layer and said power rail to electrically connect said contact layer to said power rail; and wherein

said contact layer includes a first length disposed outside said diffusion region and a second length extending from said first length into said diffusion region and electrically connected to said transistor.

2. A semiconductor device as set forth in claim 1 wherein said second length of said contact layer is electrically connected to at least one of a source and a drain of said transistor.

3. A semiconductor device as set forth in claim 1 wherein said via is further defined as a plurality of vias disposed between said power rail and said first length of said contact layer and spaced from one another.

4. A semiconductor device as set forth in claim 1 wherein said transistor is further defined as a plurality of transistors formed within said diffusion region.

5. A semiconductor device as set forth in claim 4 wherein said second length of said contact layer is electrically connected to one of said transistors and wherein said contact layer further includes a third length extending from said first length into said diffusion region and electrically connected to another of said transistors.

6. A semiconductor device as set forth in claim 5 wherein said second length and said third length are generally perpendicular to said first length.

7. A semiconductor device as set forth in claim 1 wherein said second length is generally perpendicular to said first length.

8. A semiconductor device as set forth in claim 1 wherein said gate of said transistor extends linearly and said power rail extends linearly and said gate of said transistor and said power rail are generally perpendicular to one another.

9. A semiconductor device as set forth in claim 1 wherein said contact layer comprises a semiconductor material.

10. A semiconductor device comprising:

a semiconductor substrate having a first diffusion region and a second diffusion region;

at least one transistor formed within each of said diffusion regions wherein each transistor comprises a source, a drain, and a gate;

a first power rail disposed outside and adjacent to said first diffusion region;

a second power rail disposed outside and adjacent to said second diffusion region;

a first contact layer disposed above said substrate and below said first power rail;

a second contact layer disposed above said substrate and below said second power rail; and

a plurality of vias disposed between said contact layers and said power rails to respectively electrically connect said contact layers to said power rails; wherein

said first contact layer including a first length running generally congruent with said first power rail and a second length extending from said first length into said first diffusion region and electrically connected to said at least one transistor; and wherein

said second contact layer including a first length disposed outside said diffusion region and a second length extending from said first length into said second diffusion region and electrically connected to said at least one transistor.

11. A semiconductor device as set forth in claim 11 wherein said second length of said contact layer is electrically connected to at least one of a source and a drain of said at least one transistor.

12. A semiconductor device as set forth in claim 11 wherein said at least one transistor is further defined as a plurality of transistors formed within each of said diffusion regions.

13. A semiconductor device as set forth in claim 13 wherein said second length of said first contact layer is electrically connected to one of said transistors and wherein said first contact layer further includes a third length extending from said first length into said diffusion region and electrically connected to another of said transistors.

14. A semiconductor device as set forth in claim 14 wherein said second length and said third length of said first contact layer are generally perpendicular to said first length of said first contact layer.

15. A semiconductor device as set forth in claim 11 wherein said second length of said first contact layer is generally perpendicular to said first length of said first contact layer.

16. A semiconductor device as set forth in claim 11 wherein said gates of said transistors extend linearly and said power rails extend linearly and said gates of said transistors are generally perpendicular to power rails.

17. A semiconductor device as set forth in claim 10 further comprising a metal pin layer extending from said first diffusion region to said second diffusion region.

18. A semiconductor device as set forth in claim 10 wherein said second length of said contact layer is electrically connected to at least one of a source and a drain of said at least one transistor.

19. A semiconductor device as set forth in claim 11 further comprising

a metal pin layer extending from said first diffusion region to said second diffusion region; and wherein

said contact layers each comprise a semiconductor material;

said at least one transistor is further defined as a plurality of transistors formed within each of said diffusion regions;

said second length of said first contact layer is electrically connected to one of said transistors and wherein said first contact layer further includes a third length extending from said first length into said diffusion region and electrically connected to another of said transistors;

said second length and said third length of said first contact layer are generally perpendicular to said first length of said first contact layer;

said second length of said first contact layer is generally perpendicular to said first length of said first contact layer; and

said gates of said transistors extend linearly and said power rails extend linearly and said gates of said transistors are generally perpendicular to power rails.