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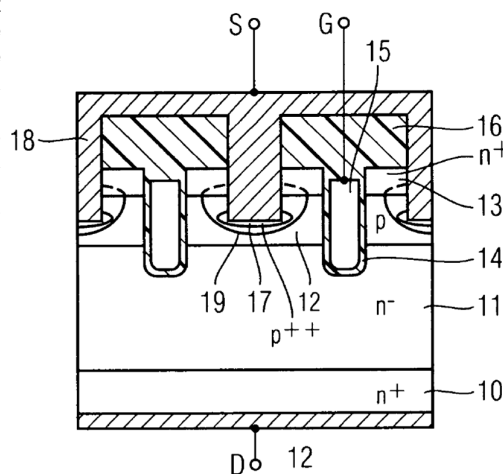
(56) Documents considered for the assessment of patentability:
DE 102 14 175 A1
US 60 31 265

The following information is taken from the documents submitted by the applicant

Request for examination in accordance with Sec. 44 Patent Act has been filed.

(54) DESCRIPTION: MOS POWER TRANSISTOR ARRANGEMENT AND METHOD OF PRODUCTION THEREOF

(57) Summary: MOS power transistor arrangement with vertical transistor structures having a zone sequence substrate (10), drift zone (11), body zone (12), source zone (13), trench gate (14, 15) and a contact zone (17) for the body zone (12). An implantation body amplification zone (19) is provided in the body zone (12) at the base of a trench, which contains the body contact zone (17). A body/source electrode (18) is provided in the trench itself.



DESCRIPTION

[0001] The present invention relates to a MOS power transistor arrangement having a vertical transistor structure in which a drift zone of a first conductivity type and a body zone of a second conductivity type opposite to the first conductivity type and a source zone of the first conductivity type are successively provided on a semiconductor substrate of the first conductivity type, and in which a trench gate extends through the source zone and the body zone into the drift zone, wherein the body zone has a contact zone at the base of a contact trench with a high doping concentration compared with the doping concentration of the body zone. Furthermore, the invention relates to a method for producing such a MOS power transistor arrangement.

[0002] An important property of MOS power transistors is avalanche strength. For this purpose, it is necessary to prevent the turn-on of a parasitic bipolar transistor formed by the vertical sequence of source zone, body zone and drift zone by a voltage drop generated by the hole current in the body zone. This can be achieved by clamping the breakdown voltage through a body contact zone located, for example, between two adjacent transistor structures. For this purpose, it is necessary to introduce this body contact zone into the space charge zone via a contact trench. If such a body contact zone is provided, the current in the body zone can flow directly into this contact zone without causing a voltage drop.

[0003] The problem here is that the depth of the contact zone must be set very precisely. A contact zone that is too shallow is not sufficient to effectively clamp the breakdown, while a contact zone that is too deep will result in too much reduction in breakdown voltage.

PRIOR ART

[0004] Specifically, a trench MOS transistor in which a body area is amplified by an implanted body amplification zone is known from WO 01/01484 A2. This is to prevent a breakdown at the oxide layer in the trench, thus improving the avalanche strength.

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[0005] Furthermore, DE 199 35 442 C1 describes a trench MOS power transistor in which a p-type layer, an n⁺ type body amplification zone, an n-type body region and an n⁺⁺ type body contact zone are provided on the edge of a gate trench, one above the other from the base of the trench.

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[0006] In the transistors known from the two documents mentioned above, the production requires an additional mask for the source implantation. In addition, further space is required for the body contact. Finally, this makes the distance between the trench wall and the body contact relatively large, and therefore the avalanche strength may be reduced.

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OBJECT

[0007] The object of the invention is to provide a MOS power transistor arrangement in which an avalanche breakdown can be clamped between the transistor structures to achieve high dielectric strength while saving space without precisely defining the depth of the body contact zone. Furthermore, a method is intended to be provided by which such a power transistor arrangement can be produced in a simple and cost-effective manner.

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[0008] This object is achieved in a MOS power transistor arrangement of the type mentioned at the outset by a body amplification zone which is introduced by implantation and subsequent annealing, and contains at least parts of the body contact zone.

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[0009] In particular, the doping concentration of the implantation body amplification zone is greater than the doping concentration of the body zone and less than the doping concentration of the body contact zone.

5 [0010] Specifically, the doping concentration of the implantation body amplification zone is selected in such a manner that no redoping of the source zone occurs upon implantation through the source zone.

[0011] The distance between the body amplification zone and the trench gate
10 is selected in such a manner that the channel insert voltage is not or only slightly affected.

[0012] In a method for producing a MOS power transistor arrangement of the type defined above, it is provided in accordance with the invention that, after
15 formation of trench gates and source zone areas, the implantation body amplification zones are implanted through the source zone areas. A contact trench is subsequently etched down to the relevant body amplification zone. The implanted body amplification zone is then implanted with the body contact zone.

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[0013] Finally, the metallization for the source and body zones is produced. The contact to the source zone is located at the side wall of the contact trench, while the contact to the body zone is located at the bottom of the trench.

25 **EXEMPLARY EMBODIMENT**

[0014] The invention is explained in more detail below with reference to an exemplary embodiment in accordance with the figures in the drawing. In the
30 figures:

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[0015] **Fig. 1A to Fig. 1E** show a known MOS power transistor arrangement and individual method steps for the production thereof; and

[0016] **Fig. 2A to Fig. 2F** show a MOS power transistor arrangement according to the invention and method steps for the production thereof.

5 [0017] **Fig. 1A to Fig. 1E** show different method steps for the production of a common MOS power transistor arrangement according to **Fig. 1E**.

10 [0018] **Fig. 1A** shows a state after production of trench gates **14, 15** and deposition of a silicon oxide layer **16**. The starting point is an n⁺ substrate **10** of silicon, an n⁻ drift zone **11**, p-body zone areas **12** as well as n⁺ source zone areas **13**. The trench gates with a gate oxide **14** and a gate electrode **15** extend through the source zone areas **13** and the body zone areas **12** into the drift zone **11**. The silicon oxide layer **16** covers the entire structure.

15 [0019] In accordance with **Fig. 1B** the silicon oxide layer **16** is structured in such a manner that parts of it remain above the trench gates **14, 15** and the intervening parts of the source zone areas **13** are exposed.

20 [0020] In accordance with **Fig. 1C** etching is then performed such that contact trenches penetrating through the source zone areas **13** to the body zone areas **12** are formed.

[0021] In accordance with **Fig. 1D** then p⁺⁺ body contact zones **17** are created at the base of the contact trenches.

25 [0022] In accordance with **Fig. 1E** then a metallization **18** of for example aluminum is applied, which contacts the contact zones **17** and the source zone areas **13**. This metallization **18** forms a source connection S. On the side of the substrate facing away from the drift zone **11**, an unspecified metallization of, for example, aluminum is applied, which forms a drain connection D. The
30 gate electrodes **15** form a gate connection G. A structure similar to the one described above is known from DE 102 34 996.7.

[0023] The trench can also be filled with a conductive stopper made of, for example, polycrystalline silicon or tungsten. The aluminum metallization is then applied to said stopper.

5 [0024] As stated at the outset, the body contact zones **17** can improve the avalanche strength of the MOS power transistor arrangement. However, the problems also indicated arise with regard to the depth of these contact zones.

[0025] To improve avalanche strength, an implantation body amplification zone
10 is provided according to the invention, which contains the aforementioned body contact zone **17**.

[0026] **Fig. 2A** to **Fig. 2F** show a MOS power transistor arrangement according to the invention with individual production steps.

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[0027] In **Fig. 2A** to **Fig. 2F** the same reference numerals are used for corresponding components as in **Fig. 1A** to **Fig. 1E**.

[0028] Other materials may be used instead of those specified. For example,
20 silicon carbide, compound semiconductor $A_{III}B_{IV}$ or another semiconductor material can be used for the substrate instead of silicon. Also, the specified conductivity types can be reversed in each case.

[0029] The starting point in the production are structures in accordance with
25 **Fig. 2A** and **Fig. 2B**, which are the same as structures in accordance with **Fig. 1A** and **Fig. 1B**, and so these structures need not be further explained here.

[0030] In accordance with **Fig. 2C**, p^+ implantation body amplification zones
30 **19** are now implanted through the source zone areas **13**. In this case, a photoresist layer (not drawn) serving to etch the silica layer **16** can serve as an additional masking layer. The body amplification zones **19** are implanted (cf. **Fig. 2E**) with the body contact zones **17** already explained on the basis of

Fig. 1D and **Fig. 1E** after insertion of the contact trench (cf. **Fig. 2D**). The contact trench is etched so deep that it is driven into the body amplification zone **19**. The body amplification zone **19** is practically not adjacent to the surface. It contains all or at least part of the body contact zone.

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[0031] For example, the doping concentration in the body amplification zone **19** is between $10E16$ and $10E18\text{ cm}^{-3}$. The doping concentration in the body amplification zone is preferably at least approximately a factor of 2 greater than the doping concentration in the body zone **12** and a factor of 2 less than the

10 doping concentration in the body contact zone **17**.

[0032] The implantation is followed by hardening to anneal the crystal lattice. The temperature and time duration of this annealing are adjusted so that no substantial diffusion out of the implanted area occurs.

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[0033] **Fig. 2F** shows a finished MOS power transistor arrangement, which in addition to the MOS power transistor arrangement according to **Fig. 1E** still has in particular the body amplification zone **19**.

20 [0034] According to the invention, the body contact zone **17** introduced by implantation is not designed to be deep enough to clamp an avalanche breakdown between the vertical transistor structures. Rather, clamping of the avalanche breakdown is achieved by implanting the body amplification zones **19** prior to etching the contact hole in accordance with **Fig. 2D**.

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[0035] The advantage of this method is that the depth of the body reinforcement zones **19** created by implantation can be controlled much better than the depth of trench etching, and thus better than the depth of the body contact zone. Due to this, a stable manufacturing process is achieved.

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[0036] In addition, the implantation of the body amplification zones **19** can be adjusted in such a manner that the lateral extensions reach the vicinity of the

channel in the area of the trench gates **14**, **15** after subsequent annealing/diffusion steps, but the insertion voltage of the transistor structures is not yet affected. This reduces drain penetration into the channel.

- 5 [0037] Another advantage over known methods without trench contacts is that source and body contacts can be generated without a mask in the contact trench. In the MOS power transistor arrangement according to the invention, holes can be extracted particularly efficiently via the body contact, which is advantageous for avalanche behavior.

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[0038] The core of the invention is thus the replacement of breakdown clamping by the only imprecisely adjustable depth of the trench according to **Fig. 2D** by breakdown clamping by means of high-energy implantation of the body amplification zones **19**.

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Claims

1. A MOS power transistor arrangement having a vertical transistor structure in which a drift zone (11) of a first conductivity type, a body zone (12) of a second conductivity type opposite to the first conductivity type, and a source zone (13) of the first conductivity type are successively provided on a semiconductor substrate (10) of the first conductivity type, and in which a trench gate (14, 15) extends through the source zone (13) and the body zone (12) into the drift zone (11), wherein the body zone (12) has a contact zone (17) at the base of a contact trench with a high doping concentration compared with the doping concentration of the body zone (12), characterized by a body amplification zone (19) which is introduced by implantation and subsequent annealing, and contains at least parts of the body contact zone (12).
2. The MOS power transistor arrangement according to claim 1, characterized in that the doping concentration of the body amplification zone (19) introduced by implantation is larger than the doping concentration of the body zone (12) and smaller than the doping concentration of the body contact zone (17).
3. The MOS power transistor arrangement according to claims 1 and 2, characterized in that the doping concentration of the body amplification zone (19) introduced by implantation is selected in such a manner that no redoping of the source zone (13) occurs during implantation through the source zone (13).
4. A method for producing a MOS power transistor arrangement according to any of claims 1 to 3, characterized in that, after forming trench gates (14, 15) and source zone areas (13), the body amplification zones (19) are implanted through the source zone areas (13).

5. The method according to claim 4, characterized in that the implantation of the body amplification zones (**19**) is adjusted in such a manner that the lateral extensions of the implantation reach the vicinity of the channel at the trench gates (**14**, **15**) after subsequent annealing/diffusion steps.

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6. The method according to claim 4 and/or 5, characterized in that the body contact zones (**17**) are implanted into the body amplification zones (**19**) and then annealed without substantial diffusion.

10 The following are 5 sheets of drawings