SEMICONDUCTOR DEVICE AND METHOD FOR MANUFACTURING SEMICONDUCTOR DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a Divisional of U.S. patent application Ser. No. 13/613,801, filed Sep. 13, 2012, which claims the benefit of U.S. Provisional Patent Application No. 61/539,232 and Japan Patent Application No. 2011-208438, filed Sep. 26, 2011, all of which are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a semiconductor device and a semiconductor device manufacturing method, and more particularly to a semiconductor device capable of fixing a potential at a surface portion of a semiconductor layer located outside an active region and a semiconductor device manufacturing method capable of manufacturing the semiconductor device.

[0004] 2. Description of the Background Art

[0005] Higher efficiency and lower loss of a power device used for conversion or control of electric energy have recently be demanded. For a MOSFET (Metal Oxide Semiconductor Field Effect Transistor) serving as a power switching device, lowering in ON resistance or the like by improving an element structure or selection of a material has been studied, and for example, a trench (groove) type element structure instead of a planar (plane) type element structure has increasingly been adopted. The trench type element structure refers to an element structure characterized by formation of a channel region along a wall surface of the trench formed in a surface of an element.

[0006] Since a MOSFET serving as a power switching device is used for conversion, control, or the like of a high voltage, it is required to achieve high efficiency and low loss as well as a high breakdown voltage. With a trench type element structure, lower loss of an element owing to lowering in ON resistance is achieved, while a breakdown voltage of an element may lower due to a defective shape of a formed trench or the like. Specifically, local electric field concentration occurs in a portion where a defective shape of a trench is present, and resulting high electric field is likely to break a gate insulating film formed on a wall surface of the trench. In order to suppress such lowering in breakdown voltage of an element due to a trench structure, for example, a MOSFET adopting such a structure that a region to serve as an active region of an element is surrounded by a trench different from the trench in the active region has been proposed (see, for example, Japanese Patent Laying-Open No. 2005-322949).

[0007] In the MOSFET proposed in PTL 1, by causing a trench surrounding an active region to function as an electric field relaxing portion, a breakdown voltage of an element can be improved. With this MOSFET, however, for example, when a high voltage of approximately 1 kV (kilovolt) is applied, it is difficult to exhibit a sufficient electric field relaxing function. Therefore, in order to obtain resistance of an element against application of such a high voltage, further improvement in element structure is demanded.

SUMMARY OF THE INVENTION

[0008] The present invention was made in view of the problems above, and an object thereof is to provide a semiconductor device capable of achieving improved breakdown voltage characteristics by fixing a potential of a semiconductor layer located outside an active region and a semiconductor device manufacturing method capable of manufacturing the semiconductor device.

[0009] A semiconductor device according to the present invention includes a semiconductor substrate having a trench formed in one main surface, a first insulating film arranged on and in contact with a wall surface of the trench, a gate electrode arranged on and in contact with the first insulating film, and a first interconnection arranged on one main surface. The semiconductor substrate includes a drift layer having a first conductivity type and a body layer having a second conductivity type, which is arranged on a side of one main surface when viewed from the drift layer. The trench is formed to penetrate the body layer and to reach the drift layer. The trench includes an outer peripheral trench arranged to surround an active region when viewed two-dimensionally. A potential fixing region where the body layer is exposed is formed in one main surface opposite to the active region when viewed from the outer peripheral trench. The first interconnection is arranged to lie over the active region when viewed two-dimensionally. The potential fixing region is electrically connected to the first interconnection.

[0010] In the semiconductor device according to the present invention, an active region and a potential fixing region located outside the active region are formed. Then, the potential fixing region is electrically connected to the first interconnection arranged to lie over the active region. Therefore, in the semiconductor device according to the present invention, a potential of a semiconductor region located outside the active region can be fixed to a potential as high as the potential of the first interconnection. Consequently, according to the semiconductor device of the present invention, a semiconductor device excellent in breakdown voltage characteristics can be provided.

[0011] In a region of the drift layer in contact with the outer peripheral trench of the semiconductor device above, an electric field relaxing region having a second conductivity type may be formed. The electric field relaxing region may be connected to the potential fixing region.

[0012] Thus, a pn junction is formed at an interface between the electric field relaxing region and the region of the drift layer other than the electric field relaxing region, and a depletion layer extending from the pn junction is formed in the drift layer. Consequently, owing to an electric field relaxing effect of the depletion layer extending from the pn junction, electric field applied to the first insulating film arranged on a wall surface of the outer peripheral trench can be relaxed. In addition, as the electric field relaxing region is connected to the potential fixing region fixed to a potential as high as a potential of the first interconnection, a potential thereof is fixed.

[0013] The semiconductor device above may further include a second insulating film arranged above the potential fixing region and a second interconnection arranged above the second insulating film. The potential fixing region may include a potential fixing region extension portion extending to a portion below the first interconnection. The gate electrode may include a gate electrode extension portion extending to a portion below the second interconnection. The potential fix-