CLAIMS

1. A method for producing a semiconductor device having a structure in which a source, a gate, and a drain are disposed so as to have a pillar shape perpendicular to a silicon substrate and a gate electrode surrounds a pillar-shaped semiconductor layer, the method comprising:

a first step including forming a planar silicon layer on the silicon substrate and forming a first pillar-shaped silicon layer and a second pillar-shaped silicon layer on the planar silicon layer;

a second step following the first step, including forming an oxide film hard mask on the first pillar-shaped silicon layer and the second pillar-shaped silicon layer, and forming a second oxide film on the planar silicon layer, the second oxide film being thicker than a gate insulating film; and

a third step following the second step, including forming the gate insulating film around each of the first pillar-shaped silicon layer and the second pillar-shaped silicon layer, forming a metal film and a polysilicon film around the gate insulating film, forming a third resist for forming a gate line such that the metal film and the polysilicon film formed around the first pillar-shaped silicon layer are

connected to the metal film and the polysilicon film formed around the second pillar-shaped silicon layer, and performing anisotropic etching on the polysilicon film and the metal film to form the gate line, the polysilicon film having a thickness that is smaller than half a distance between the first pillar-shaped silicon layer and the second pillar-shaped silicon layer.

2. The method for producing a semiconductor device according to Claim 1, comprising:

after the third step,

a fourth step including depositing a fourth resist, exposing a portion of the polysilicon film on an upper side wall of each of the first pillar-shaped silicon layer and the second pillar-shaped silicon layer, removing the exposed portion of the polysilicon film by etching, stripping the fourth resist, and removing the metal film by etching to form a first gate electrode and a second gate electrode that are connected to the gate line.

3. The method for producing a semiconductor device according to Claim 1, wherein a thick oxide film is deposited on the first pillar-shaped silicon layer, the second pillar-shaped silicon layer, and the planar silicon layer,

a thin oxide film is deposited on side walls of the first pillar-shaped silicon layer and the second pillar-shaped silicon layer; and the ~~oxide films~~ thick oxide film and the thin oxide film are removed by isotropic etching to form the oxide film hard mask on the first pillar-shaped silicon layer and the second pillar-shaped silicon layer and to form the second oxide film on the planar silicon layer, the second oxide film being thicker than the gate insulating film.

4. The method for producing a semiconductor device according to Claim 2, further comprising a fifth step including

forming a first n-type diffusion layer in an upper portion of the first pillar-shaped silicon layer,

forming a second n-type diffusion layer in a lower portion of the first pillar-shaped silicon layer and in an upper portion of the planar silicon layer,

forming a first p-type diffusion layer in an upper portion of the second pillar-shaped silicon layer, and

forming a second p-type diffusion layer in a lower portion of the second pillar-shaped silicon layer and in an upper portion of the planar silicon layer.

5. The method for producing a semiconductor device

according to Claim 4, further comprising a sixth step including forming silicides on the first n-type diffusion layer, the second n-type diffusion layer, the first p-type diffusion layer, the second p-type diffusion layer, and the gate line.

6. A semiconductor device having a structure in which a source, a gate, and a drain are disposed so as to have a pillar shape perpendicular to a silicon substrate and a gate electrode surrounds a pillar-shaped semiconductor layer, the semiconductor device comprising:

a planar silicon layer formed on a silicon substrate;

first and second pillar-shaped silicon layers formed on the planar silicon layer;

a gate insulating film formed around said first pillar-shaped silicon layer;

a first gate electrode having a laminated structure of a metal film and a polysilicon film and being formed around said gate insulating film;

a gate insulating film formed around said second pillar-shaped silicon layer;

a second gate electrode having a laminated structure of a metal film and a polysilicon film and being formed around said gate insulating film, said polysilicon film having a

thickness that is smaller than half a distance between said first pillar-shaped silicon layer and said second pillar-shaped silicon layer;

a gate line connected to said first and second gate electrodes, said gate line having an upper surface located lower than upper surfaces of said first and second gate electrodes, wherein the gate line has a metal film;

a second oxide film formed between said gate line and said planar silicon layer, the second oxide film being thicker than said gate insulating films;

a first n-type diffusion layer formed in an upper portion of said first pillar-shaped silicon layer;

a second n-type diffusion layer formed in a lower portion of said first pillar-shaped silicon layer and in an upper portion of said planar silicon layer;

a first p-type diffusion layer formed in an upper portion of said second pillar-shaped silicon layer; and

a second p-type diffusion layer formed in a lower portion of said second pillar-shaped silicon layer and in an upper portion of said planar silicon layer.

7. The semiconductor device according to Claim 6, wherein the gate line has a laminated structure of the metal film and a silicide.

8. The semiconductor device according to Claim 6, wherein a center line of the gate line is displaced from a line that connects a center point of the first pillar-shaped silicon layer to a center point of the second pillar-shaped silicon layer by a first predetermined distance.

9. The semiconductor device according to Claim 8, comprising silicides formed on the first and second n-type diffusion layers and the first and second p-type diffusion layers.