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

on~~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, and

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.

~~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.~~

2~~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 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.

3~~4~~. The method for producing a semiconductor device according to Claim 1~~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.

45. The method for producing a semiconductor device according to Claim 3 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;~~

~~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.~~