Claims:

1. A silicon single crystal substrate formed by slicing silicon single crystal grown with a Czochralski method, comprising:

a first main surface; and

a second main surface opposite to said first main surface,

resistivity in a center of said first main surface of said silicon single crystal substrate being not lower than 50 Ω•cm and a rate of change in resistivity in said first main surface being not higher than 3%,

average density of oxygen precipitates bulk micro defects in a device formation region which is a region lying between said first main surface and a plane at a depth of 50 μm from said first main surface toward said second main surface being lower than 1×10^{8} /cm^{3}, and

average density of oxygen precipitates bulk micro defects in a region lying between a plane at a depth of 300 μm and a plane at a depth of 400 μm from said first main surface toward said second main surface being not lower than 1×10^{8} /cm^{3} and not higher than 1×10^{9} /cm^{3}.

2. The silicon single crystal substrate according to claim 1, wherein

said silicon single crystal substrate has oxygen concentration not lower than 5.0×10^{17} atoms/cm^{3} and not higher than 7.0×10^{17} atoms/cm^{3} and has nitrogen concentration not lower than 2.0×10^{13} atoms/cm^{3} and not higher than 4.0×10^{14} atoms/cm^{3}.

3. A device, comprising:

the silicon single crystal substrate according to claim 1 or 2; and

a CMOS, a DMOS, and a bipolar transistor formed in said device formation region.

4. A method of manufacturing a silicon single crystal substrate, comprising the steps of:

preparing an initial silicon melt having boron concentration not higher than 4×10^{14} atoms/cm^3 and a ratio of phosphorus concentration to the boron concentration not lower than 0.42 and not higher than 0.50;

growing silicon single crystal with a Czochralski method from said initial silicon melt; and

slicing said silicon single crystal to form the silicon single crystal substrate;

in said step of growing silicon single crystal, said silicon single crystal being grown under such conditions that a ratio of a rate of cooling an edge portion of said silicon single crystal to a rate of cooling a central portion of said silicon single crystal from a melting point of silicon to 1350°C is not lower than 1/4 and not higher than 2.0 and the rate of cooling said central portion from 1200°C to 1100°C is not less than 6°C/minute, and

said silicon single crystal having oxygen concentration not lower than 5.0×10^{17} atoms/cm^3 and not higher than 7.0×10^{17} atoms/cm^3 and having nitrogen concentration not lower than 2.0×10^{13} atoms/cm^3 and not higher than 4.0×10^{14} atoms/cm^3.

5. The method according to claim 4, further comprising a step of annealing the silicon single crystal substrate, wherein

in said annealing step, a heat treatment at a temperature

not lower than 1200°C and not higher than 1250°C is carried out for a period not shorter than 1 hour and not longer than 8 hours in a noble gas atmosphere in which impurity concentration is not higher than 0.5% in volume ratio or in a non-oxidizing atmosphere.

Claims:

1. A method of manufacturing a silicon single crystal substrate, comprising the steps of:

preparing an initial silicon melt having boron concentration not higher than 4×10^{14} atoms/cm^3 and a ratio of phosphorus concentration to the boron concentration not lower than 0.42 and not higher than 0.50;

growing silicon single crystal with a Czochralski method from said initial silicon melt; and

slicing said silicon single crystal to form the silicon single crystal substrate;

in said step of growing silicon single crystal, said silicon single crystal being grown under such conditions that a ratio of a rate of cooling an edge portion of said silicon single crystal to a rate of cooling a central portion of said silicon single crystal from a melting point of silicon to 1350°C is not lower than 1.4 and not higher than 2.0 and the rate of cooling said central portion from 1200°C to 1100°C is not less than 6°C/minute, and said silicon single crystal having oxygen concentration not lower than 5.0×10^{17} atoms/cm^3 and not higher than 7.0×10^{17} atoms/cm^3 and having nitrogen concentration not lower than 2.0×10^{13} atoms/cm^3 and not higher than 4.0×10^{14} atoms/cm^3.

2. The method according to claim 1, further comprising a step of annealing the silicon single crystal substrate, wherein in said annealing step, a heat treatment at a temperature not lower than 1200°C and not higher than 1250°C is carried out for a period not shorter than 1 hour and not longer than 8 hours in a noble gas atmosphere in which impurity concentration is not higher than 0.5% in volume ratio or in a non-oxidizing atmosphere.