CLAIMS

[Claim 1]

A method for manufacturing a magnetic tunnel junction element, comprising:

a step of forming a multilayer film which has a first magnetic film and an oxidation film including at least one of Mg, Zn, and Al, of which a thickness of the first magnetic film is 2 nm or less, and of which an interface between the first magnetic film and the oxidation film is in a film surface direction;

a step of forming a mask layer that is patterned on the multilayer film; and

a step of performing plasma etching with respect to the multilayer film, by using a mixed gas of a hydrogen gas and a nitrogen gas,

wherein a ratio of a flow rate of the hydrogen gas to a flow rate of the mixed gas is 50% or less.

[Claim 2]

The method for manufacturing a magnetic tunnel junction element according to Claim 1,

wherein the first magnetic film is formed upper than the oxidation film,

the first magnetic film is plasma etched, by setting a ratio of the flow rate of the hydrogen gas to the flow rate of the mixed gas to be a first flow ratio,

the oxidation film is plasma etched, by setting a ratio of

the flow rate of the hydrogen gas to the flow rate of the mixed gas to be a second flow ratio,

a ratio of an etching rate of the first magnetic film to an etching rate of the mask layer when the ratio of the flow rate of the hydrogen gas to the flow rate of the mixed gas is set to be the first flow ratio is higher than the ratio of the etching rate of the first magnetic film to the etching rate of the mask layer when the ratio of the flow rate of the hydrogen gas to the flow rate of the mixed gas is set to be the second flow ratio, and

the second flow ratio is 50% or less.

[Claim 3]

The method for manufacturing a magnetic tunnel junction element according to Claim 2,

wherein the multilayer film includes a second magnetic film that is formed lower than the oxidation film, and

the second magnetic film is plasma etched, in accordance with the second flow ratio.

[Claim 4]

The method for manufacturing a magnetic tunnel junction element according to Claim 1,

wherein plasma etching of the multilayer film is performed by adding an additional gas to the mixed gas, and

the additional gas is a rare gas including at least one of He, Ne, Ar, Kr, and Xe, or a gas including at least one of CO,

CO_2, and O.

[Claim 5]

The method for manufacturing a magnetic tunnel junction element according to any one of Claims 1 to 4,

wherein the first magnetic film is a CoFeB film, and the oxidation film is a MgO film.

[Claim 6]

The method for manufacturing a magnetic tunnel junction element according to any one of Claims 1 to 4,

wherein the mask layer is a Ta film.

[Claim 7]

A plasma processing apparatus comprises:

a reactor in which plasma processing with respect to a substrate where a multilayer film which has a first magnetic film and an oxidation film including at least one of Mg, Zn, and Al, of which a thickness of the first magnetic film is 2 nm or less, and of which an interface between the first magnetic film and the oxidation film is in a film surface direction is formed, is performed,

an inductive antenna which generates an induced magnetic field,

a radio frequency power source which supplies a radio frequency voltage to the inductive antenna,

an end point determination device which decides an end of

the plasma processing by monitoring a plasma emission, and

a first and second mass flow controllers which supply gas to the reactor

wherein the multilayer film is plasma etched by using a mixed gas of a hydrogen gas and a nitrogen gas,

a flow rate of the hydrogen gas is controlled by the first mass flow controller based on a signal from the end point determination device,

a flow rate of the nitrogen gas is controlled by the second mass flow controller based on the signal from the end point determination device,

a ratio of a flow rate of the hydrogen gas to a flow rate of the mixed gas is changed to a second flow ratio from a first flow ratio, based on the signal from the end point determination device, and

the second flow ratio is 50% or less.

[Claim 8]

The plasma processing apparatus according to Claim 7,

wherein the first magnetic film is formed upper than the oxidation film, and

the signal is generated when the end point determination device detects the oxidation film.

[Claim 9]

The plasma processing apparatus according to Claim 7,

wherein a ratio of an etching rate of the first magnetic

film to an etching rate of the mask layer when the ratio of the flow rate of the hydrogen gas to the flow rate of the mixed gas is set to be the first flow ratio is higher than the ratio of the etching rate of the first magnetic film to the etching rate of the mask layer when the ratio of the flow rate of the hydrogen gas to the flow rate of the mixed gas is set to be the second flow ratio.