form a pattern with a good cross-sectional shape. Furthermore, a surface roughness of the absorber film is needed to be flat because not only defect detection sensitivity deteriorates when the surface roughness is large, but also oxygen is easy to diffuse to the film having a large surface roughness thereby the etching rate may be decreased.

The present invention has been made to solve the above problems, and an object of the present invention is to provide a reflective mask blank having pattern resolutionability improved by an absorbent film having excellent processability, a method of manufacturing thereof, and a reflective mask manufactured by using the reflective mask blank.

The inventors have been found that, in a reflective mask blank for EUV light, an absorber film consisting of a single layer consisting of a first layer composed of tantalum and nitrogen, or a plurality of layers consisting of, from the substrate side, a first layer composed of tantalum and nitrogen, and a second layer composed of tantalum and nitrogen, and oxygen of not more than 40 at%, particularly the absorber film including the first layer containing 55 to 70 at% of tantalum and 30 to 45 at% of nitrogen, has a reduced film stress and a high etching rate.

In one aspect, the invention provides a reflective mask blank that is a material for a reflective mask used in EUV lithography using EUV light as the exposure light, including a substrate, a multilayer reflection film that is formed on one main surface of the substrate and reflects the exposure light, and an absorber film that is formed on the multilayer reflection film and absorbs the exposure light, wherein

the absorber film is a single layer consisting of a first layer, or a plurality of layers consisting of, from the substrate side, a first layer and a second layer,

the first layer is composed of tantalum and nitrogen,

the second layer is composed of tantalum and nitrogen, and oxygen of not more than 40 at%, and

the first layer contains 55 to 70 at% of tantalum and 30 to 45 at% of nitrogen.

In one aspect, there is provided a reflective mask blank that is a material for a reflective mask used in EUV lithography using EUV light as the exposure light, comprising a substrate, a multilayer reflection film that is formed on one main surface of the substrate and reflects the exposure light, and an absorber film that is formed on the multilayer reflection film and absorbs the exposure light, wherein

the absorber film is a single layer consisting of a first layer, or a plurality of layers consisting of, from the substrate side, a first layer and a second layer,

the first layer is composed of tantalum and nitrogen,

the second layer is composed of tantalum and nitrogen, and oxygen of not more than 40 at%,

the first layer contains 55 to 70 at% of tantalum and 30 to 45 at% of nitrogen,

the absorber film consists of, in a thickness direction, a substrate-side portion, a middle portion, and a portion remote from the substrate, and

the absorber film has an amorphous or crystal structure at the middle portion, and crystallinity at each of the substrate-side portion and the portion remote from the substrate is higher than crystallinity at the middle portion.

Preferably, the absorber film has an amorphous or crystal structure at the middle portion in a thickness direction, and a crystallinity at the substrate side is higher than that at the middle portion and/or a crystallinity at the side remote from the substrate is higher than that at the middle portion.

Preferably, the absorber film has a surface roughness RMS of not more than 0.6 nm.

CLAIMS:

1. A reflective mask blank that is a material for a reflective mask used in EUV lithography using EUV light as the exposure light, comprising a substrate, a multilayer reflection film that is formed on one main surface of the substrate and reflects the exposure light, and an absorber film that is formed on the multilayer reflection film and absorbs the exposure light, wherein

the absorber film is a single layer consisting of a first layer, or a plurality of layers consisting of, from the substrate side, a first layer and a second layer,

the first layer is composed of tantalum and nitrogen,

the second layer is composed of tantalum and nitrogen, and oxygen of not more than 40 at%,

the first layer contains 55 to 70 at% of tantalum and 30 to 45 at% of nitrogen,

the absorber film consists of, in a thickness direction, a substrate-side portion, a middle portion, and a portion remote from the substrate, and

the absorber film has an amorphous or crystal structure at the middle portion, and crystallinity at each of the substrate-side portion and the portion remote from the substrate is higher than crystallinity at the middle portion.

2. The reflective mask blank of claim 1 wherein the absorber film is free of β-Ta crystal phase, α-Ta crystal phase and cubical TaN crystal phase.

3. The reflective mask blank of claim 1 or 2 comprising a protection film wherein the protection film is intervened between the multilayer reflection film and the absorber film, is contact with the multilayer reflection film, and has different etching property from the absorber film.

4. The reflective mask blank of any one of claims 1 to 3 further comprising a conductive film formed on another main surface of the substrate.

5. The reflective mask blank of any one of claims 1 to 4 wherein the absorber film is disposed contiguously on the multilayer reflection film.

6. The reflective mask blank of any one of claims 1 to 4 comprising a protection film wherein the protection film is intervened between the multilayer reflection film and the absorber film, is contact with both of the multilayer reflection film and the absorber film, and has different etching property from the absorber film.

7. A method of manufacturing a reflective mask blank of any one of claims 1 to 6, comprising a step of forming the absorber film by a reactive sputtering in which magnetron sputtering using a Ta target and a sputtering gas is applied, the sputtering gas being a rare gas, and nitrogen gas N_2 as a reactive gas.

8. A reflective mask manufactured from the reflective mask blank of any one of claims 1 to 6.