[DOCUMENT] SPECIFICATION

[TITLE OF THE INVENTION] REFLECTIVE MASK BLANK, REFLECTIVE MASK, AND METHOD ~~FOR~~OF MANUFACTURING SEMICONDUCTOR DEVICE

[Technical Field]

[0001]

The present invention relates to a reflective mask blank which is an original form for manufacturing a transfer mask used for manufacturing a semiconductor device, etc., a reflective mask and a method of manufacturing the same, and a method of manufacturing a semiconductor device.

[Background Art]

[0002]

A light source of an exposure apparatus in manufacture of semiconductor devices has evolved while gradually shortening the wavelength, and in order to realize finer pattern transfer, EUV lithography using extreme ultraviolet rays (EUV: Extreme Ultra Violet; extreme ultraviolet ray is hereinafter referred to as EUV light) having a wavelength around 13.5nm is being developed. In EUV lithography, a reflective mask is used since there are not many materials that are transparent to EUV light.

[0003]

Techniques related to a reflective mask for the EUV lithography and a mask blank for manufacturing the same are disclosed in Patent Documents 1 and 2.

[Prior Art Publications]

[Patent Documents]

[0004]

[Patent Document 1]

Japanese Patent Application Publication 2004-039884

[Patent Document 2] International Publication WO 2019/009211

[Summary of the Invention]

problems. As a result, it was found that these problems occurred due to the difference in an oxygen deficiency rate of an SnTaNbO-based material forming an absorber film. ~~An oxygen deficiency rate herein refers to a ratio obtained by dividing an actual oxygen content [atom%] of an SnTaNbO-based material by a theoretical oxygen content [atom%] assuming that the SnTaNbO-based material is in a stoichiometrically stable oxidation state (i.e., Sn, Nb, and Ta in the material are all present in SnO_2, Nb_2O_5, and Ta_2O_5; also referred to as complete oxidation state).~~ The oxygen deficiency rate is calculated by [OI-OR]/OI, where OR is an oxygen content of an absorber film (thin film for pattern formation) of an SnTaNbO-based material, and OI is an ideal oxygen content where all Sn, Ta, and Nb are in a stoichiometrically stable oxide state (i.e., Sn, Nb, and Ta in the material are all present in SnO_2, Nb_2O_5, and Ta_2O_5; also referred to as complete oxidation state).

[0034]

An absorber film of an SnTaNbO-based material tends to have a slower etching rate of dry etching by chlorine-based gas than an absorber film of an SnO-based material. An absorber film of an SnTaNbO-based material tends to have less extinction coefficient k to EUV light than an absorber film of an SnO-based material. As an oxygen deficiency ratio of an absorber film of an SnTaNbO-based material becomes smaller, its etching rate approaches an etching rate of an absorber film of an SnO-based material. Further, as an oxygen deficiency ratio of an absorber film of an SnTaNbO-based material decreases, an extinction coefficient k to EUV light approaches the numerical value of an extinction coefficient k to EUV light of an SnO-based material. However, it was newly found that when an oxygen deficiency ratio of an absorber film of an SnTaNbO-based material is less than 0.15, chemical resistance greatly decreases and the significance of containing Ta and Nb is lost.

[0035]