such as MoSi, irradiation with the ArF excimer laser as the exposure light source causes a phenomenon that the transmittance or the phase difference varies and, further, a line width changes (thickens).

Patent Document 2, Patent Document 3, and so on disclose SiNx as a material for forming the phase shift film.

Prior Art Document(s)

Patent Document(s)

[0006]

Patent Document 1: JP 2010-217514 A

Patent Document 2: JP H8-220731 A

Patent Document 3: JP 2014-137388 A

Summary of the Invention

Problem to be Solved by the Invention

[0007]

Patent Document 3 mentioned above describes that a MoSi-based film has low ArF lightfastness because transition metal (Mo) in the film is photoexcited and destabilized due to irradiation with an ArF excimer laser. In Patent Document 3, SiNx which is a material containing no transition metal is used as a material for forming a phase shift film.

[0008]

Thus, by using a SiNx-based material containing no transition metal as the material of the phase shift film, it is certainly possible to improve the ArF lightfastness. In the meanwhile, a life duration of a mask has heretofore been determined by the number of times of mask cleaning for the purpose of eliminating haze occurring in the transfer mask. However, because of a decrease in number of times of mask cleaning as a result of recent

For the phase shift film 2 after the heat treatment and the cooling mentioned above, a transmittance and a phase difference with respect to ArF excimer laser light (wavelength: 193 nm) were measured by a phase shift amount measurement apparatus (MPM-193 manufactured by Lasertec Corporation). As a result, the transmittance was 16.9 % and the phase difference was 176.1 degrees.

[0110]

Next, for the phase shift film 2 after the heat treatment and the cooling mentioned above, analysis of in-depth distribution of a secondary ion intensity of silicon was carried out by secondary ion mass spectrometry in the manner similar to Example 1. The measurement conditions are similar to those in Example 1. Measurement of the secondary ion intensity of silicon for the phase shift film 2 in Comparative Example was carried out at measurement intervals of 0.54 nm on average in a depth direction. In the phase shift film 2 of Comparative Example, the in-depth distribution of the secondary ion intensity of silicon obtained as a result of the analysis has a tendency that the secondary ion intensity reaches a peak in a region (surface region) from the surface of the phase shift film 2 to a depth of 10nm, thereafter falls down once, and gradually increases therefrom towards the transparent substrate in a subsequent internal region. Furthermore, the secondary ion intensity considerably decreases in a region (substrate neighborhood region) extending over a range of 10 nm from the interface with the transparent substrate towards the surface region. This tendency is substantially same as those in Example 1 and Example 2 mentioned above. However, a degree (slope) of increase of the secondary ion intensity in the internal region towards the transparent substrate is slightly greater in Comparative Example than in Example 1 and Example 2.

[0111]

From the result of the in-depth distribution of the secondary ion intensity