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Suppression of F⁻ ion incidence to growing film surface by using a double-grid retarding electrode in sputter deposition of MgF₂ thin films

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MgF₂ thin films deposited by magnetron sputtering show optical absorption in the visible range because of the formation of F defects by the incidence of energetic F⁻ ions to substrate. In this study, effectiveness of a double-grid electrode equipped in the front of the substrate on suppression of F⁻ ions incidence to substrate has been examined in MgF₂ sputter-deposition. The apparatus used in the experiments was a batch-type system with the cathode of a sintered MgF₂ plate (76.2 mm dia.). The distance between the target and the substrate was 55 mm. A double-grid electrode (a square of 120 mm × 120 mm) was equipped between the target and substrate. The grid adjacent to the target was grounded and the other was driven. The distance from the grounded grid to the target was 35 mm. The retarding voltage was changed from 0 to 200 V. The pressure of discharge gas of Ar was kept at 0.8 Pa. The cathode power was 100 W. Borosilicate glass plates (80 × 80 × 0.9 mm³) were used as substrate. Thickness of thin films was measured by using a stylus profiler. Optical transmittance and reflectance were measured by a double-beam spectrophotometer. The change in the retarding voltage affected both the film deposition process and properties. By applying a retarding voltage of 50 V, the extinction coefficient of thin films was reduced to <0.001 in the visible range. Film deposition rate was increased by 2 to 3 times by applying a retarding voltage of 100 -150 V. In addition, the change in the film thickness uniformity distribution showed that etching in the area opposite to the cathode erosion was suppressed by applying retarding voltages > 50 V. A self-bias generated on the cathode with an rf power of 100 W was measured to be 58 V. The retarding voltage needed to increase deposition rate and to reduce optical absorption was well correlated to the self-bias of the cathode. The effectiveness of the use of the retarding electrode has been well proved.

KeywordsMgF₂

Negative F ions

Magnetron sputtering

retarding electrode