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Effects on Film Properties Caused by He addition to Ar/C_2H_2 PECVD

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1. Introduction

In recent years, semiconductor memory has achieved higher performance, supported by miniaturization and the development of higher aspect ratio structures. The complex structuring leads to the thinning of photomasks. As a result, the decrease in the etching resistance becomes a key issue. As a solution of this, hardmasks is being used with photomasks [1].

Hydronated amorphous carbon (a-C:H) film is often used as hardmask. a-C:H films have various good properties such as high hardness and chemical inertness [2]. However, a-C:H films have high compressive stress and tend to peel off substrates. Therefore, low-stress a-C:H films are required [3].

Previous studies demonstrated that the properties of a-C:H films change by the mixing rare gases such as Argon, Neon, Helium in magnetron sputtering [4]. In addition of that, little is known about effects of rare gas mixing on the qualities of PECVD a-C:H films. In this study, we investigated effect of Helium addition on properties of a-C:H films deposited by C_2H_2 /Ar/He PECVD.

2. Experimental

Experiments were performed using a capacity coupled plasma (CCP) reactor [5]. To generate plasma, we supplied an RF voltage at 13.56 MHz the self-bias voltage was -220 V. We set the total flow rate 6 sccm with 1 sccm of C_2H_2 and 5 sccm of Ar+He fixed. The He mixing ratio (He/He+Ar) was varied from 0% to 80%. The pressure was 5, 10, 40 mTorr. Optical emission spectroscopy was used as a plasma diagnostic. The film properties were evaluated by stress (Veeco, Dektak 8) Ellipsometry (HORIBA, AutoSE), X-ray reflectometry (RIGAKU, SmartLab) and Raman spectroscopy(Jasco, RS-3100).

3. Results

Figure 1 shows effects of He mixing ratio on the film stress. With increasing the He mix ratio, the film stress decreases from 5.0 GPa to 3.2 GPa at 5 mTorr, from 6.5GPa to 4.4 GPa at 10 mTorr and from 4.2 GPa to 1.2 GPa at 40mTorr. Figure 2 shows effects of He mixing ratio on the mass density. The mass density remains constant (~2.1 g/cm^3) at 5, 10 mTorr. The mass density decreases from 2.1 g/cm^3 to 1.2 g/cm^3 with increasing the He mixing ratio at 40mTorr. Further details, including results from Raman spectroscopy and OES analysis, and discussion will be presented at the conference.

References

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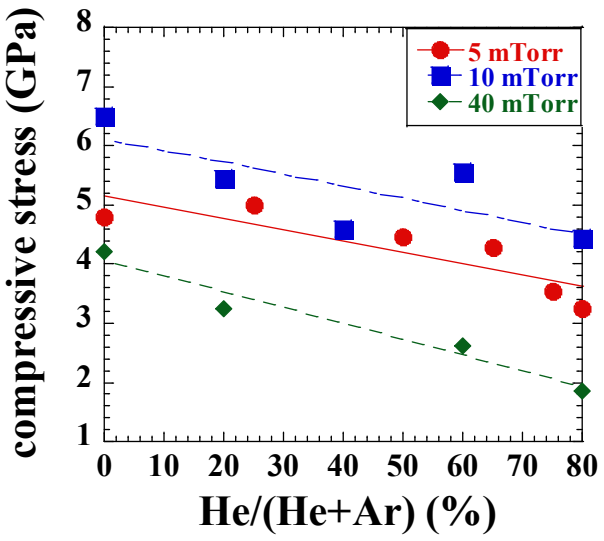

Fig. 1. He mixing ratio dependence of film stress.

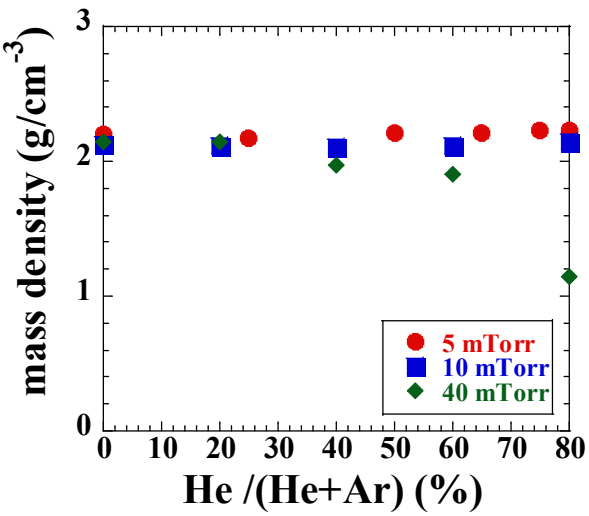

Fig. 2. He mixing ratio dependence of mass density.