29p-B9-5

# Analysis of Plasma Potential in Photoemission-Assisted Plasma Used for Dry Planarization Process

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In the previous study, we have reported that the photoemission-assisted plasma (PA-plasma) [1] which is one of the DC discharge plasmas combined with UV (λ = 172 nm) irradiation can decrease the roughness of metal surfaces [2, 3]. In the process, $Ar^+$ ion collision with the metal surface plays an important role. For more precision controlling of the surface planarization process using PA-plasma, the kinetic energy of ions must be measured and controlled. In this study, we manufactured a Langmuir probe system to measure the plasma potential of PA-plasma. Using obtained potential value from this study, the kinetic energy of ions that collide to the substrate surface can be obtained.

Figure 1(a) shows the PA-plasma apparatus with the Langmuir-probe system. The probe is made by a W wire with ϕ0.8 of diameter. The W wire is inserted into an $Al_2O_3$ tube for isolation. 15 mm length of W wire is exposed from the tube. The probe position can be changed from near the substrate to electrode side. The gap space between the substrate and electrode is 29 mm. The bias voltage ($V_S$) dependences of discharge current ($I_S$) on a 2-inch Si substrate in vacuum condition, under glow discharge and Townsend discharge conditions are shown in Fig. 1 (b). Probe position dependence of plasma potential in vacuum condition ($V_S$ = 100 V), glow ($V_S$ = 150 V) and Townsend ($V_S$ = 60 V) discharge plasma were shown in Fig. 1 (c) that are referred as plasma potential gradient.

In the vacuum condition, there are no ions and the plasma potential gradient is similar to the electric potential gradient, but it shift away from the electric potential gradient, it is considered that because of the UV irradiation. However, under Ar discharge plasma as glow discharge, the plasma potential is independent to probe position, and the potential drop is almost 90% of the bias voltage. It is considered that there is ion sheath above the substrate surface with width smaller than 1mm, when the $Ar^+$ ion collides to the substrate surface ion kinetic energy will be lost in elastic scattering through the ion sheath. On the other hand, under Townsend discharge, it is considered that there is no significant ion sheath and the plasma potential gradient is similar with that of in vacuum condition. According to the plasma potential gradient, the kinetic energy of ions can be calculated. In the presentation, the relation between ion energy and surface planarization process will be discussed.

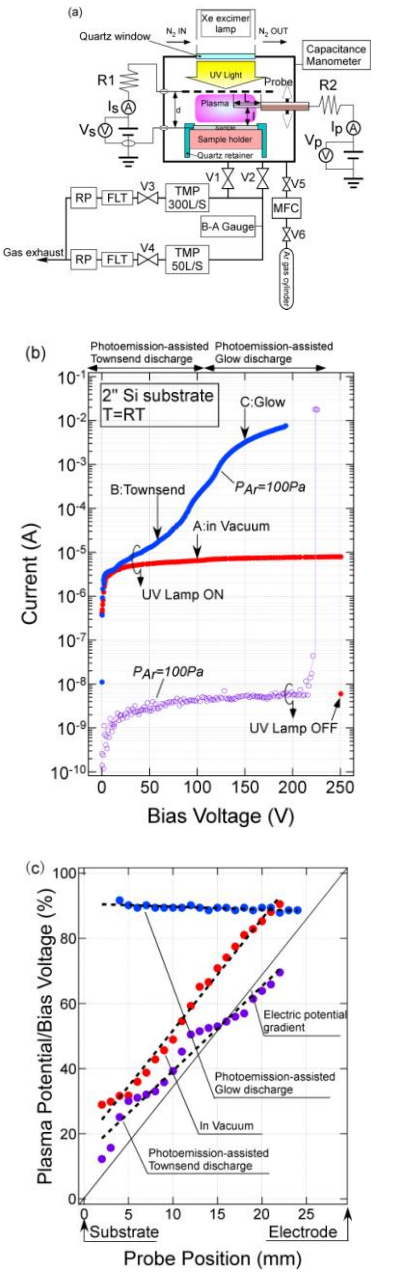


**Fig. 1** (a) Schematic of photoemission-assisted plasma with a Langmuir-probe system. (b) $I_S$ dependence of $V_S$ on a 2-inch size Si substrate. (c) The probe position dependence of plasma potential under each discharge conditions.

**Reference**

[1] Y. Takakuwa, Japan Patent No. 3932181 (2007).

[2] Y. Ohtomo *et al.,* Surf. Interface Anal. **44** (2012) 670.

[3] Y. Ohtomo *et al*., J. Vac. Soc. Jpn. **54** (2011) 224.