APPLICATION NOTE [SE22]

Impedans PLASMA MEASUREMENT

Using Impedans Semion RFEA System to measure the effect of gas pressure on Ion Energy in a very-high frequency (VHF) magnetron sputtering discharge.

INTRODUCTION:

To understand the mechanism of film growth, the ion energy at the substrate surface is of great interest. This resulted in many investigations focusing on the ion energy at the substrate side, but these works generally only report the common 13.56 MHz RF magnetron sputtering discharge. For high-frequency magnetron sputtering, however, the effect of the working pressure on the ion energy at the substrate is lacking. In addition to this, the effect of excitation frequency, especially at different working pressures, has seldom been reported. Therefore, in this work, the ion energy at the substrate side of Ag target magnetron sputtering system driven by 13.56 MHz, 27.12 MHz and 60 MHz in the pressure range of 1.0–10.0 Pa was investigated. The ion velocity distribution function (IVDF) was measured using Impedans Semion retarding field energy analyser (RFEA), which was placed at the substrate holder.

EXPERIMENTAL SETUP:

The schematic of the home-made magnetron sputtering system is shown in Figure 1. The Ag target was biased with 13.56 MHz, 27.12 MHz and 60 MHz power through the corresponding matching box. Argon was used as the discharge gas and the working pressure was chosen as 1.0–10.0 Pa with a flow rate of 2.5–17.0 sccm. Semion HV-2500 was used to measure IVDF.

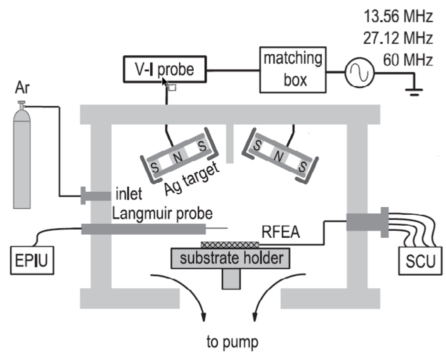

Figure 1. Schematic of the magnetron sputtering discharge setup.

RESULTS:

Figure 2 shows the IVDFs at pressures ranging from 1.0–10.0 Pa for 13.56 MHz, 27.12 MHz and 60 MHz driven magnetron sputtering discharge at a discharge voltage (sputtering power) of Vrms=116±8 V (P=205 ±4W), Vrms=62 ±1 V (P=216 ±4W) and Vrms=134 ±5 V (P=78 ±2W), respectively. At the pressure of 1.0 Pa, the higher ion energy is found in a single peak at around 49.5 eV, 52.5 eV and 51.2 eV, respectively.

The variation of the maximum ion energy E (designated as the ion energy at maximum peak) with the pressure is shown in Figure 3. Figure 4 shows the variation of IVDFs with discharge voltage (or sputtering power) at the pressure of 1.0 Pa for the 13.56 MHz, 27.12 MHz and 60 MHz magnetron sputtering cases. The evolution trends for the three frequencies has completely different behaviours.

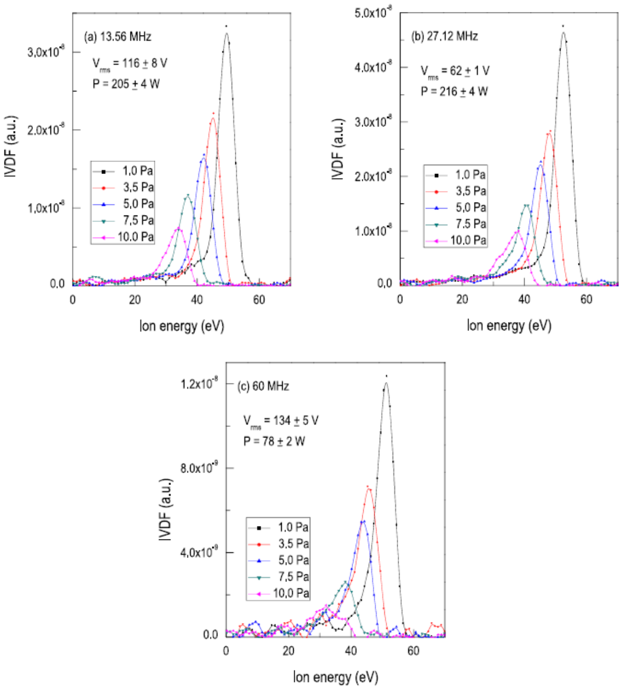

Figure 2. Variation of IVDFs with pressure for the (a) 13.56 MHz, (b) 27.12 MHz and (c) 60 MHz driven magnetron sputtering discharge at discharge voltages of Vrms=116±8V, Vrms=62±1V and Vrms=134±5V, respectively.

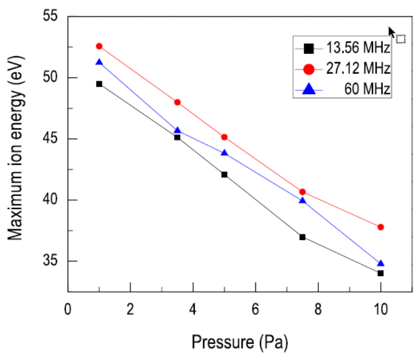

Figure 3. Variation of maximum ion energy with pressure for the 13.56 MHz, 27.12 MHz and 60 MHz driven magnetron sputtering discharge at discharge voltages of Vrms=116 ± 8V, Vrms=62 ± 1 V and Vrms=134 ±5V.

For increasing discharge voltages, the ion energy at 13.56 MHz monotonously decreases, while at 60 MHz it monotonously increases. At 27.12 MHz the ion energy initially decreases before starting to increase as the discharge voltage increases.

Figure 5 shows the variation of IVDFs with discharge voltage (or sputtering power) at the pressure of 10.0 Pa for the 13.56 MHz, 27.12 MHz and 60 MHz magnetron sputtering. The evolution trends are different from those at 1.0 Pa. At the higher pressure, as the discharge voltage is increased, the ion energy increases for all frequencies.

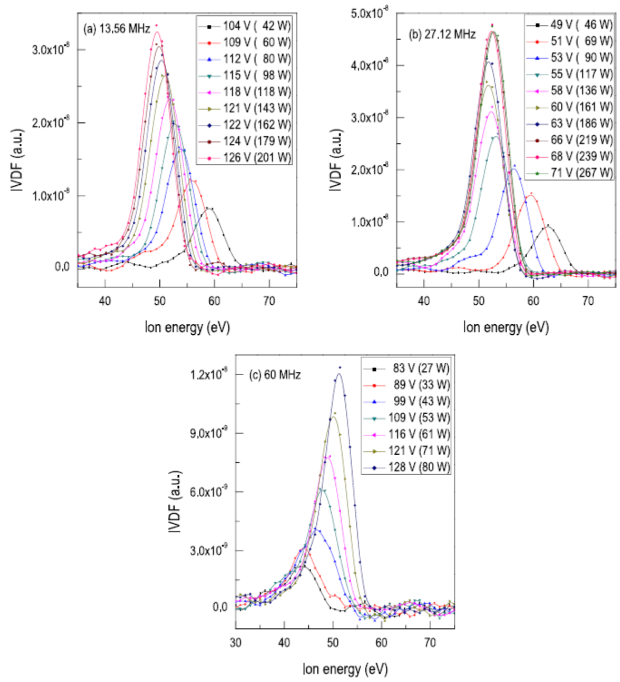

Figure 4. Variation of IVDFs with discharge voltage (or sputtering power) at the pressure of 1.0 Pa for the (a) 13.56 MHz, (b) 27.12 MHz, and (c) 60 MHz driven magnetron sputtering discharge.

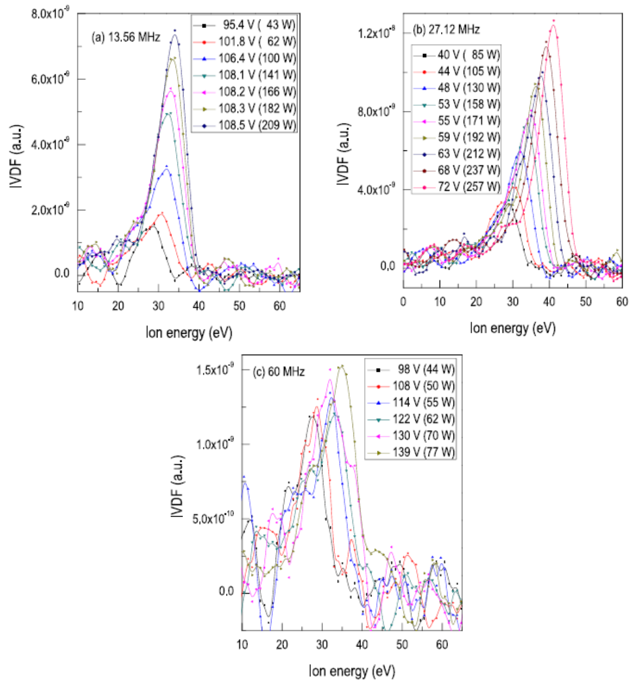

Figure 5. Variation of IVDFs with discharge voltage (or sputtering power) at the pressure of 10.0 Pa for the (a) 13.56 MHz, (b) 27.12 MHz, and (c) 60 MHz.

CONCLUSION:

In this work, the effect of working pressure on the ion energy distribution at the substrate side of Ag target RF and very-high frequency (VHF) magnetron sputtering discharge was investigated.

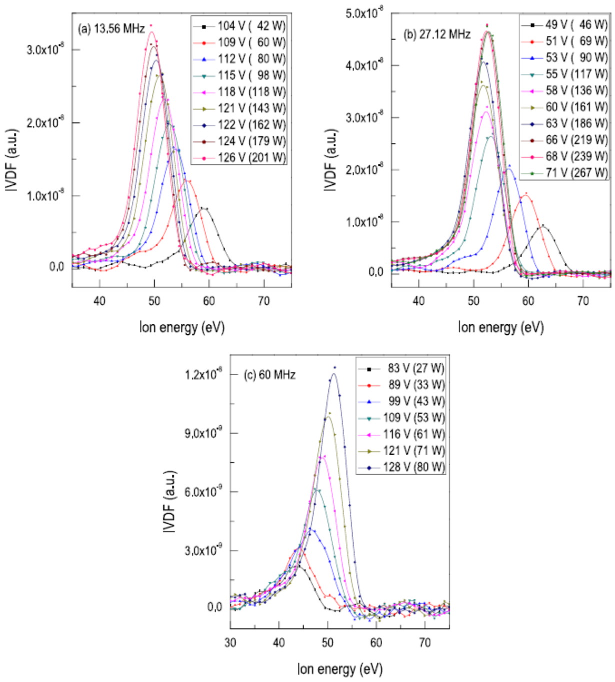

Figure 6. Variation of maximum ion energy with discharge voltage at different pressures for the (a) 13.56 MHz, (b) 27.12 MHz and (c) 60 MHz driven magnetron sputtering discharge.

CONCLUSION:

In this work, the effect of working pressure on the ion energy distribution at the substrate side of Ag target RF and very-high frequency (VHF) magnetron sputtering discharge was investigated. At lower pressure, the evolution of maximum ion energy (E) with discharge voltage (V) varied with the excitation frequency, and exhibited a decreasing trend for the 13.56 MHz driven magnetron sputtering discharge, an initially decreasing and then increasing trend for the 27.12 MHz driven magnetron sputtering discharge, and an increasing trend for the 60 MHz driven magnetron sputtering discharge, while for higher pressures all frequencies showed increasing energies as the discharge voltage was increased.

REFERENCE:

* Weichen NI et al., "Effect of gas pressure on ion energy at substrate side of Ag target radio-frequency and very-high-frequency magnetron sputtering discharge" Plasma Sci. Technol. 24 025506 (2022).

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