Voltage balancing of external antenna for inductively coupled plasma for mixture of Oxygen, Nitrogen, Hydrogen, Ammonia, and Forming Gas

Jong Woo Park [1], Sang Moon Yoo [1], Hyo Jeong Seo [1], Aram Kim [1], and Sung Jin Yoon [1]

[1]*TD Center, PSK Inc., Korea, Republic of*

In modern semiconductor industry, Inductively Coupled Plasma (ICP) is widely used in Photo-Resist (PR) strip process, attributed to its high-density and uniform plasma at low pressure. [1] Particularly, mixture of Oxygen/Nitrogen gas is common, since many PR consists of hydrocarbon backbone. However, as semiconductor process becomes sophisticated, issues such as wafer oxidation demands alternative gas chemistries. [2] Moreover, high voltage formed at the antenna causes severe damages on the dielectric wall by sputtering effect, thus causing dielectric wall erosion and generates particles. [3] To overcome such matters, wide variety of gas chemistry other than Oxygen/Nitrogen was studied along with various end capacitors to reduce dielectric wall damage. [4] In this research, electric property, especially the high voltage formed at each end of the ICP source antenna, was examined according to different gas chemistry. Discharge chamber consisted of three-turn solenoidal type antenna operated with 13.56 MHz RF generator and pi-type matching network. Antenna surrounded tubular dielectric wall with inner-diameter of 200 mm. Capacitor was installed at the end of the antenna to balance the high voltage formed, which ranged from 20 pF to 120 pF. Mixture of Oxygen, Nitrogen, Hydrogen, Forming Gas (4%-H2/96%-N2), and Ammonia was delivered to the discharge chamber, while chamber pressure varied from 0.2 to 2 Torr. High-voltage formed at either end of the antenna varied according to gas chemistry. It is expected that different plasma density for each gas affected total impedance of the discharge chamber in operation. Ratio of high voltage formed at the terminal and start of antenna increased for all gas chemistries as capacitance of end capacitor increased. We report optimized end-capacitance for diverse process conditions commonly used for PR strip process.

1. V.A. Godyak, “Electrical and plasma parameters of ICP with hiogh coupling efficiency”, Plasma Source Sci. Technol. 20, 2011.

2. S. Yang, et al. “Hydrogen Plasma Characteristics for Photoresist Stripping Process in an Cylindrical Inductively Coupled Plasma”, Journal of Semiconductor Technology and Science, 13.4(2013): 387

3. Sugai, Hideo, Kenji Nakamura, and Keiji Suzuki. \"Electrostatic Coupling of antenna and the shielding effect in inductive RF plasmas.\" Japanese journal of applied physics 33.4S (1994): 2189

4. Suzuki, K., et al. \"Effects of capacitance termination of the internal antenna in inductively coupled plasma.\" Plasma Sources Science and Technology 9.2 (2000): 199.