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The Anode/Cathode Electrode Switching Function of

Samco's PECVD System
PD-200STL

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Introduction

Since its inception as a manufacturer of plasma-enhanced chemical vapor deposition (PECVD) equipment, Samco has been providing enabling PECVD process and hardware technologies to the market. In addition to the commonly used silane gas chemistry, Samco has developed liquid source CVD™ technology that utilizes liquid precursors that are safe and easy to use for the deposition of silicon nitride and silicon oxide thin films. Furthermore, Samco has developed a unique cathode-coupled PECVD system configuration whereby a radio frequency (RF) is applied to the lower/substrate electrode and ionic species are involved in depositing a high-density and conformal film at a rapid rate. The cathode-coupled PECVD has been widely adopted by manufacturers of optical waveguide and RF filter devices. This report introduces the new cathode-coupled PECVD system, model PD-200STL that allows for switching of the RF driven electrode to be either the upper electrode (anode-coupled) or the lower/substrate electrode (cathode-coupled).

Specifications

The PD-200STL (Figure 1) is equipped with one matching unit that is connected to the upper electrode and another one connected to the lower/substrate electrode that facilitates the switching of the RF power connection to either electrode turning it to be either hot or ground (Figure 2). This enables the selection of either an anode or cathode coupled processing mode to meet different film property requirements. Switching of the RF driven electrode can be conveniently programmed in the process recipe using the system touch display without necessitating any manual hardware changes.

The PD-200STL is equipped with a ø220 mm carrier tray that supports wafer sizes ranging from small pieces to 8". The substrate heater temperature can be controlled from ambient temperature to 400°C. Samco has consolidated its expertise in the anode and cathode coupled PECVD processes, which enables the PD-200STL to deposit films with tunable properties.

Figure 1 PD-200STL system appearance

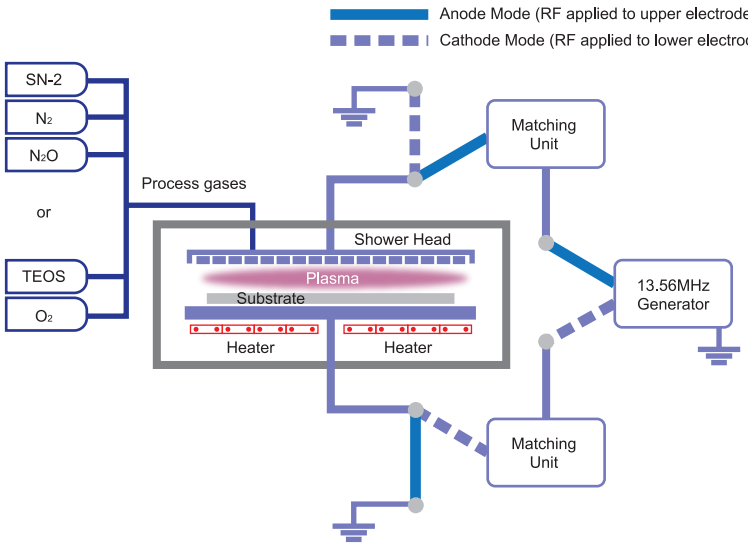

Figure 2 PD-200STL reaction chamber diagram

Process Data

	Process	Hardware Configuration	Process Chemistry
1	Void-free gap-filled SiO_2	Cathode-coupled	TEOS, O_2, Ar
2	Low temperature SiO_2 film deposition	Cathode-coupled	TEOS, O_2
3	Refractive index control of SiON film	Anode-coupled	SN-2 (Liquid precursor), N_2O, N_2

Using the PD-200STL, it is possible to fill triangular hole patterns with approximately 200 nm width without voids. Using solely the cathode-coupled PECVD technique, the film is selectively deposited on the side of the pattern apertures, thereby closing the apertures prior to the filling of the holes, resulting in the formation of voids. However, if the cathode-coupled PECVD process is augmented by the Ar sputtering/etch-back process, the two alternating processes can achieve void-free gap-filling, even with pattern width that is close to 200 nm (Figure 3).

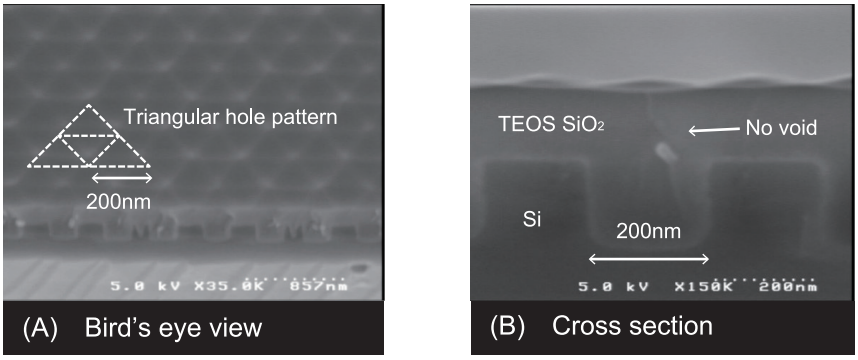

Figure 3 SEM images of gap-filled SiO_2 film
Photo courtesy of Professor Nobuhiko Nishiyama, Tokyo Institute of Technology.

Secondly, we have demonstrated deposition of silicon oxide film at low temperatures using the cathode-coupled configuration. 2 µm thick silicon oxide film was deposited on a ø4" silicon wafer at a substrate heater temperature of 80°C. Despite the film thickness, no cracks were observed in the film. Furthermore, deposition thickness uniformity of 1% was obtained using a 5-point measurement (Figure 4).

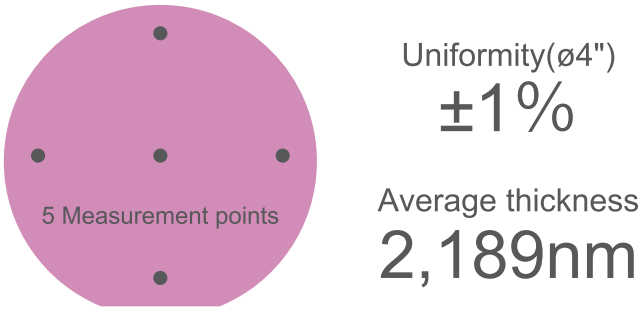

Figure 4 ø4" TEOS-SiO_2 deposition uniformity and average thickness

Finally, Figure 5 illustrates refractive index tuning of silicon oxynitride (SiON) film deposited using SN-2 liquid precursor in the anode coupled configuration. By adjusting the N_2O flow rate, the refractive indices from 1.514 to 2.003 (λ = 633 nm) can be obtained.

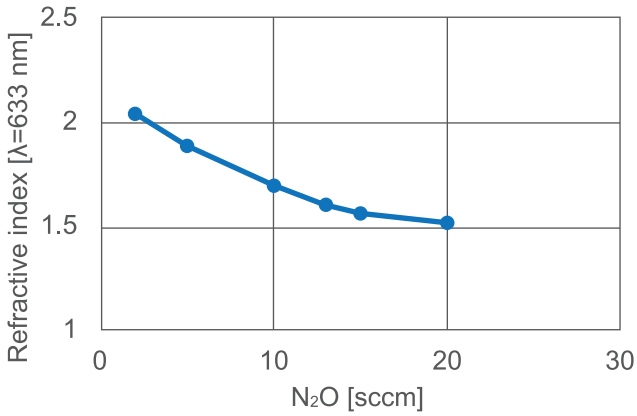

Figure 5 Refractive index control of the SiON film using anode coupled PECVD method

Three sets of deposition data obtained on the PD-200STL have been presented above. The PD-200STL is an extremely versatile system that allows for a diverse range of deposition conditions by utilizing both the anode coupled and the cathode coupled configurations.

Conclusions

The PECVD system, model PD-200STL, is equipped with an anode/cathode switching function that allows for a wide range of film deposition conditions possible, thereby providing differentiation and versatility to support broad research and development requirements.

Acknowledgment

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