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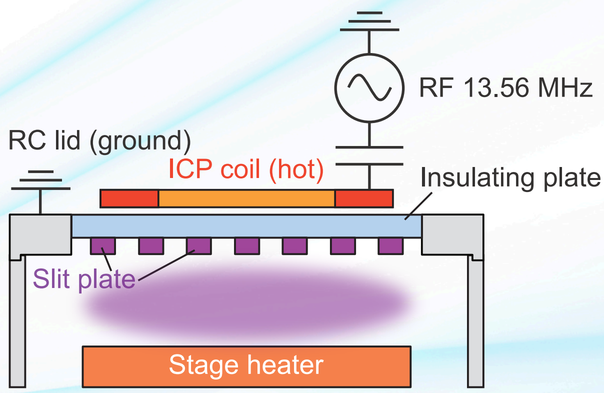
# Plasma Enhanced & Thermal ALD System

# AD-800LP



# Plasma Enhanced & Thermal ALD System: AD-800LP

## Introduction

As semiconductor devices become smaller and thinner, atomic layer deposition (ALD), with nano-level controllability of film thickness and excellent step-coverage, is becoming increasingly important[1]. Insulating oxide films such as $AlO_x$ and $SiO_2$ have been the predominant ALD film materials. However, in recent years, the range of ALD film materials has expanded to include nitrides, metals, conductive films, and various other types of films[2, 3]. Accordingly, there is a great demand for ALD systems that can handle deposition of films using precursors with lower vapor pressure and deposition of conductive films. This report introduces the Samco's cutting edge ALD system model "AD-800LP" developed to meet the expanding demands and its process results.

## Features

The AD-800LP is a load-locked, plasma enhanced, thermal ALD system; three features of the AD-800LP are presented below.

1. Reaction chamber heatable to 200°C to eliminate cold spots and prevent particle generation
2. ICP coils for deposition of conductive films
3. Removable and washable reaction chamber

The first feature is the capability to heat the reaction chamber to 200°C. A cartridge heater in the reaction chamber heats the entire reaction chamber efficiently and uniformly. The exhaust piping is also heated to eliminate cold spots and prevent the condensation of precursors with low vapor pressure. Therefore, the AD-800LP can handle a wide variety of precursors.

The second feature is the ICP coil. Figure 1 shows a schematic diagram of the ALD reaction chambers. In former iterations of our ALD system, the RF electrode is installed on the upper side of the reaction chamber. In the deposition of conductive films such as metal or TiN, the insulating plate may be covered by the conductive film, causing the conduction between RF electrode and grounded chamber lid. The AD-800LP uses an ICP coil placed outside the reaction chamber to prevent conduction between the ICP coil electrodes and the reaction chamber lid, while enabling high-density plasma. Furthermore, a top slit plate is employed to prevent the insulating plate from being covered by a conductive film and interfering with the magnetic field. The AD-800LP is capable of repeated deposition of even conductive films.

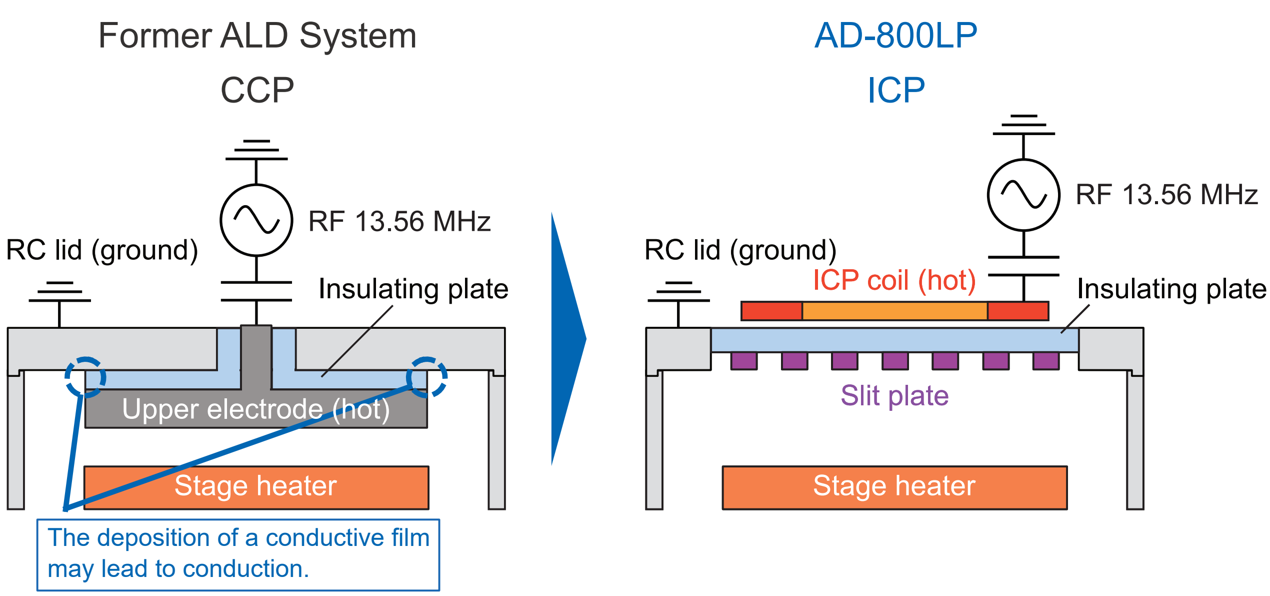


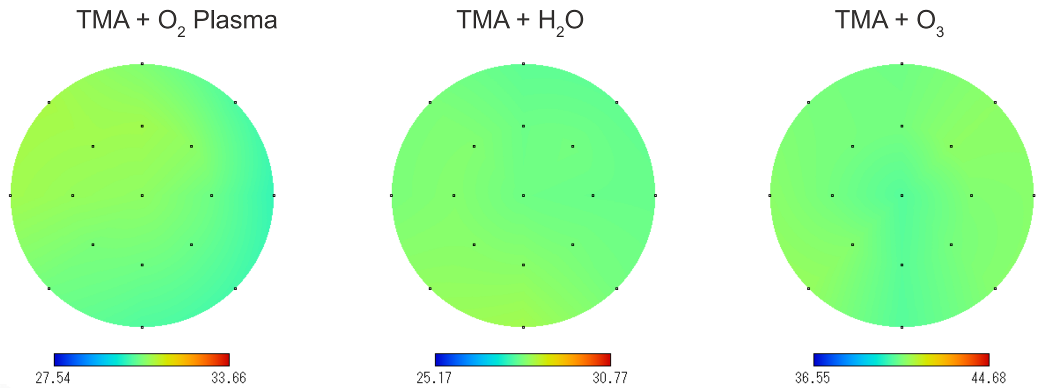

Figure 1. Schematic diagram of former ALD system and AD-800LP reaction chamber

The third feature is the removability of the reaction chamber for maintenance. Because ALD has excellent coverage properties, even if an adhesion preventing plate is installed in the reaction chamber, the films may be deposited on the back side of the plate and the inner wall of the reaction chamber.

It is difficult to clean the films adhering to the inner wall of the reaction chamber. The AD-800LP can provide stable processes in the long-term by removing the reaction chamber, and cleaning it every few years.

## Process Results

Figure 2 shows the results of $AlO_x$ film deposition on an 8-inch Si wafer using the AD-800LP. The films were deposited using TMA (trimethylaluminum) and three oxidants: $O_2$ plasma, $H_2O$ supply, and $O_3$ supply. The stage heater temperature was set to 300°C. The film thickness was measured with an ellipsometer (HORIBA, Ltd., Auto SE). Excellent in-plane uniformity of less than ± 2% was obtained with all oxidants. Film thickness control at the nano level is realized, and the film deposition per cycle is 0.08 to 0.1 nm / cycle.




| | | | |
|---|---|---|---|
| In-plane uniformity: | ±1.47% | ±0.90% | ±0.81% |
| Number of cycles: | 300 cycles | 300 cycles | 500 cycles |
| Average film thickness: | 30.60 nm | 27.97 nm | 40.61 nm |
| Film thickness per cycle: | 0.1 nm/cycle | 0.09 nm/cycle | 0.08 nm/cycle |

Figure 2. AD-800LP $AlO_x$ deposition results using three oxidants; $O_2$ plasma, $H_2O$, and $O_3$

## Conclusion

The new ALD system AD-800LP, capable of depositing films using low vapor pressure materials and conductive films, and the results of $AlO_x$ film deposition using three different oxidants were presented. Samco is also working on film deposition using other materials, which will be introduced in another technical report.

## References


1) S.M. George, Chem. Rev. 2010, 110, 111-131.
2) April 2016 vol. 93 Samco Now Technical-Report
3) October 2021 vol. 115 Samco Now Technical-Report



### Acknowledgements

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## Principles of ALD

Figure 3 shows one cycle of ALD. Step 1 to 4 is called one cycle, and each atomic layer is deposited one by one by repeating this cycle.

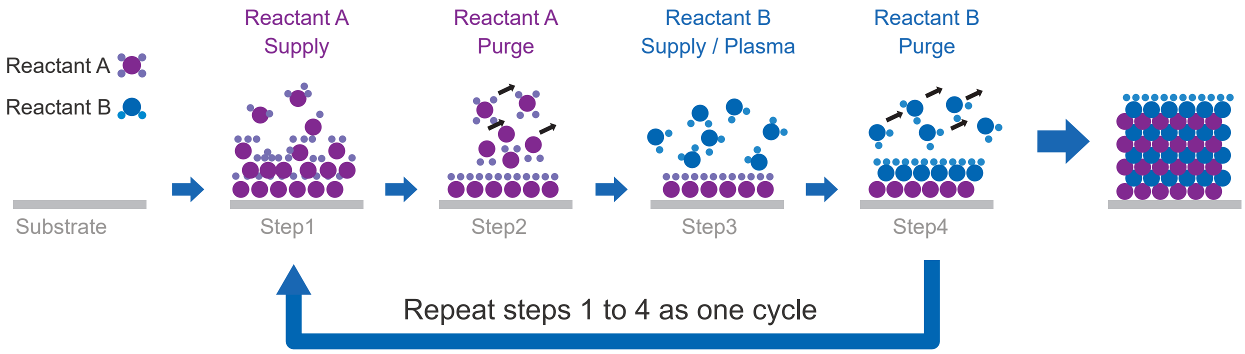


Figure 3. Diagram showing one cycle of ALD

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