

Characteristics of electrostatic Chuck(ESC)

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1. Introduction

Electrostatic chucks are commonly used as the means of holding silicon wafers in place on semiconductor manufacturing equipment such as the plasma CVD and thermal CVD systems.

Further enhancement of purity, cooling characteristics, and corrosion resistance is sought of those systems to meet constantly growing demands in semiconductor industry, such as downsizing, higher integration, more uniform etching temperature, higher purity level, and reduction of particles.

Many semiconductor manufacturers are also beginning to use electrostatic chucks for retaining printed boards, LCD glass substrates, etc. These industrial changes are leading to further diversification of electrostatic chucks.

Introduced below are Al_2O_3 (room temperature up to 200°C) and AlN (over 150°C) electrostatic chucks developed and manufactured by our company based on proprietary particulate technologies.

2. Main Features of Electrostatic Chucks

2.1 Al_2O_3 Electrostatic Chucks

Table 1 shows the main characteristics of Al_2O_3 electrostatic chuck materials in comparison with those of AlN counterparts.

Measurement item	AS101	ANS101	ANS102
Main compound	Al_2O_3	AlN	AlN
Volume resistivity $\Omega \cdot \text{cm}$	10^{11}	10^{14}	10^{15}
Room temperature	10^9	10^{13}	10^{14}
300°C		10^{11}	10^{12}
Dielectric constant (1MHz)	17	9	9
Dielectric loss (1MHz)	0.07	0.0002	<0.0001
Dielectric strength KV/mm	9	14	18
Thermal conductivity W/mK	30	110	60
Room temperature	22	70	40
200°C			
Thermal expansion coefficient (20-400°C) $\times 10^{-6}/\text{K}$	7.8	4.4	4.7
4-point flexural strength MPa	450	400	400
Vickers hardness	2200	1200	1200
Surface roughness (Ra) μm	<0.01	<0.02	<0.02
Resistance against ClF_3 400°C	Good	Good	Good
halogen gas Cl_2 600°C	Good	Good	Good
HCl 600°C	Good	Good	Good

Table 1 Characteristics of ESC materials

Al_2O_3 electrostatic chuck (AS101) has excellent thermal conductivity, mechanical characteristics (hardness, strength), and resistance against corrosion (oxygen plasma, CFC gases) identical to or better than that of the high-purity high-density Al_2O_3 . Compared with the conventional aluminum oxide-based electrostatic chucks, AS101 gives high purity (metal impurities <50ppm excluding silicone and aluminum) and good surface roughness (Ra<0.01). Temperature dependence of resistance is very low with a digit reduction of resistance per 100°C of temperature rise.

As the result, the Al_2O_3 electrostatic chuck has the following advantages over the conventional aluminum oxide type:

- 1) Better cooling characteristics.
- 2) Useable in an atmosphere in which the suction surface is exposed to oxygen plasma.
- 3) Reduction of metal contamination.
- 4) Useable in a wide temperature range (room temperature ~ 200°C).

The suction characteristics of the Al_2O_3 electrostatic chuck are shown in Figs. 1 and 2. The suction force increases with an increase of the applied voltage. It reaches approximately 200gf/cm² at 500V and approximately 400gf/cm² at 800V.

Suction at 500V becomes stabilized 10 seconds after the voltage is applied, and falls to 0gf/cm² within 2.5 seconds after the voltage is released. Thus the chuck has excellent response in both suction and release.

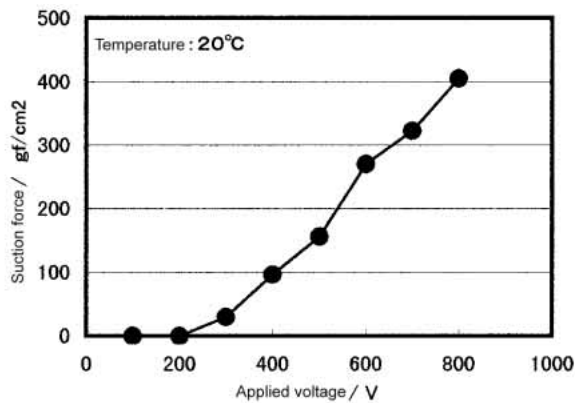


Fig. 1 Relation between applied voltage and suction force of Al₂O₃ electrostatic chuck (AS101)

2.2 AlN electrostatic chuck materials

Table 1 shows the main characteristics of AlN electrostatic chuck materials. AlN electrostatic chuck has hardness and strength identical to or higher than those of the conventional AlN counterparts. It also has good surface roughness (Ra<0.02) and chemical stability.

The suction characteristics of the AlN electrostatic chuck (ANS101) are shown in Figs. 3 and 4. The suction force increases with an increase of the applied voltage. It reaches the constant suction force at 800V at the chuck surface temperature 200°C and 250°C alike (200°C: 400gf/cm²; 250°C: 400gf/cm²).

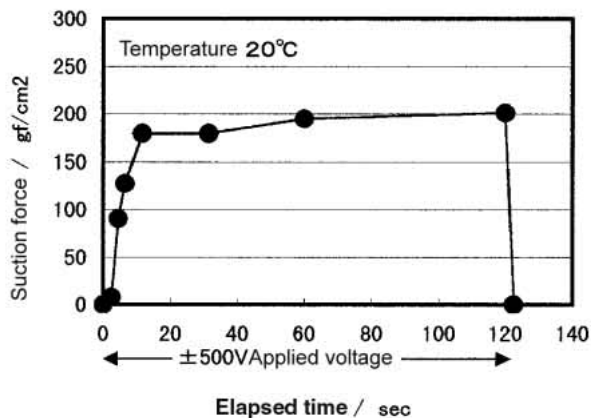


Fig. 2 Clamping/de-clamping time of Al₂O₃ ESC (AS101)

Suction at 500V becomes stabilized 20 seconds after the voltage is applied, and falls to less than 1/10 the constant suction force within 5 seconds at 250°C or within 10 seconds at 200°C.

Fig. 5 shows the wafer heating characteristics in vacuum (10⁻⁶Torr) in the thermal CVD system heater unit having an AlN electrostatic chuck (ANS101).

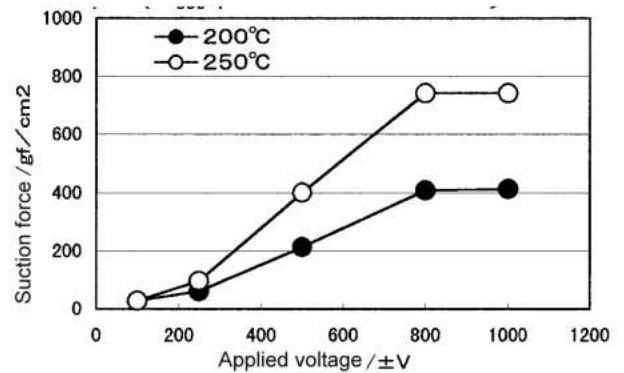


Fig. 3 Relation between applied voltage and suction force of AlN electrostatic chuck (ANS101)

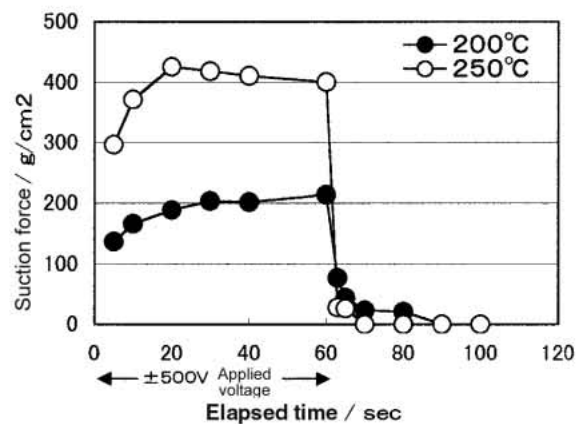


Fig. 4 Clamp and release characteristics of AlN electrostatic chuck (ANS101)

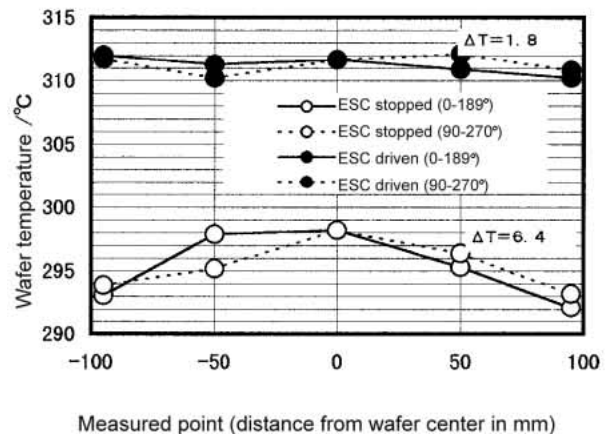


Fig. 5 Heating uniformity of AlN electrostatic chuck (ANS101)

When the wafer temperature was near 300°C, it rose about 20°C within 10 seconds after the electrostatic chuck was driven, and the temperature uniformity improved substantially from 6.5°C to 1.8°C.

3. Concluding Remark

Today, the Al_2O_3 electrostatic chuck is used for plasma etching operated in a temperature range from room temperature to 200°C .

The AlN electrostatic chuck is combined with heaters and RF electrodes and supplied as heater unit for thermal CVD and plasma CVD systems.

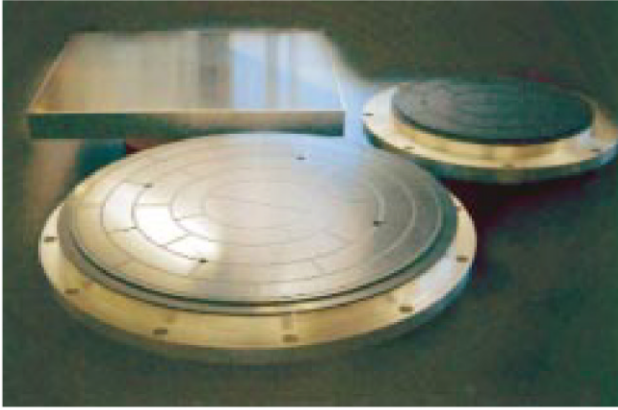


Fig. 6 Electrostatic chucks for plasma etching systems