# Process Overview (How it Works)

## Plasma Basics for the Analogee 200D

The Analogee process chamber is comprised of several control elements:

- a power input to initiate and sustain the plasma
- a gas input
- a gas dispersion plate to uniformly introduce the appropriate process gas
- a pressure controller to reproducibly duplicate the critical operating pressure
- a platen for the wafer to control its temperature

In the case of the Analogee 200D, radio frequency power at 13.56 MHz is introduced to the upper electrode, where process gas is also introduced. The lower part of the chamber, the chuck, is a grounded surface and the secondary electrode.

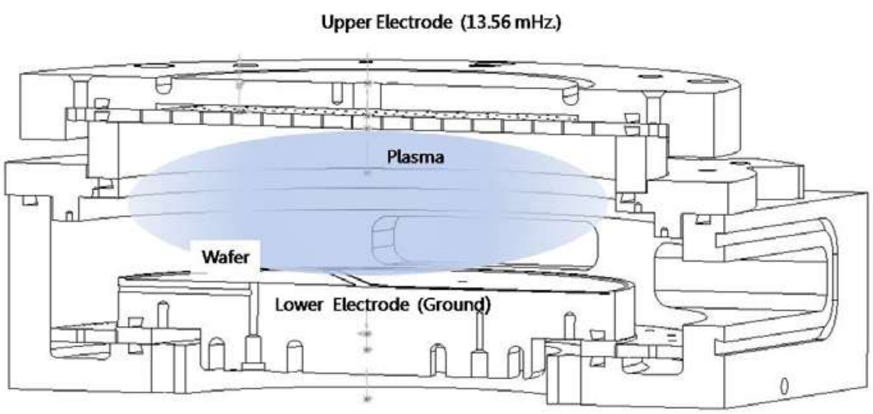


Figure 43—System plasma basics

A process plasma is formed between the upper and lower electrode and contains both ions and neutrals, which react with the wafer surface.

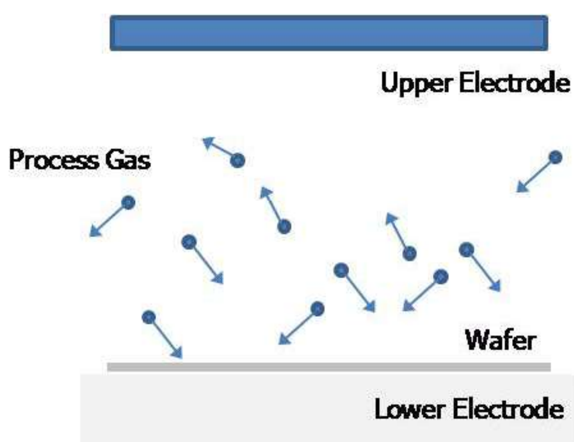


Figure 44—Process plasma interacts with wafer

# System Hardware Description

## Electrodes

Upper electrode: The RF powered electrode in the 200D System is made of aluminum and contains channels for water cooling as well as process gas flow. The electrode is electrically isolated from the chamber; for that reason, it is important that the cooling water have low electrical resistivity.

Lower Electrode or Chuck: The chuck or wafer platen is grounded. The chuck, as well as the chamber walls, provide a ground for the plasma with the chuck being the primary ground.

## Water

On the Analogee 200D, the temperature of the chuck and upper electrode are controlled by a water recirculator for temperatures up to 30 degrees C. The recirculator is a separate unit usually placed in the equipment chase. Temperature control of the chuck is a critical process parameter where the upper electrode temperature is not as critical. While a cold chuck can be better for certain types of processes, it is recommended that the wafer platen not be colder than dew point so there is no condensation.

Because the 200D is open to atmosphere during the load and unload cycles, atmospheric moisture will be present in the chamber during the beginning of each process cycle. In the case of descum, hotter temperatures can be used to the benefit of the process. In an etch process, higher temperatures will increase the photoresist etch rate and lower the effective selectivity.

Recommendations on chuck temperature: Chuck temperature is process specific, for chuck temperatures up to 40 degrees Celsius both the upper electrode and chuck can be controlled by the recirculator. However, for processes above 40 degrees C, the temperature of the platen should be controlled with the embedded electrical heaters.

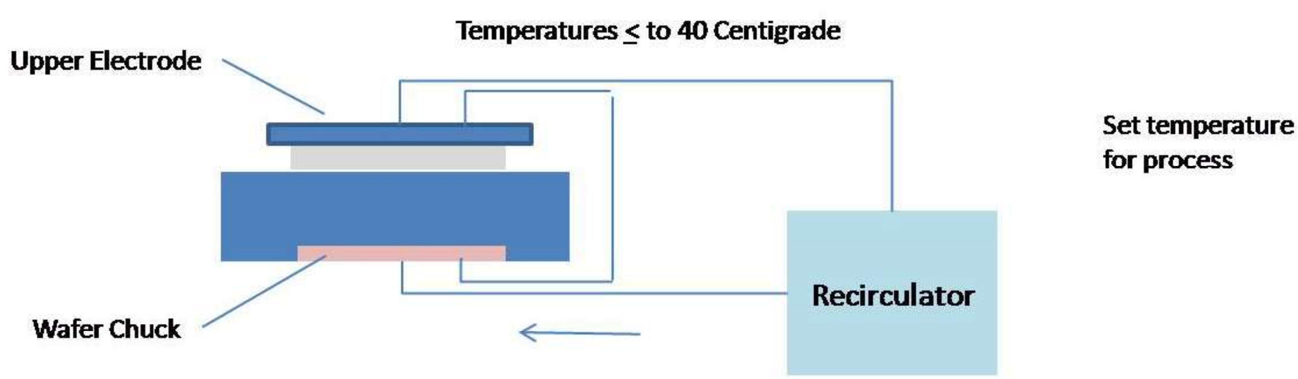


Figure 45—Water cooling process

# Process: Descum

A "descum" process is used to improve the integrity of the resist image. When resist is imaged, there can be residues of polymer left in the chamber, a "foot", that if not removed will degrade the image integrity. The solution to the problem is to perform a short duration oxygen plasma which isotropically (all directions at the same time) removes resist. The general chemical reaction is O (atomic oxygen) + C + N (photoresist) = CO and CN.

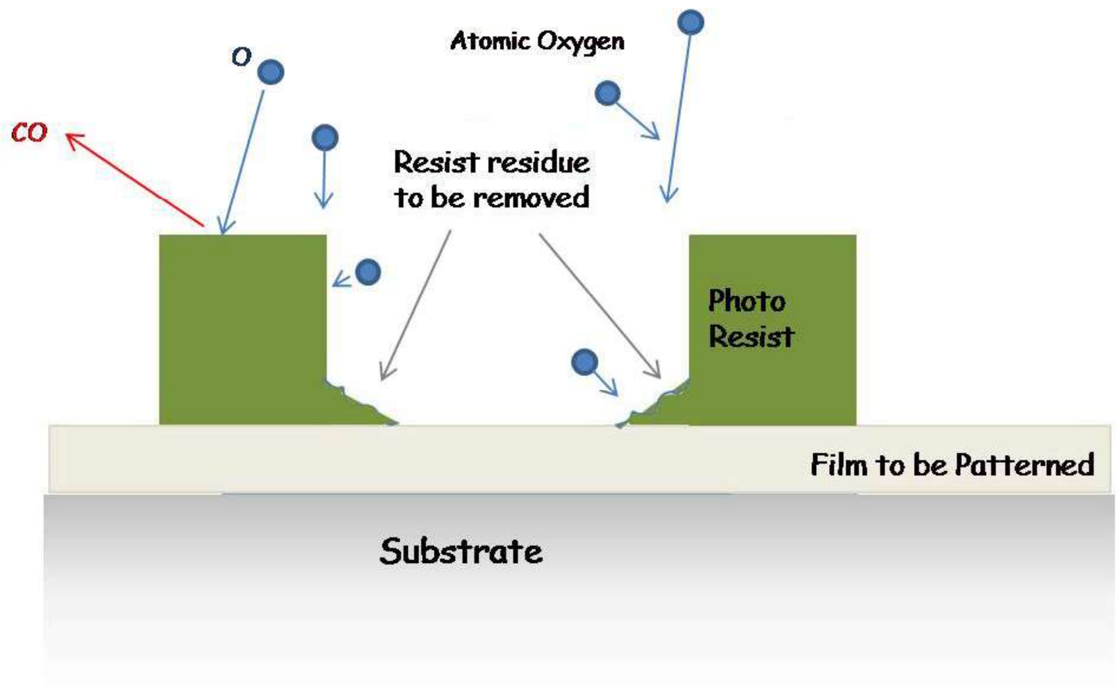


Figure 46—Descum process

# Operating Conditions: Standard Descum Process

The Analogee descum process requires RF, O2, pressure control, and a temperature-controlled wafer chuck.

Typical process conditions are shown in the following table. At these conditions, a blanket photoresist wafer (dependent on the resist and pretreatment) will have 500 to 700 Angstroms of photo resist removed at $\leq$ 5% nonuniformity. (1 StDev/Average Etch Rate)

**Typical Process Conditions**

| Control Parameter | Setting |
|---|---|
| Gas Flow | O2 350 Sccm |
| RF Power | 225 Watts |
| Pressure | 750 mTorr |
| Chuck Temperature | 30 Centrigrade |

# Process Trends: Etch Rate and Uniformity

Compared to many semiconductor processes, descum is not overly sensitive to small control changes, the following normalized graph shows this.

It is easy to see that there are no significant changes in **etch rate** as a function of either a 10% pressure, flow, or power change. For example, a 10% change in RF power results in only about a 3% change in descum rate.

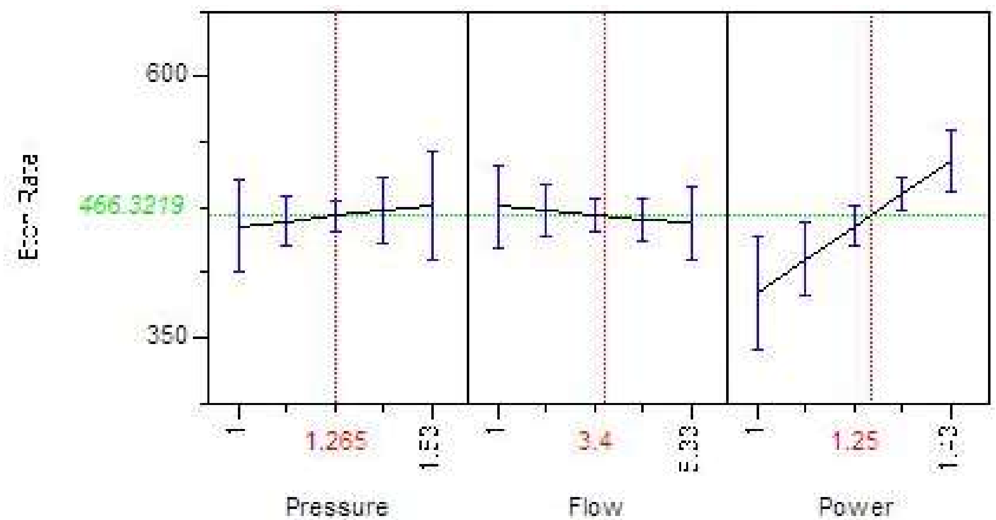


**Figure 47—Descum rate vs pressure, flow, and power changes around operating point**

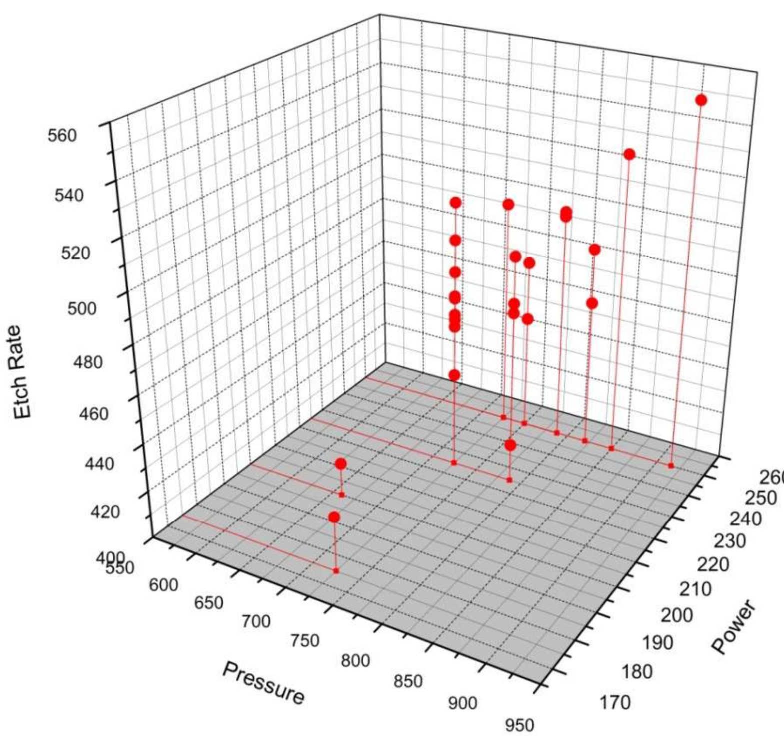


**Figure 48—Etch rate vs pressure and power**

Descum uniformity is also relatively insensitive to small changes in pressure and power. However, it is more sensitive to changes in total gas flow, a 10% flow change can correlate to approximately a .5% change in non-uniformity. For example, increasing the gas flow from the center operating point will improve uniformity but have a slight negative effect on the resist removal rate. The following graph shows the effect of control parameter changes on wafer nonuniformity.

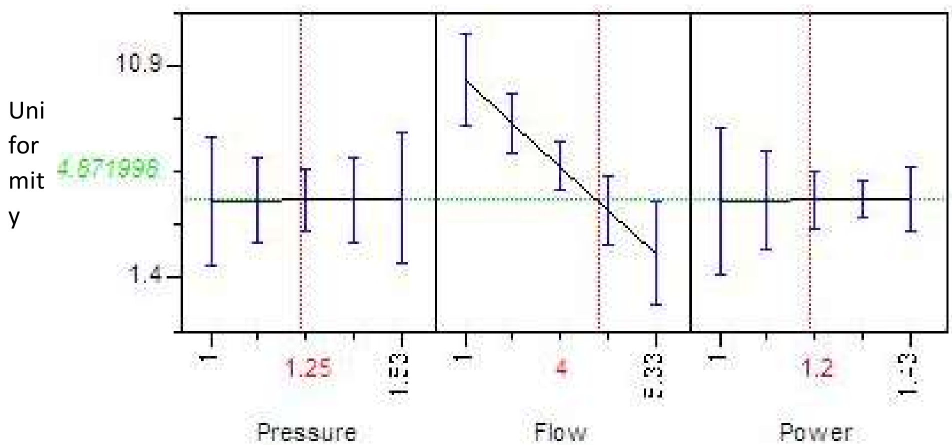


Figure 49—Descum uniformity vs pressure, flow, and power changes around operating point

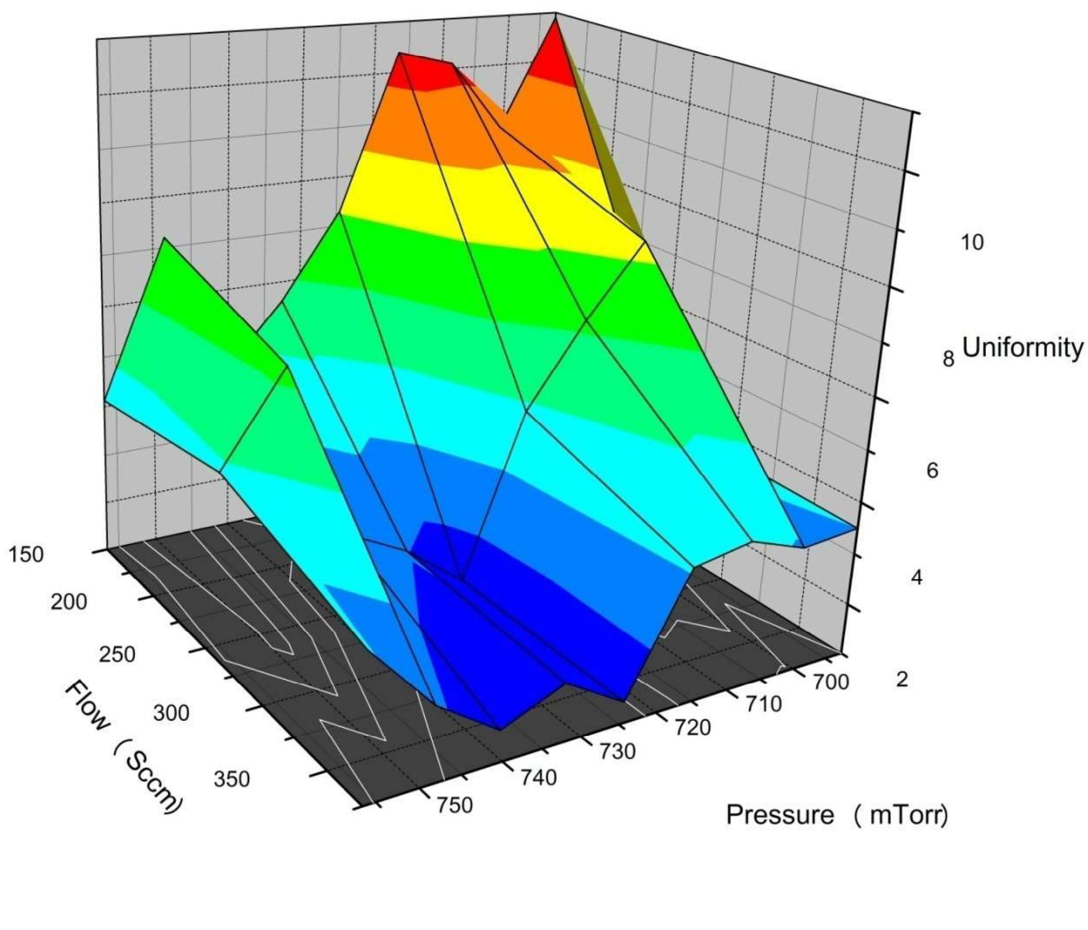


Figure 50—Map of etch uniformity based on flow and pressure

The process control that has the largest impact on both etch rate and uniformity is wafer temperature. As in a photoresist strip where the reaction rate is more chemical, the descum rate is heavily dependent on the wafer temperature. In general, the wafer temperature can be an independent control for adjusting the descum rate, increasing temperature causes an increase in descum rate.

There is a tradeoff however, since there is a resulting increase in etch non-uniformity with the increase in temperature. At ambient temperature, uniformities below 5% can be achieved. However, at a 50 degrees C chuck temperature, uniformities may be on the order of 6 or 7%.

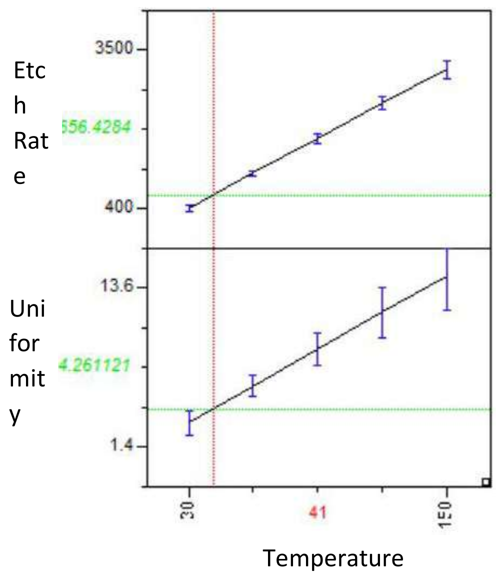


**Figure 51—Descum rate and uniformity changes vs temperature**

Process trends: Following is a table that gives a relative comparison of changes in the process controls.

### Basic Trends with Control Changes

| Control Variable | Etch Rate | Uniformity |
|---|---|---|
| RF Power Increase | Increase | Slightly worse |
| Oxygen Flow Increases | Small decrease | Improves |
| Pressure Increase | Slight increase | Negligible |
| Temperature | Large increase | Slightly worse |

# Process Reproducibility

A precondition is recommended if the tool has been idle for more than 30 minutes. The simplest preseason is cycling up to 5 wafers using the standard process condition. Alternatively, a single wafer with a longer cycle can be used. The seasoning will condition the reactor walls and improve the wafer-to-wafer reproducibility. Following the conditioning, wafer to wafer rate and uniformity should be <5%.

# Process Endpoint

In a descum, there is only a partial removal of photoresist, making endpoint impractical. With respect to the "foot", the amount of residual photoresist comprises such a small surface that being able to detect its removal is beyond detection limits for endpoint systems.