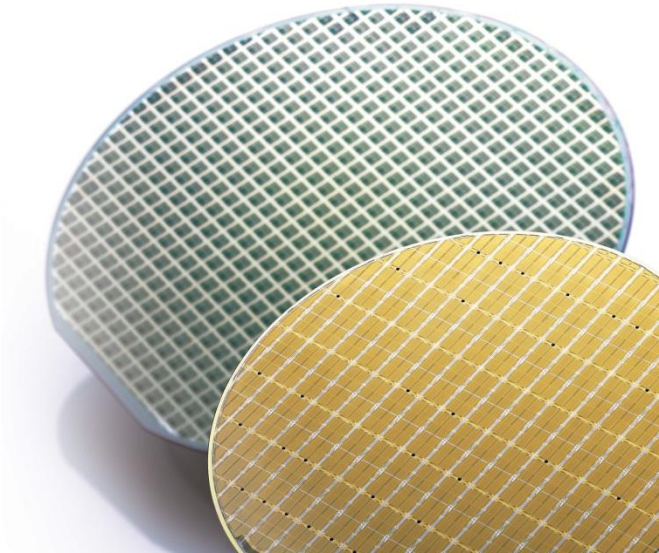
samco
PARTNERS IN PROGRESS

UV-Ozone Technology and Applications



Introducing SAMCO

SAMCO
PARTNERS IN PROGRESS

Your Global Partner in Progress

Over the last **30 Years** SAMCO has provided

Over **3,200 Thin Film Solutions** to our

Global Partners **in 23 Countries**

Core Technology

The Three Technologies
Leading SAMCO's Global Expansion

Chemical Vapor Deposition:

- Anode Coupled PECVD
- Liquid Source Cathode Coupled PECVD (LS-CVD®)
- Metal Organic CVD (MOCVD)

Plasma Etching:

- Reactive Ion Etchers (RIE)
- Inductively Coupled Plasma Etchers (ICP)
- Deep Reactive Ion Etchers (BOSCH DRIE)

Surface Treatment:

- Plasma Cleaners
- UV-Ozone Treatment

What is Ozone?

Overview:

- Ozone (O_3) consists of three oxygen atoms.
- More reactive (less stable) than O_2
- Retards UV light in the upper atmosphere
- Toxic and harmful to respitory systems (lower atmosphere)
- Effective etchant / cleaner of organics
- Next to F^2 it is a strong oxidizer
- Half life in dry air is 12 hours (40min in water)

Facts:

Item	Oxygen	Ozone
Scientific Name	O2	O3
Molecular Weight	32	48
Boiling Point	-183C	-112C
Melting Point	-219C	-193C
Colour (gas)	None	Light blue (weak)
Smell	None	Fishy
Magnetic Properties	Paramagentic	Diamagnetic
Space Between Atoms	10.7nm	12.8nm

History

The Discovery:

- In 1972 Boron and Kunz found UV-Light had capability to de-polymerize a variety of photoresist polymers.
- Optimal wavelengths of 184.9nm + 253.7nm discovered
- Introduction of O_3 found to improve reaction speed
- First advanced, high rate system created by SAMCO in 1984

Widely Used and Proven:

- Effectiveness shown in wettability and ESCA tests
- Today used in a variety of etching/cleaning applications
  - de-scumming photoresist
  - removal of polyimide and organic residues
  - removing ink from wafers
  - activation of ITO layers in OLED's
  - cleaning prior to packaging in LED's
  - formation of thin oxide layers

Proven as an effective, low damage cleaning technique!

The Process

Fundamentals:

- The substrate is placed in the flow of either oxygen or ex-situ generated O3, and irradiated with UV light.
- The 184.9nm band dissociates molecular oxygen into triplet oxygen, which combines with ground state molecular oxygen to form ozone.
- The 253.7nm band dissociates O_3 produced via the 184.9nm band, or the ozone generator, into molecular oxygen or singlet atomic oxygen.
- The 184.9 and 253.7nm bands also activate the organic material being etched.
- The organic materials are broken down into simple volatile oxidation products such as CO_2, H_2O, etc.
- Before removing the sample an N_2 purge is conducted and the remaining ozone evacuated from the system.

Improving Rates

Variables Effecting Etch. Rates:

Variable 1: Temperature

- Temperature has large effect on reaction rates
- Etch rates can be increased up to 28 fold when coupled with an ex-situ ozone generator.

Variable 2: Ozone Concentration

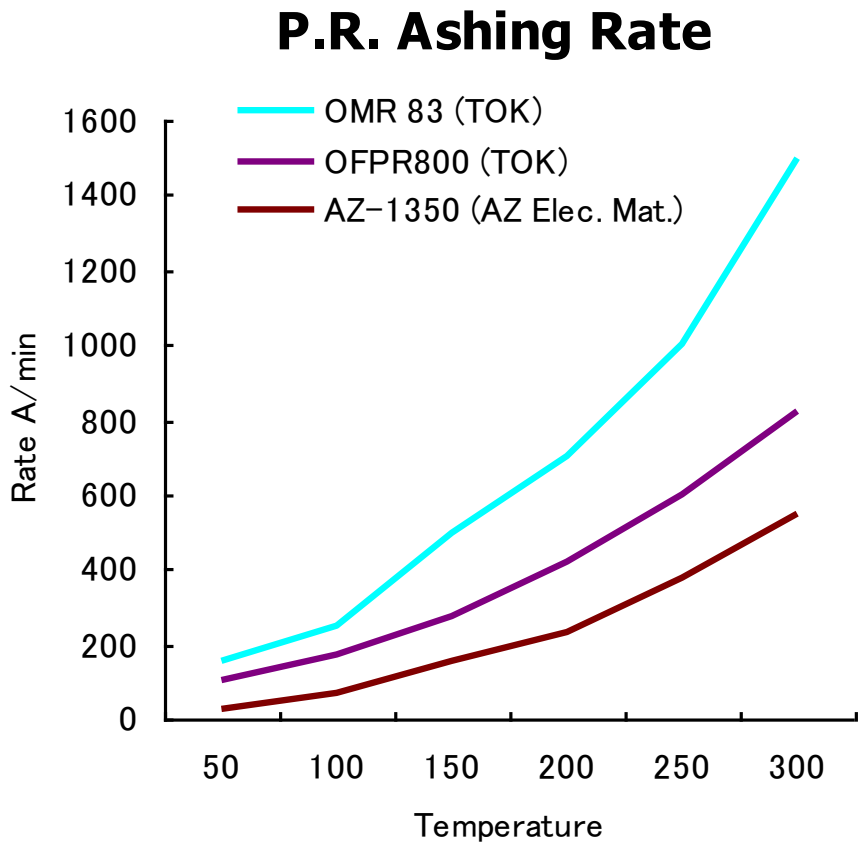
- Increased ozone concentration increases reaction rates especially at lower temperatures.
- Etch rates found to increase an average of 2-fold with an 5-fold increase in inlet ozone.

Variable 3: UV Light

- Effectiveness of UV light proved at multiple temperatures

Temperature

Effect of Temperature on Reaction Rates

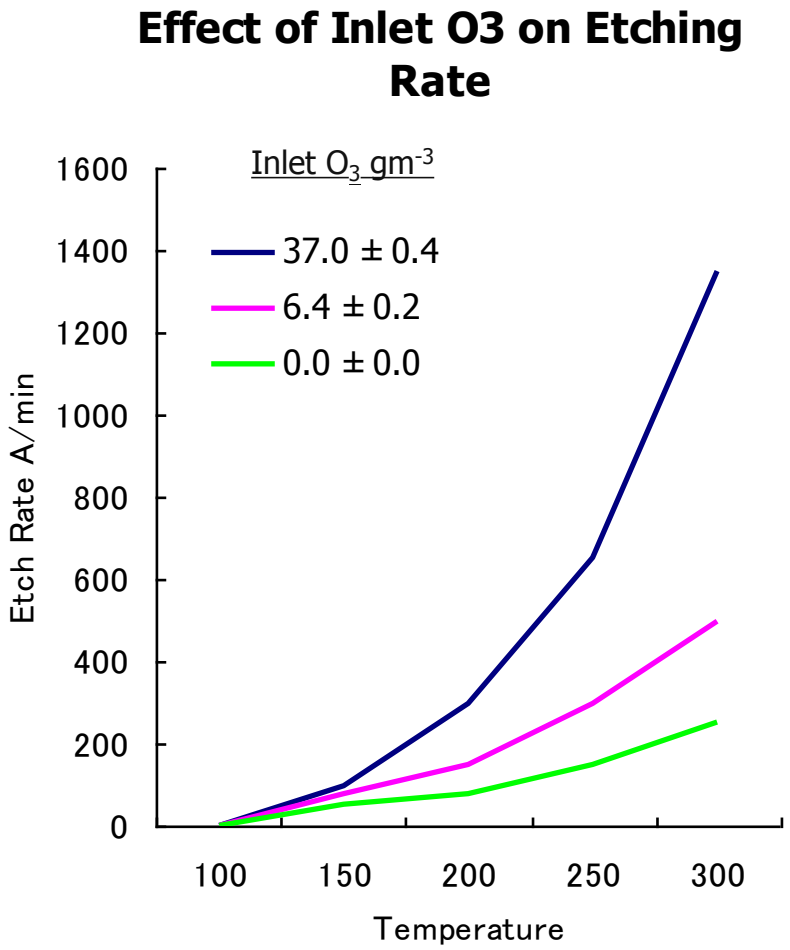


Results from SAMCO Research:

- Three different resist types were processed at increasing temperatures and the ashing rate measured.
- Ozone and oxygen flow was held constant.
- Etch rates increased by up to 28-fold, showing the benefits of temperature systems with temperature control.

Ozone Concentration

Effect of Ozone Concentration



Results from SAMCO Research:

- The ashing rates of a common photoresist were measured at various ozone concentrations and temperatures.
- Rates increase with increased ozone concentration.
- Enhancement of etch rates was proportionally greater at lower temperatures:
  →150~200°C = 3.8 fold
  →200~250°C = 2.1 fold
- Rates increase with increased ozone concentration.

UV Light

Effect of UV on Performance

Results from SAMCO Research:

- The effects of UV on the ashing rate of negative and positive resists were investigated at a constant temperature of 300°C.
- The combination of both UV light and ozone was shown to be the most effective:
  - → Negative Resist = 1.6 fold
  - → Positive Resist = 1.4 fold
- Further research showed UV light provided even greater benefits at lower temperatures.

Ashing Rates Using UV, Ozone, and UV-Ozone

Resist	Type	Ashing Rate (@300°C, 500sccm O2), A/min		
		UV	Ozone	UV-Ozone
OMR 83	Negative	600	900	1500
OFPR 800	Positive	400	700	950

Damage

Comparison to Plasma Cleaning

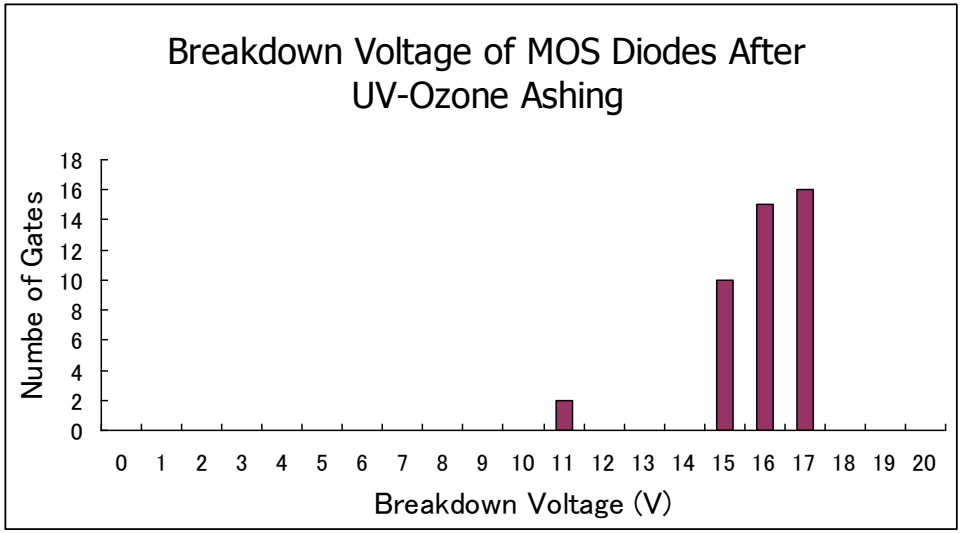
UV-Ozone is a low damage process compared to other currently available cleaning techniques.

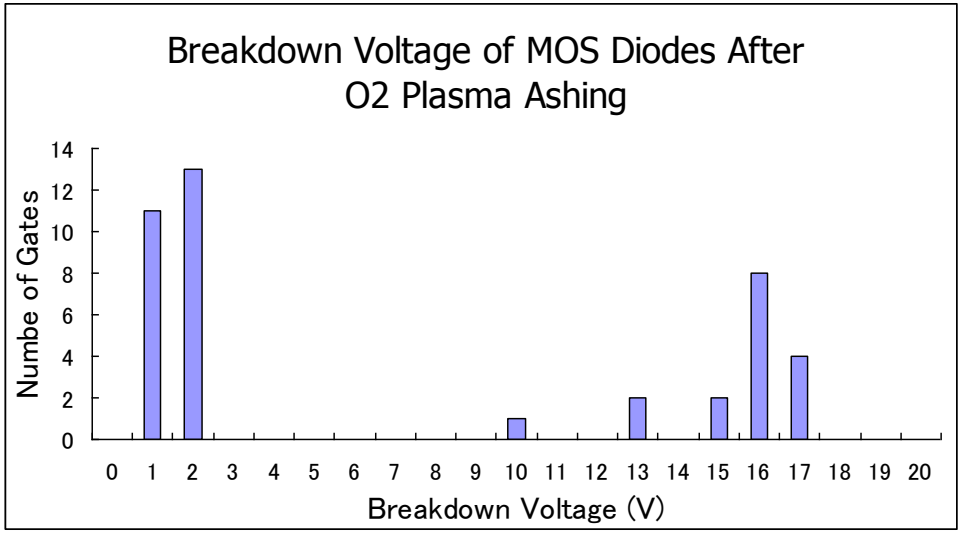
SAMCO Experiment:

- Oxygen plasma and UV-Ozone resist removal from a radiation sensitive MOS diaode was compared and damage to the devices compared.
- Plasma Asher: 120W, 0.X torr, 10 minutes
- UV-Ozone: 0.4Watt/cm^2 UV energy, 270^oC.

Damage Free

Comparison with Plasma Cleaning





Result:

- Plasma processing caused heavy damage to the gate MOS diode probably due to charge effects.
- After UV-Ozone processing the breakdown voltage remained high with no visible damage.
- UV-ozone is perfect for damage sensitive applications

Safety

Concerns and Mitigations:

Concerns:

1) Short-wavelength UV light can cause serious skin and eye injury.
2) Inhalation of ozone gas by the operator.

Mitigations:

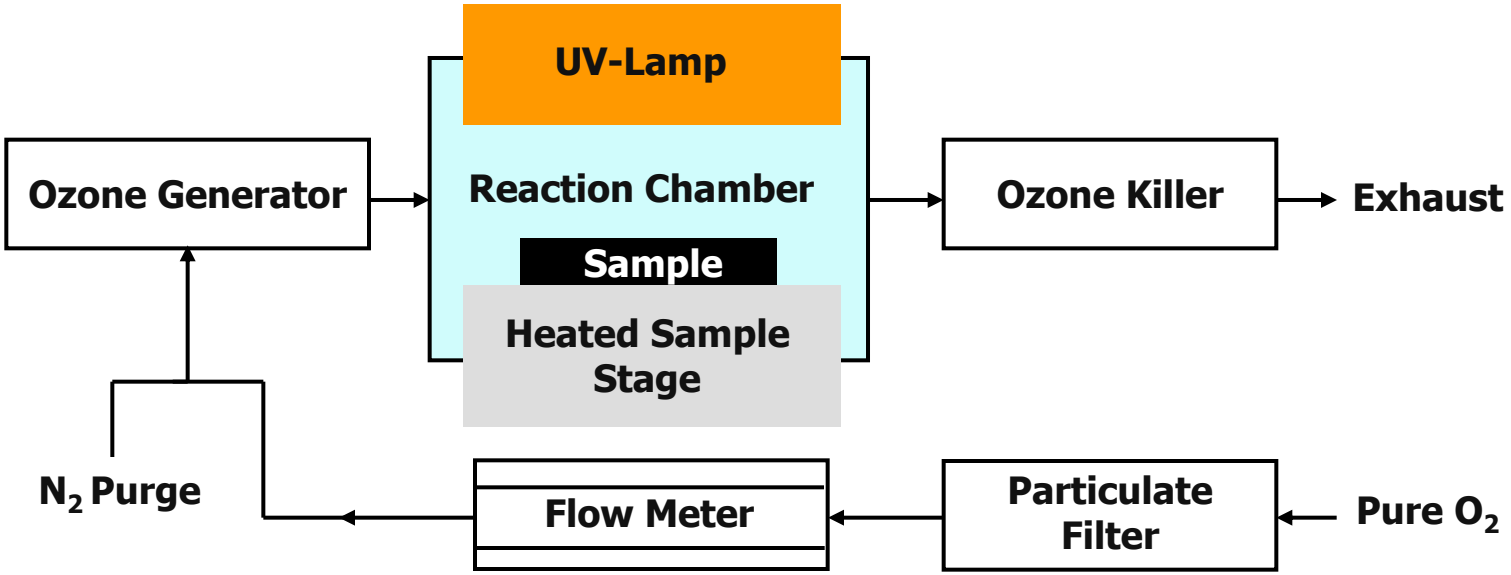
1) All systems should include multiple interlocks to prevent usage when the lid is open.
2) Reaction chambers should be enclosed in casing and the casing evacuated using a duct
3) The reaction chamber must be purged with nitrogen before removing the samples.
4) Evacuated gases should pass through a ozone killer to eliminate the ozone.

Advanced Systems

In 1985 an all new type of UV-Ozone system was launched by SAMCO allowing the adjustment of multiple process variables. It was the first advanced, high rate, low particle system.

System Features:

1) Heated Sample Stage (0~350°C
2) Ex-Situ Silent Ozone Generator
3) Pure O2 Source
4) Fully Sealed Reactor



SAMCO UV-2

Today's High Performance UV System

Hardware Features:

- Process up to 200mm samples
- Bench top compact design
- Heated sample stage to 350°C increases cleaning / ashing rates
- Rapid heat up and cool down mechanism
- High concentration ozone generator
- Highly uniform UV-Lamp and UV-Ozone flow.
- UV intensity meter

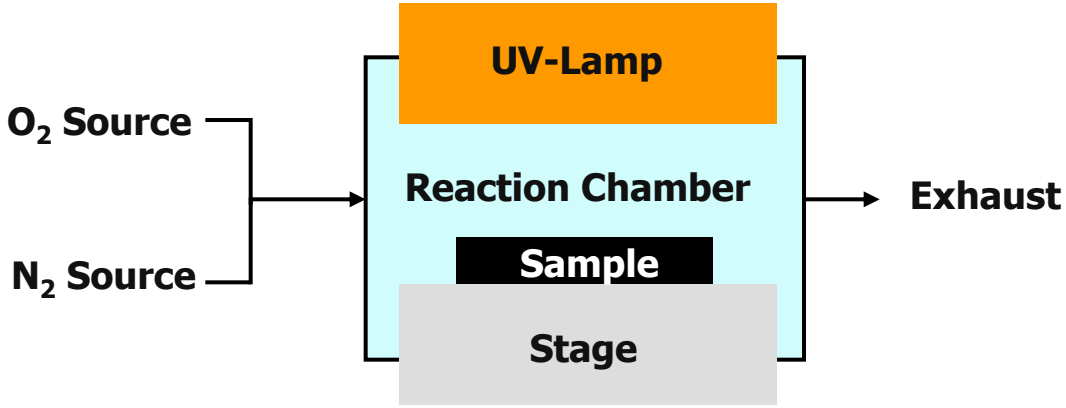
Key Components

UV Lamp
- Produces 184.9nm + 253.7nm light
- Made from fused silica.
- Must achieve uniform light intensity over the surface

Reaction Chamber
- Must be sealed to protect the user from Ozone

Gas Sources
- O_2 source used during processing
- N_2 source used for N2 purge prior to removing the sample

Exhaust
- The ozone should be killed or evacuated to a safe location



SAMCO UV-2

Today's High Performance UV System

Safety Features:

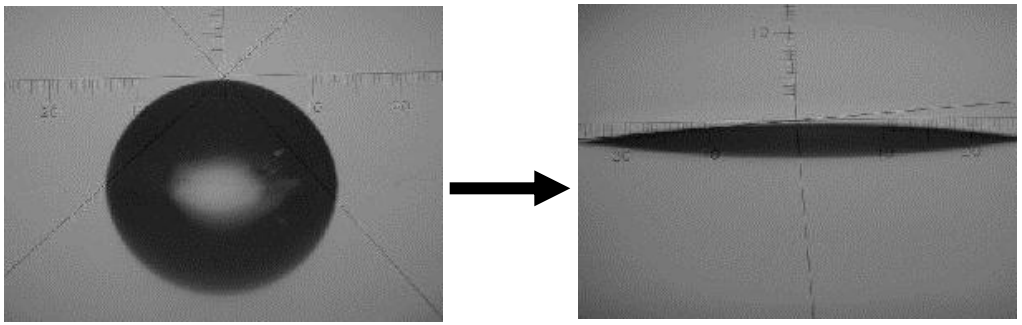
- Sealed chamber
- Drawer interlock to prevent operator from exposure to UV and ozone during the cleaning process
- Automatic N_2 purge at the end of every process
- Built-in ozone decomposition unit
- System is built to UL standards and is CE marked.

Applications

A Variety of Applications

- Removing organic contamination
- Descumming photoresist and polyimide
- Modifying surfaces for better adhesion and encapsulation
- Bond Pad Cleaning
- Final cleaning before wafer bonding
- Pre-clean of wafers prior to deposition
- Pre-clean of wafers prior to Epi growth
- Growth of thin stable oxide films
- Improving surface wettability
- AFM Probe Cleaning
- UV Curing of resist

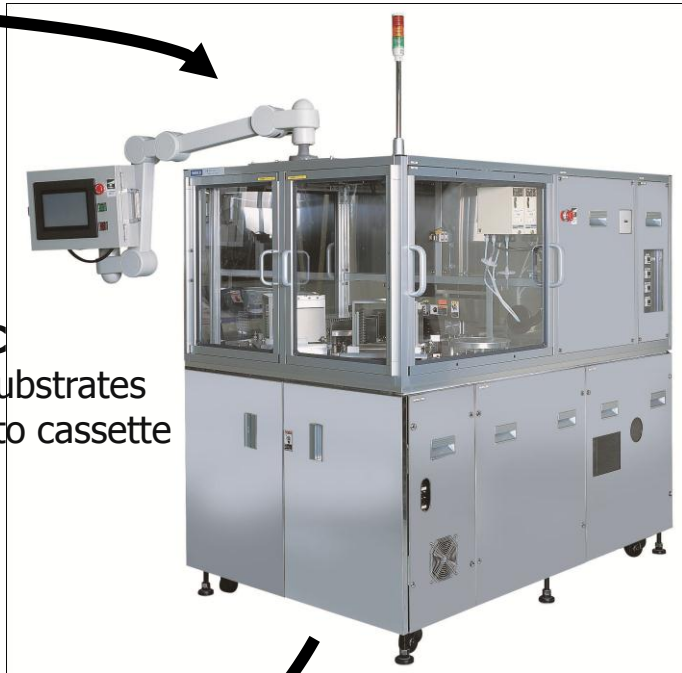
Improvement in Wettability



Complete Range

From R&D to Mass Production

UV-2
- 200mm substrates



UV-300HC
- 200mm substrates
- Cassette to cassette

UV-5000
- Large Panels / Boards
- Automatic handling

Summary

Dry, Low Contamination, Zero Damage Cleaning Possible!

- After being discovered in 1972, today UV-Ozone cleaning has become common place in many fabrication facilities and laboratories.
- UV-Ozone is effective at removing organic contamination, improving bonding strength, and improving wettability.
- Systems equipped with a high-temperature heater and ozone generator provide improved throughput
- The process is completely dry and zero damage.
- UV ozone cleaners are a cost effective solution because no vacuum pump, expensive components, or expensive chemicals are required
- When equipped with a nitrogen purge and ozone cataliser the systems are a safe alternative to wet / plasma cleaning.
- Systems are available for every budget and every processing requirement.
  - From "Lamp in a box systems" to High rate, high specification systems
  - From bench-top systems to automatic mass-production systems