Application Note 6.01

Dissolved ozone measurement in ultrapure water for semiconductor manufacturing

- Measures down to 1 ppb to protect ozone sensitive materials
- Sensor is calibrated in air; no wet chemistry is required
- Low drift; reliable readings with no time-consuming recalibration.

Application Description

The continued reduction of wafer circuitry geometry has fueled a trend toward even stricter guidelines for ultrapure water in semiconductor manufacturing. To meet this challeng the use of ozone in the production of ultrapure rinse water is on the increase.

Ozone is injected into ultrapure water systems on either a continuous or a periodic basis. The dissolved ozone reacts with impurities to disinfect and reduce dissolved organics.

Ozone can be generated for this application by different methods. The corona discharge process uses air or oxygen as a feed gas. The feed gas is passed through an electrical discharge between two electrodes causing the reaction:

$$3\,O_2 \xrightarrow{\text{electrical charge}} 2\,O_3$$

To reduce the possibility of water contamination, high purity oxygen is commonly used as a feed gas. However, the feed gas contributes to higher dissolved oxygen levels. Thus some type of degasification system, along with oxygen analysis, is required to guard against wafer oxidation.

(See also, Application Note No. 6.02, *Dissolved oxygen measurement in ultrapure water for semiconductor manufacturing*.)

With the generation of ozone via electrolytic decomposition the reaction at the anode is:

$$3\,H_2O \rightarrow O_3 + 6\,H^+ + 6\,e^-$$

In addition, the reaction at the cathode is:

$$6\,H^+ + 6\,e^- \rightarrow 3\,H_2$$

This method reduces the amount of dissolved oxygen after ozone injection, and is fast becoming the method of choice in semiconductor applications.

Whether performed periodically or continuously, ozone can be injected at various locations in the ultrapure water loop. These can include the deionized (DI)water storage tanks or after the final polishing beds. Common ozone concentration levels for continuous injections are between 25-50 ppb, while levels for periodic injection are typically between the range of 200-300 ppb.

Ion exchange resin beds are degraded by exposure to ozone. Ozone has a cumulative effect on these exchange resins, causing an increase in total

organic carbon (TOG) and conductivity of the effluent water. To prevent this, UV ozone destruct units are installed just before the primary polishing beds.

Typical Measurements

Dissolved ozone should be measured after ozone injection to control ozone production and thus insure the efficacy of treatment. An ozone analyzer is also placed on the outlet of the ozone destruct unit to insure that ozone

levels of no more than 1 ppb reach the resin. Additional measurement points insure adequate ozone concentration levels at other locations in the DI water loop. A portable ozone analyzer can be used to check point-of-use locations when ozonation of the complete system is required.

Installation Recommendations

The dissolved ozone sensor should be installed in a flow chamber on a side stream, to prevent contamination.

Since ultrapure water has very few impurities, dissolved ozone is relatively stable but it will still deplete slightly with time. To insure the most accurate measurements, sample tube length should be kept to a minimum, and 200-300 ml/min flow should be maintained. To monitor this flow rate a flow meter is recommended on the outlet of the flow chamber.

Recommended System Components

Model	Description
510CCC/ P1C0P000	Orbisphere 510 Controller O_3 (EC), O_3 (EC), O_3 (EC), Panel Mount, 100-240 VAC, 0/4-20mA, Ext. Press
C1100-T00	Electrochemical ozone sensor, Titanium version, Maximum pressure 100 bar
32001.151	Flow chamber, titanium, Viton “O” rings
32502.03	Sensor cable with two connectors, length 3 meters (lengths to 500 meters available)

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