Influence of CO2 Bubbling (Carbonation) During Semiconductor Wafer Sawing Process

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Purpose

- To study the impact of ultra-clean de-ionized (DI) water at semiconductor wafer sawing process
  - Is pure DI water with resistivity in the order of 17 MΩ-cm really a poor electrical conductor?
  - Is the “high resistivity” of DI water generating static charges and resulting in wafer damages?
- To clarify the negative impact of carbonised DI water on wafer corrosion

Background Information

- Cleaning of wafers in wafer sawing process requires clean water. DI water with resistivity in the order of 17 MΩ-cm is used for this application.

- There are concerns that the high resistivity of DI water coupled with pressure cleaning would create static charges which lead to ESD failures.

Background Information – continued

- There are also unproven claims that the high resistivity of DI water would create static charges and attracts dust particles which results in non clean wafers.

- A well known but not well understood industrial practice is to use CO2 gas mixed with DI water to bring down the resistivity to about 0.5 MΩ-cm while maintaining the purity of the water.

Resistivity vs Resistance To Ground

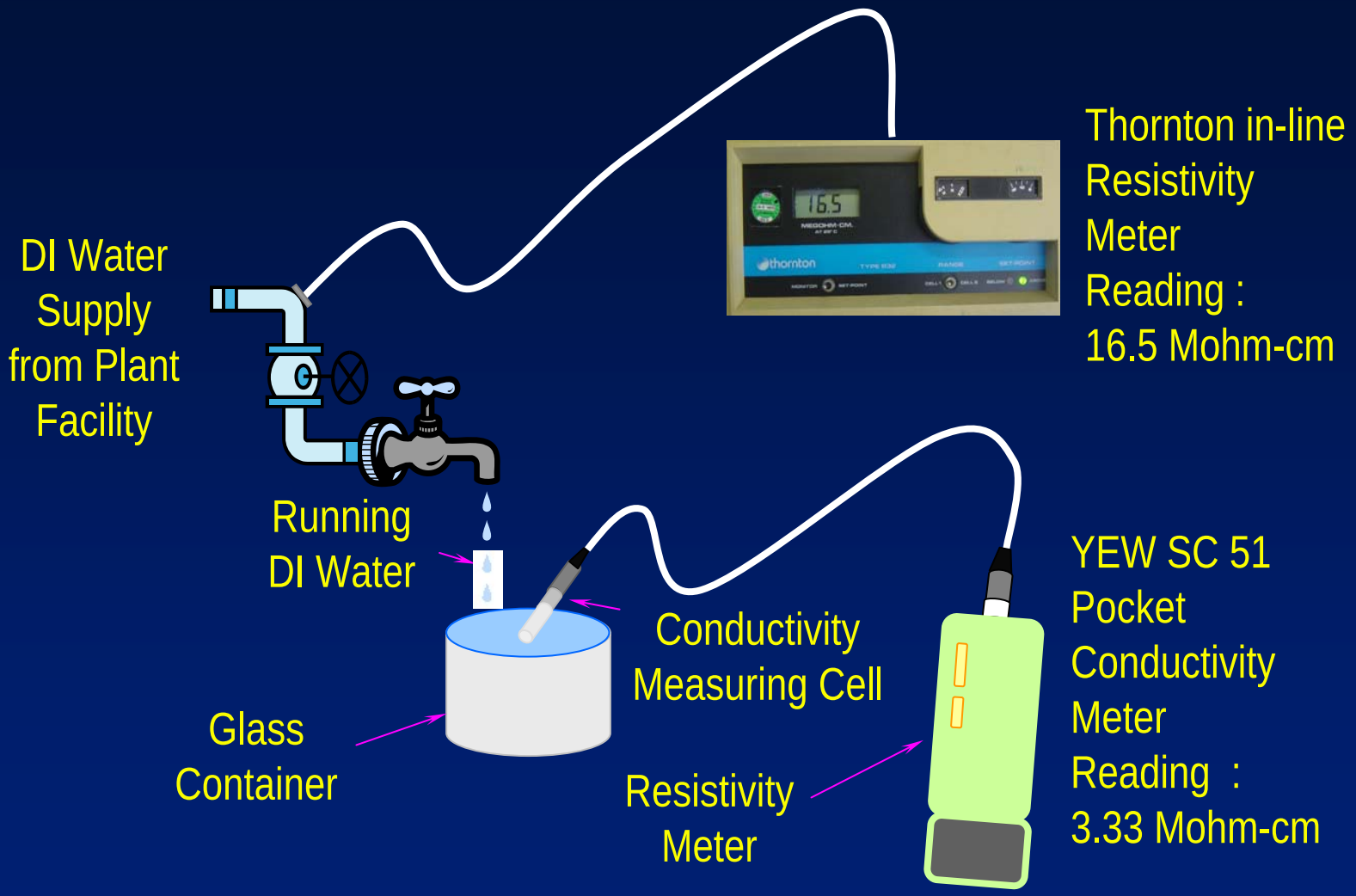
- Resistivity

  The parameter that defines the purity of DI water is Resistivity. The measurement unit is MΩ-cm.

- Resistance to Ground (Rtg)

  To better understand the electrostatic problem associated with the use of DI water, it is necessary to determine the relation between Resistivity (Rs) and Resistance to Ground (Rtg).

Set Up 1 For Resistivity Measurement



Thornton In-line Meter Compare with YEW Portable Meter

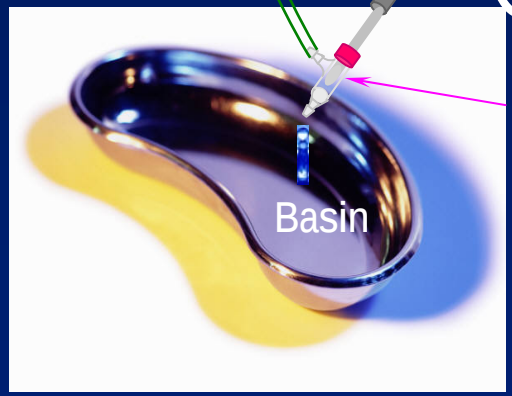
Set Up 2 For Resistivity Measurement

Thornton in-line Resistivity Meter Reading : 16.5 Mohm-cm

DI Water Supply from Plant Facility

Remarks: Distance between Thornton in-line resistivity meter and conductivity cell LR 325/01 is 12 meters

Running DI Water

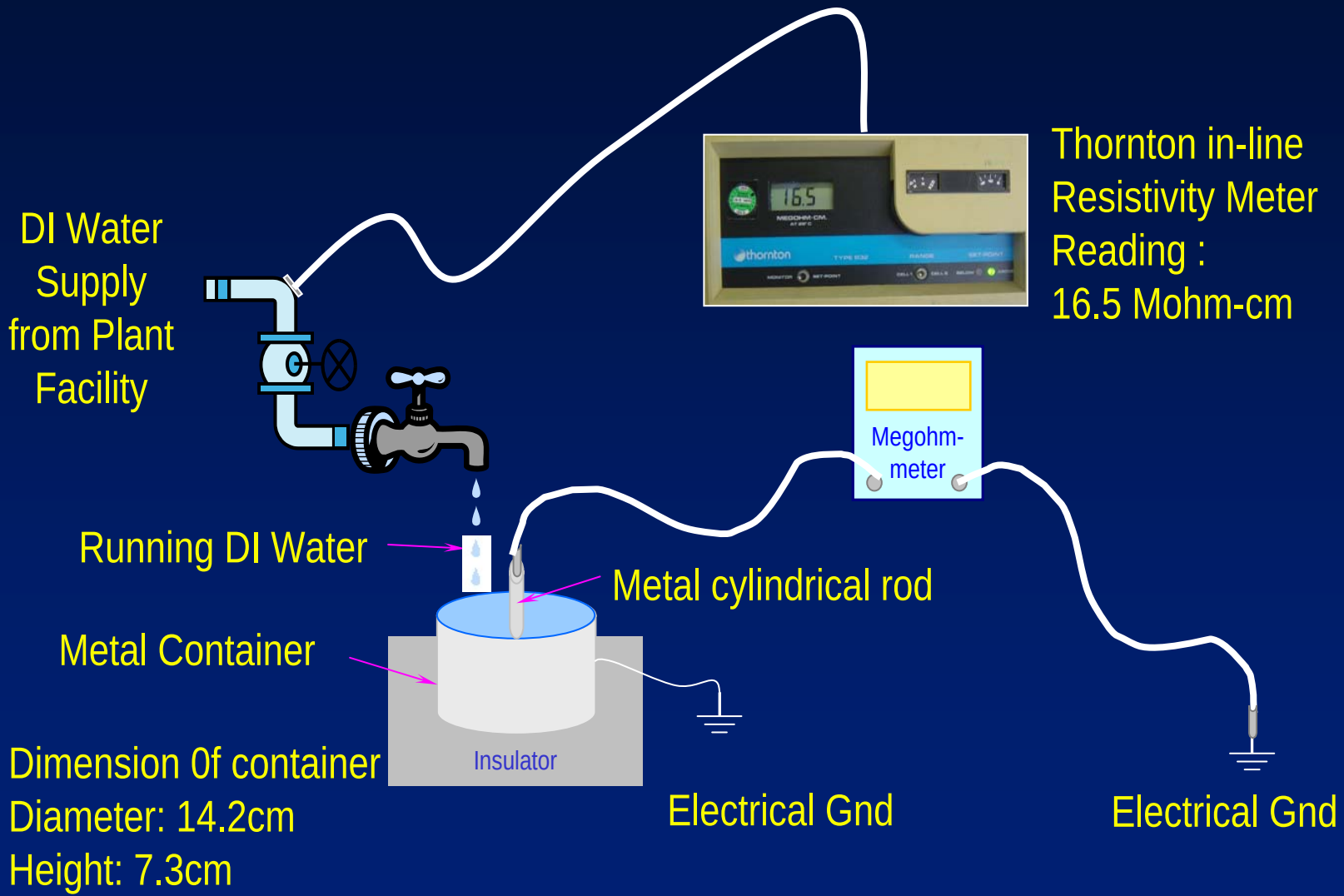


Conductivity Cell LR 325/01

WTW cond 330i Portable Resistivity Meter Reading : 3.64 Mohm-cm

Thornton In-line Meter Compare with WTW cond 330i Portable Meter

DI Water Rtg Measuring Method



DI Water Measurement Results

	DI Water	Carbonised DI Water
Rtg	1.7×10^5 ohm	2.5×10^4 ohm
Resistivity (in-line meter)	16.5×10^6 ohm-cm	4.8×10^5 ohm-cm
Resistivity (Set up 1)	3.33×10^6 ohm-cm	
Resistivity (Set up 2)	3.64×10^6 ohm-cm	

DI Water Measurement - Findings

The measurement showed that for DI water with a resistivity in the order of 16.5×10^6 ohm-cm, the Resistance to Ground (Rtg) value is still in the electrostatic conductive range (about 1.7×10^5 ohm). DI water in electrostatic conductive range should not pose any problem to dissipate charges built up at the wafer.

Wafer Charging Test

- Wafer mounted onto the sawing foil – charging values: 10kV – 12 kV
- Mounted wafer placed on chuck of sawing machine: charging values dropped to ~400V due to charge compensation
- Immediately after rinsing, charging values dropped to less than 10 V
- NO difference observed between the experiment with and without CO_2 bubbling

Wafer Charging Test - Findings

The test conducted confirms that the Rtg of normal DI water without CO_2 bubbling has the capability to drain off charges fast enough before the grounded sawing blade is contacting the wafer. There is no risk for the devices on the wafer.

Cleaning Efficiency of CO2 Bubbled Water

- DI water without CO2 bubbling is termed as "hungry water" (ion deficiency). It will grab any contamination ions as it comes into contact.

- DI water saturated with CO2 is no longer "hungry water". The cleaning efficiency would not be as good as pure DI water without CO2 bubbling?

Negative Impact of CO2 Bubbling

Carbonation occurs when carbon dioxide is dissolved in water. This process is generally represented by the following reaction, where water and gaseous carbon dioxide react to form a dilute solution of carbonic acid.

$$H_2O + CO_2 \leftrightarrow H_2CO_3$$

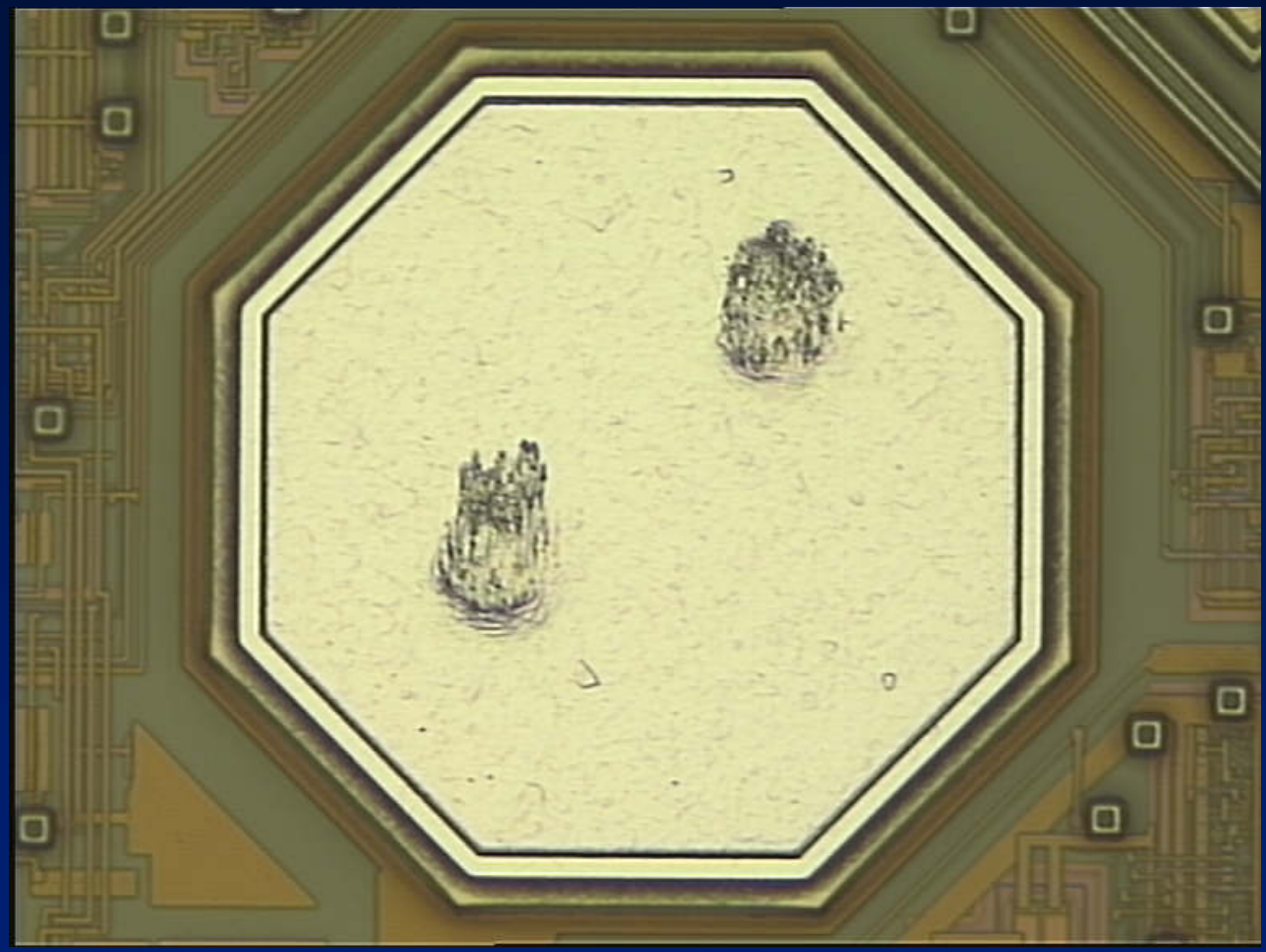
Galvanic Corrosion

- Semiconductor wafer with AlSiCu metalisation system is more sensitive to galvanic corrosion.
- The AlCu system exists in two phases
  - Al rich phase with very little Cu
  - Intermetallic compound Al_2Cu
- The electrode potentials for these two phases are different.
- DI water, which has an ion deficiency, tends to grab any ions in contact with and provides the electrolyte environment for corrosion called galvanic corrosion.

Galvanic Corrosion – Continued

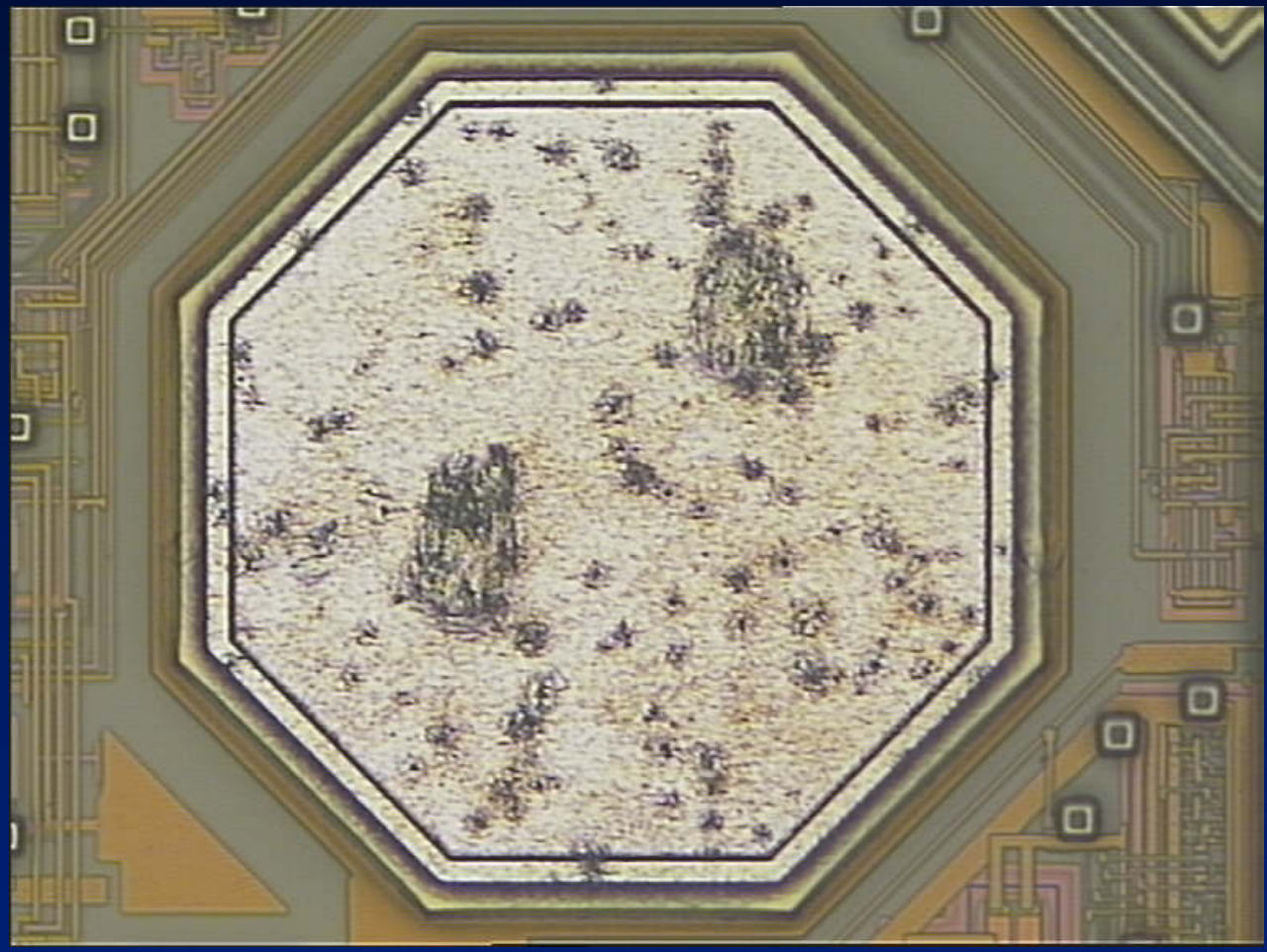
- The CO_2 bubbling process, which forms a dilute solution of carbonic acid, provides an even better environment for galvanic corrosion.
- Factors that affect the galvanic corrosion at wafer sawing process
  - Temperature
  - Exposure time in the process
  - CO_2 bubbling that was intended to increase the conductivity of DI water to prevent wafer from charging

Corrosion Study



Bond pads on the IC chip before wafer sawing

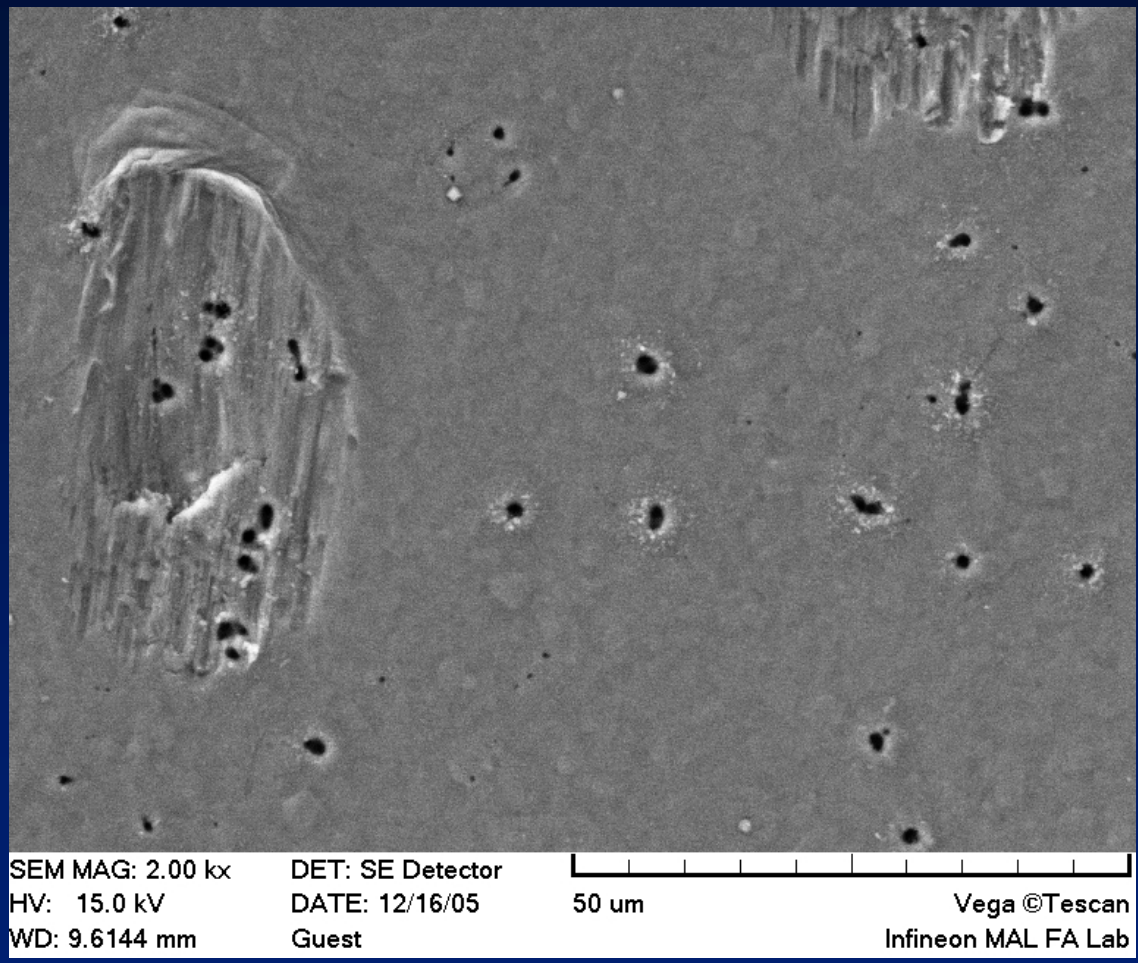
Corrosion Study



Bond pads on the IC chip after wafer sawing

(DI water with CO2 bubbling at 25⌖C)

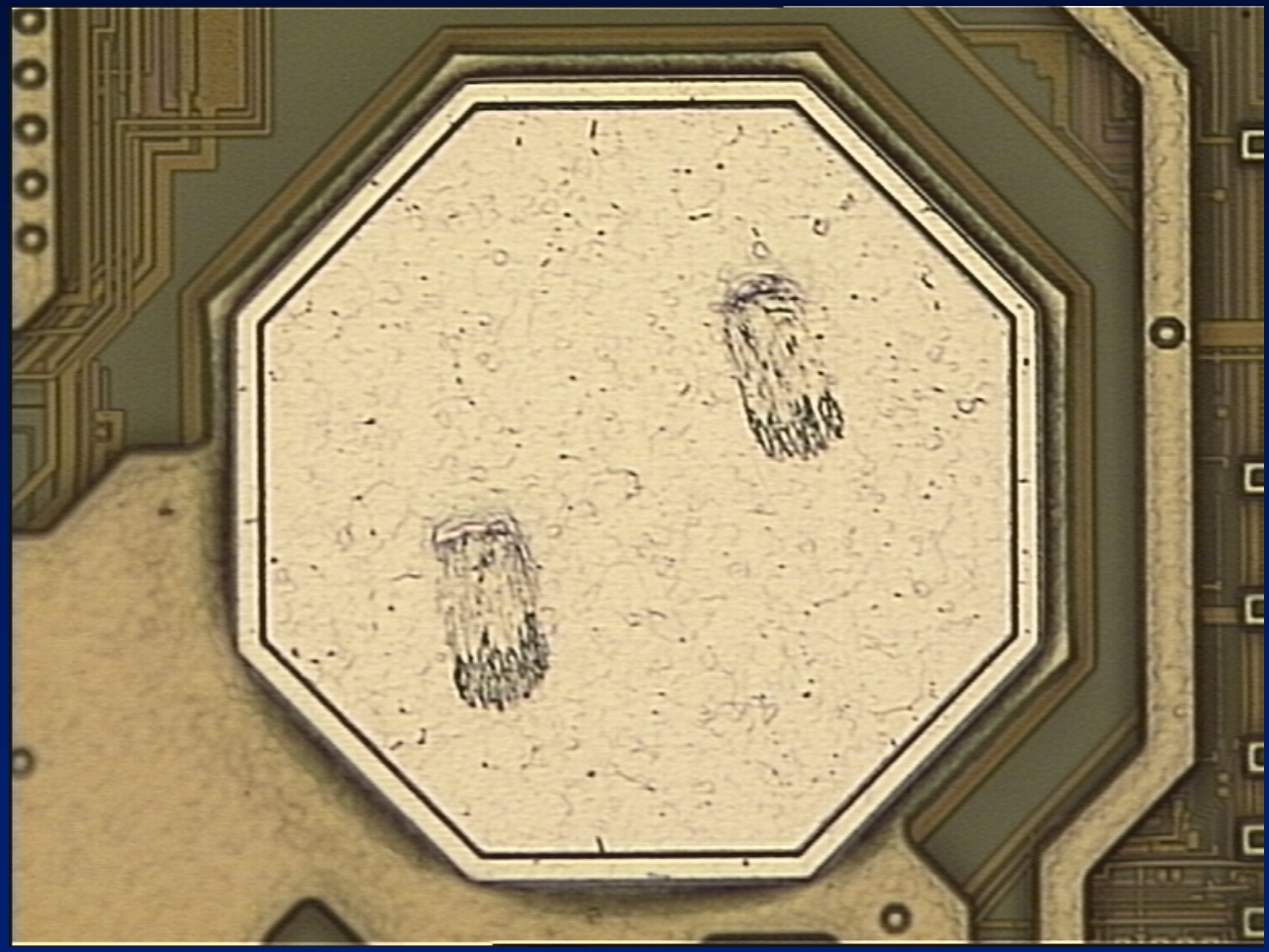
Corrosion Study



SEM photo - Bond pads on the IC chip after wafer sawing

(DI water with CO2 bubbling at 25⌖C)

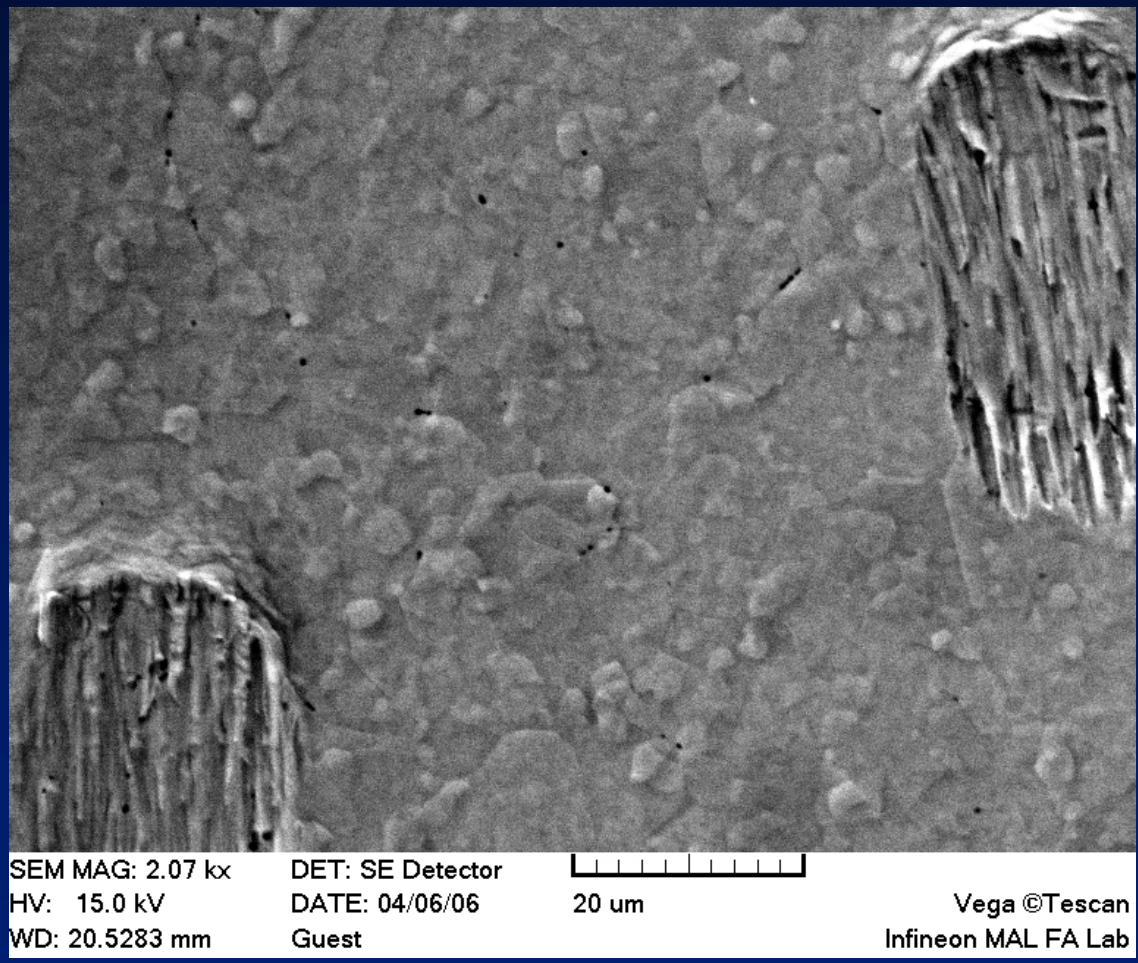
Corrosion Study



Bond pads on the IC chip after wafer sawing

(DI water with CO2 bubbling at 20⌖C)

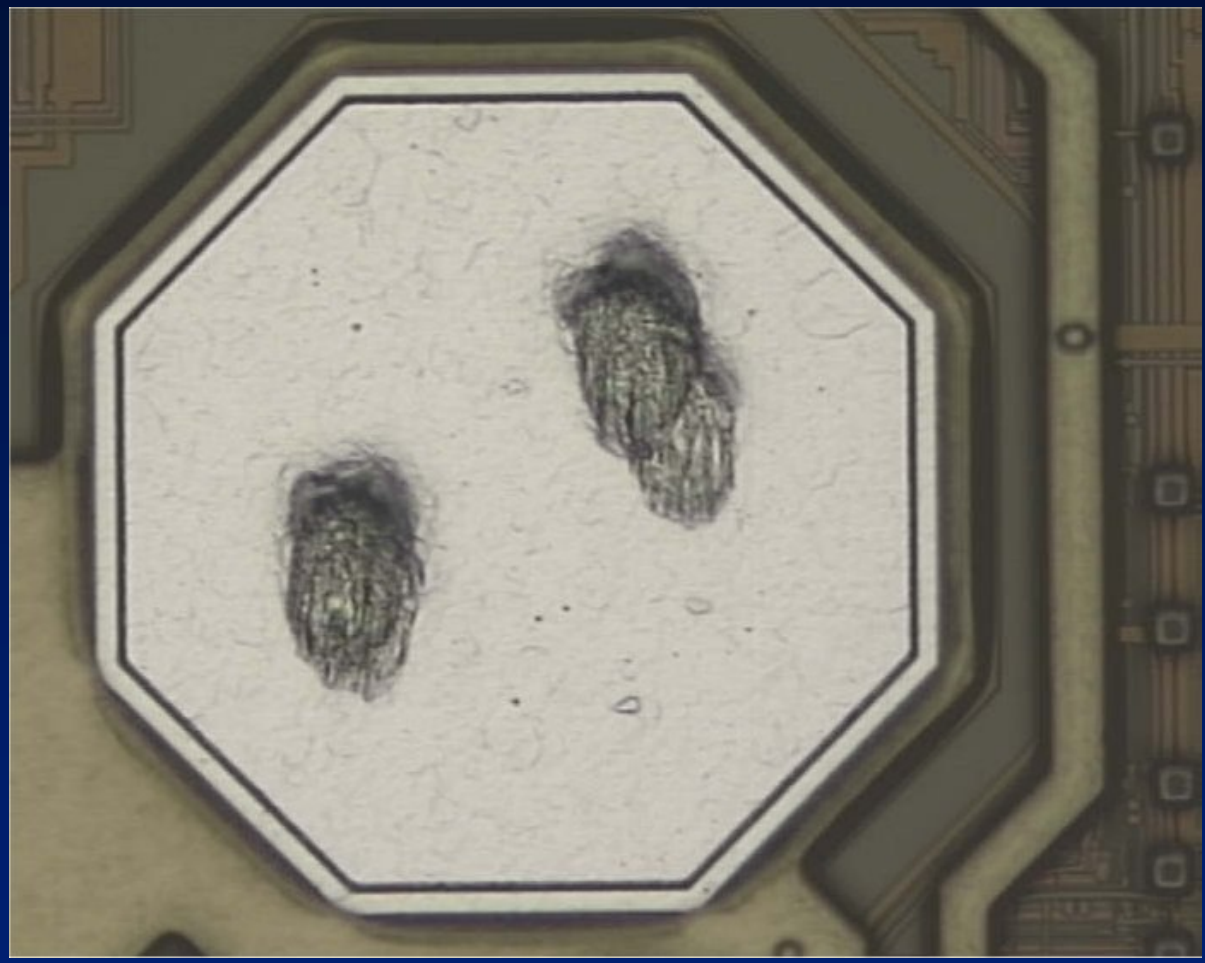
Corrosion Study



SEM photo - Bond pads on the IC chip after wafer sawing

(DI water with CO2 bubbling at 20⌖C)

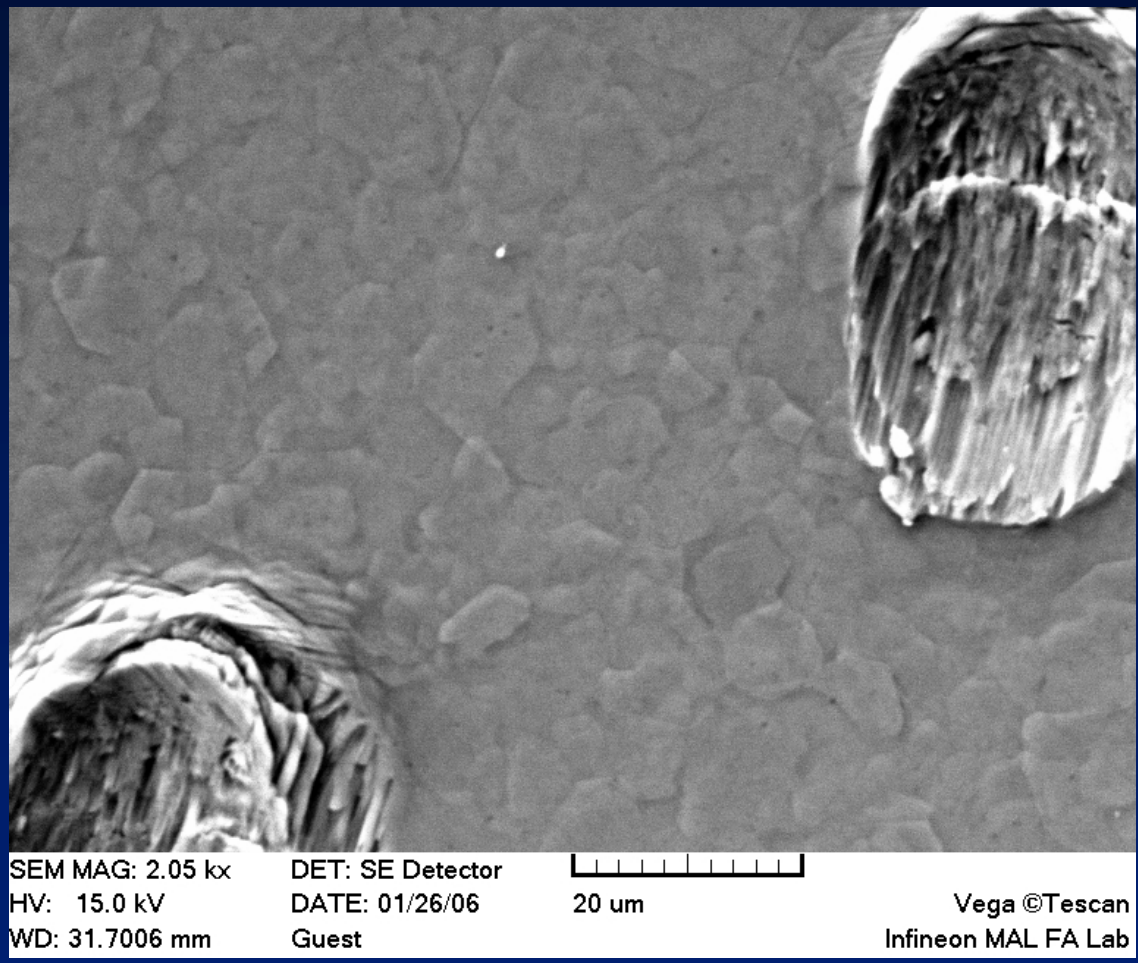
Corrosion Study



Bond pads on the IC chip after wafer sawing

(DI water with CO2 bubbling at 18 C)

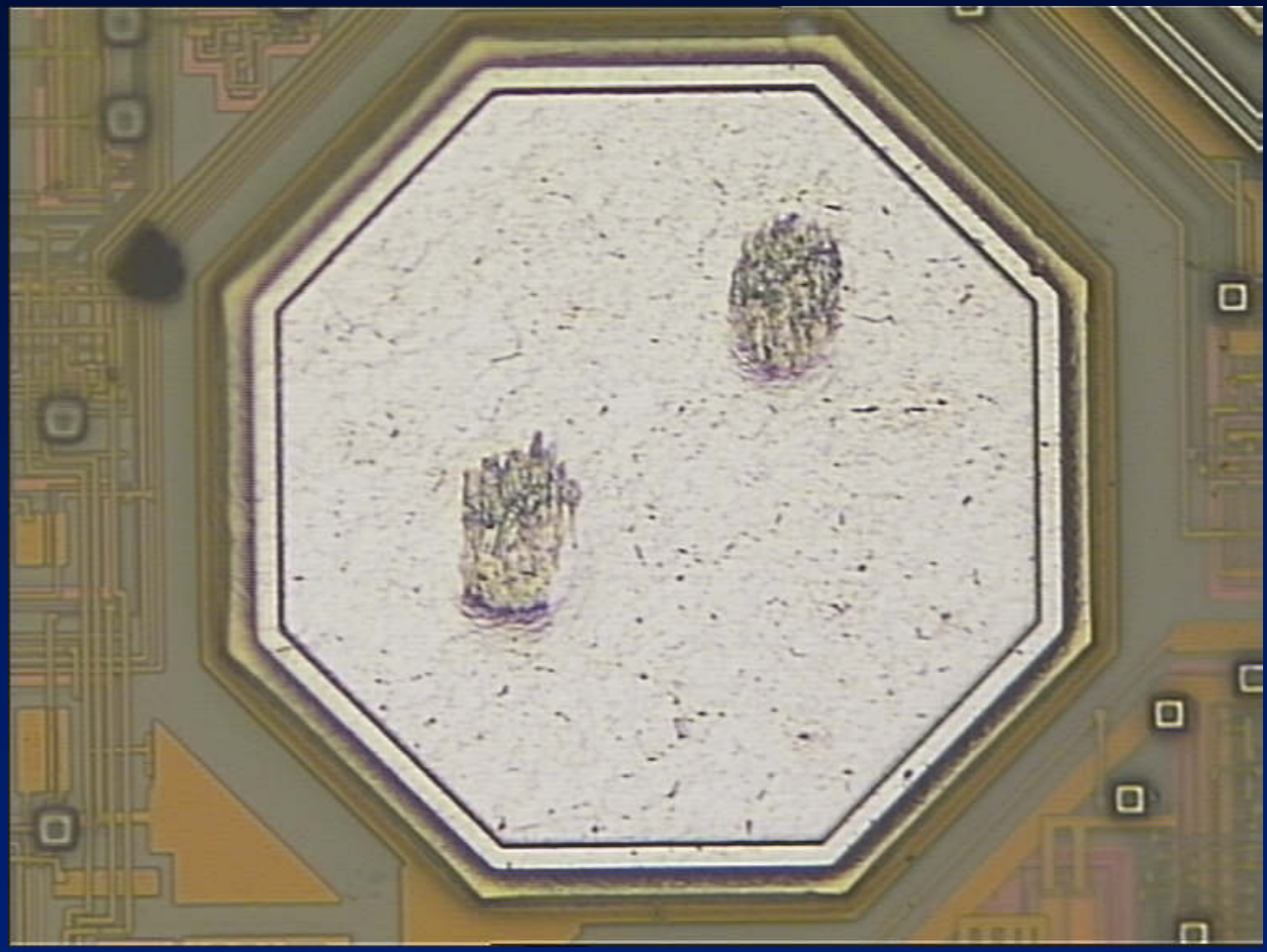
Corrosion Study



SEM photo - Bond pads on the IC chip after wafer sawing

(DI water with CO2 bubbling at 18⌖C)

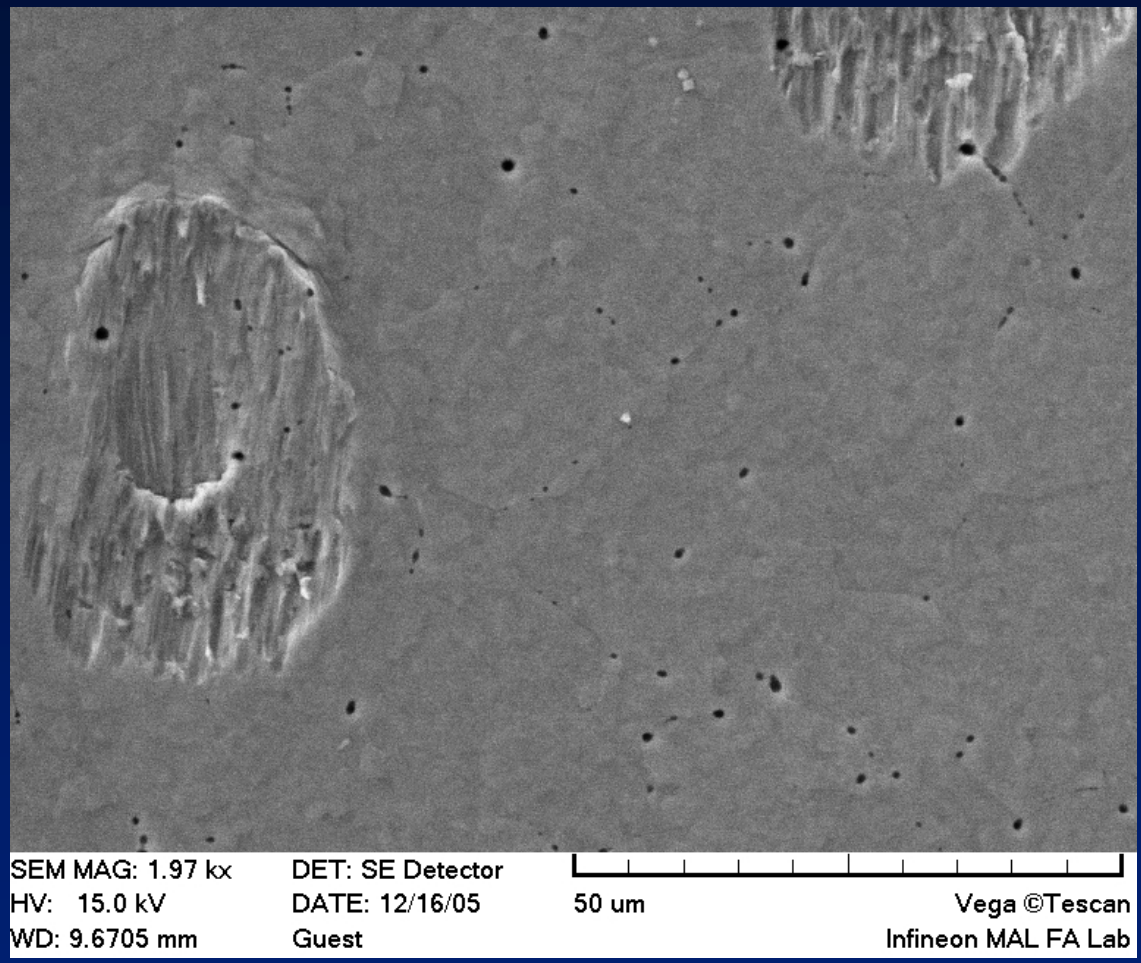
Corrosion Study



Bond pads on the IC chip after wafer sawing

(DI water without CO2 bubbling at 25⌗C)

Corrosion Study



SEM photo - Bond pads on the IC chip after wafer sawing

(DI water without CO2 bubbling at 25⌖C)

Conclusions

- ESD concerns at semiconductor back end wafer sawing process were investigated.
- The results do not support the claim that there are static issues for DI water without CO2 bubbling.
- On the contrary, DI water with CO2 bubbling contributes negative impact on bond pad metal corrosion.
- Cleaning efficiency of ion rich DI water (through intended CO2 bubbling process) is questionable and yet to be investigated. DI water saturated with ions is no longer "hungry water"!

Backup Slides

Challenges Faced

- Encountered corrosion issues immediately after wafer sawing (galvanic corrosion)
- The Al-Si-Cu metallization system exists in two phases at different electrode potentials
- DI water has ion deficiency and grabs the ions from the surrounding and provides the electrolytic environment for galvanic corrosion

Challenges Faced (Cont.)

- The rate of corrosion is dependent on :
  - Temperature of DI water (less corrosion at lower temperature)
  - Dicing process time
  - Sensitivity of the different wafer types
- The rate of corrosion is accelerated further when CO_2 bubbled DI water is introduced
- CO_2 bubbling provides an even better environment for galvanic corrosion

Overview of the Wafer Sawing Process

- Dicing Operation
  - Main part of the sawing process time, up to 3h where the wafer is exposed to mild carbonic acid (CO_2 bubbled DI water is used)
- Post Dicing High Pressure Cleaning Operation
  - Short process time, ca. 45 s, where the wafer is exposed to mild carbonic acid (CO_2 bubbled DI water is used)
  - High pressure water spray is applied to the surface of the wafer

Conclusions

- There is no ESD concern at the dicing operation of the wafer sawing process
- CO_2 bubbling at dicing operation does not add value to the process. On the contrary, it can have negative impact in terms of chip corrosion and high wear out rate of the sawing blade
- Tribo-charging is confirmed at the high pressure spray cleaning process. CO_2 bubbling is able to reduce the tribo-charging to about 100V

Conclusions (Cont.)

- The most practical solution to electrostatic charging problems at semiconductor wafer sawing
  - Use DI water without CO_2 bubbling during the dicing process
  - Use DI water with CO_2 bubbling during the high pressure spray cleaning process

By this, the tribo-charging on the surface of the wafer can be reduced to a minimum safe level although a damaging effect has not been proven so far