Advancements in RH measurement in wafer and reticle environments

ALLYN JACKSON, *CyberOptics Corp., Minneapolis, MN*

Key IC fabrication steps are sensitive to moisture in semiconductor wafer environments. As the technology node advances, the need for characterizing and minimizing the exposure to relative humidity (RH) has become critical in all 29nm geometry fabs and below. These RH control requirements create a need for a wireless wafer-like humidity sensor which simultaneously measures RH at several points across the wafer as well as throughout the entire IC manufacturing environment.

Challenges with current methods for characterizing N2 FOUPS

Current methods for characterizing N2 Purge FOUPs have problems. These methods are typically not real time, are time consuming, are hard to use and are not able to take RH measurements under production conditions therefore are not reflective of these conditions. In addition, wired (**FIGURE 1**) hand-held RH meters (**FIGURE 2**) and single trace hand-held meters are limited to one area and cannot move throughout the process environment. Other options are hand-made alternatives (**FIGURE 3**) such as a wafer with RH sensors simply taped on. Lastly, they are often limited without data files generated so consequently statistics and quality standards cannot be established.

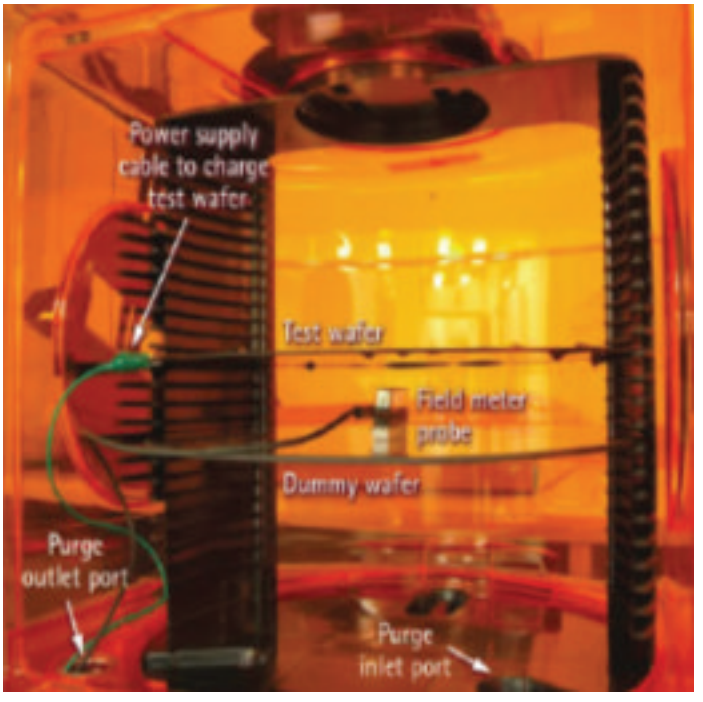

FIGURE 1. FOUP with Wired RH Sensors Attached

RH environment test target and goals

The test at the customer involved putting an RH meter inside the FOUP pointing around slot 13. The goal was to repeat the RH meter profile for testing a FOUP on one loadport without the need to open the FOUP. Starting at 40% RH (cleanroom environment), the first step was to run high purity, high volumnet

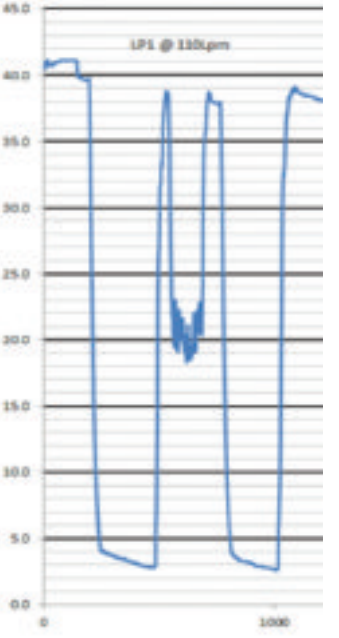

FIGURE 2. Hand-held RH Meter with Single Trace RH Reading

FIGURE 3. Silicon Wafer With 4 RH Recording Sensors Taped on.

N2 pre-purge for 4-5 minute and then take the reading. The second step is to conduct a maintenance purge to 5% and measure the results in 5 locations across the wafer. The next step was to run a process purge to 20% and take sample readings across various locations. The goal of the testing it to test the efficiency of the N2 purge FOUP diffusers to ensure that uniform purge levels are maintained.

FIGURE 4. WaferSense® Auto Multi Sensor Measurement Device.

In response to the need for a reliable easy to use method of qualifying N2 and XCDA environments, the WaferSense® Auto Multi-Sensor (AMS) by CyberOptics (**FIGURE 4**) was developed. WaferSense AMS is a wireless wafer-like device with five RH sensors to measure the RH profile across the entire wafer surface.

AMS is a complete and easy-to-use system which communicates wirelessly via Bluetooth to the MultiView™ application (**FIGURE 6**) and moves like a normal wafer to all locations in the wafer process environment providing a true characterization of the N2 purge uniformity. Such previously hard to accomplish tasks such as characterizing purge FOUP diffuser uniformity and measuring actual RH percentages are now easily accomplished with AMS. (**FIGURE 5**) AMS is a true multi-functional device which also measures vibration and can be used for leveling to ensure proper wafer handling.

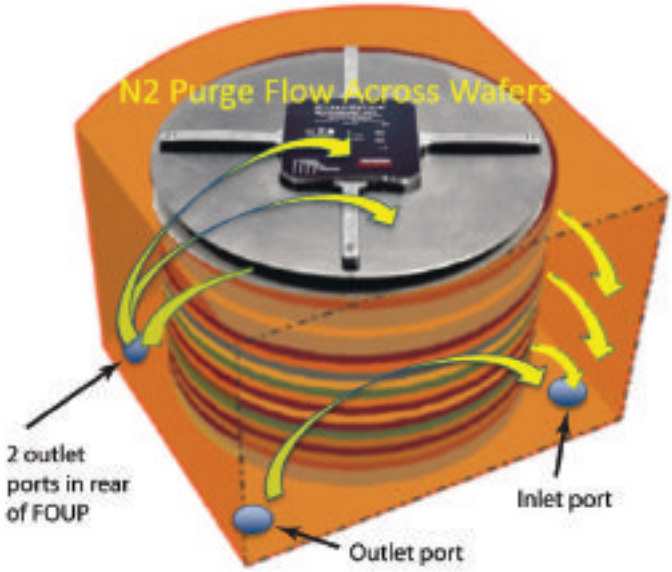

FIGURE 5. N2 Purge FOUP with 3 Inlet and one Outlet Ports.

29nm geometry fabs and smaller require well controlled N2 and XCDA purge environments to prevent defects and yield loss. AMS300 simultaneously measures RH in real-time at five locations on the wafer while it transfers like a wafer to qualify N2 and XCDA environments. The AMS device significantly shortens the task of qualifying

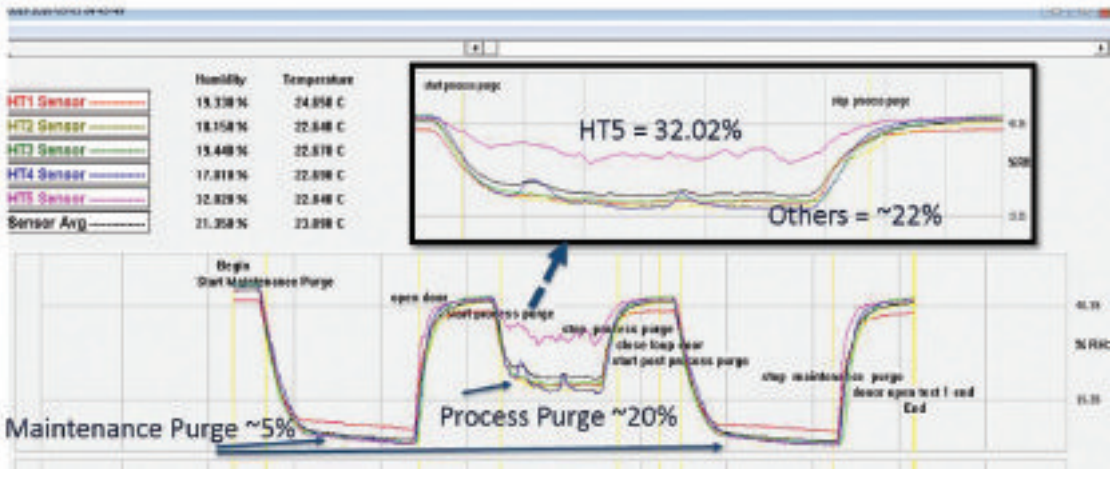

FIGURE 6. Profile of N2 Purge Using MultiView™ Software to Displays RH Measurements in 4 Sensor Locations across the Wafer Surface.

these environments. In addition, the AMS300 provides and vibration and leveling measurement capabilities to ensure proper wafer handling and reduced particles. The overall result for the fab is improved N2 purge environment uniformity which results in reduced defects and reduced labor costs.

Reducing reticle haze effects

193nm Immersion scanners are adversely affected by a phenomenon called "Reticle Haze" when proper measures are not taken to measure and control it. There are three areas that need to be controlled to reduce this haze effect on reticles, one of which is controlling RH. Reticle haze is accelerated when H2O is present. (**FIGURE 7**).

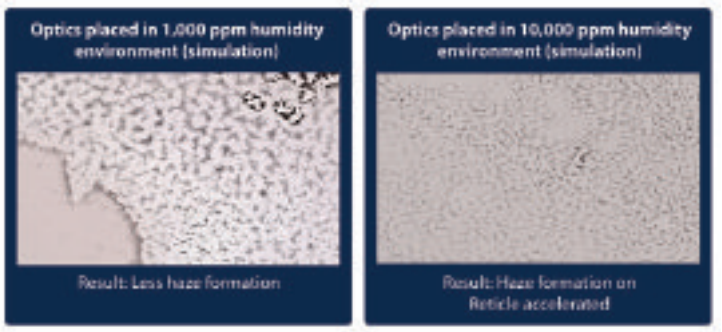

FIGURE 7. Reticle Haze Formation Accelerated with H2O

There is a key need for a measurement device that will eliminate the inefficiencies of the current methods.

Challenges with current methods for monitoring RH in reticle environments

There are several limitations with the current reticle environment RH measurement methods, for example, hand-held RH sensors (**FIGURE 9**.) are inconvenient and they can compromise the reticle environment. Plus, many areas are inaccessible by hand-held RH sensors, in-situ RH sensors or benchtop type RH sensors. (**FIGURE 8**.)

FIGURE 8. Benchtop RH Sensor

Additionally, the importance of particle, leveling, vibration and RH control has rarely been overlooked in reticle environment. However, the need to maximize both yields and tool uptimes in reticle mask environments requires best-in-class practices.

FIGURE 9. Wired In-Situ RH Sensor

Whether for diagnostics, qualification or preventative maintenance, equipment engineers need to efficiently and effectively make measurements and adjustments to the tools. Legacy particle, vibration, leveling and RH measurement methods are typically cumbersome, non-representative, not real time, compromise the production environment and are costly with downtime required to take the tool offline for these tasks.

By contrast, best practice methods involve collecting and displaying data in real-time, speeding equipment alignment or set-up. Real-time data also speeds equipment diagnostic processes, saving valuable time and resources. Equipment engineers can also make the right adjustments consistently by using objective and reproducible data that enhances process uniformity.

The ReticleSense® AMSR (**FIGURE 10**) is an actual glass reticle that measures H2O in the reticle environment and is

FIGURE 10. ReticleSense® Auto Multi Sensor Measurement Device.

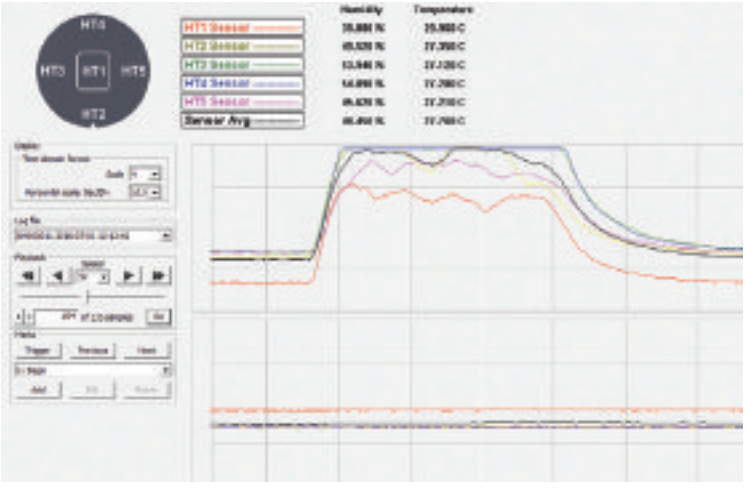

FIGURE 11. RH Measurement

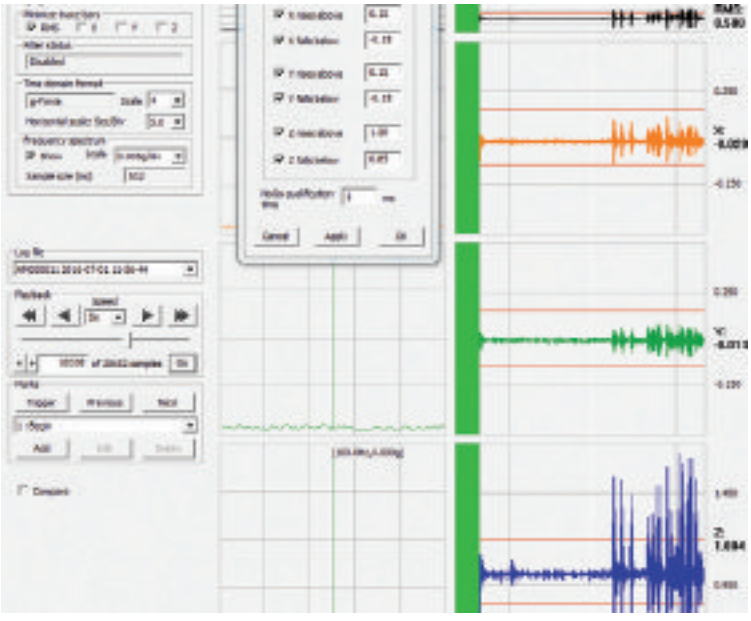

FIGURE 12. Vibration Measurement

compatible with ASML, Canon and Nikon scanners. AMSR is used to travel throughout the entire reticle environment and measures RH. (**FIGURE 11**) It helps locate the sources of the H2O which results in increased reticle lifetime. Two additional measurement capabilities of the device include measuring X, Y and X vibration (**FIGURE 12**) and inclination. (**FIGURE 13**).

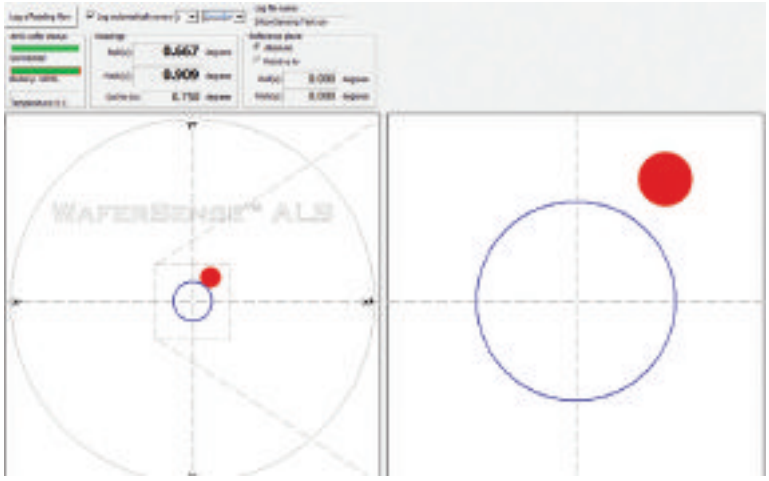

FIGURE 13. Leveling Measurement

Conclusion

The AMSR travels the entire path of the reticle and can measure humidity in all locations. In immersion scanner environments, monitoring humidity is critical in reticle reducing haze. Equipment qualifications can be done faster as the same device also measures vibration and leveling. Controlling inclination, RH and vibration are all important factors in increasing yield and reducing downtime.

For RH measurements in N2 and XCDA reticle mask environments, the use of a real-time measurement device, the Auto Multi Sensor, delivers on three compelling bottom lines for the fab – saving time, saving expense and improving yields.