APC FOR FLUID DELIVERY PROCESSES

Introduction

Advanced Process Control (APC) will play a pivotal role in many semiconductor processes as the industry migrates to new 300 mm tools and processes and upgrades older 200 mm tool sets.

A key goal for APC will be the reduction of process related excursions to maximize yields and profits. Measurement and metrology equipment installed in fluid delivery processes will enable APC for fluid processing steps in etching, cleaning, CMP and plating applications.

The NT® Integrated Flow Controller enables Advanced Process Control (APC) for fluid handling operations in wet processing tools used throughout the semiconductor manufacturing process. By using DeviceNet communication protocol, the flow controller provides key information for fault detection and classification and predictive maintenance. In addition, the flow controller provides fast, accurate and repeatable flow control for run-to-run control and real-time control for fluid delivery processes.

In wet processing equipment, several operational parameters may be affected by the fluid delivery process: chemical blend ratios, chemical concentration, fluid flow rate, fluid dispense pressure, nozzle spray pattern, etch rate and chemical mechanical planarization rate. By using metrology equipment and liquid flow controllers, these parameters may be adjusted using an APC system to develop optimal flow and dispense conditions for the fluid delivery system.

This paper will discuss the requirements for sensing and control equipment for integration within an Advanced Process Control system. This paper will also review the use of DeviceNet communication protocol for liquid flow controllers, which enables the implementation of APC for fluid delivery processes.

APC Requirements for Sensing and Control Equipment

The sensors/controllers used in fluid delivery processes must meet basic requirements for usage by an APC system: provide fault detection and fault classification, provide predictive maintenance information, allow for interoperability and interchangeability, respond to run-to-run change requests and respond to real-time control change requests.

Fault Detection and Classification

The sensor/controller must be capable of detecting and classifying a fault or a condition that is outside of preset specifications. By detecting abnormal conditions, the process tool can then terminate wafer processing to minimize or eliminate wafer scrap events. By properly classifying the type and the source of the fault, the component causing the fault can be identified immediately to bring the tool online rapidly and avoid downtime. Using fault detection and classification data as a diagnostic tool enables tool users to keep unscheduled downtime events to a minimum.

Predictive Maintenance

The sensor/controller must provide the APC system with information regarding the sensor/controller status and any preventive maintenance. By monitoring key attributes associated with routine maintenance, the user can plan for the necessary service and schedule appropriate time to minimize unnecessary downtime.

Interoperability and Interchangeability

An industry standard communication protocol is required to ensure the sensor/controller is interoperable and interchangeable across many sensor suppliers. By using an open and modular architecture, like DeviceNet communication, sensors can communicate and transfer data to the APC system within a standardized format.

Respond to Run-to-run Control Changes

Information collected from sensors and metrology equipment allows the APC system to change parameters on a run-to-run basis. Parameters and data from each previous run are used to set the parameters of subsequent runs, with the ultimate goal of reducing the run-to-run process variations and avoiding wafer scrap. As the batch size of each run is reduced, such as with 300 mm single wafer processes, the user approaches the panacea of real-time control adjustments.

Respond to Real-time Control Adjustments

The capability to adjust process parameters in real-time is dependent upon the sensor and the metrology equipment providing fast and accurate data to the APC system. By adjusting parameters while the process is running, the process can operate at optimal conditions during each wafer run.

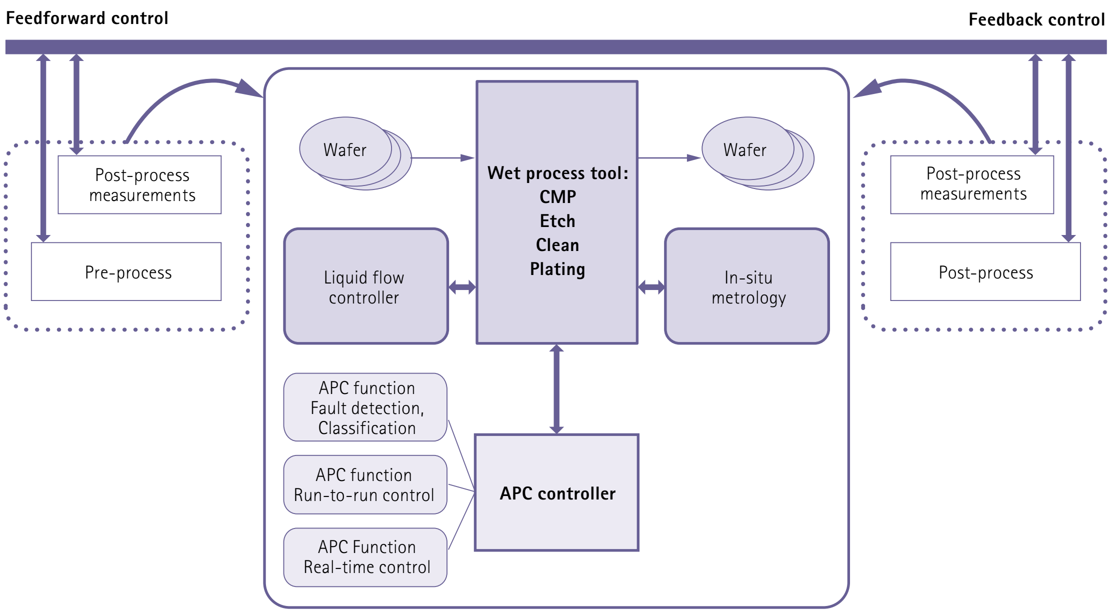

Figure 1. A generalized APC schematic to achieve better uniformity of process parameters by using liquid flow control.

DeviceNet Communication

The NT Integrated Flow Controller uses DeviceNet communication protocol to transmit the required process data, faults, alarms and diagnostic information to the APC control system. The DeviceNet communication protocol is preferred for semiconductor instrumentation and sensors/controllers, and the SEMI® organization has adopted and developed standards for using DeviceNet communication, including:

- ODVA DeviceNet Specification, Volume I and II, Revision 2.0, Errata 5, dated March 31, 2002
- Interface Guidelines for DeviceNet Devices on Semiconductor Manufacturing Tools, Revision 2.4, dated June 6, 2003

What is DeviceNet Communication?

DeviceNet is a low level communication protocol for sensors, actuators and higher level devices (i.e., liquid flow controllers). Originally developed for industrial control applications, DeviceNet communicates control related information, including product configuration, status, diagnostics and fault conditions.

DeviceNet is an open network communication protocol commonly used in the industrial controls market and the "language" of the protocol is defined by the guidelines set forth by the Open DeviceNet Vendor Association (ODVA). The protocol allows for the digital adjustment of the flow set point and broadcasts messages if errors are detected or a fault or alarm condition exists.

In addition, the flow controller also has visual indicators, LEDs, mounted on the product enclosure to indicate the health of the controller and its status on the network.

Listed below are some of the benefits of using the DeviceNet communication enabled flow controller:

- Lower installation costs
- Reduced wiring; "daisy chain" eliminates point-to-point wiring
- Lower check-out and startup costs
- Interoperability
- Interchangeability, use products from multiple vendors "seamlessly"
- Lower maintenance costs, increased uptime
- Network and device diagnostic information available digitally
- Local (LEDs) visual indication and network health notification
- Increased process flexibility
- Allows devices to be reconfigured between batches or "on the fly"
- Devices can be added to the network while the network is live (i.e., "hot swap")
- Digital measurement accuracy
- Increased speed of communications

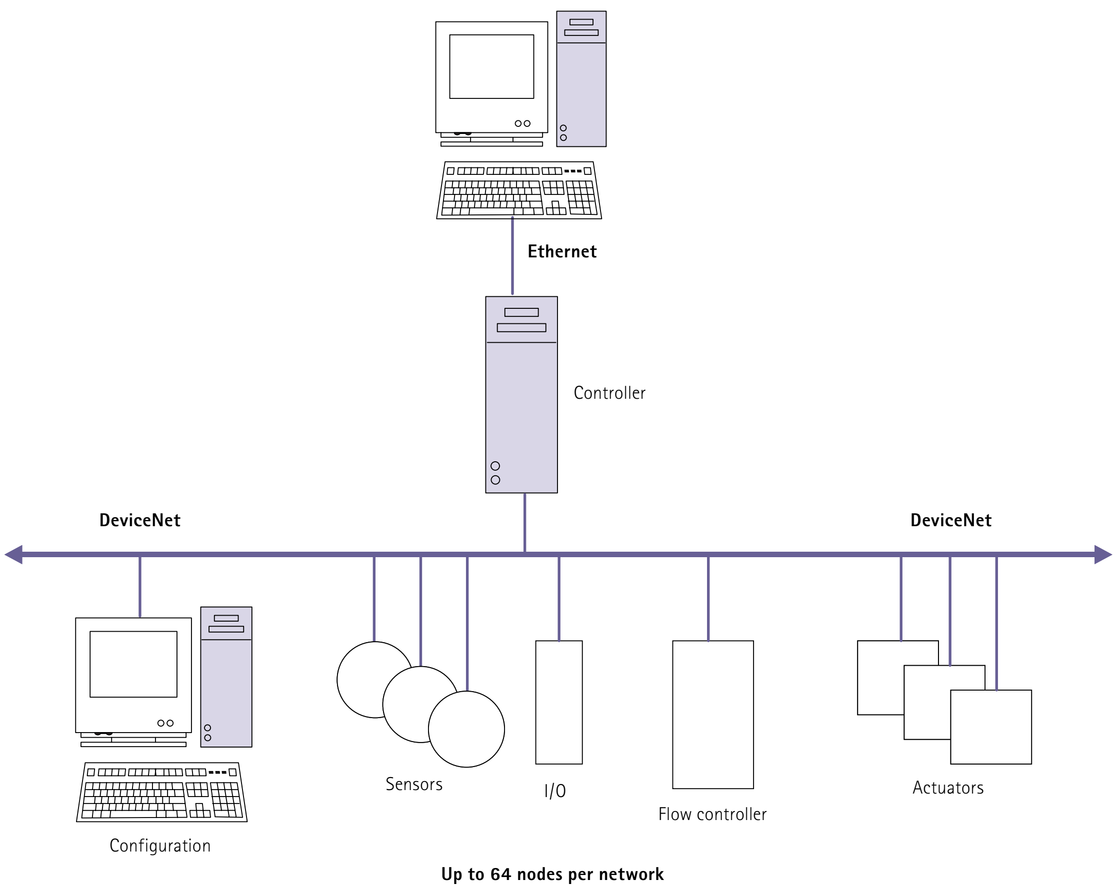

Figure 2. Typical DeviceNet communication network.

Flow Controller Faults and Diagnostics

Listed below are some of the faults and diagnostics available from the NT Integrated Flow Controller with DeviceNet communication:

Flow Measurement Faults:

- Flow alarm/warning status
- Flow high/low alarm trip point
- Flow high/low warning trip point

Pressure Measurement Faults:

- Pressure alarm/warning status
- Pressure high/low alarm trip point
- Pressure high/low warning trip point

Valve Controller (Actuator) Faults:

- Actuator safe state value
- Actuator override value

Figure 3. NT Integrated Flow Controller with DeviceNet communication protocol.

The NT Integrated Flow Controller

The NT Integrated Flow Controller utilizes a differential pressure (DP) flow measurement, a high performance control valve and embedded electronics to provide accurate closed-loop control for in-situ monitoring and control of process fluid flow. High accuracy and repeatability allow users to optimize bath chemistry for immersion processes and fine-tune blend ratios for point-of-use chemical dispense applications.

Conclusion

By using DeviceNet communication protocol, the NT Integrated Flow Controller enables the use of Advanced Process Control systems for fluid delivery processes and equipment. By reducing the number of process related excursions, the APC system will minimize unplanned downtime and increase overall process yields for etching, cleaning, CMP and plating processes.

ENTEGRIS, INC.
Corporate Headquarters | 129 Concord Road | Billerica, MA 01821 USA
Customer Service Tel. +1 952 556 4181 | Customer Service Fax +1 952 556 8022
In North America 800 394 4083 | *www.entegris.com*

Entegris
creating a material advantage

 3963-1887ENT-0313