BLOOMY CONTROLS, INC.
839 Marshall Phelps Rd.
Windsor, CT 06095-2170
860-298-9925
inquiry@bloomy.com

Field Offices:
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New Jersey 201-818-0117

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LabVIEW Speeds Development of CMP Semiconductor Fabrication Control System

The Advanced Process Control (APC) Group within IBM's Microelectronics Division in East Fishkill, NY, is developing and managing the implementation of a new endpoint detection system to control a chemical mechanical polishing/planarization (CMP) semiconductor wafer fabrication process at IBM development and manufacturing lines around the world. The group decided to migrate its endpoint program written in Microsoft Visual Basic to National Instruments (NI) LabVIEW. The project will use a new digital telemetry system to transmit digitized sensor data, which will be acquired by the control program using RS-232 communication. While the instrument is being built as part of the digital receiver, the IBM development group contracted Bloomy Controls to design and develop a LabVIEW RS-232 communications driver and to simulate full functionality of the digital receiver. This simulation tool will enable IBM to develop the wafer-polishing control program in parallel with the design and fabrication of the actual digital receiver.

System Overview

While details of IBM's CMP semiconductor wafer fabrication process control system are confidential, including the nature of the sensor data, Figure 1 gives a general overview. The system has three main components: a transducer embedded inside the polisher, a wireless receiver, and a polishing control PC, which will be connected to communicate with IBM's production control network.

Two cables connect the polisher and the wireless receiver. One RS-232 cable connects the receiver and the endpoint control PC, which also will be connected to IBM's production network. In this way, the control PC receives the START signal from the polisher and issues STOP or ALARM signal to the polisher, all through RS-232 communication. Within the polisher, the sensor signal is acquired, conditioned, and digitized. It then modulates the FM carrier before being transmitted wirelessly. The transmitted signal is processed

Continued on page 2

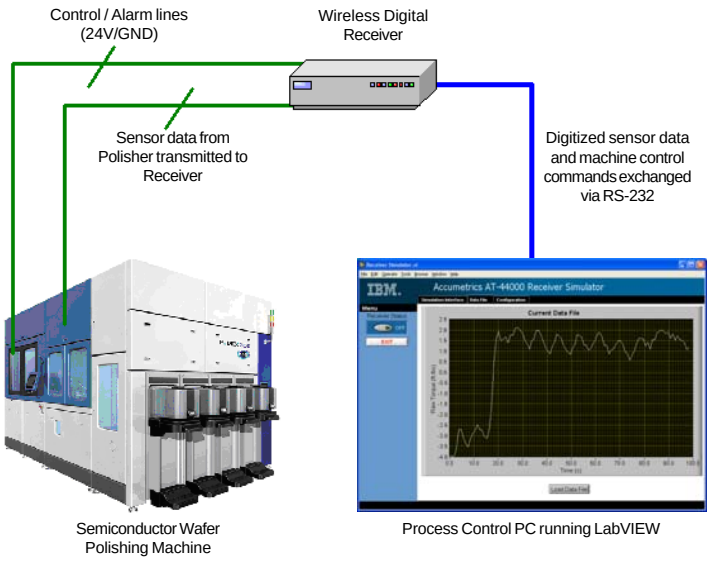

Figure 1. Illustration of CMP process control configuration

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inside the receiver unit to recover the embedded digital sensor data, which is sent to the control PC for further analysis and endpoint control. This "all digital" approach of digitizing sensor signal prior to transmission and communication via RS-232 makes the data virtually immune to the noise introduced during the signal propagation. This approach also eliminates additional hardware associated with the data acquisition and signal conditioning.

The wireless receiver transmits data blocks to the process control PC via RS-232. Data blocks, sent by the wireless receiver every 10 milliseconds, contain the coded digital information of the latest sensor measurement and machine status. The process control PC parses the data packets, evaluates machine status, and applies the new sensor data to a complex set of calculations to determine if the polishing operation should stop. The process control PC also can send the receiver a variety of commands related to machine control and sensor calibration.

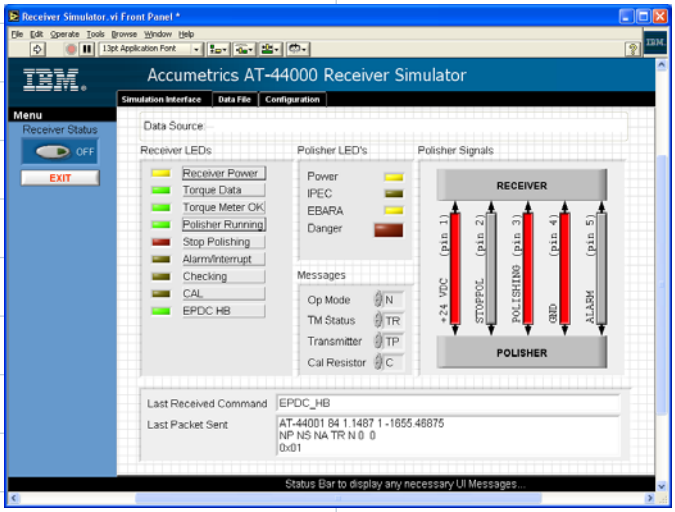

Figure 2: LabVIEW user interface of wireless receiver simulator

RS-232 LabVIEW Driver for Wireless Receiver

To communicate with the wireless receiver being built, a LabVIEW communication driver is needed. The driver must perform the following:

- Support two-way serial communication via RS-232
- Receive and parse data blocks sent from the receiver every 10 milliseconds
- Send "heartbeat" or watchdog command to the receiver once per second
- Send a variety of machine control and calibration commands to the receiver.

LabVIEW's serial communications is implemented using VISA functions. Bloomy Controls' professional LabVIEW style guidelines require VISA functions be used to ensure code uniformity, robust performance, and ease of transition to other protocols if required in the future.

LabVIEW string functions and shift registers handle the data block parsing. Sensor data is extracted from each data block and passed to higher-level VIs for smoothing and analysis. Other data relating to machine condition will be extracted from the data block and routed to subVIs for evaluation. The driver sends a heartbeat command to the wireless receiver at regular one-second intervals. The receiver is designed to generate an alarm if the heartbeat command is not received within a four-second period.

In addition to the heartbeat command, the driver can send 11 other commands to the wireless receiver for functions such as stop polishing; check sensor, sensor zeroing and calibration, and alarming. While the driver is developed to communicate with the receiver, the LabVIEW-based simulator allows for thorough testing of the driver prior to the physical receiver being available.

LabVIEW-based Simulator

To streamline development efforts and meet the project timetable, IBM desired to fully replicate the functionality of the wireless receiver. Bloomy Controls designed the simulator to provide the following core features:

- Load sensor data from user-selected file
- Construct and transmit data blocks every 10 milliseconds
- Receive and respond to commands from process control PC
- Allow user to click on front-panel LEDs to simulate the desired machine condition change.

Measurement data files, captured during actual wafer polishing, are provided by IBM for more realistic simulations. The user selects the desired data file through a standard Explorer-type interface. The simulator then adds one sensor data point at a time to data blocks it constructs and sends. Each data block contains information about the current machine status, as reflected on the user interface (Figure 2). The simulator is designed to react to commands received from the process control PC just as the actual wireless receiver would react. For example, if a stop polishing command were received, the applicable front-panel indicators would reflect this new status and subsequent data blocks would acknowledge the receipt of the command. The user interface includes status LEDs that match the physical wireless receiver. The LEDs are interactive, allowing the user to click on them to change the state of that parameter.

Why LabVIEW?

The APC Group at IBM previously developed and deployed with success a large number of wafer fabrication process control systems based on Visual Basic (VB). These systems also made use of NI Measurement Studio, which provided integrated measurement tools for VB and hardware compatibility with the NI DAQ hardware used. While existing VB/NI-DAQ systems continue to work well, the new Microsoft .net technology is not backward compatible with VB 6.0, making it difficult to maintain and improve the software and support end-user requests for enhancements.

Recognizing that LabVIEW would allow for faster incorporation of end-user requests, IBM contracted Bloomy Controls to help migrate the existing VB application to LabVIEW and provide ongoing, long-term support. Their primary reason being that many projects required the APC Group's attention, leaving little time to support the timetable for this task.

As mentioned above, the system will communicate with IBM's production control network. The availability and ease-of-use of LabVIEW-based tools for the required network protocols such as Modbus and SECS/GEMS also were key factors in the decision to go with LabVIEW.

Results

Developing the LabVIEW simulation tool will allow the IBM group to perform parallel development on multiple aspects of the wafer fabrication process control system. The simulation tool will ensure the driver software performs as intended with a minimum cost and significant savings in development time. When the physical wireless receiver is ready, there will be less troubleshooting or costs associated with modifications or rework.

Using LabVIEW, Bloomy Controls was able to deliver the simulation tool and driver in just a few weeks. This fast delivery gives IBM access to the wireless receiver functionality months before the physical unit is available. Development of the entire endpoint control system will be much faster as a result of early prototyping and troubleshooting facilitated by the simulation tool.

Contact Bob Hamburger (860) 298-9925 or inquiry@bloomy.com to discuss your simulation needs.

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Newsletter Staff

Editor, Phia Pascua Blume