Chemical usage reduction through real time monitoring

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MOTIVATION

The Texas Instruments production site in Freising/Germany started using the WetSpec200[(1)] near-infrared analyzer in 2013. The plan was to reduce chemical consumption and increase productivity for our legacy wet benches.

As in other fabrication sites, older equipment for wet processing had pour process control. The concentration of SC1 bath was not monitored. An etchrate test was done after every refill. The short bath lifetime caused 31% of planned downtime through refills and bath heating.

Fig.1 WetSpec200 CI-SEMI

DESCRIPTION OF THE APPROACH

The WetSpec200 measures the absorption spectrum of a fluid sample in the near-infrared . The device sends light from a halogen lamp through optical fibers to a flow cell with sapphire windows, after which it is sent back through optical fibers to a grating-based spectrometer. The spectrum is measured with an array of photo detectors.

The wavelength calibration of the spectrometer is fully automatic. For every measurement a dark spectrum and a reference spectrum (the lamp spectrum) are measured as well, thereby achieving excellent stability and repeatability. Chemical concentration is derived from changes in the spectrum through a software approach called "chemometrics"[(2)]. A "training set", a series of measurements with known concentrations, is supplied for the chemistry in use.

An algorithm correlates the spectral data to changes in concentration, creating a "calibration model", which is then used for determining the concentration of unknown solutions on-line. CI-Semi can supply models for different chemistries, for different concentration ranges and for different temperature ranges.

A proprietary fiber optic multiplexer allows for the use of up to eight flow cells, improving the cost efficiency of the instrument.

Flow cells are available with wetted parts of Teflon'", PEEK, or stainless steel, depending on the application. Wetted parts also include sapphire windows and Kalrez'" or Teflon'" encapsulated O-rings.

The system is housed in one 2U 19-inch rack unit and includes Ethernet, RS232 and 4-20 mA communications. A graphic user interface is provided that allows control of the instrument from remote computers through the user's local network.

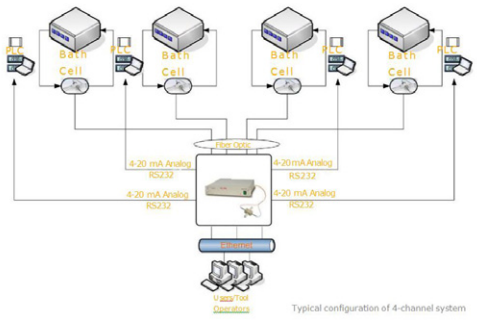

Fig.2 Typical configuration of a 4-channel system

INNOVATION

The first flow cell was installed on a classical 1:1:4 SC1 bath at 45°C (H2O2 : NH4OH : H2O). The flow cell gets installed in the recirculated line, after the filter housing. After the measurement outputs (NH3 and H2O2 concentration) were calibrated against data from an outside lab, we started to optimize the bath lifetime. A new software allowed spiking combined with a controlled opening of the drain valve. This gave us the opportunity to remove a defined amount of used acid and add fresh chemical in period intervals. So we made sure that the NH3 concentration stayed within a certain range and the tank does not get overfull. With this method the bath lifetime of the chemical mixture could be increased from 4 hours to 24 hours.

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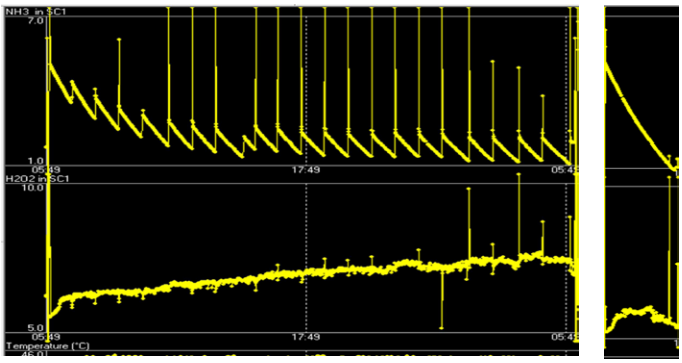
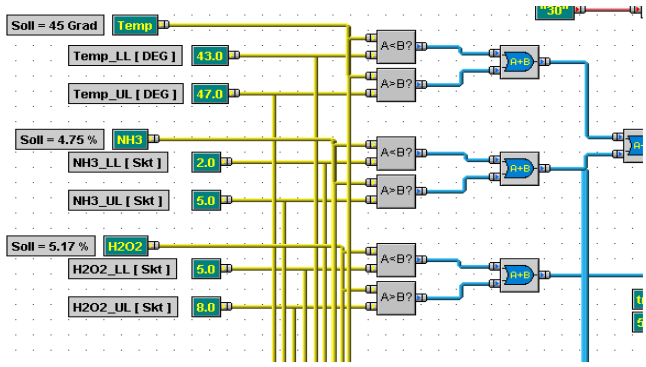


Fig.3 NH3 and H2O2 concentration for the 24 hours bath lifetime compared to the old process with 4 hours lifetime



Now the measurement values from the WetSpec were fed into TIMS[3]. With this method production is now regulated automatically. TIMS triggers whether manufacturing can start a lot or not. Every minute 3 data points are transmitted. The temperature of the bath is measured as well. So in addition the system provides a redundant measurement of the temperature.

Spiking is triggered every 60 minutes. TIMS forces a 5 minute interruption until the chemistry is stable again. It was proven, that the etchrates stayed stable over the 24 hours lifetime. With the improved process control in real time the routine etchrate testing could be eliminated.

RESULTS

On April 14th 2014 the SC1 bath TIN1 was released to production with the new conditions. The uptime of the equipment was brought from 67% to 93%. Within one year the savings in chemicals will be 30.000$. This only counts for the chemistry itself, not for the time heating the bath, the energy for heating and the disposal of the acid.
The approach of combining the WetSpec analyzer with a new software, TIMS and Automation was phased out to 4 other etch tanks. Here is a summary of the results for the other equipments:

Wet Bench	Chemistry	Ao old	Ao new	lifetime increase by factor
HOX2	buffered HF	95%	97%	1.48
TIN3	dilute SC1	74%	79%	3
TIN4	Pilot Recycling	84%	97%	30
TIN7	dilute SC1	91%	94%	2

Fig.4 Part of the TIMS model for TIN1

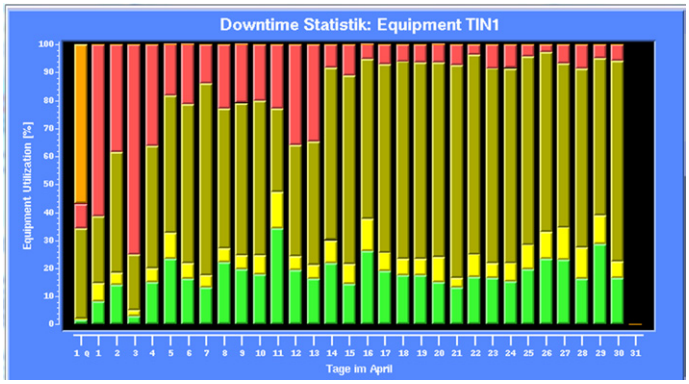


Fig.5 Downtime statistics of equipment TIN1 after implementation of real time monitoring combined with TIMS

REFERENCES

(1) WetSpec200: near-infrared analyzer from CI-SEMI, distributor POSAS GmbH
(2) Application Note1 WS200, CI-SEMI
(3) TIMS: Tool Interdiction Monitoring System, TI