Smart Sensing
Embedded Spectroscopy Platform

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Personal introduction

Background: Process Analysis
- DSM
- AKZO Nobel Chemicals
- Aspenpharma

2016: Sales Engineer Elscolab
- Optical measurements
- Spectroscopy

Process
- Industrial Process Monitoring
  - pH/O2/CO2/Cond. (liq)
  - UV/VIS/NIR
  - Turbidity
  - Concentration Analysers
  - Refractometry - Brix
  - Online / Inline Colour
  - Online Gloss
  - Inline Viscosity
  - TOC Sodium Silica
  - O2/CO2/CO Humidity (gas)
  - Galvanic Isolators & Displays

Enviro
- Environmental Water Monitoring
  - Flow / Velocity
  - Level
  - Multiparameter Sensors
  - Total Solids
  - Water Sampling
  - Portable Meters (pH/Cond./DO)

Lab
- Laboratory Equipment & Consumables
  - -80 -40 -20 Freezers
  - Refrigerators
  - Sample Storage
  - Lab Safety Monitor
  - Pipets (single...384 channels)
  - Flow Cabinets & PCR
  - Centrifuges Ovens
  - Waterbaths
  - Viscosity
  - pH/O2/Conductivity
  - Cuvets

Colour
- Colour, Appearance & Design Tools
  - Coating Test Instruments
  - Design Tools
  - Colour Meters
  - Cuvettes
  - Calibration Filters
  - Gloss Meters
  - Light Cabinets
  - Visual Colour evaluation
  - Total Colour Management
  - Road test instruments
  - Layer thickness
Spectroscopy

Study of the interaction between matter and electromagnetic radiation

- Position  > Characterization
- Level  > Amount
Computing

From ~1970’s: Advent of computers

• Scanning spectrometers
  – UV/ Vis
  – (N)IR
  – Raman

• Computing power and speed
  – Fourier Transformation
  – Pre-processing
  – Chemometric

• Sophisticated applications
  – CIE Color
  – Moisture, Fat, Protein
  – MON, RON, BTX, Blending
  – Substance and product characterization
  – Reaction monitoring
Computing power

Color:

Chemometric:
Laboratory Setup

- Process
- Sampling & Transportation
- Preparation
- Analysis
- Hours
- Result
- Action
On-line Setup

(Liquid, Solid, Gas)

Process

Sampling

Transportation

Analysis

Action

Seconds

Result

PROFI®

BUS
Partner in Spectroscopy

• About
  – Operates worldwide with subsidiaries in the US and partners;
  – Specializes in developing operating electronics for detector arrays and spectral sensors.
  – Leading company in UV–VIS, NIR and Raman spectroscopy

• Products
  – Electronics
  – OEM, custom setups
  – Catalogue spectrometer systems
Embedded Spectroscopy Platform

Embedded System:
An embedded system is a device with a dedicated function, Unlike the general purpose pc. This design optimizes size, power consumption, reliability, performance and costs. It is embedded as part of a complete device often including hardware and mechanical parts. Only an interface for parameterization is needed.
Incentive

Applications in Mobile, Machinery and Agriculture

• **End-user**
  – Measurement principle irrelevant
  – Act, feel and talk like a sensor

• **Environment**
  – Vibration and temperature
  – Moisture and dust

• **Disadvantage PC operating systems (Windows, Linux)**
  – Data and Internet Security
  – Stability
  – Upgrades / Updates

• **Dimensions**
Objective

Smart spectral sensor based on an embedded platform

• Integration
  – Electrical (Power, Voltage)
  – Dimension (Compact)
  – Environment (Protection, Cooling)
  – Real-time capabilities

• Spectrometer Control
  – Spectral chip
  – Alarm and status (Lamp intensity)
  – Method selection (Product change)
  – Handling triggers (Background)

• Data Processing
  – Scan elimination (Bubbles, particles)
  – Preprocessing (Derivative, Baseline)
  – Evaluation (FT, Chemometric, Color)
  – Calculations

• Communication
  – Control system
  – Specific protocols
  – External sensor (GPS, temperature)
  – Handshake/Watch-dog
Result

Conventional installation

Embedded approach
Architecture

Storage Cloud/Server

Configuration

WAN/LAN

Spectrometer

Machine Controller

Industrial Comm.

Control Room
Combine Harvester

**Controller**
Operation harvester
Parameter visualization

**Embedded system**
1Hz measurement rate
Data evaluation with 10 chemometric models
CAN-Bus

**Remote measurement head**
NIRS Reflectance
2x 10.000h lamps, Lamp control
Internal reflectance standard
Electroplating

- PCB and Wafer production
  - Fully automated
  - High quality regime

- Fe$^{3+}$/Cu$^{2+}$ concentration

- UV-Vis spectroscopy
  - Continuous, fast
  - Accurate

- Autonomous sensor
Electroplating Application

- Two main wavelengths $\text{Fe}^{3+}$ and $\text{Cu}^{2+}$
- Temperature
  - Variation
  - Needs compensation
  - Measure and correction within spectrometer

![Graph showing absorbance vs. wavelength and concentration of $\text{Cu}^{2+}$](chart)
Electroplating System

- Mini Xenon Flash lamp
- UV-Vis spectral sensor
- Custom flow cell
  - Full Teflon
  - Quartz transmission
  - Low restriction
  - Temperature sensor
- Dimensions: 240 x 200 x 130mm
- IP65
- EtherCat
Electroplating implementation
Expansion of the platform

E.g. Fiber optic version

• Single channel
  – Measurement channel
  – Reference internal channel

• Remote sampling
  – Probes (Reflectance, Transmittance, ATR)
  – Flow cells (Transmittance, ATR)
  – Reflectance heads
Wrap up

www.embedded-spectroscopy.com

Classical vs Embedded, depends on situation

.... An approach for chemical industry?