CLOUD INTEGRATION OF ELECTRODE MANUFACTURING VIA AUTOMATED TRACKING AND ANALYSIS OF MACHINE AND QUALITY DATA

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Overview

1. Motivation
2. Electrode Manufacturing Process
3. Cloud Integration
    1. Cloud-based Data Management
    2. Data Acquisition
    3. Combined Data Evaluation
4. Summary and Outlook

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1. Motivation

- Process chain, **traceability** of process parameters

https://www.eirichusa.com/media/k2/galleries/50/Lithium%20Ion%20Battery%20Paste.jpg

https://lygte-info.dk/pic/BatteryDisassembly5000mAh/DSC_5480.jpg

- Research: Find causal connections between parameters
- Production: Quality assurance
- Legal requirements

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2. Electrode Manufacturing Process

As it was …

Slurry production → Coating and drying

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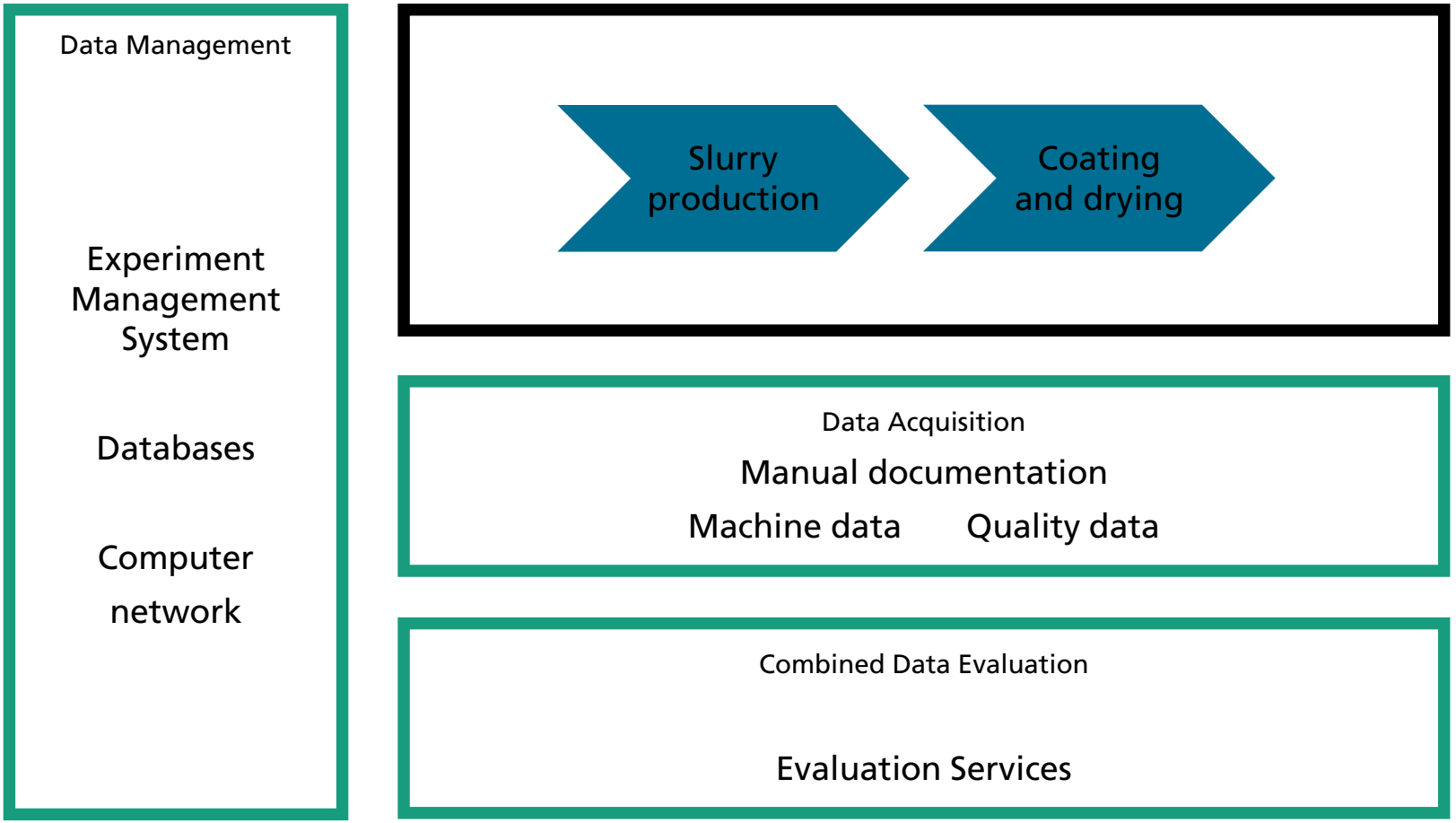
2. Electrode Manufacturing Process

… and with our extensions.



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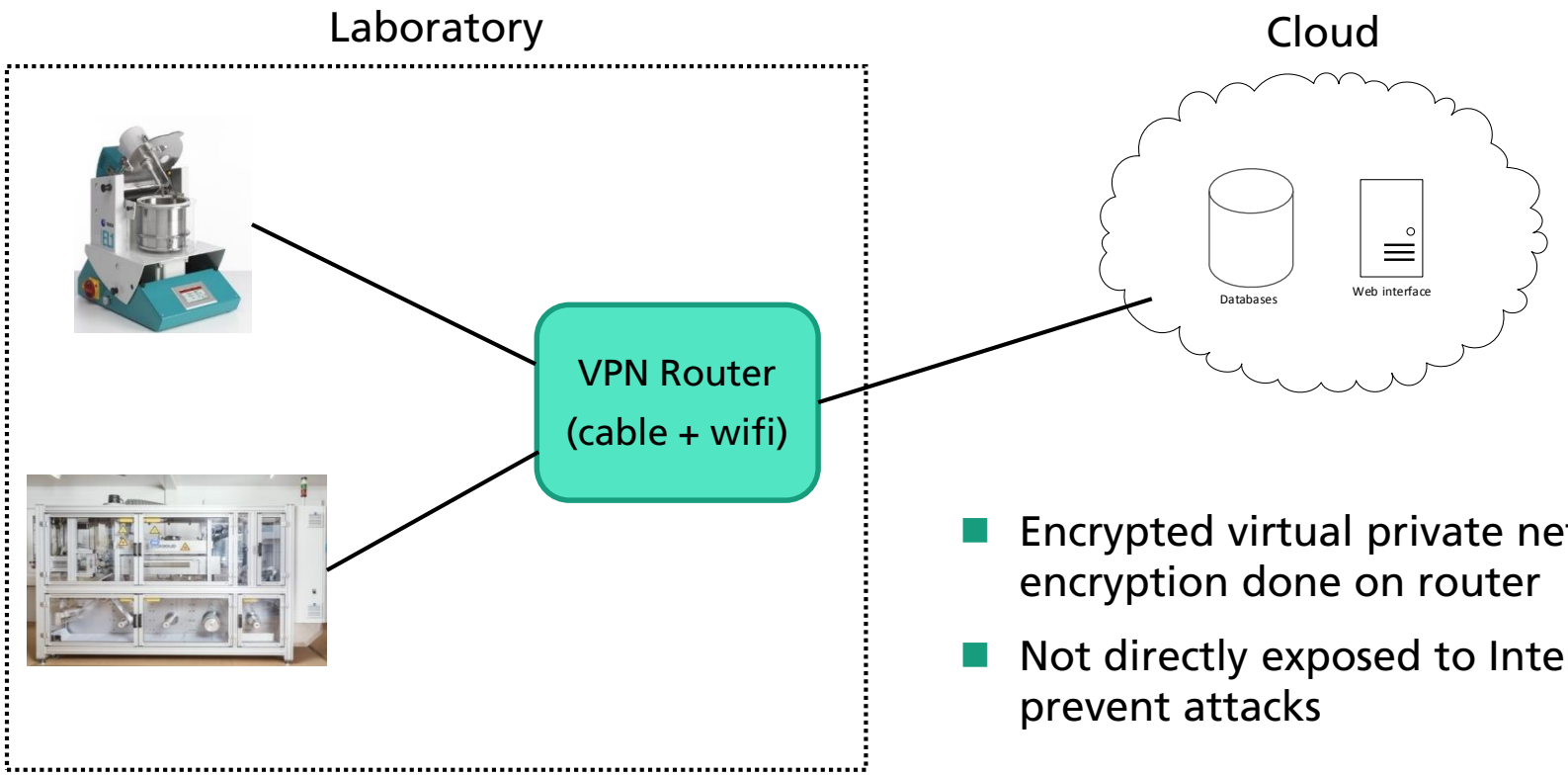
3. Cloud Integration
3.1 Cloud-based Data Management

Cloud Connectivity



- Encrypted virtual private network; encryption done on router
- Not directly exposed to Internet, prevent attacks

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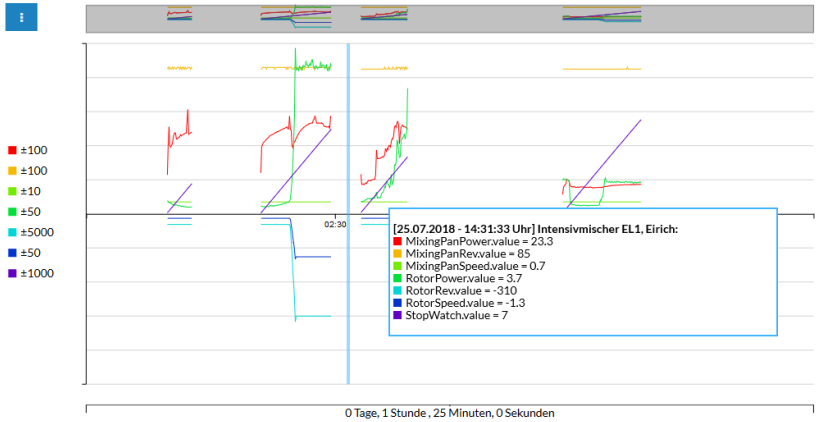
3. Cloud Integration
3.1 Cloud-based Data Management

Experiment Management System

- “MES for laboratory demands”
- Creation and tracking of our experiments in a cloud environment: Data access anywhere, any time.
- Notion of experiments, machines, materials, products, etc.
- Storage of data as time series, e. g. “motor power each 1 sec”.
- Visualization of machine data in a diagram to compare the course of individual fields



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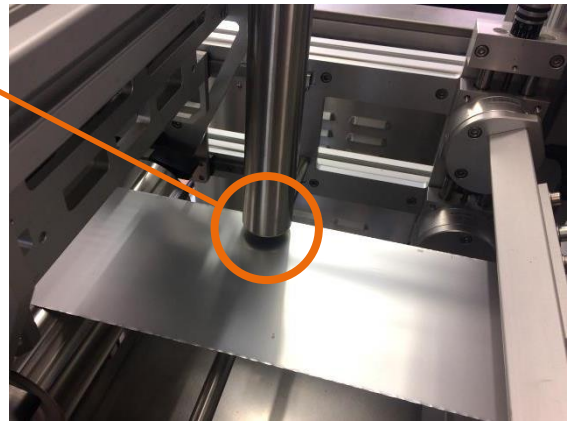
3. Cloud Integration
3.2 Data Acquisition

Electrode Band Tracking

- Printer, marks the band with a data matrix code.
- Can be applied and read automatically at high machine speeds.
- Printing speed aligned to R-2-R web speed
- Prints experiment ID, retrieved from experiment management system
- Only little impairment of the electrode layer due to small code



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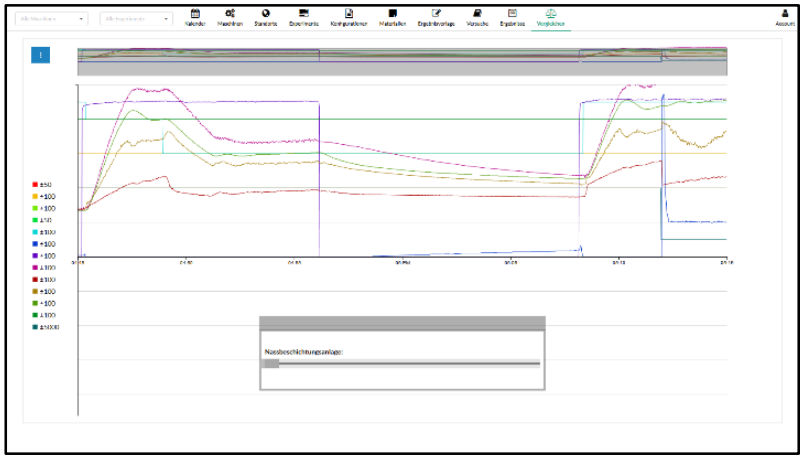
3. Cloud Integration
3.2 Data Acquisition

Machine Data and Manual Inputs

- Relevant parameters
  - Mixer: rotor power, rotations per min, …
  - R-2-R machine: pump speed, web speed, web tension, drying temperature, …
  - Plus manually measured inputs like: slurry viscosity, optical surface quality, …
- Machine data acquisition
  - Mixer has USB interface, was equipped with mini computer
  - R-2-R has OPC-UA interface, attached via standard IP network
- Readout and storage of machine data by implemented cloud services



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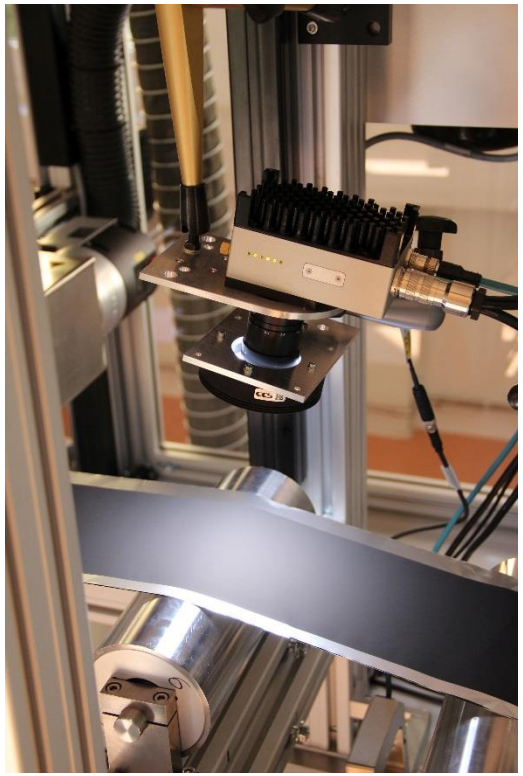
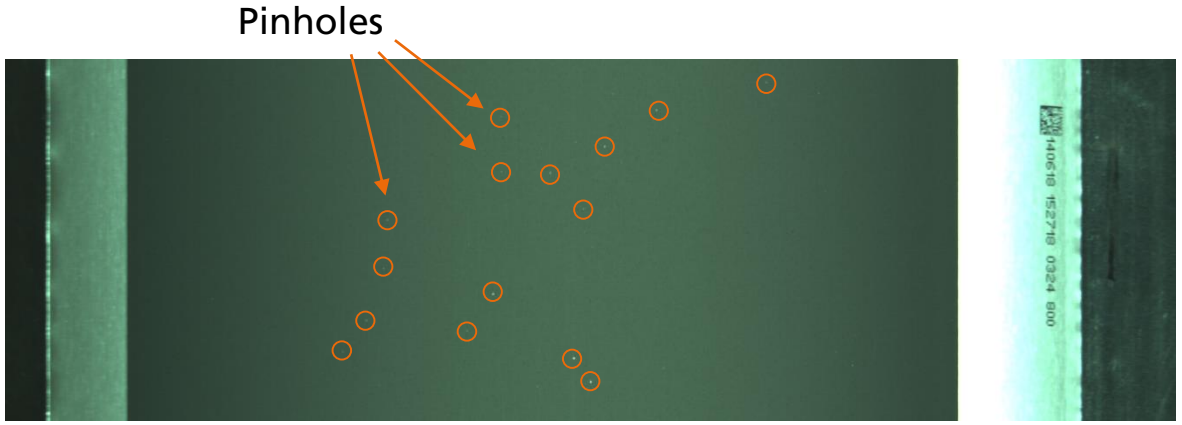
3. Cloud Integration
3.2 Data Acquisition

Coating Quality Features

- Camera, white illumination, 500 lines/s
- In-line, cloud-controlled
- Storage of raw images in cloud database
- Detected features:
  - Pinholes in coating
  - (Agglomerations – only big ones)





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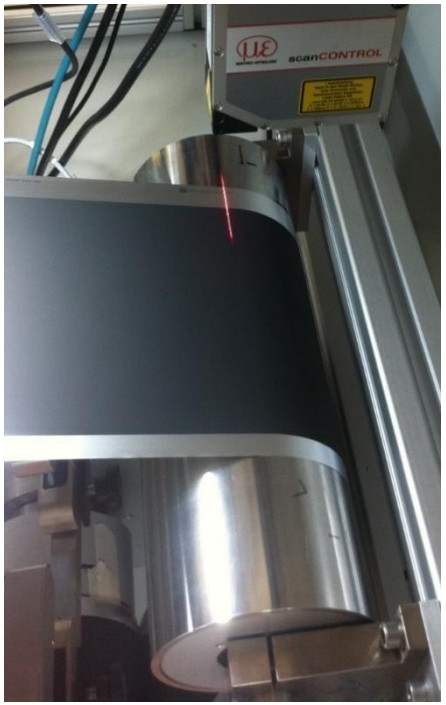
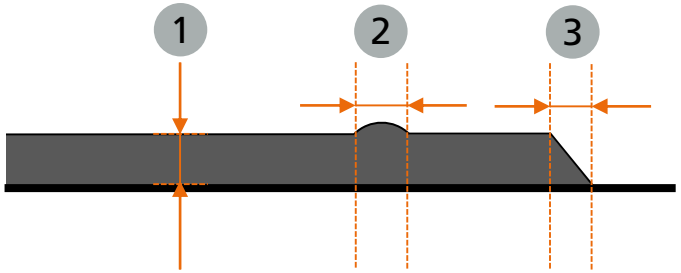
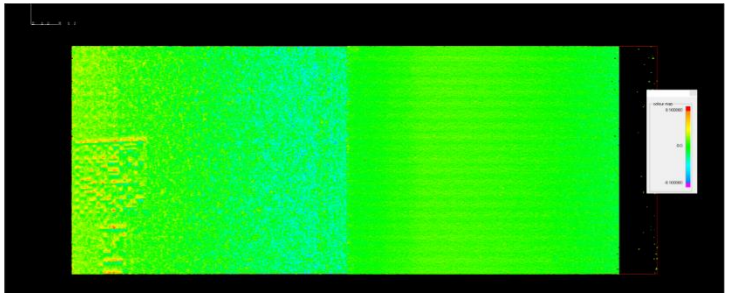
3. Cloud Integration
3.2 Data Acquisition

Coating Quality Features

- 3-D laser sensor, 500 profiles/s, measurement width 25 mm
- In-line, cloud-controlled
- Storage of raw height profiles in database
- Detected features:
    1. Thickness of coating
    2. Height anomalies (surface ratio)
    3. Position and steepness of edge







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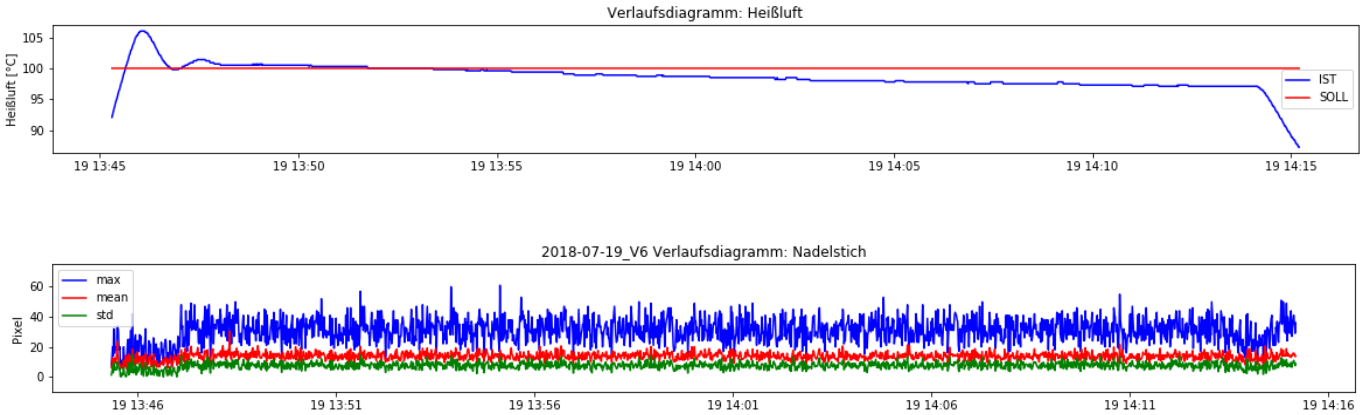
3. Cloud Integration
3.3 Combined Data Evaluation

- Manual execution of investigation
- Using machine learning methods
- Comparison of machine and quality data



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4. Summary and Outlook

Summary

- Traceability
  - Cloud integration possible for modern and older devices
  - Data storage and processing in the cloud
  - Printer, camera and 3-D sensor controlled by central experiment management system
- Quality data acquisition
  - Visual camera + illumination: pinholes
    - appropriate detection quality and price
  - 3-D sensor: coating thickness, height anomalies, edge steepness
    - in-line, but limited accuracy compared to e.g. 3-D micro CMM
    - difficult trade-off: resolution vs. measurement range vs. price

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4. Summary and Outlook

Outlook

- Improve quality feature detection
  - Use more appropriate optical system to improve pinhole and agglomeration detection
  - Results seem plausible, but prove it.
- Collect more data
  - Execute more experiments, varying parameters

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- Project participants at Fraunhofer IPA:
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  - Andreas Frommknecht
  - Carsten Glanz
  - Fabian Schulz
  - Martin Schmauder
  - Ozan Yesilyurt

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