Perspectives for inline metrology introduction

System selection and dimensioning strategies

SURAGUS GmbH

Efficient Testing Solutions

AIMCAL R2R Conference USA 2018
Roll 2 Roll Web Coating and Finishing
With SPE's FlexPackCon
Phoenix, Arizona, October 28 - 31, 2018
List of Content

1. Company
2. Motivation
3. Process for system selection
4. Process for system dimensioning and setup
5. Summary
SURAGUS GmbH is a German Metrology Specialist

**SURface ArGUS = Surface guard**

**Technology**
- Eddy current-based testing solutions (SURAGUS)
- Other integrated metrology (OEM)

**Location and Presence**
- R&D and manufacturing in Germany
- EddyCus systems are present on six continents

**Ownership**
- German privately owned

**Applications**
- Quality assurance of functional thin-films

**Values**
- accurate and reliable solutions
- smart solutions (reverse calibration, automated self-reference, T stabilized)
- high technical flexibility (gap sizes, sensor setups, traverse and fixed)
- excellent service (close contact / short response times)
Motivation

„Perspectives for inline metrology introduction - System selection and dimensioning strategies”

- **Personal history**
  - Explaining this process more than 100 times in the past

- **Relevance for process engineers**
  - Process engineers have often a different focus and background (physics or chemistry)
  - They are often new to this task since the introduction of new metrology is not part of their daily business
  - They thankful for a standardized approach and a positive experience in introducing new tools

- **Relevance at this time**
  - Many business run on high throughput. Hence, companies introduce new metrology tools to achieve higher yield at higher throughput at high quality

- **Contribution**
  - Contributing to this conference by providing a process with best practice approach and lessons learnt
Aspects for inline metrology selection

Many questions need to be asked and answered when getting a new inline metrology tool:

- What is the **best solutions and not just a solution** for acquiring the needed information
  - Technology
  - Vendor
  - Sensor setup, numbers, type(s), position(s), mounting
  - Parameterization
  - Interfaces
  - Visualization & software
  - Data storage

Here is a process to get the best solutions:
1. Definition of the measurement task

Which Information is required to achieve the technical goals?

- **Type of information**
  - Physical parameter
    - E.g. thickness, color, absorption, sheet resistance, barrier properties
  - Relative / absolute
    - Relative to ensure homogeneity
    - Absolute to ensure a specific function

- **Quantification of information**
  - Once per roll, once per inch, once per mm
  - Center measurement vs. cross web measurement, image

- **Recipient of information**
  - Process engineer, coating equipment, product customer
2. Definition of requirements for selecting a technology

What are the requirements for selecting a technology?

- Requirements for inline thin-film thickness gauging tools
  - Measurement range
  - Accuracy
  - Automation ability
  - Reliability/maturity
  - Applicable in-line or in vacuum (includes speed)
  - Costs suiting the budget
3. Selection of capable technologies

How this can be measured? (Technology)

- **Research**
  - Literature, internet, network, exhibition/conferences

- **Clustering of technology**
  - Direct vs. indirect methods
  - Destructive vs. non-destructive methods
  - Often destructive methods allow the direct measurement, whereas most non-destructive (non-contact) methods use indirect relations and, therefore, require calibration or reference parameters.

- **Considering material stack eg. substrate separation**
  - Conductive and non-conductive
  - Transparent and semi or non-transparent
  - Reflective and non-reflective
  - Ferromagnetic and non-ferromagnetic
4. Assessing available methods against the requirements

Overview mechanical thickness gauging methods

- Typically requires physical contact and a physical step
- Well known technology
- Inexpensive

<table>
<thead>
<tr>
<th>Method</th>
<th>Range [μm]</th>
<th>Automation</th>
<th>in-situ</th>
<th>in-line</th>
<th>Accuracy [%]</th>
<th>Speed [s]</th>
<th>Maturity [h,m,l]</th>
<th>Relative costs [h,m,l]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dial Gauge</td>
<td>0.1 - 1000</td>
<td>(+)</td>
<td>+</td>
<td>&gt; 0.5</td>
<td>1</td>
<td>60</td>
<td>h</td>
<td>l</td>
</tr>
<tr>
<td>Profile Method</td>
<td>0.025 - 0.1</td>
<td>+</td>
<td>+</td>
<td>0.05</td>
<td></td>
<td></td>
<td>h</td>
<td>m</td>
</tr>
</tbody>
</table>

4. Assessing available methods against the requirements

Overview thickness determination by weight measuring

- Medium costs
- Inline and insitu applications
- Mature technology

<table>
<thead>
<tr>
<th>Method</th>
<th>Range [μm]</th>
<th>Automation</th>
<th>in-situ</th>
<th>in-line</th>
<th>Accuracy [%]</th>
<th>Speed [s]</th>
<th>Maturity [h, m, l]</th>
<th>Rel. costs [h, m, l]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis &amp; micro weights</td>
<td>0 - ...</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>0,01</td>
<td>60</td>
<td>h</td>
<td>m</td>
</tr>
<tr>
<td>Quartz monitor method</td>
<td>0.0005 - 1</td>
<td>+</td>
<td>+</td>
<td></td>
<td>0.1nm</td>
<td>0.1</td>
<td>h</td>
<td>m</td>
</tr>
<tr>
<td>Chem. quant. analysis</td>
<td>0.001 - ...</td>
<td>-</td>
<td></td>
<td>+</td>
<td>0.01</td>
<td>1h</td>
<td>l</td>
<td>m</td>
</tr>
<tr>
<td>Coulometric method</td>
<td>0.007 - 100</td>
<td>-</td>
<td></td>
<td>+</td>
<td>2..10</td>
<td>1..10</td>
<td>l - m</td>
<td>m</td>
</tr>
</tbody>
</table>

4. Assessing available methods against the requirements

Overview of radiometrical thickness gauging methods

- Variety of testing methods and setups are available
- Mature technology
- Medium to high costs
- Requires safety measure to cope with radioactive tools

<table>
<thead>
<tr>
<th>Method</th>
<th>Range [μm]</th>
<th>Automation in-situ in-line</th>
<th>Accuracy [%]</th>
<th>Speed [s]</th>
<th>Maturity [h,m,l]</th>
<th>Rel. costs [h,m,l]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radioact. transm.(α)</td>
<td>0.001 - 1</td>
<td>+</td>
<td>+</td>
<td>3.5</td>
<td>&gt; 1</td>
<td>m - h</td>
</tr>
<tr>
<td>Radioact. transm.(β)</td>
<td>0.15 - 200</td>
<td>+</td>
<td>+</td>
<td>2.5nm</td>
<td>0.05s</td>
<td>h</td>
</tr>
<tr>
<td>Tracer method</td>
<td>0 - *</td>
<td>+</td>
<td>+</td>
<td>0.001nm</td>
<td>&gt; 60</td>
<td>l</td>
</tr>
<tr>
<td>Beta-Back-Scattering</td>
<td>0.05 - 300</td>
<td>+</td>
<td>+</td>
<td>1.15</td>
<td>5.60</td>
<td>m - h</td>
</tr>
<tr>
<td>Fluorescence method</td>
<td>0.005 - 400</td>
<td>+</td>
<td>+</td>
<td>1.5</td>
<td>1..15min</td>
<td>h</td>
</tr>
</tbody>
</table>

4. Assessing available methods against the requirements

Overview of magnetic thickness gauging methods

- Mature technologies
- Low to medium high cost
- Require magnetic layers

<table>
<thead>
<tr>
<th>Method</th>
<th>Range $[\mu m]$</th>
<th>Automation</th>
<th>in-situ</th>
<th>Accuracy $[%]$</th>
<th>Speed $[s]$</th>
<th>Maturity $[h, m, l]$</th>
<th>Rel. costs $[h, m, l]$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inductive methods</td>
<td>0.5 - 2000</td>
<td>+</td>
<td>+</td>
<td>1.5</td>
<td>0.1..0.5</td>
<td>h</td>
<td>l - m</td>
</tr>
<tr>
<td>Adhesion strength</td>
<td>5 - 1000</td>
<td>-</td>
<td>+</td>
<td>3..10</td>
<td>5..10</td>
<td>h</td>
<td>l</td>
</tr>
</tbody>
</table>

4. Assessing available methods against the requirements

**Overview of optical thickness gauging methods**

- Limitation to transparent layers (thin metal layers)
- Sensitivity towards micro structural effects and micro roughness
- Well inline applicable
- Medium to high costs

<table>
<thead>
<tr>
<th>Method</th>
<th>Range $[\mu m]$</th>
<th>Automation</th>
<th>in-situ</th>
<th>in-line</th>
<th>Accuracy $[%]$</th>
<th>Speed $[s]$</th>
<th>Maturity $[h, m, l]$</th>
<th>Rel. costs $[h, m, l]$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microscopy methods</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interferometric methods</td>
<td>0.004 - 2</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>0.8nm</td>
<td>20..60</td>
<td>m</td>
<td>m - h</td>
</tr>
<tr>
<td>Light irradiation</td>
<td>0.001 - 0.15</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>0.1$\lambda$</td>
<td>0.1s</td>
<td>l - m</td>
<td>m</td>
</tr>
<tr>
<td>Ellipsometry</td>
<td>0.001 - 3</td>
<td>-</td>
<td></td>
<td>+</td>
<td>&lt; 1</td>
<td>10</td>
<td>l - m</td>
<td>m - h</td>
</tr>
</tbody>
</table>

4. Assessing available methods against the requirements

Overview of ultrasonic thickness gauging methods

- Works for volume material from 250 µm
- Requires coupler medium like water even though there air coupled solution available
- Medium costs

<table>
<thead>
<tr>
<th>Method</th>
<th>Range [µm]</th>
<th>Automation</th>
<th>in-situ</th>
<th>in-line</th>
<th>Accuracy [%]</th>
<th>Speed [s]</th>
<th>Maturity [h,m,d]</th>
<th>Rel. costs [h,m,d]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impulse echo method</td>
<td>250 – &gt; 10cm</td>
<td>(+)</td>
<td>+</td>
<td>0.05mm</td>
<td>0.1</td>
<td>l-m</td>
<td>m</td>
<td></td>
</tr>
</tbody>
</table>

4. Assessing available methods against the requirements

Overview of electrical thickness gauging methods

- Medium costs
- Medium speed
- Low to medium maturity

<table>
<thead>
<tr>
<th>Method</th>
<th>Range [µm]</th>
<th>Automation</th>
<th>in-situ</th>
<th>in-line</th>
<th>Accuracy [%]</th>
<th>Speed [s]</th>
<th>Maturity [h, m, l]</th>
<th>Rel. costs [h, m, l]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Four point method</td>
<td>0.1 - 10</td>
<td>+</td>
<td>+</td>
<td>(+)</td>
<td>1</td>
<td>0.5</td>
<td>l - m</td>
<td>m</td>
</tr>
<tr>
<td>Capacity method</td>
<td>0.01 - 100</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>2</td>
<td>0.1</td>
<td>m</td>
<td>m</td>
</tr>
<tr>
<td>Breakdown field strength</td>
<td>0.02 - 25</td>
<td>(+)</td>
<td></td>
<td>+</td>
<td>5..10</td>
<td>1..10</td>
<td>l</td>
<td>m</td>
</tr>
</tbody>
</table>

4. Assessing available methods against the requirements

Overview of eddy current thickness gauging methods

- Requires conductive coating
- Very large measurement range
- Fast measurement method
- Mature method
- Medium to high costs

<table>
<thead>
<tr>
<th>Method</th>
<th>Range</th>
<th>Automation</th>
<th>+-situ</th>
<th>in-line</th>
<th>Accuracy [%]</th>
<th>Speed [s]</th>
<th>Maturity [h, m, l]</th>
<th>Rel. costs [h, m, l]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eddy Current</td>
<td>0.0005 - 500</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>0.5..10</td>
<td>0.001</td>
<td>h</td>
<td>m - h</td>
</tr>
</tbody>
</table>

4. Assessing available methods against the requirements

Focus the view on those technologies that fulfil the requirements

- Apply exclusion criteria's (e.g. 100 nm layer thickness and measurement time of 10 seconds)

<table>
<thead>
<tr>
<th>Method</th>
<th>Range [µm]</th>
<th>Automation</th>
<th>in-situ</th>
<th>in-line</th>
<th>Accuracy [Â­Å­]</th>
<th>Speed [s]</th>
<th>Maturity [h, m, l]</th>
<th>Rel. costs [h, m, l]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartz monitor</td>
<td>0.0005 - 1</td>
<td>+</td>
<td>+</td>
<td></td>
<td>0.1nm</td>
<td>0.1</td>
<td>h</td>
<td>m</td>
</tr>
<tr>
<td>Light irradiiation</td>
<td>0.001 - 0.15</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>0.1λ</td>
<td>0.1s</td>
<td>l - m</td>
<td>m</td>
</tr>
<tr>
<td>Radioact. transm. (α)</td>
<td>0.001 - 1</td>
<td>+</td>
<td>(+)</td>
<td>+</td>
<td>3.5</td>
<td>&gt; 1</td>
<td>h</td>
<td>m - h</td>
</tr>
<tr>
<td>Beta-Back-Scattering</td>
<td>0.05 - 300</td>
<td>+</td>
<td></td>
<td>+</td>
<td>1.15</td>
<td>5.60</td>
<td>h</td>
<td>m</td>
</tr>
<tr>
<td>Four point method</td>
<td>0.1 - 10</td>
<td>+</td>
<td>(+)</td>
<td>+</td>
<td>1</td>
<td>0.5</td>
<td>l - m</td>
<td>m</td>
</tr>
<tr>
<td>Capacity method</td>
<td>0.01 - 100</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>2</td>
<td>0.1</td>
<td>m</td>
<td>m</td>
</tr>
<tr>
<td>Eddy Current</td>
<td>0.0005 - 500</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>0.5..10</td>
<td>0.001</td>
<td>h</td>
<td>m - h</td>
</tr>
</tbody>
</table>

5. Selecting one or two technologies for further consideration

Assumption - metal coatings 10 nm – 1,000 nm on non-conductive substrates

- Large measurement range, high speed and maturity are most relevant for the selection

<table>
<thead>
<tr>
<th>Method</th>
<th>Range [$\mu$m]</th>
<th>Automation</th>
<th>in-situ</th>
<th>in-line</th>
<th>Accuracy [%]</th>
<th>Speed [s]</th>
<th>Maturity [h, m, l]</th>
<th>Rel. costs [h, m, l]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartz monitor</td>
<td>0.0005 - 1</td>
<td>+</td>
<td>+</td>
<td></td>
<td>0.1nm</td>
<td>0.1</td>
<td>h</td>
<td>m</td>
</tr>
<tr>
<td>Light irradiation</td>
<td>0.001 - 0.15</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>0.1$\lambda$</td>
<td>0.1s</td>
<td>1 - m</td>
<td>m</td>
</tr>
<tr>
<td>Radioact. transm. ($\alpha$)</td>
<td>0.001 - 1</td>
<td>+</td>
<td>(+)</td>
<td>+</td>
<td>3..5</td>
<td>&gt; 1</td>
<td>h</td>
<td>m - h</td>
</tr>
<tr>
<td>Beta-Back-Scattering</td>
<td>0.05 - 300</td>
<td>+</td>
<td>+</td>
<td></td>
<td>1.15</td>
<td>5..60</td>
<td>h</td>
<td>h</td>
</tr>
<tr>
<td>Four point method</td>
<td>0.1 - 10</td>
<td>+</td>
<td>(+)</td>
<td>+</td>
<td>1</td>
<td>0.5</td>
<td>1 - m</td>
<td>m</td>
</tr>
<tr>
<td>Capacity method</td>
<td>0.01 - 100</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>2</td>
<td>0.1</td>
<td>m</td>
<td>m</td>
</tr>
<tr>
<td>Eddy Current</td>
<td>0.0005 - 500</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>0.5..10</td>
<td>0.001</td>
<td>h</td>
<td>m - h</td>
</tr>
</tbody>
</table>

6. Comparing selected technologies

### 4-point-probe testing

- Contact / Contact quality influences measurement
- Possible damage to sensitive layers
- Single point sheet resistance testing only
- Wearing of probe with time
- No measurement of encapsulated films
- Only for hard and insensitive layers

### Non-contact eddy current testing by EddyCus

- Non-contact & real-time, no wearing
- **High accuracy** without influence of contact resistance
- **No harm** or artifacts to sensitive films
- **High resolution mapping**, inline measurement for **process control**
- Encapsulated films & multilayer systems
- Best usage for touch-sensitive layers

#### Sample Number 4PP-measurement Eddy Current

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.496</td>
<td>0.052</td>
<td>0.467</td>
<td>0.64</td>
<td>0.485</td>
<td>0.0002</td>
<td>0.4842</td>
<td>0.4847</td>
</tr>
<tr>
<td>2</td>
<td>1.120</td>
<td>0.022</td>
<td>1.079</td>
<td>1.16</td>
<td>1.120</td>
<td>0.0001</td>
<td>1.1203</td>
<td>1.1206</td>
</tr>
<tr>
<td>3</td>
<td>1.759</td>
<td>0.032</td>
<td>1.720</td>
<td>1.81</td>
<td>1.772</td>
<td>0.0002</td>
<td>1.7715</td>
<td>1.7721</td>
</tr>
<tr>
<td>4</td>
<td>4.430</td>
<td>0.100</td>
<td>4.300</td>
<td>4.61</td>
<td>4.425</td>
<td>0.0006</td>
<td>4.4244</td>
<td>4.4263</td>
</tr>
<tr>
<td>5</td>
<td>11.840</td>
<td>0.200</td>
<td>11.350</td>
<td>12.09</td>
<td>11.622</td>
<td>0.0102</td>
<td>11.6055</td>
<td>11.6421</td>
</tr>
<tr>
<td>6</td>
<td>30.400</td>
<td>0.500</td>
<td>29.800</td>
<td>31.30</td>
<td>30.498</td>
<td>0.0241</td>
<td>30.4544</td>
<td>30.5360</td>
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<tr>
<td>7</td>
<td>82.500</td>
<td>0.700</td>
<td>81.500</td>
<td>83.40</td>
<td>81.359</td>
<td>0.1145</td>
<td>81.2294</td>
<td>81.4972</td>
</tr>
</tbody>
</table>

**Correlation EddyCurrent vs. 4 Point Probe**

\[ y = 0.987x + 0.0649 \]
7. Understanding selected technology in depth

How does eddy current testing work?

1. A primary magnetic field is created when alternating current is injected into an induction coil
2. Eddy Currents are generated when the coil is placed over a conductive sample
3. The characteristics of the Eddy Currents are determined by material characteristics
4. The Eddy Currents generate a secondary magnetic field opposed towards the primary field
5. The impedance of the coil is affected by material differences that influence conductivity
6. This influence is measured by a pick up coil
7. Understanding selected technology in depth

How does eddy current testing work?

Variants
- Sender: inductive coils
- Receiver: inductive coils, hall sensors, fluxgate sensors, GMR, SQUIDs

Types of Eddy Current testing
- Single frequency, multi-frequency, spectral, impulse Eddy Current etc.

Setup for layer characterization
- Frontside reflection mode
- Backside reflection mode
- Transmission
7. Understanding selected technology in depth

What can be achieved with Eddy Current monitoring

- Metal layer thickness measurement from 2 nm – 2 mm
- Sheet resistivity measurement from 0.1 mOhm/sq to 10,000 Ohm/sq
- Imaging solution mapping
- Defectoscopy
- Combined optical and electrical testing solutions
7. Understanding selected technology in depth

Correlating information

- Numerical calculations show that for silver layers in the thickness range from 5 to 20 nm the emissivity \( e \) does not depend explicitly on the film thickness and may be written as

\[
e = 4\epsilon_0 R_\square c = 0.1 R_\square / (3\pi),
\]

\[
e = 0.0106 R_\square
\]

7. Understanding selected technology in depth

Correlating information

- Thickness and sheet resistance do correlate

Sheet resistance $R_{\Omega}$ or $R_S$ is derived by assuming that the film width equals the film length ($w = l$)

$$R = \frac{\rho \cdot l}{w} \equiv R_S \frac{l}{w}$$

The unit of $R$ is $\Omega$

The unit of $R_S$ is $\Omega$ ($\Omega$ is typically used in order to distinguish between resistance)

Correlation Ag thickness and sheet resistance for very thin layers

$y = 0.0167x^4 - 0.3833x^3 + 3.4833x^2 - 16.117x + 42$

8. Hardware selection and dimensioning strategies

**Isotropic vs anisotropic sensors**

- Wire and mesh structures can have an anisotropic sheet resistance
- Anisotropy can be optimized according to the layout of the contact pattern
- Anisotropy can save material and improve optical transparency
- Anisotropy can be measured in non-contact mode by inline anisotropy sensor

![Isotropic vs anisotropic films](image)

**Enhanced sheet resistance**
8. Hardware selection and dimensioning

Technology insight – Anisotropy image of 200 x 200 mm nano wire at 1 mm measurement pitch

Anisotropy strength (blue=low anisotropy, red=high)

Direction of the least present sheet resistance
8. Defining measurement setup

Sensor selections and mounting

- Selecting sensor head type
  - Measurement range, spot size, sensitivity
  - Suiting space and mounting requirements
    - Geometry selection if available
    - Mounting and cord exit selection
8. Defining measurement setup

Mounting frame concepts

- Design of measurement bridge
  - Where are the mounting points?
  - Do I need flexibility in changing sensor position or during installation
  - Customized frame per available space and other requirements
  - Extruded Aluminum frames for flexible mounting vs steel frame and combined frames
8. Hardware selection and dimension

Travelling integrated sensor setup

Fixed sensor inline stacking setup
8. Hardware selection and dimension

Where is my information? How can this information be obtained?

- What can be changed?
  - Can the center to edge homogeneity be influenced?
  - Monitor different sources and its overlap
- May line defects occur?
8. Hardware selection and dimensioning

Frame layouts - fixed sensor installation

- In-vacuo / ex-vacuo
- Fix or variable sensor positioning
- Available space at place of integration
- Freestanding autarkic measurement bridge vs. integrated solutions
- Mounting opportunities to existing structure (conveyor belt, deposition chamber)
8. Hardware selection and dimension

Frame layouts - fixed sensor installation
8. Hardware selection and dimension

Frame layouts - travelling sensor installation
9. Selecting position of integration

Where is the best position of the system?

- Requirements from process view
  - Close to deposition for prompt process feedback
- Requirements for metrology systems
  - High tension zone for low fluttering is preferred (between two rollers)
  - Installation close to rollers so in tension loss the sensor does not contact to the web
  - Horizontal versus vertical integration (considering calibration process)
- Space requirements
  - Sensor vibrations should be avoided if possible
  - Considering maximum temperature if existing (e.g. 60°C / 140°F)
  - Large temperatures fluctuations without self-referencing opportunity require a temperature compensation which is available for all sensors
- Distance to power supply, options to mount sensors and control elements
10. Data acquisition setup

Where do I need this information? When and how long do I need this information?

- How much data is needed for process control and documentation in the perspective of the entire data infrastructure?
- 5 Vs of big data (for high number of tools, process and monitoring data)
  - Data volume
  - Data velocity
  - Data variety
  - Data veracity
  - Data value
- Data architecture
  - Storage system: DAQ, MES, metrology tool SQL, other tools, raid options
  - Storage: how long, which data → statistics of roll versus entire data
- When to measure
  - Measurement mode (continues push mode, triggered mode, time based mode)
10. Interface selection

Where do I need this information? When and how long do I need this information?

- Recipient of information may be process engineer, coating equipment, product customer
- Information types may require to use different interfaces for Metrology System to Process System communication
  - MS → PS: Measurement values (thickness, sheet resistance, temperature, assessed data status)
  - MS → PS: System status (metrology system ok, threshold and error handling)
  - PS → MS: trigger for equidistant measurement, reset position trigger after roll change, run self-reference
- Typical interfaces options
  - Digital:
    - UDP: very fast, no response
    - TCP: slower; message receipt statement
    - CSV file dumping
  - Analog
    - 4 – 20 mA, 0 - 24V
11. Calibration

What is the best reference for my measurement values?

- A system can not measure better than the accuracy of the references!
- Which reference is the right one?
  - „Old / own“ offline measurement gauge references?
  - The reference standards used by my customer?
  - Golden standards
    - NIST / VLSI standards
    - Metrology tool manufacturer reference standards characterized by use of NIST standards
      - Stable and homogeny coatings across the measurement range
      - Depending on the measurement range, a reference set consists of 5 to 15 samples depending on the measurement range
11. Calibration

How to calibrate in difficult environments?

- Smart calibration
  - Inverse calibration for not accessible calibration areas
  - Cold characteristics
  - True layer thickness calibration
- Structured film testing
- On edge testing
Steps and Work Flow for Integration

Workflow for technical integration

- Mounting of entire preassembled frame
- Mounting of control cabinet
- Installation of wiring according block wiring diagram
- Setup of software / interfaces
- System test
- In place – recalibration
- Final check
12. Done installing

Exploring the benefits - Fine-tuning the processes

- Fast ramp-up
  - Deposition tool installation
  - Start up after maintaince or work break
  - Start up target change

- Process enhancement
  - maximum target usages
  - Etc.  Here our job ends 😊
Take home messages

- Many questions need to be raised along the installation of new inline metrology tools
- It looks quite complicated but in the end it is a standard process that is moderated by the vendor
- Good vendors have such process and ask those questions and make a package proposal
- Getting the best solutions requires some work from the vendor and metrology manufacture
- The benefit of a good selection and dimensioning process can last over decades
For questions and requests please feel free to contact us...

Contact us for

- Discussion
- Consulting on design decisions
- Requesting support

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Introducing Four General Testing Setups

Non-contact single point measurement

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Non-contact imaging solutions

Inline / tool integrated

Portable testing

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