The Latest Developments in On-line Measurement and Control for Film Extrusion & Coating Applications
NDC Business Focus

- High Value Measurement & Control Solutions for raw & intermediate materials used in manufacturing of consumer goods

Robust stable measurements, unaffected by the environment, fit for process control
NDC Technologies Businesses

- **Food & Bulk**
  - On line and At line IR measurement solutions for composition analysis

- **Web - Packaging**
  - Film thickness, coat weight, moisture, scanning profile measurement display & control systems

- **Cable & Tube**
  - Diameter, speed, length, ovality, wall thickness

- **Metals**
  - Thickness, width, flatness and coating weight

**Measurement Technologies**
- NIR, Gamma Backscatter, Beta Transmission, X-Ray Backscatter, Transmission X-ray Fluorescence Microwave, UV Fluorescence, Laser Calliper, Laser diameter Ultrasonics, X-ray Thickness, Width and Flatness
NDC Web Solutions

► Measurement & control Systems

► 10,000 Systems installed worldwide:

► Measuring thickness, basis weight, coating weight and barrier layers for:
  - Converting
  - Paper
  - Nonwovens
  - Extrusion
  - Flexible Packaging
  - Rubber & PVC Calendering
A very Brief History of the Gauging Industry

• 1940’s – start of the nuclear era [Manhattan Project (1942 to 1946)].

• 1951 first nuclear energy generation

• 1948 Tracerlab (USA) invented and sold the 1st on-line basis weight sensor; a Krypton 85 beta transmission gauge.

• 1965 NDC was founded by a former employee of Tracerlab (Mr Fishman) who invented and marketed the gamma backscatter sensor
A very Brief History of the Gauging Industry

An advert you are unlikely to see today!

Indeed you are more likely to see these signs

September 1949
A very Brief History of the Gauging Industry

• Measurex founded in 1969 -> very influential and significant player within the history of our industry bringing out the first computer based systems.

• Alfrey & Schrenk developed multilayer film technology in the 60’s. Early 70’s Brun developed 1st NIR sensor to measure barrier layers. Only in mid 80’s did these films commercially take off. NIR development grew from there.

• Egan (part of Davis Standard) filed the 1st autodie patent (1972). But it was EDI/Welex who in 1974 went commercial with the air cooled bolt heater concept (LFE was the gauge partner).

• 1995 the worlds first 10.4m film line (BOPP) was commissioned.

• 2016 the worlds first 6.3m CPP lines was commissioned
Manufacturing Considerations

<table>
<thead>
<tr>
<th>Quality Improvements</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>MD Spread Reduction</td>
<td>30-50%</td>
</tr>
<tr>
<td>CD Spread Reduction</td>
<td>50-80%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Material Savings</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight or Thickness Down Gauging</td>
<td>1-5%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Downstream Savings</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced Scrap due to:</td>
<td></td>
</tr>
<tr>
<td>- Slitting</td>
<td>10-20%</td>
</tr>
<tr>
<td>- Quality rejects</td>
<td></td>
</tr>
<tr>
<td>- Rerind</td>
<td></td>
</tr>
<tr>
<td>- Downgrade</td>
<td></td>
</tr>
<tr>
<td>- Customer returns</td>
<td></td>
</tr>
<tr>
<td>of machine direction &amp; profile scrap</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Production Increase</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Change Time</td>
<td>10-30%</td>
</tr>
<tr>
<td>Start Up Time</td>
<td>10-30%</td>
</tr>
<tr>
<td>MD/CD Scrap Reduction</td>
<td>30-50%</td>
</tr>
</tbody>
</table>
Achieving Optimum Results with Gauging

- Application-matched Measurements & Controls
- No Surprises
- Reliable Accuracy
- Intuitive OS
- Effective Controls
- Repeatable Measurements
- Management Decisions
- Doc. results/Confidence
- Uptime
- Support/training
- TCO
- Acceptance

ROI

CONTD RESULTS

Measured by Commitment

NDC Technologies Proprietary & Confidential Information. Document Reference Number
Consider - TCO

- In Korea buying a system with a radiation sensor

Initial purchase cost $X

Cost of ownership:
- Importation license
- Monthly Radiation Safety Administration Fee (per person)
- Source exchange/disposal fee + shipping

TCO after 10-years = $X

So total cost of the system = $2X
Consider – Application Matched Solutions

- Low repeatability
  - Low accuracy

- High repeatability
  - High accuracy

- High repeatability
  - Low accurate

- High repeatability
  - High accurate
# Speciality Films & Flexible Packaging

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Requirements</th>
</tr>
</thead>
</table>
| **Product Quality** | Minimal quality variation  
                     Flat roll structure  
                     Runs efficiently through conversion  
                     Meets customer specifications |
| **Process Performance** | Minimum raw material use  
                               Fast start up  
                               Fast grade change  
                               Minimum scrap  
                               Fast problem identification |
# Web Gauging Requirements

<table>
<thead>
<tr>
<th>Item</th>
<th>Expectations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement</td>
<td>Accurate, repeatable measurement&lt;br&gt;Measurement sensitivity &lt;0.1 microns&lt;br&gt;Accurate die bolt mapping&lt;br&gt;Non-contacting measurement&lt;br&gt;Non-nuclear measurement</td>
</tr>
<tr>
<td>Profile Resolution</td>
<td>High streak resolution &lt;5mm</td>
</tr>
<tr>
<td>Scan Speed</td>
<td>Fast scan up to 650mm/second</td>
</tr>
<tr>
<td>Controls</td>
<td>Robust control strategies</td>
</tr>
<tr>
<td>HMI Interface</td>
<td>Provide an effective process interface</td>
</tr>
</tbody>
</table>
Introducing FilmPro
Accurate Measurements: Introducing FilmPro

- One gauge provides superior measurement across a wide range of films
- Efficient optical design for best precision
- New modular Fringe Suppression Optics (FSO) for thin, clear films
- Multilayer discrimination for up to 6 components
- Measures:
  - Clear, pigmented and some black tinted films
  - Weight and thickness of voided, microporous and breathable films
  - Oil content in microporous film
### IR Measurement Discrimination

<table>
<thead>
<tr>
<th>LDPE, HDPE, LLDPE, EVA*, PP</th>
<th>EVOH</th>
<th>PET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyamides (PA)</td>
<td>Surlyn™</td>
<td>PS</td>
</tr>
</tbody>
</table>

#### Transmission vs. Wavelength

- **Polyethylene**
- **Polyester**

% Transmission

<table>
<thead>
<tr>
<th>Wavelength (micrometres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
</tr>
<tr>
<td>2.0</td>
</tr>
<tr>
<td>2.5</td>
</tr>
<tr>
<td>3.0</td>
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</tbody>
</table>
The Fast Fourier Transform Package (FFT) can be used to pinpoint high-frequency disturbances from out-of-round rolls, bad bearings and material surging.

This FFT display identifies a dominant thickness disturbance every 1.8 secs, or 1.99m, which was found to be an out-of-round roll.
Black Stretch Film CD sample

CPE black stretch film

Lab
Filmpro

Measured by Commitment
FilmPro Measurement Accuracy

**Thin, Clear PET**

**Voieded PET**

**Thin Film PP**

**Thin, Clear PET**

**BOPP Filled & Clear**

**Thin, Clear PA**

**CPE Black Stretch Film**

**PE Film Stretch Blown**

**Black Stretch CD**
FilmPro Summary

- Fast, accurate thickness measurement for film, sheet and coated products
- Measurements include thickness, mass, moisture, density and oil content
- Safe, reliable and more accurate than other sensor technologies
- Pre-selected wavelengths are based on sound spectroscopy and chemical/physical rationale:
  - Most applications require only 3-4 component wavelengths with additional reference wavelengths
## Coating & Laminating Applications

### Flexible Packaging
- Packaging Laminates
- Pouches
- Multi-wall bags

### Coated / Laminated Papers
- Industrial grade papers
- Release liners
- Adhesive tapes & labels
- Photographic papers
- Crystal & powder packaging
- NCR, CB, CF & CFB
- Labels

### Coated Paperboard
- Bleached board
- Food packaging
  - Liquid Packaging
  - Cup Stock
Common Coating & Laminating Structures

- NDC IR technology provides measurement visibility into the base, coating and laminating structures
  - Extruded sheet and films (clear or pigmented) and coatings:
    - PE, PP, PA, BOPP, PET etc.
  - Co-extrusion layer thickness:
    - PE, PA, EVOH, PP, Surlyn and other polymers where spectra do not overlap.
- Continuous multi-layer measurement for up to six components
- Near and mid-IR measurement capability
NDC710S Infrared Backscatter Sensor

- Backscatter sensor for measuring thin to thick organic coatings and moisture:
  - Clear & pigmented coatings
  - Moisture in paper, textiles and nonwovens
  - Able to discriminate up to 6 multi-layer coatings

- Coatings on paper, board, textiles, polymer films and other scattering substrates:
  - Water or solvent-based
  - Solvent-less
  - Wax dip
  - Impregnation
  - Polymer extrusions
  - Impregnation
  - Barrier coatings
  - Lacquers
  - Hot melt
NDC710S Infrared Backscatter Sensor

- Custom-made filters:
  - Up to 10 filters handle a broad range of IR measurement applications
  - 6 simultaneous component measurement

- High-speed filter wheel:
  - 8000rpm for fast measurement response
  - 7.5msec measurement rate

- Segmented mirror:
  - High-efficiency segmented mirror
  - Improves pass-line insensitivity

- IR source:
  - Off-axis collecting mirror for efficient source focussing
  - 20W Low heat generation source
  - 5 year source warranty

- Brushless DC motor:
  - 5 year warranty

- Measurement beam:
  - 27mm wide beam
  - 10mm beam for high-resolution APC applications

- Near & Mid IR measurement capability:
  - Detectors can measure wavelengths from 1 to 5 μ

- Reference detector:
  - Used for baseline correction
  - Compensates for optical and electrical changes

- Window Contamination Monitor:
  - Checks dust and dirt build up and scattered light from contamination
  - Detects powders, haze and condensation

- Sintered Air Purge:
  - Keeps optical path clean

- Environmentally designed:
  - IP 65 sealed sensor enclosure

Coating Films
The following coatings are measured with the –CH band:

- Label stock
- Wax barriers on paper
- Polymer extrusion on paper/foils:
  - Sugar wraps
  - Sacking
  - Packaging
  - Aseptic cartons
- Cold seal adhesives on paper/films
- Wallpaper PVC plastisol coatings on paper
- UV Cured lacquers on paper
- Acrylic coatings on paper pre-metallizing
- Epoxy resin coatings (carbon fiber applications)
NDC SR710S Infrared Backscatter Sensor

- Designed to measure the thickness of clear coatings on shiny or reflective surfaces
- Lacquer coat weights from 0.5-25gm²
- Ultra thin coatings from 20-1000mg/m²

Applications include:
- Clear and lightly pigmented thin organic lacquer coatings, adhesive coatings.
- Wax on aluminum or steel and thin water-based coatings.
NDC SR710S Coating & Laminating Applications

- Flexible packaging:
  - Vinyl, acrylic, epoxy, polyester, nitrocellulose & lacquers
- Can stock:
  - Vinyl lacquers and lube coatings on aluminum
- Air conditioning foil:
  - Water based coatings on foils
- Metallized packaging:
  - Lacquers on metallized surfaces and di-isocyanate adhesives in laminating
- PE/Surlyn coatings:
  - Aluminium (aseptic packaging)
- Cigarette
  - Foil laminated to paper
- Protective/heat seal lacquers:
  - Aluminum (yoghurt tops etc.)
With shiny substrates, two strong reflections are captured by the gauge; one off the primary surface, with no absorption data, and the second off the substrate surface, which contains the needed absorption information.

The two signals combine with a phase shift. If they are in phase, the gauge signal is stronger; out of phase, and the signal is weaker; this creates measurement errors.

The phase shift / intensity depends on the coating thickness and refractive index.

Thin, clear coatings are the most problematic between 1 and 25 microns.
Interference Suppression Using Polarized Infrared Light at the Brewster Angle

- Curves a and c represent the two planes of polarized light
- Curve b represents unpolarized light
- At the Brewster angle, one plane of polarized light (curve c) is not reflected by the coating surface
- This totally eliminates optical interference effects

At the Brewster angle, $R_1$ becomes zero and prevents optical interference.

The Brewster angle is a function of the refractive index of the coating.

![Graph showing reflectance vs. angle of incidence](image)
NDC SR710S Infrared Backscatter Sensor

- **Custom-made filters:**
  - Up to 10 filters handle a broad range of IR measurement applications
  - 6 simultaneous component measurement

- **Brushless DC motor:**
  - 5 year warranty

- **IR source:**
  - Off-axis collecting mirror for efficient source focussing
  - 20W low heat generation source
  - 5 year source warranty

- **Measurement beam:**
  - 25 wide beam -10mm beam for high resolution APC applications
  - Presented to the product at the Brewster angle

- **High-speed filter wheel:**
  - 8000rpm for fast measurement response with 7.5msec measurement rate

- **Steering Mirror:**
  - Achieves the required Brewster angle

- **Reference Detector:**
  - Monitors and compensates for source output

- **Polarizer**

- **Window Contamination Monitor:**
  - Checks dust and dirt build up and scattered light from contamination
  - Detects powders, haze and condensation

- **Sintered Air Purge:**
  - Keeps optical path clean

- **Coated Substrate**
SlimTrak Scanner
## OptiMike OM190HP Sensor Specifications

- **Measurement Range:** 50 to 5000 microns
- **Measurement Backing Roll:** High-performance stainless steel
- **Reproducibility ± 2-sigma:** ± 0.5 microns
- **Accuracy ± 2-sigma:** ± 5.0 microns
- **Response Time:** 10msec
- **100% Streak Response:** 1.6 mm
- **Measurement Resolution:** 0.10 microns
- **Maximum Sheet Temperature:** 50°C
- **Maximum Sheet Width:** 2500mm
- **Roll Wrap:**
  - 1mm product: 64°
  - 5mm product: 85°
Thank you