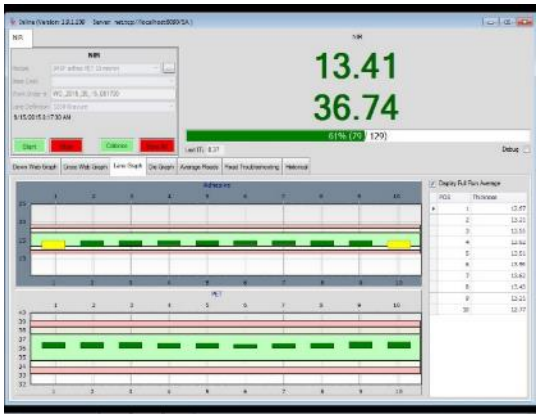
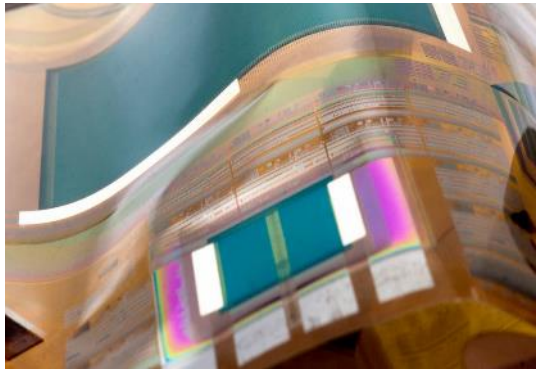
Real-time in-process wet or dry thickness measurement of thin films and discrete layers in R2R applications



specMETRIX

Technology by SENSORY ANALYTICS



Novel in-Process coating thickness measurement technology

Uses ‘Ruggedized Optical Interference’ (ROI) technique

Yields coating thickness or film weight results

Lab and In-line configurations – with OEM options

Measurement of thin coatings and discrete layers

Rapid adoption by performance films leaders

Recognized innovation award-winning technology:

- EU: Metpack Gold Innovation Award
- USA: AIMCAL Technology of Year
- Asia: ICE Asia Innovation Award

Flexible Films: Broad industrial utilization of technology

- Flexible Packaging
- Window Films
- Thin Films & Coatings
- Aerospace & Defense
- Medical Devices
- Automotive Industry
- Electronics
- Metal Containers

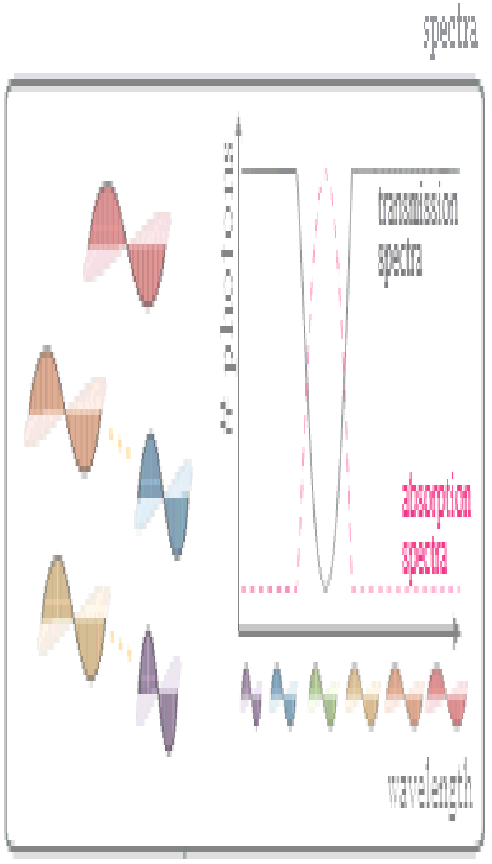
Alternate Technologies: Optical and Non-optical tools

- Multiple optical and non-optical methods available for thickness/coat weight measurement
- Within optical field, various different measurement technologies used:
  - Optical Reflection
  - Optical Transmission
  - Optical Absorption
- Most current tools face limitations within R2R production environments

Alternate Optical Technologies, with limitations

Optical Absorption/ Transmission:

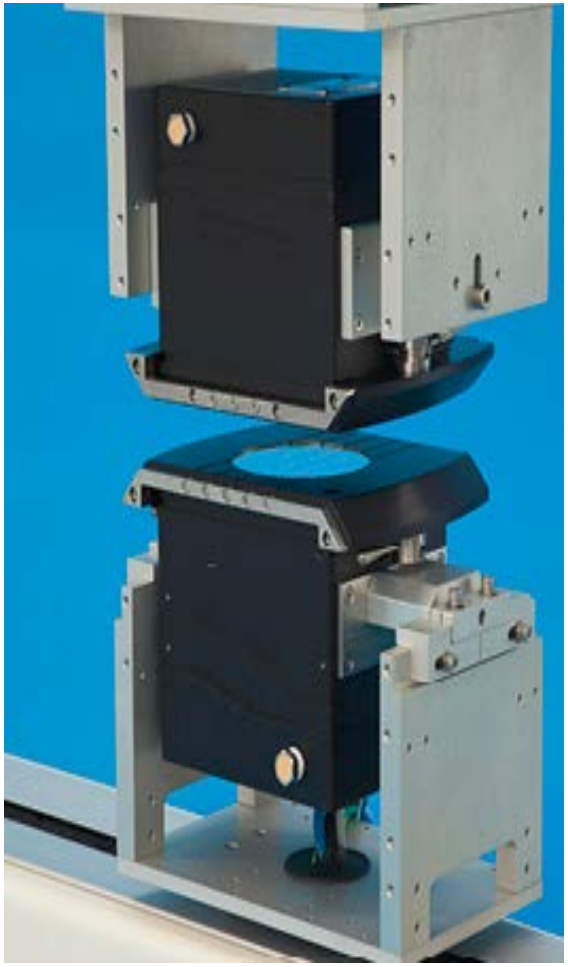
- ✓ Non-absolute thickness measurement method
- ✓ Depends on magnitude of absorption/transmission
- ✓ Limited wavelengths vs. broad wavelength range
- ✓ Different wavelengths used for different coatings
- ✓ Not suitable for discrete layer measurements



Alternate Non-Optical Technologies, with limitations

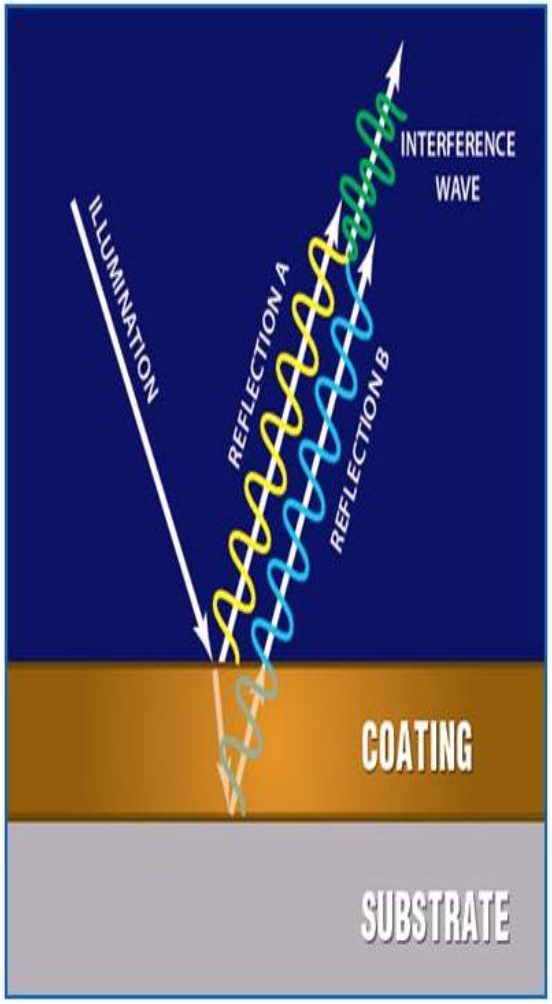
Beta/Gamma Nuclear gauging:

- ✓ Non-absolute thickness measurement method
- ✓ Based on of nuclear technology
- ✓ Differential type of measurement technique
- ✓ Adds extra administrative and cost burdens
- ✓ Cannot measure thinner coatings below 5 microns
- ✓ Cannot measure individual layer thickness
- ✓ Substrate variations can impact reading accuracy



Overview: Exclusive ROI Optical technologies

- ✓ Proprietary '**ruggedized optical interference**' ROI technology
- ✓ Yields absolute thickness measurement results
- ✓ Substrate independent
- ✓ Measures clear and opaque coatings
- ✓ Not affected by base color or printed substrate
- ✓ Uses non-invasive white light optical source(s)
- ✓ Scalable for off-line or in-process use – wet or dry
- ✓ Current range:0.15 to 250 micron thickness
  (0.2 g/m^2 to 300g/m^2) or (0.006 to 10 mils)



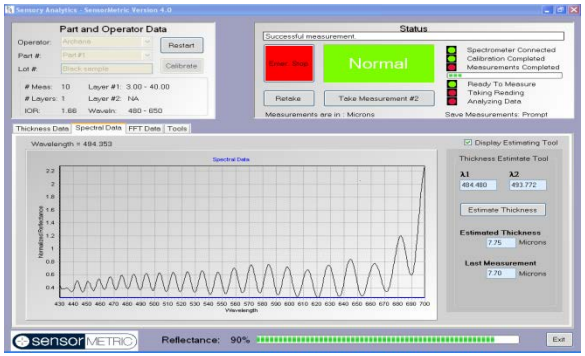
Technical advantages: ROI optical methods

- **Discrete layer measurements**
  - Not a differential or total coat weight measurement method
  - Discrete film weights of single or dual layers can be measured
- **Absolute thickness measurements**
  - Highly precise measurement data in real-time
  - Single streamlined In-line system can replace multiple systems
    - One system can measure two layers simultaneously
  - No necessity to calibrate on supplied thickness/ weight standards
    - No need to *teach* the system since actual thickness is measured
- **Takes wet or dry in-process coating/layer measurements**
  - Ability to monitor coatings immediately after application
  - Multiple probe and scanning configurations to meet QA needs
  - Reports absolute wet or dry thicknesses
- **Fast, non-contact and non-destructive method**
  - Continuous readings eliminate need for weight tests on discs
  - Sample integrity is maintained
  - No source degradation
  - Intrinsically safe probes for wet coatings

Optical system performance: Key ROI differences

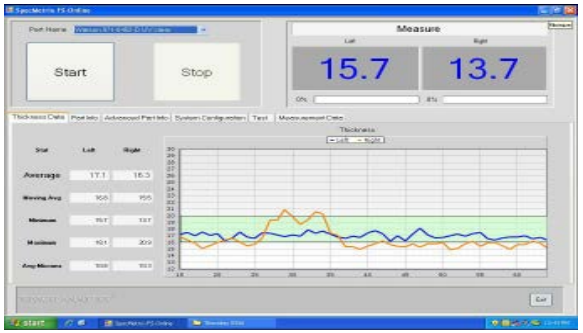
- ✓ Works well even on non-smooth coatings and varied substrates
- ✓ Does not require clean room environment for accurate measurement
- ✓ Easily handle web flutter by making necessary dynamic light detection adjustments
- ✓ Unique ability to handle wrinkles in the coated web
- ✓ In-line sensor distance to web does not need to be exact or fixed
- ✓ No calibration is necessary for measuring each applied coating
- ✓ Works on most *roll to roll*, *roll to sheet and slot die* coating processes

Data Analysis: ROI based system data outputs

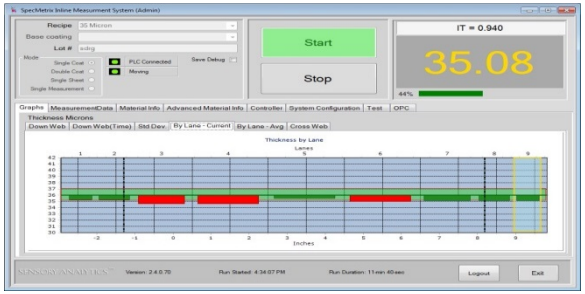


Precise thickness and coat weight results:

nanometers	mg/sq. inch
microns	gsm
mils	lbs/ream



Simple user and operator interfaces
Requires minimal input from operator
OPC, TCP/IP, PLC integration options



Management gets more reliable results:

- Automatic data recording and storage
- No manual recording or data manipulation
- Direct porting to SPC and QA systems

Performance: Customer Gage R&R Results

Gage R&R Study - ANOVA Method

SpecMetrix Thickness Measurement System
Gage R&R
Statistical Interpretation

```
Gage R&R for Measurements

Gage name:       Specmetrix Gage R&R
Date of study:   01/05/2011
Reported by:     V.G
Tolerance:
Misc:
```

Two-Way ANOVA Table With Interaction

Source	DF	SS	MS	F	P
Parts	2	6535.41	3267.70	151533	0.000
Operators	2	0.04	0.02	1	0.460
Parts * Operators	4	0.09	0.02	0	0.818
Repeatability	18	1.01	0.06		
Total	26	6536.55			

Alpha to remove interaction term = 0.25

Two-Way ANOVA Table Without Interaction

Source	DF	SS	MS	F	P
Parts	2	6535.41	3267.70	65305.5	0.000
Operators	2	0.04	0.02	0.4	0.669
Repeatability	22	1.10	0.05		
Total	26	6536.55			

Gage R&R

Source	VarComp	%Contribution (of VarComp)
Total Gage R&R	0.050	0.01
Repeatability	0.050	0.01
Reproducibility	0.000	0.00
Operators	0.000	0.00
Part-To-Part	363.073	99.99
Total Variation	363.123	100.00

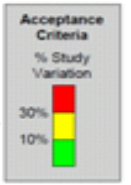
0.01% of the total variation is from the measurement system
0.01% of the total variation from repeatability problems
0.00
0.00
99.99% of the total variation is from part to part.

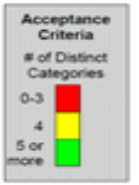
Source	StdDev (SD)	Study Var (6 * SD)	%Study Var (%SV)
Total Gage R&R	0.2237	1.342	1.17
Repeatability	0.2237	1.342	1.17
Reproducibility	0.0000	0.000	0.00
Operators	0.0000	0.000	0.00
Part-To-Part	19.0545	114.327	99.99
Total Variation	19.0558	114.335	100.00

1.342% Measurement System STDV (R&R) as a % of Total Observed Process STDV

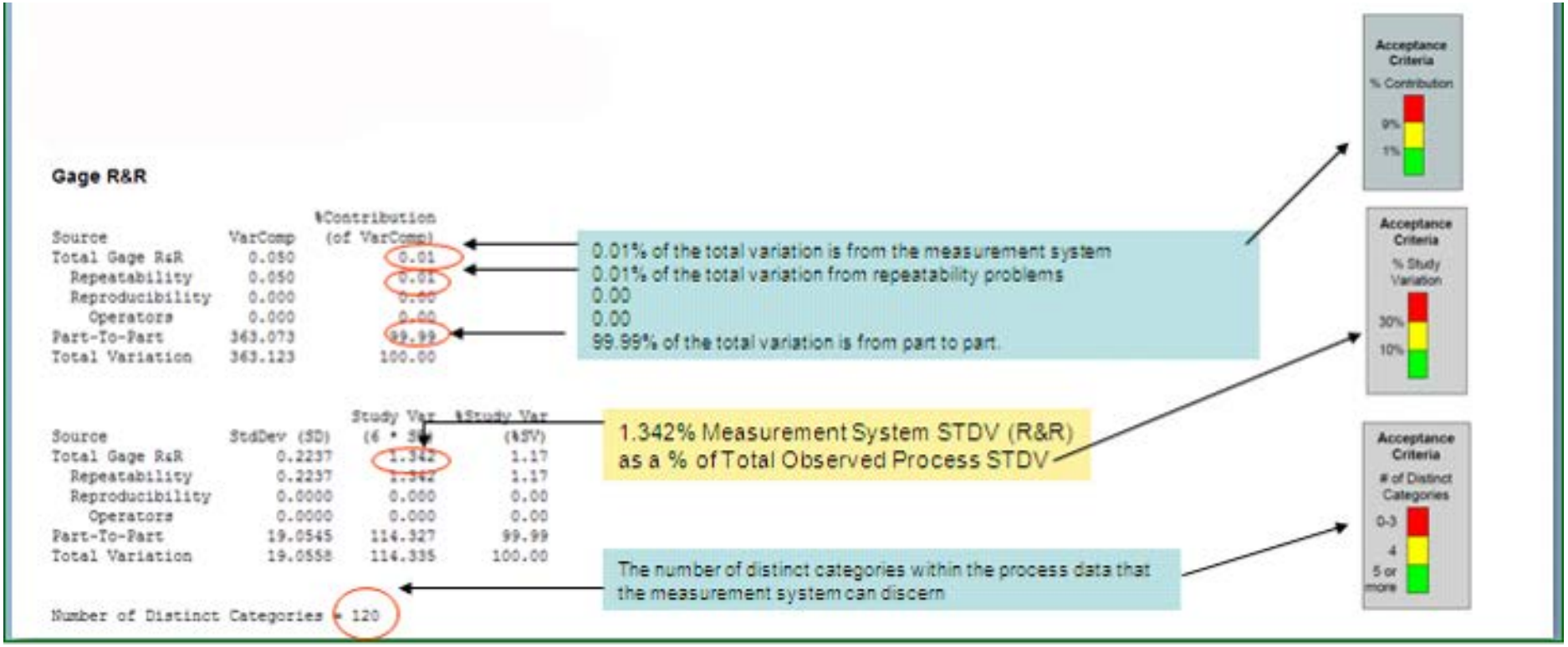
Number of Distinct Categories = 120

The number of distinct categories within the process data that the measurement system can discern





Performance: Customer Gage R&R Results



- Actual Gage R&R test result using NIST thickness standards
- Certified standard used so that only gauge variability is tested
- All SpecMetrix systems pass a <5% Gage R&R requirement

Range of Use: QA and Production applications

Corporate Teams

- QA Labs and sample testing
- Technical and R&D centers
- Pilot lines
- Coating supplier tech centers
- Film weight forensics/ Claim review

Manufacturing Plants

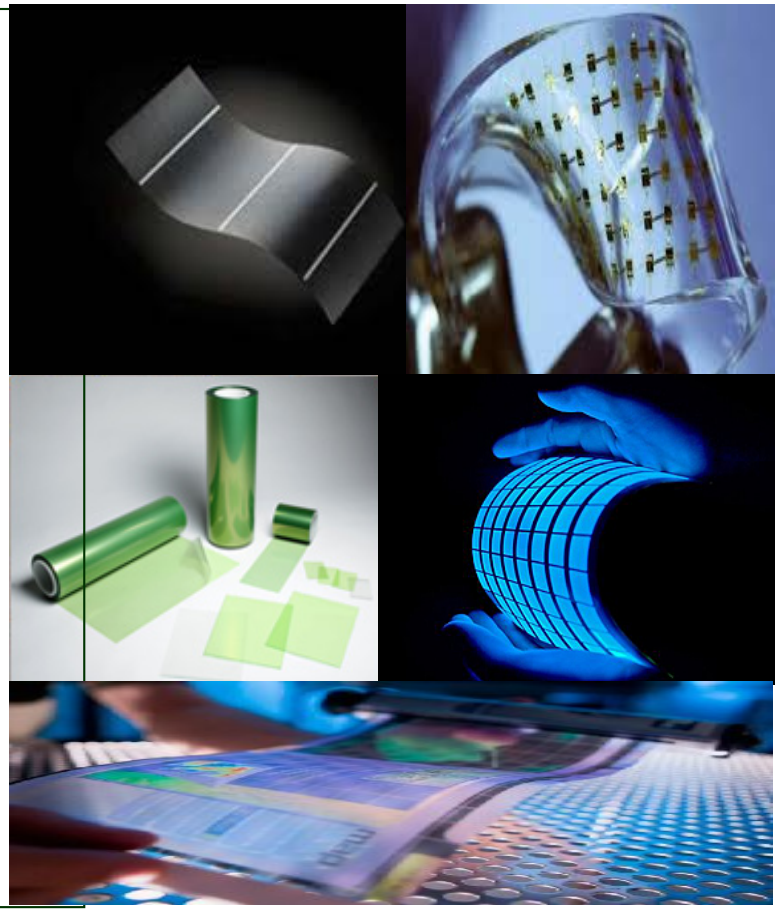
- QA work stations
- Incoming inspection
- In-process coating measurements
- Production floor

Selected film, foil & coating thickness applications

- Scratch Resistant coatings – including UV hard coats
- Anti-reflective coatings
- Adhesives: solvent-based, water-based & pressure sensitive
- Coatings on foils, tapes and metallized films
- Solar control and specialty films
- TiO2 filled opaque base films
- Barrier coatings – including nano-barrier coatings
- Silicone coatings and release liners
- Optical enhancement coatings

Expanding R2R Opportunities for ROI

- Transparent conductors
- Flexible electronics
- Thermal transfer ribbons
- Touch screen displays
- Organic LEDs
- Conformal coatings
- Passive (nano) barrier films
- Lubricious coatings & pretreatments



Roll-to-Roll Coatings and Substrates

Example Coatings:

- Scratch resistant
- Heat Seal
- Embossable
- Barrier Coatings

Example Substrates:

- Film (PET/PE/OPP, etc.)
- Foil
- Polycarbonate
- Steel
- Aluminum

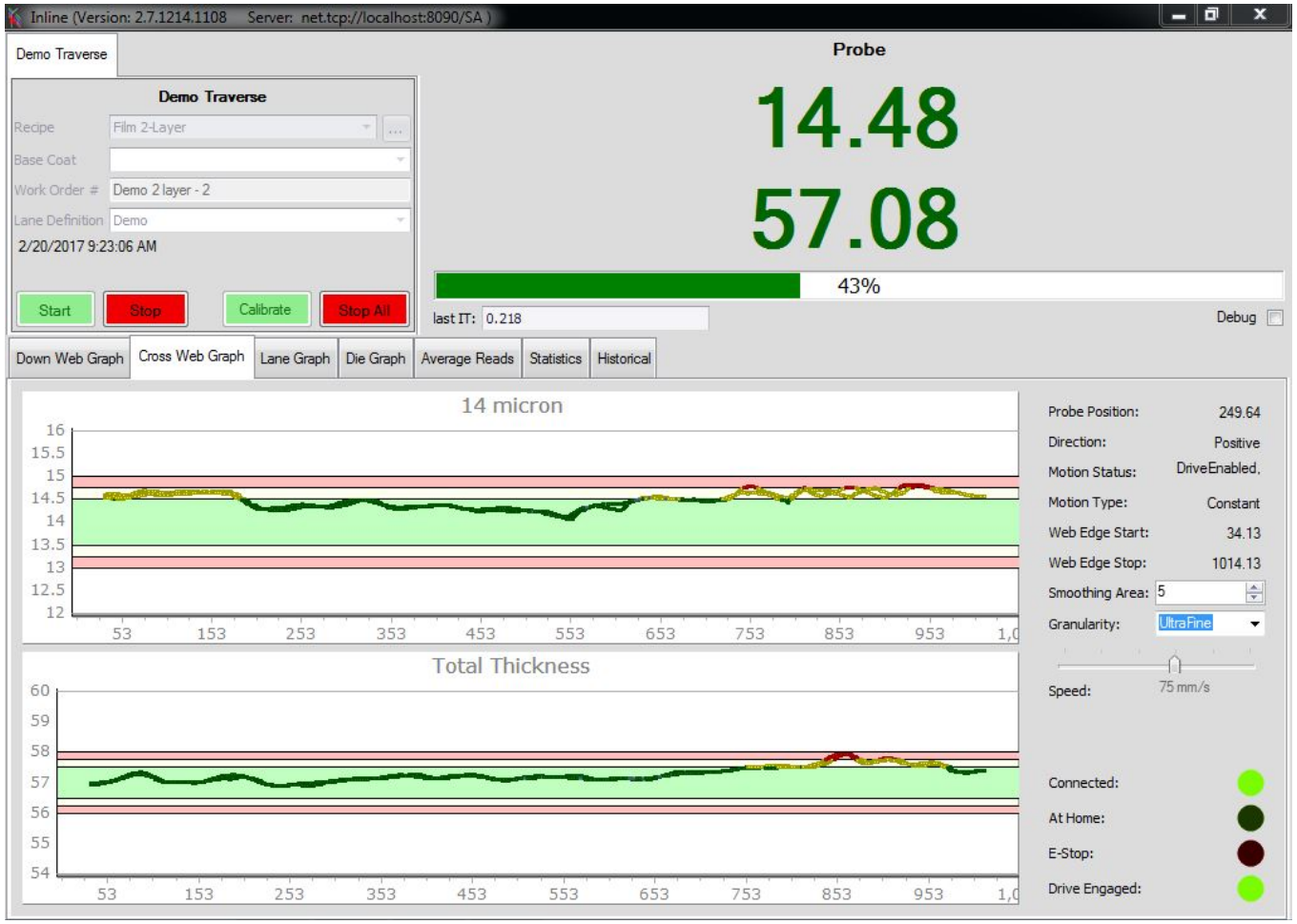
In-Process Benefits: Technology impact on production

- ✓ Elimination of labor intensive and less accurate weight gauging
- ✓ Optimized coating utilization and film weight distribution
- ✓ Real-time adjustments can be made to in-process adhesive layers
- ✓ Streamlined film weight checks and 1st piece inspections
- ✓ Traceable quality certifications for each production run or coil
- ✓ Reduced product rework and less coating spoilage
- ✓ Objective measurement data supply helps eliminate manual errors
- ✓ Reduced new coating trial times, set-up and changeover times
- ✓ Reductions in waste streams, solvent, coating and oven usage

Technology Implementation: Multi-Channel fixed

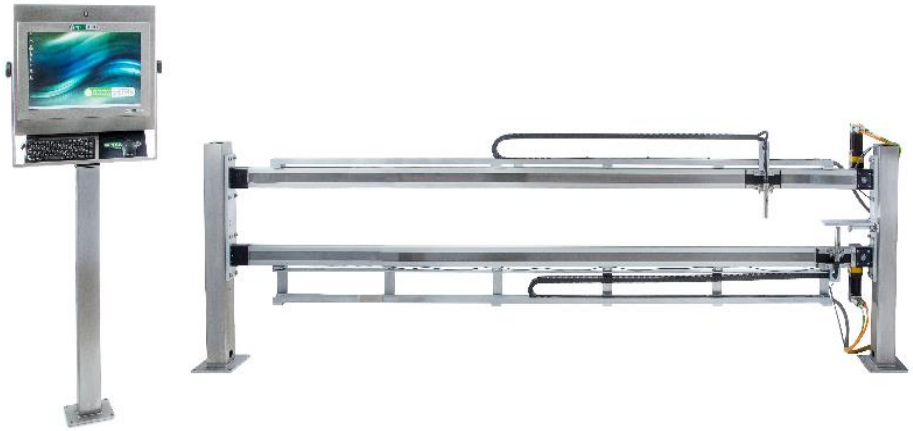
- Regularly used for in-process coating measurement for 100% inspection on fixed points

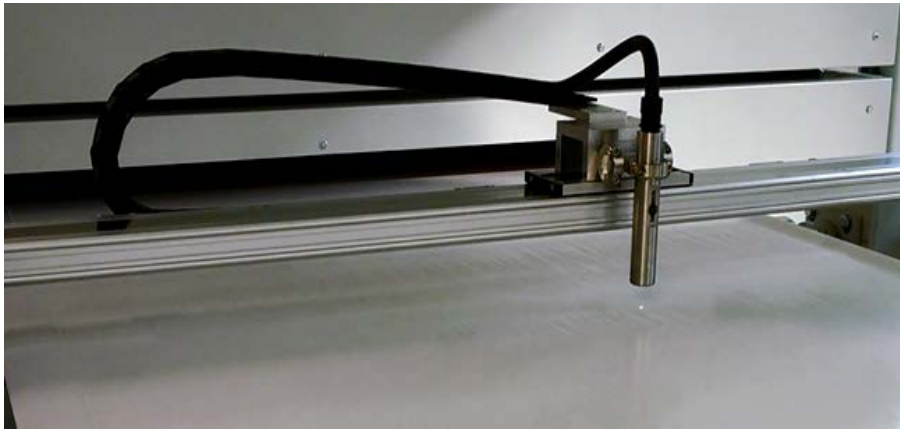
Technology Implementation: Dual layers or coatings

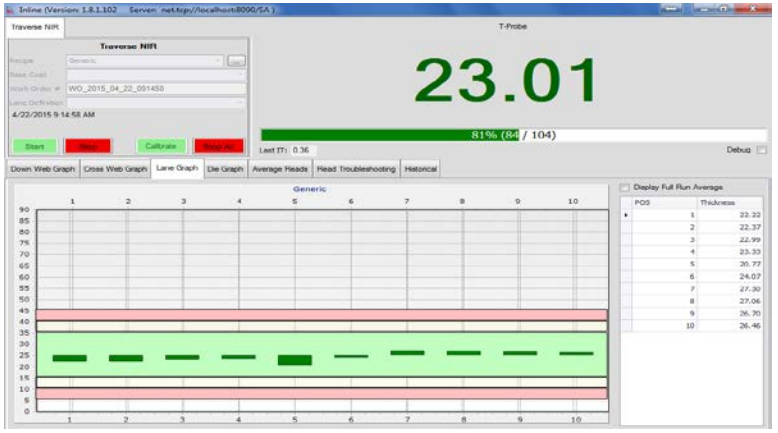


- Dual line configuration for sequential measurement of two coating layers

Technology Implementation – Web Scanning systems



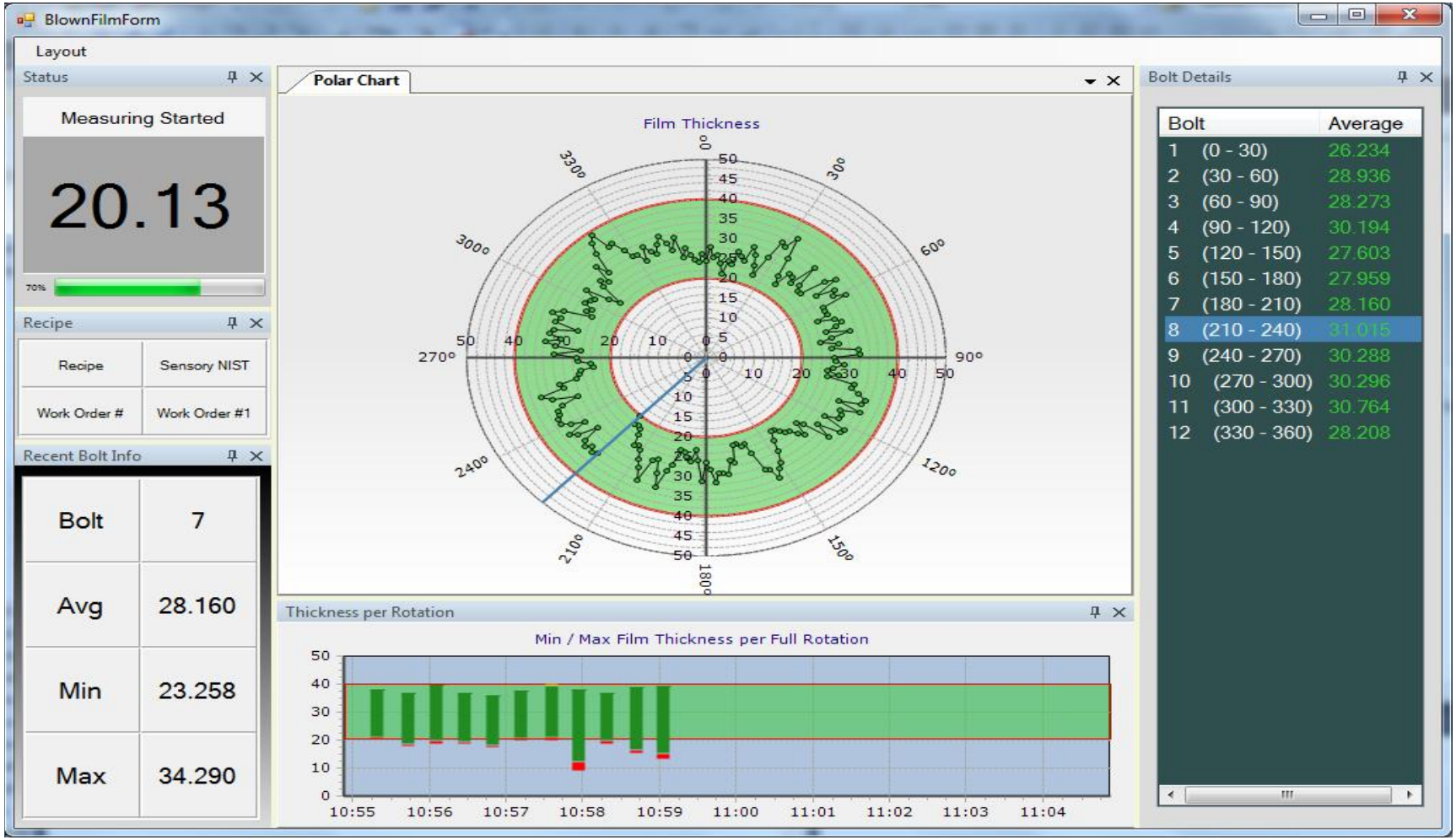




- Provides full side-to-side coating thickness characterization over webs or coils
- Light weight and robust scanning heads compared to traditional scanning gages

Technology Implementation – Partner Pilot Lines

Technology Implementation– Blown Film Thickness



Available as OEM accessory or to replace aging nuclear gauges

Thin Films and R2R Coating Applications
Trials and Measurement Results

Performance: Measurement stability over time

Product	Days	Layer1	Layer2	Layer3
302398	Day1	1.630	3.250	6.750
	Day2	1.610	3.310	6.750
	Day3	1.630	3.220	6.770
	Day4	1.650	3.180	6.800
	Day5	1.630	3.270	6.880
	Standard Deviation	**0.014**	**0.049**	**0.054**
302386	Day1	1.590	3.240	6.850
	Day2	1.570	3.250	6.800
	Day3	1.560	3.240	6.840
	Day4	1.610	3.280	6.800
	Day5	1.570	3.250	6.800
	Standard Deviation	**0.020**	**0.016**	**0.025**
302558-2	Day1	1.590	3.280	6.190
	Day2	1.470	3.360	6.220
	Day3	1.530	3.230	6.310
	Day4	1.550	3.300	6.200
	Day5	1.590	3.280	6.160
	Standard Deviation	**0.050**	**0.047**	**0.057**
302558-2B	Day1	1.560	3.200	6.110
	Day2	1.540	3.220	6.150
	Day3	1.540	3.210	6.160
	Day4	1.500	3.100	6.000
	Day5	1.510	3.220	6.170
	Standard Deviation	**0.024**	**0.051**	**0.070**

- Measurements taken on same sample daily for five days
- High demonstrated repeatability over extended periods

Measurement Results: Adhesive on Polypropylene

- Typical adhesive thickness is around 35 to 40 microns
- Label Application with polypropylene film

	Adhesive	Polypropylene Film
	thickness(μ)	thickness(μ)
1	35.56	127.45
2	36.25	126.98
3	35.45	127.34
4	36.54	126.66
5	35.47	126.59
6	35.69	126.81
7	35.24	126.36
8	36.54	127.66
9	35.48	126.601
10	35.29	126.41

Measurement Results: UV Embossing

- R2R UV embossing has several advantages over R2R low embossing in terms of low process temperature, low embossing pressure and high process speed.

- UV curable resin applied on PET substrate

	UV Curable coating
Meas#	thickness(μ)
1	105.14
2	106.21
3	105.45
4	105.92
5	106.54

Measurement Results: Barrier coating on film

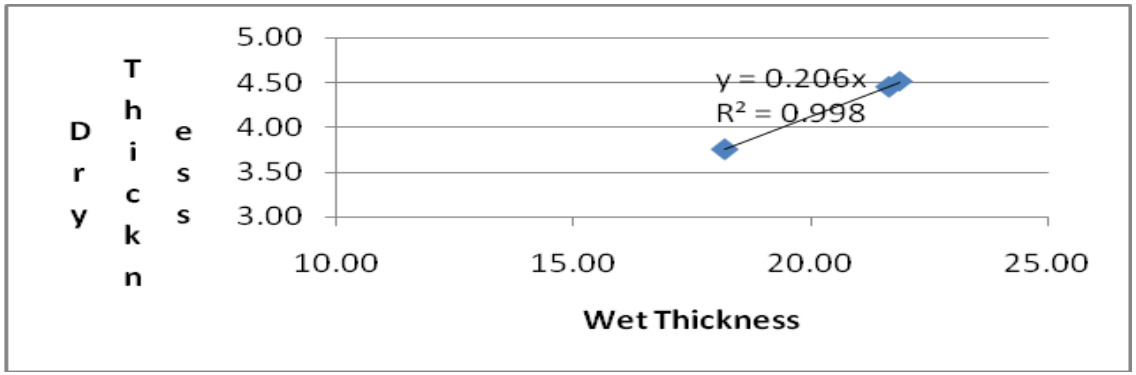
- Thin barrier coating applied in the wet state on a film
- Used for food packaging

	Barrier Coating
Meas#	thickness(μ)
1	0.544
2	0.538
3	0.527
4	0.547
5	0.542

Correlation: Wet (In-line) to Dry Results

- Thickness of wet and dry in-line measurements taken over an extended period of time on applied coatings
- Strong correlation between wet and dry measurements.
- Real-time thickness/weight data available for wet or dry coatings immediately following application

Meas #	Wet Thickness	Dry Thickness	
	wet(µ)	dry(µ)	Correlation factor
1	18.20	3.75	*4.85*
2	21.66	4.45	*4.87*
3	22.20	4.52	*4.91*



Conclusions & Opportunities

- Robust and accurate in-process thickness measurement technology
- Non-contact, non-destructive and low maintenance alternative
- Flexible technology for use in diverse applications & markets
- Excellent results for R2R applications for thin films and coatings
- Ability to measure wet or dry and dual in-process layers – even in sub-micron range
- Improve product quality, minimize process control issues
- Reduced costs through minimizing over application and waste stream

Questions?

For additional information:

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specMETRIX

Technology by SENSORY ANALYTICS

AIMCAL - Table Top Display
Booth 65