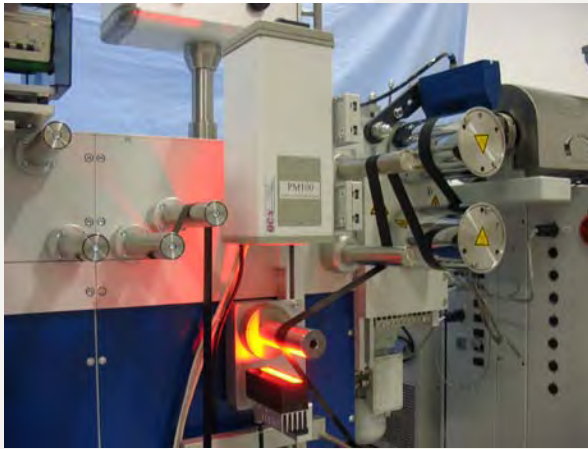


# Improving the Surface Smoothness of Semiconductive Shields



Laurent Gervat & Sébastien Quinebèche, Arkema  
Oliver Hismann, OCS Optical Control Systems GmbH

EVATANE® LOTRYL®  
LOTADER® OREVAC®

# Contents

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- Online control analyzer
- The Nip Detector for semiconductors
- Semiconductor needs and composition
- Smoothness analysis
- Conclusions

# Online Laboratory Control Lines

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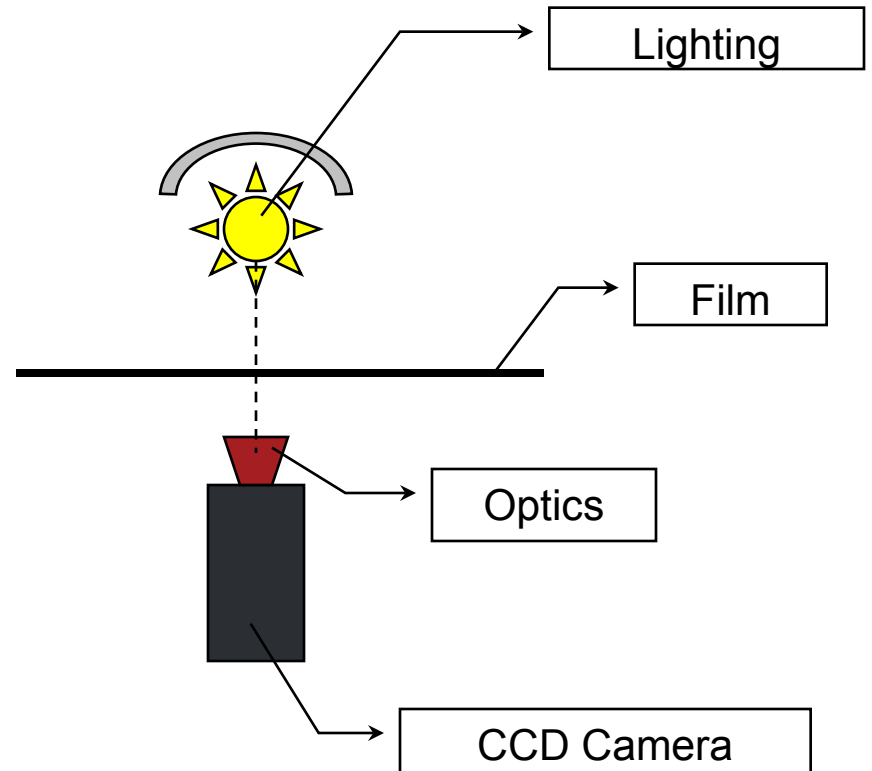
- online Contamination
- online Near Infra Red
- online Haze
- online Gloss
- online Melt Index
- ...

# Common Film Inspection: Transmission Mode

---

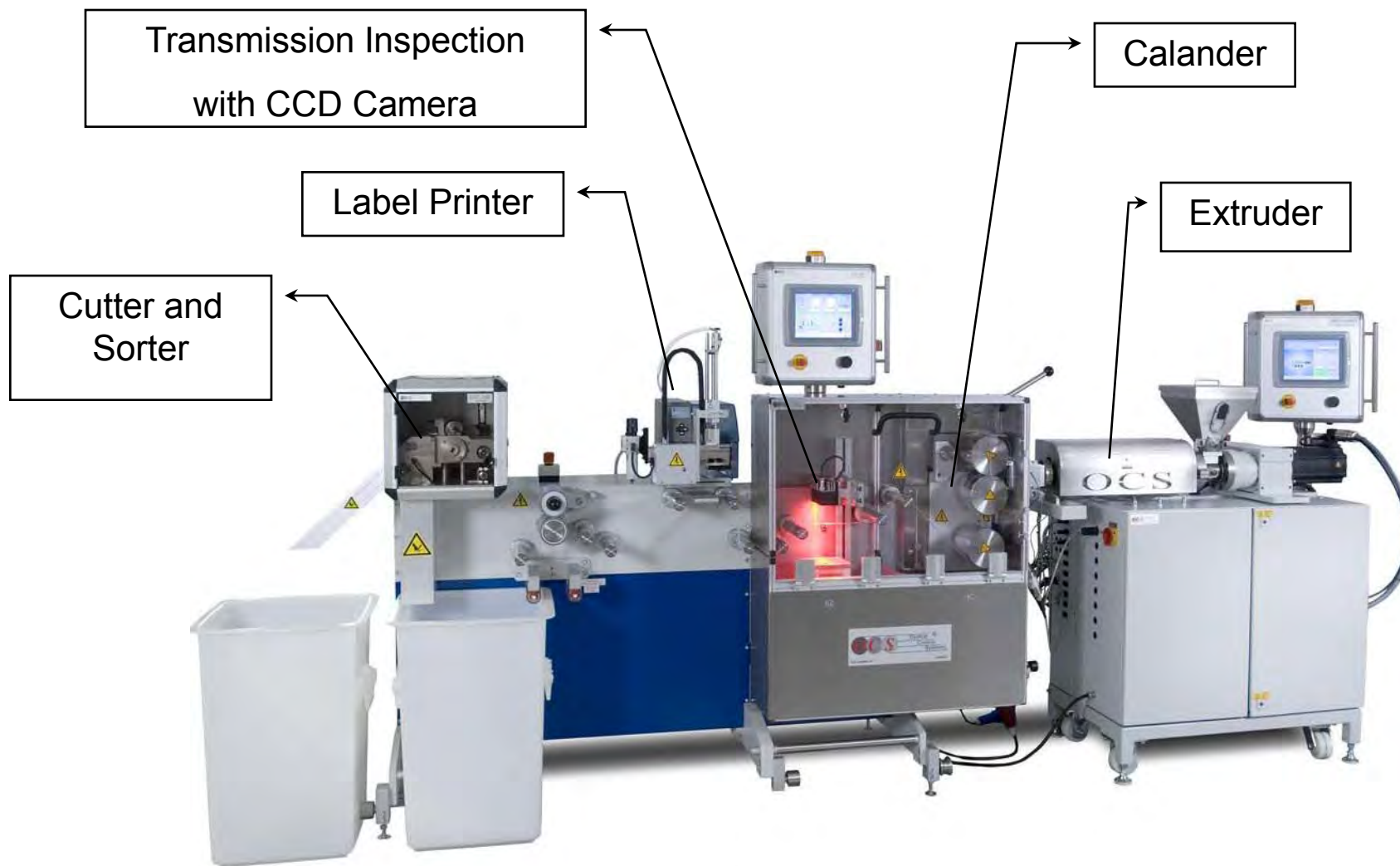


Transmission Mode



# Tape Test for XLPE

---



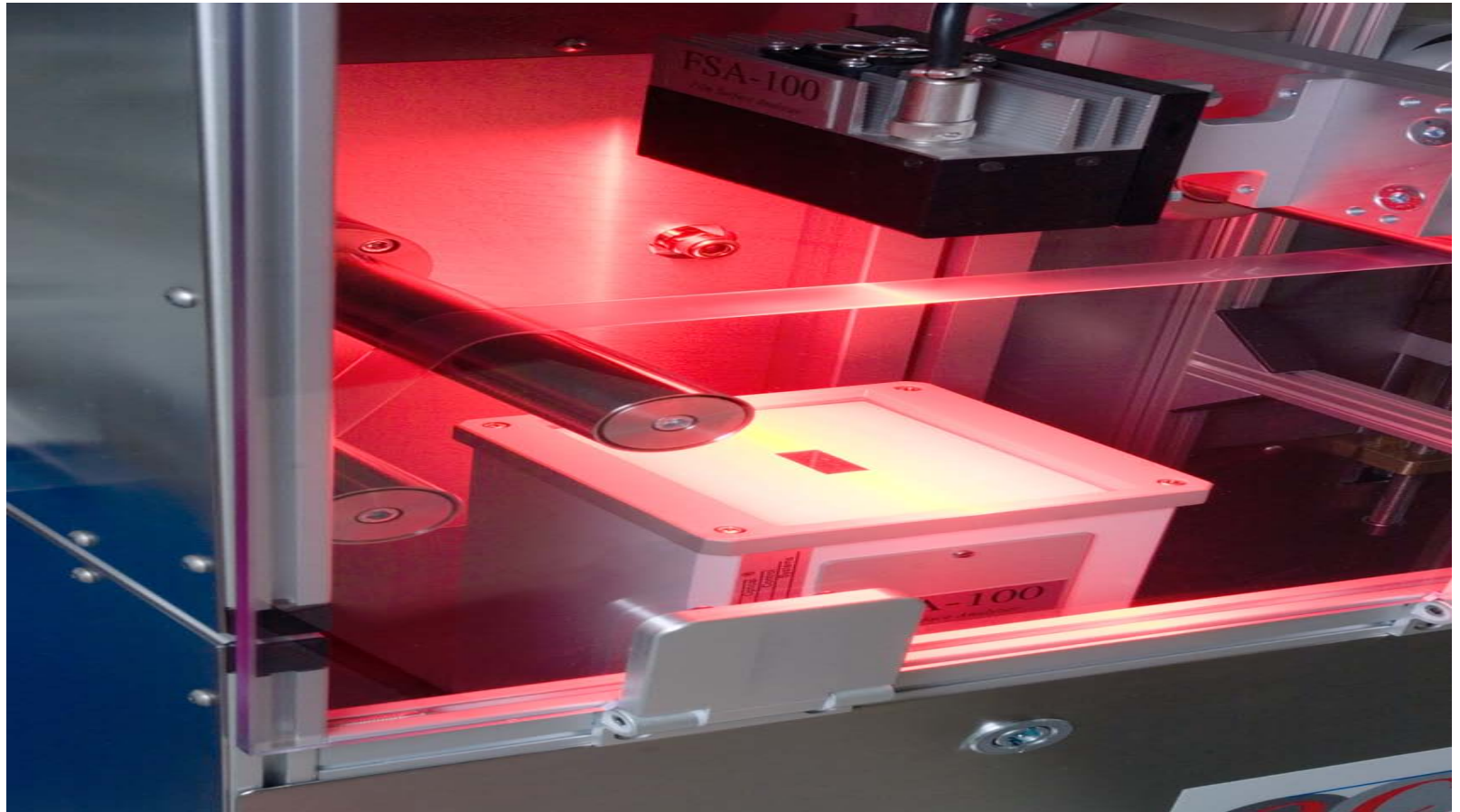
# Tape Test: Calander

---



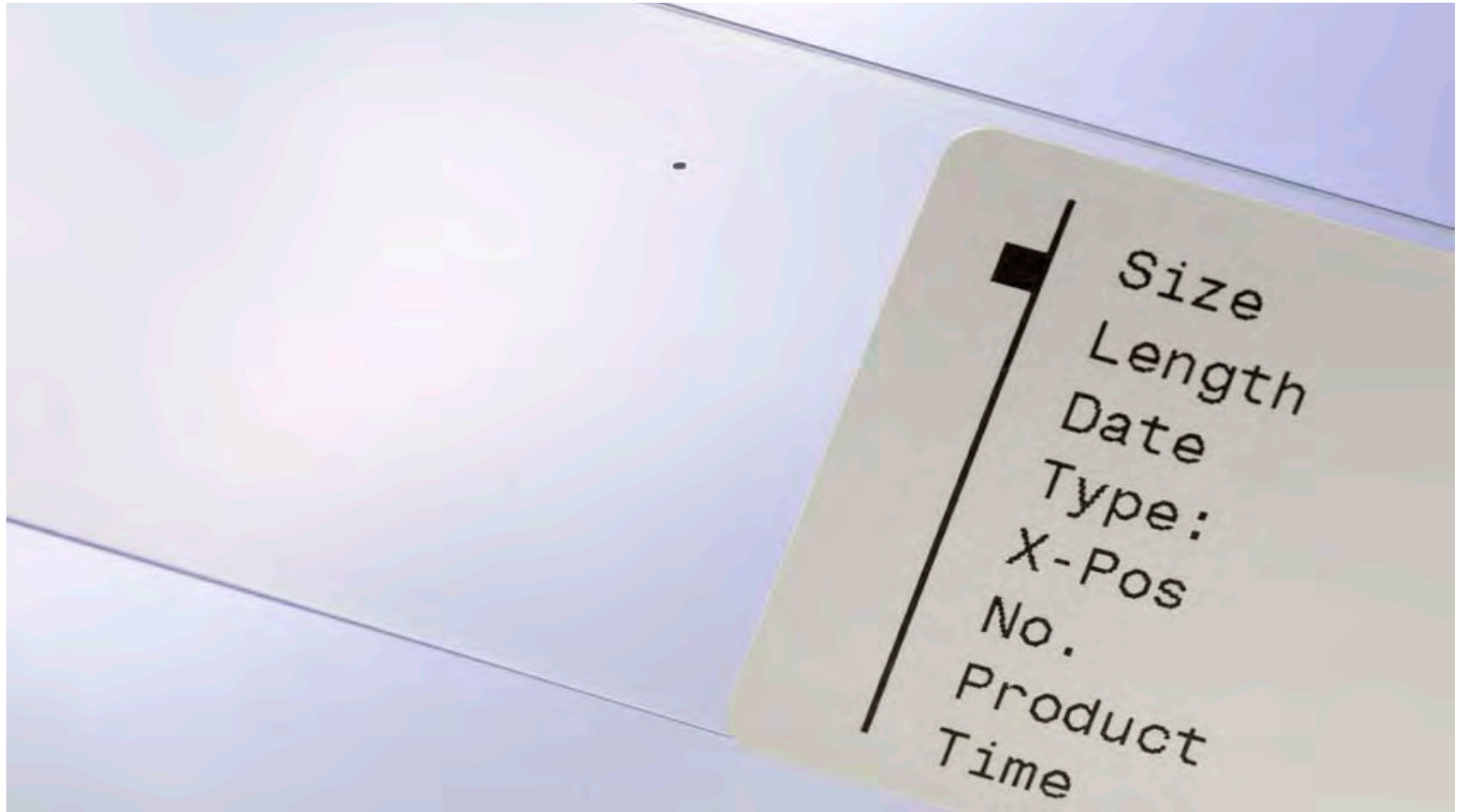
# Tape Test: Detection Camera

---



# Tape Test for XLPE

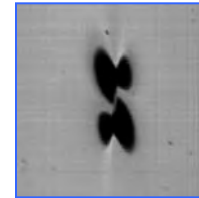
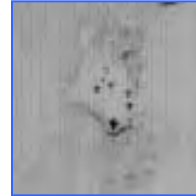
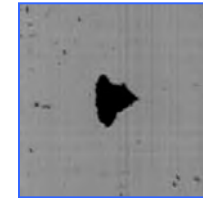
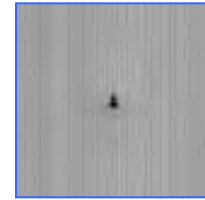
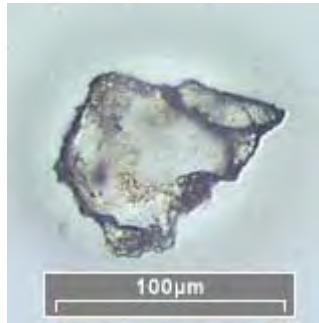
---



# Defect Types

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- Gels
- Black Specs
- Contaminations
- Metal Pieces
- Nips



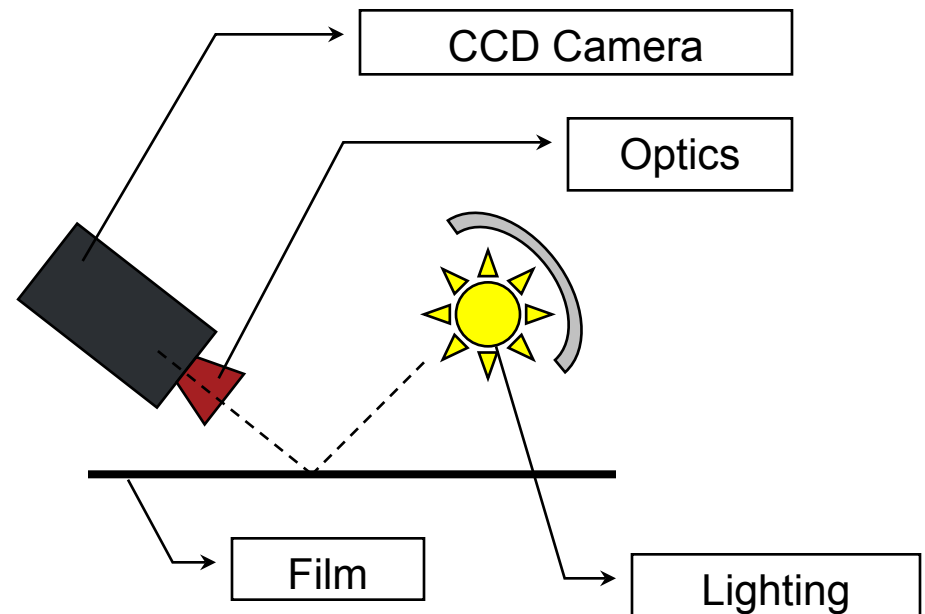
--> Ideal for transparent polymers  
but not suitable for semicon!

# ==> Film Inspection in Reflection Mode

---

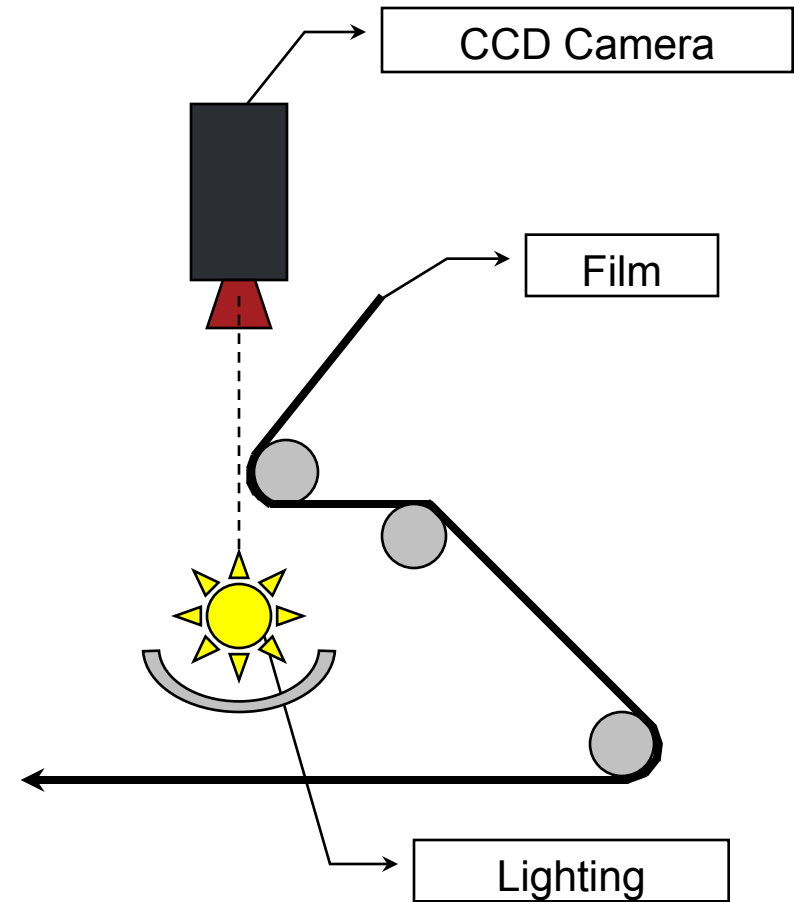


Reflection Mode



# Nip Detection System for Semiconductors

---



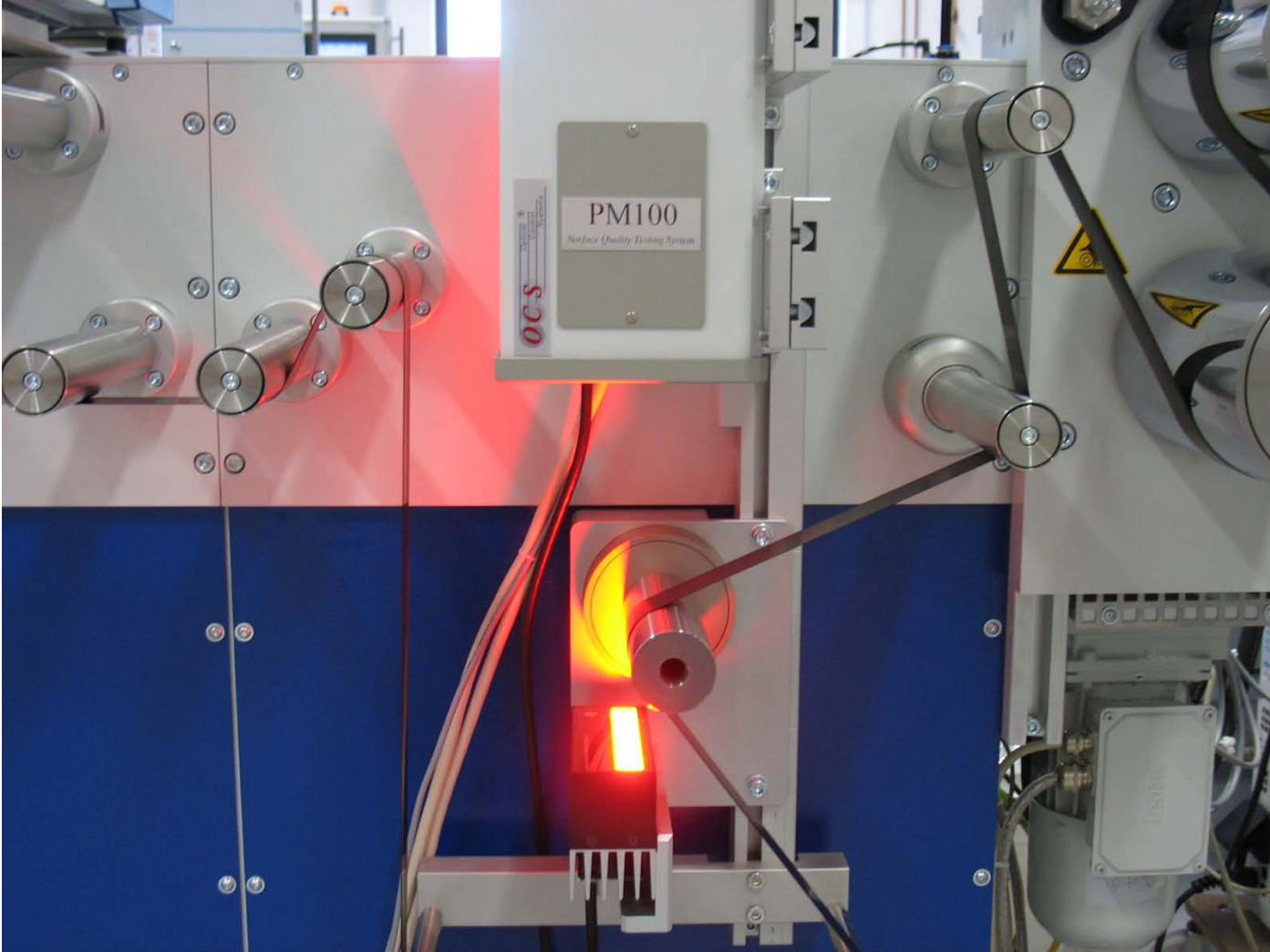
# Nip Detection System for Semiconductors

---



# Camera + High Precision Roll

---



# Choice of the Important Parameters

PM 100 - Settings

Main Menu Load Save


Information & Classes Evaluation File Manager

### Material Information

%11%	OPTICAL CONTROL SYSTEMS	<input type="checkbox"/> Fix	%21%	FILM SURFACE MEASUREMENT 100	<input type="checkbox"/> Fix
%12%		<input type="checkbox"/> Fix	%22%		<input type="checkbox"/> Fix
%13%		<input type="checkbox"/> Fix	%23%		<input type="checkbox"/> Fix
%14%		<input type="checkbox"/> Fix	%24%		<input type="checkbox"/> Fix
%15%		<input type="checkbox"/> Fix	%25%		<input type="checkbox"/> Fix
%16%		<input type="checkbox"/> Fix	%26%		<input type="checkbox"/> Fix
%17%		<input type="checkbox"/> Fix	%27%		<input type="checkbox"/> Fix
%18%		<input type="checkbox"/> Fix	%28%		<input type="checkbox"/> Fix


Change Material Information, at start of Measurement.

### Height Classes




- Height Class 1 100 [µm]
- Height Class 2 200 [µm]
- Height Class 3 300 [µm]
- Height Class 4 400 [µm]
- Height Class 5 500 [µm]
- Height Class 6 600 [µm]
- Height Class 7 700 [µm]
- Height Class 8 800 [µm]
- Height Class 9 900 [µm]
- Height Class 10 >

### Basediameter Classes



- Basediameter Class 1 100 [µm]
- Basediameter Class 2 200 [µm]
- Basediameter Class 3 300 [µm]
- Basediameter Class 4 400 [µm]
- Basediameter Class 5 500 [µm]
- Basediameter Class 6 600 [µm]
- Basediameter Class 7 700 [µm]
- Basediameter Class 8 800 [µm]
- Basediameter Class 9 900 [µm]
- Basediameter Class 10 >

### Halfdiameter Classes



50 [%]

- Halfdiameter Class 1 100 [µm]
- Halfdiameter Class 2 200 [µm]
- Halfdiameter Class 3 300 [µm]
- Halfdiameter Class 4 400 [µm]
- Halfdiameter Class 5 500 [µm]
- Halfdiameter Class 6 600 [µm]
- Halfdiameter Class 7 700 [µm]
- Halfdiameter Class 8 800 [µm]
- Halfdiameter Class 9 900 [µm]
- Halfdiameter Class 10 >

# Defect Details

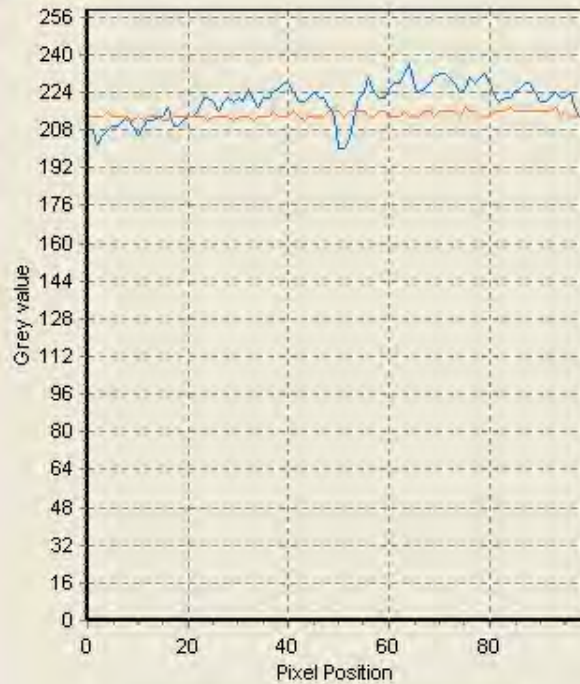
Defect size	28µm 57	28µm 58	50µm 59	70µm 60	24µm 61	24µm 62	24µm 63	49µm 64
Position	10.641m / 0.093m	11.136m / 0.059m	11.379m / 0.107m	11.652m / 0.067m	11.654m / 0.089m	11.764m / 0.098m	11.882m / 0.091m	11.901m / 0.067m
Defect size	24µm 65	28µm 66	26µm 67	24µm 68	26µm 69	56µm 70	26µm 71	34µm 72
Position	12.168m / 0.074m	12.670m / 0.117m	12.966m / 0.105m	13.382m / 0.082m	13.469m / 0.067m	14.252m / 0.076m	14.335m / 0.072m	14.490m / 0.103m
Defect size	26µm 73	29µm 74	24µm 75	26µm 76	24µm 77	31µm 78	64µm 79	45µm 80
Position	14.509m / 0.092m	15.829m / 0.129m	15.985m / 0.077m	16.419m / 0.068m	16.792m / 0.121m	17.434m / 0.073m	17.768m / 0.121m	18.175m / 0.117m
Defect size	30µm 81	29µm 82	37µm 83	40µm 84	40µm 85	59µm 86	28µm 87	38µm 88
Position	18.287m / 0.104m	18.622m / 0.084m	18.692m / 0.126m	18.754m / 0.086m	18.826m / 0.087m	18.931m / 0.087m	19.000m / 0.106m	19.138m / 0.113m

# Defect Details

## Mosaic detail view

Mosaic detail data

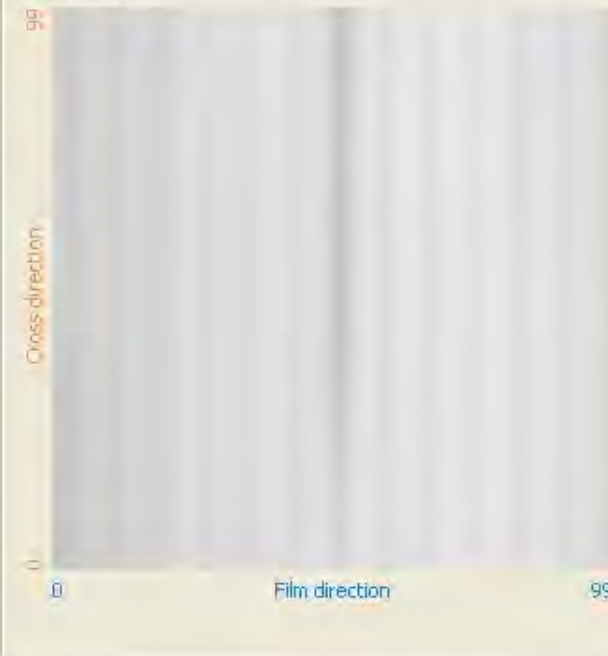
Grey values Histogram



— Cross Direction — Film Direction

Show legend

Mosaic image



Information

Position 20 px 81 px  
 Position 300 [µm] 3240 [µm]  
 Grey value 214

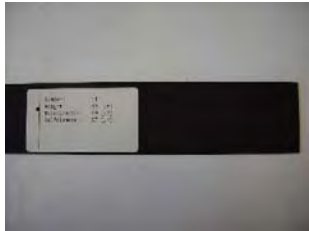
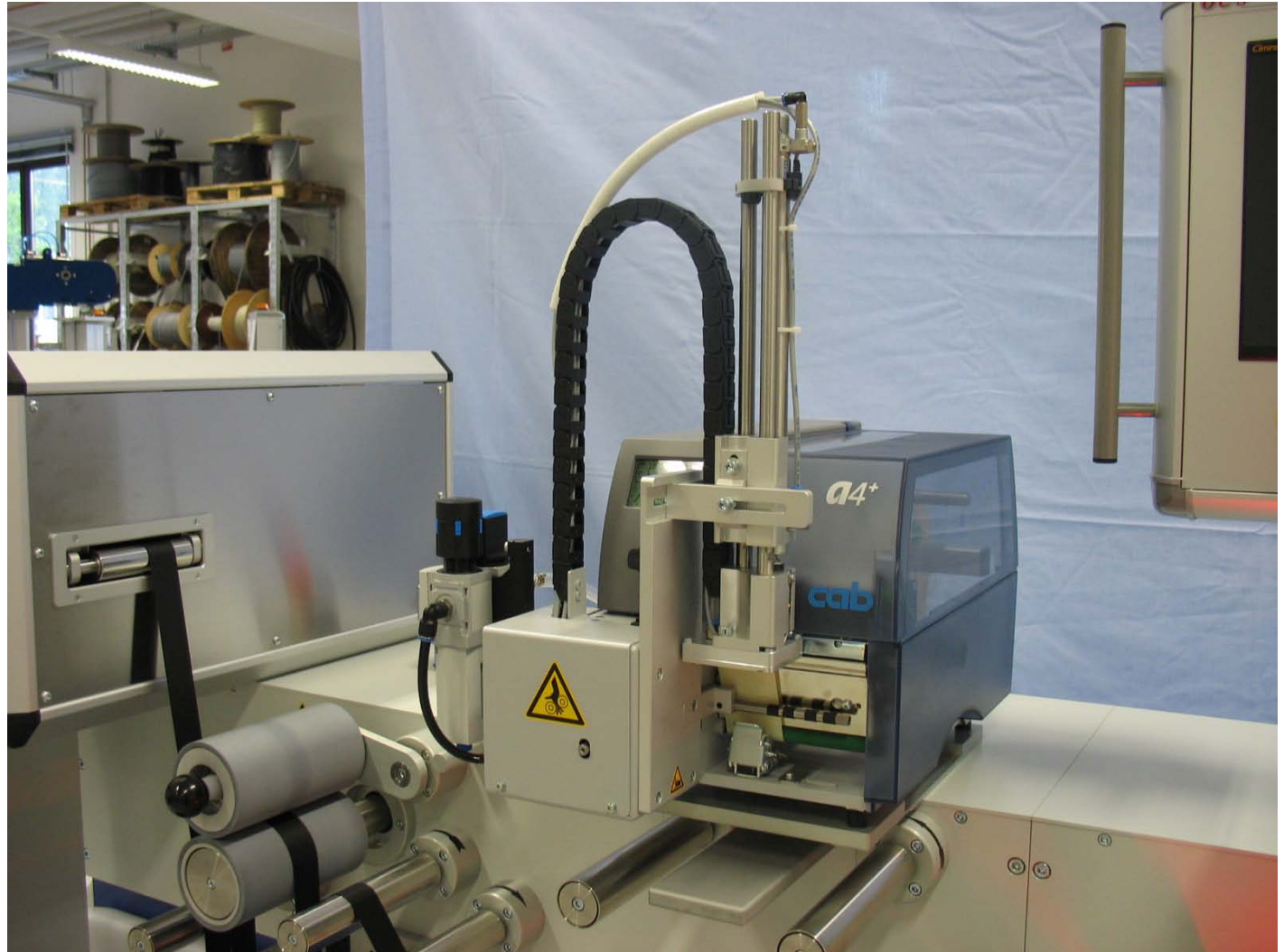
Defect data

Date	16/10/2009
Time	10:23:29
Run length	1,8880 [m]
Defect ID	0:10
Diameter	26 [µm]
Defecttyp / Level	0
Shape factor	15,00
Ø Shape factor	30,00
Elements	6
Bright elements	0
Min. transparency	87,11 [%]
Ø Transparency	87,11 [%]
Gradient	0,00 [%]
Max. pos. deviation	0
Ø pos. deviation	0
Pos. deviation pixel-pixel	0
Pixel 0	11
Pixel 1	0
Pixel 2	0
Pixel 3	0
Defect length	680 [µm]
Defect width	15 [µm]
First X-Position	16,55 [mm]
Last X-Position	16,55 [mm]
X-Position	16,55 [mm]

Print

# Automatic Defect Labeler

---



# Semiconductive Shields

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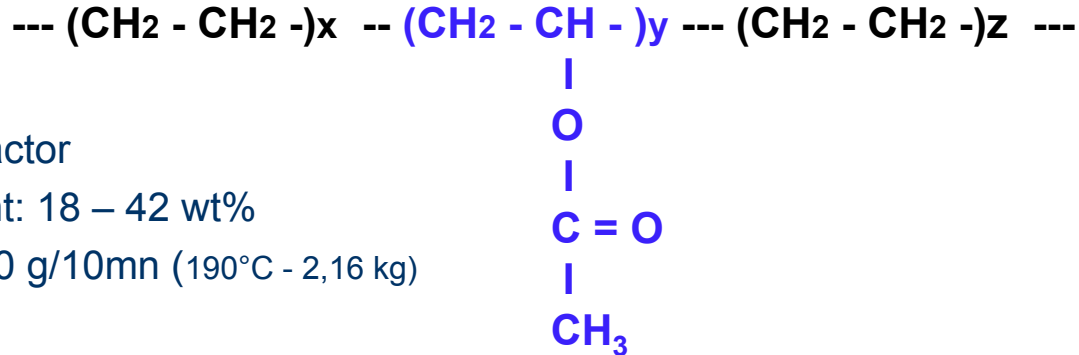
## Must...

- Be in intimate contact with the insulation
  - ⇒ Polar polymer
- Homogenize the electrical field to prevent electrical breakdowns
  - ⇒ 30-40% CB to ensure  $VR < 100 - 1000 \Omega.m$
- Have a surface smooth and free from defect
  - ⇒ Suitable carbon black, suitable polymer & additives
- Ensure long term thermal stability, up to 250°C (Overheating)
  - ⇒ Thermally stable polymer
- Minimize vented treeing
  - ⇒ Suitable carbon black, Acrylate-Ethylene copolymer
- Maintain suitable flexibility
  - ⇒ Low Tg polymer
- Reduce shrink-back
  - ⇒ Polar polymer

# EVA vs. EDA

---

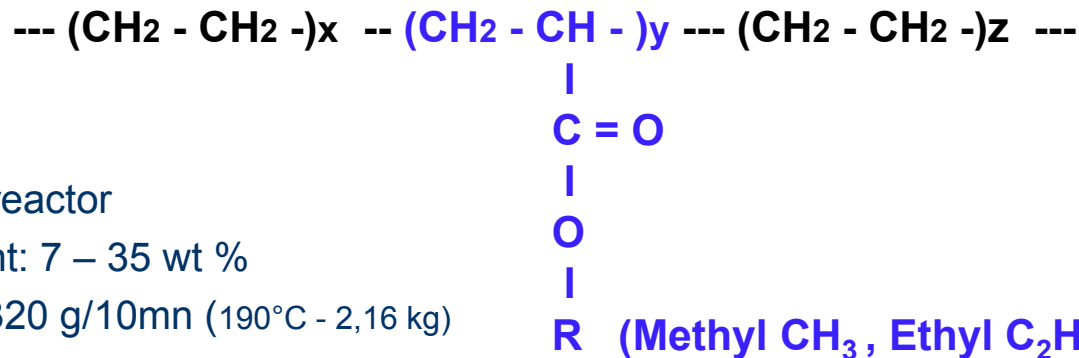
## *EVA: Ethylene – Vinyl Acetate*



- Tubular reactor
- V.A. content: 18 – 42 wt%
- MFI: 3 - 800 g/10mn (190°C - 2,16 kg)

---

## *EDA: Ethylene – Acrylic Ester*



- Autoclave reactor
- A.E. content: 7 – 35 wt %
- MFI: 0.3 - 320 g/10mn (190°C - 2,16 kg)

# EVA or EDA?

---

- In terms of electrical properties, smoothness, extrudability and mechanical properties, EVA and EDA are equivalent.
- Above 150°C, EVA starts to degrade ==> to withstand overheating up to 250°C as specified by AEIC CS5, IEC 502, etc. EDA are safer
- With copper conductors, EVA has two drawbacks:
  - copper catalyzes EVA oxidation
  - EVA may stick too strongly to the copper
- ⇒ EVA usage limited to external SC and to the lower side of MV when used as a conductor shield

# Experimental Work

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- Compounding: Buss PR 46
- Formulations:

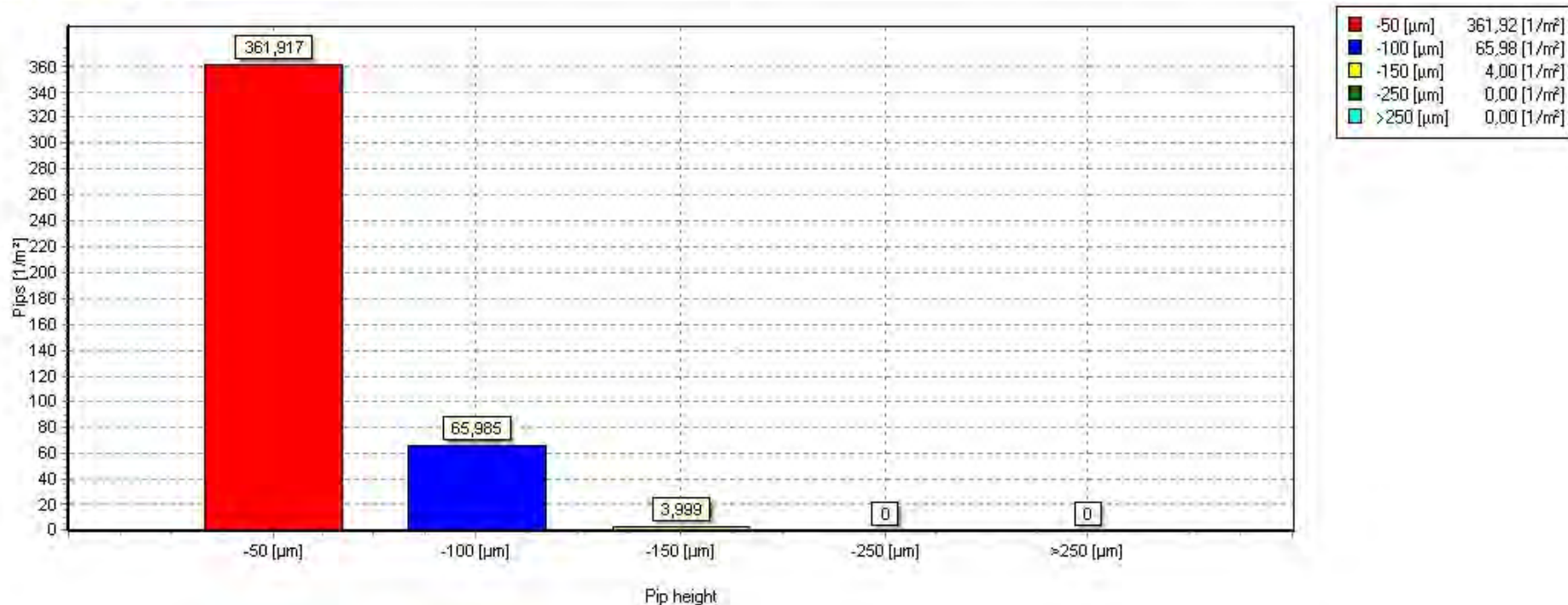
	% Acrylate	Type of Acrylate	MFI					
Carbon Black				39	39	39	39	39
Acrylate-Ethylene Copolymer	17	BA	07	60.2	59,6		48.16	48.16
Acrylate-Ethylene Copolymer	20	MA	08			60.2		
Acrylate-Ethylene Copolymer	28	BA	175				12.04	
Acrylate-Ethylene Copolymer	25	EA	250					12.04
Lubricant					0,6			
Antioxidant (TMQ)				0.8	0.8	0.8	0.8	0.8
Trial #				4	5	3	2 and 6	1

# Results: 1/ Standard "17BA07" Formulation

## File statistics

Product Reference	79273	Parcel length	10,24 [mm]	Ø Grey value	210	Ø Pip height	37 [µm]
Lot Number	17BA07 N, PE17004149	Parcel width	11,76 [mm]	Filter size	50 (50)	Ø Pip base diameter	51 [µm]
Operator	Arkema	Parcel area	120,422 [mm <sup>2</sup> ]	Ø Film speed	5,00 [m/min]	Ø Pip half diameter	28 [µm]
		Inspected parcels	4 153 (4 153)	Ø Noise	1,64 [%]	Y-Resolution	40 [µm]
		Inspected area	0,500 [m <sup>2</sup> ]	X-Resolution	15 [µm]		
		Inspected length	42,527 [m]				
		Start	16/10/2009 13:45:05	Stop	16/10/2009 13:53:35	Duration	0:08:30

## Height histogram

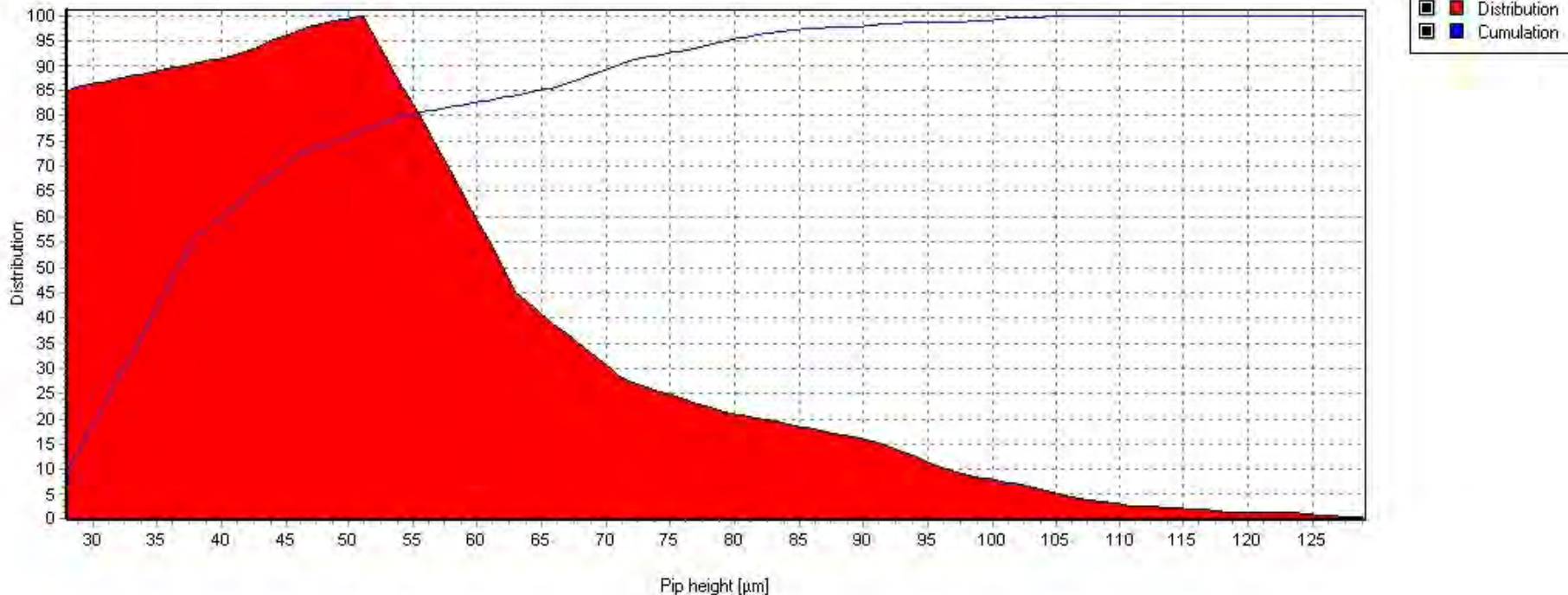


# 1/ Standard “17BA07” Formulation

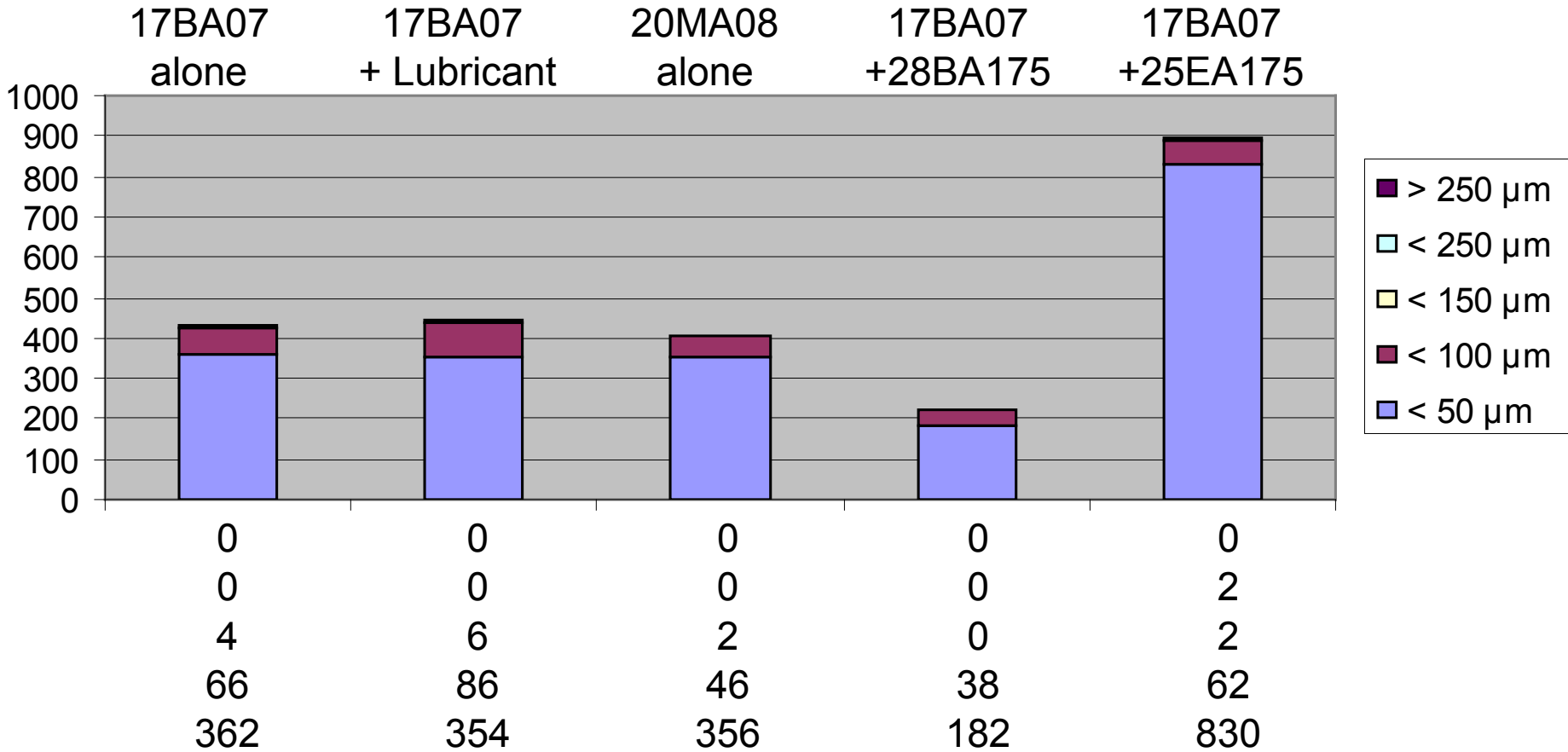
## File statistics

Product Reference	79273	Parcel length	10,24 [mm]	Ø Grey value	209	Ø Pip height	39 [µm]
Lot Number	17BA07 N, PE17004149	Parcel width	11,76 [mm]	Filter size	50 (50)	Ø Pip base diameter	53 [µm]
Operator	Arkema	Parcel area	120,422 [mm <sup>2</sup> ]	Ø Film speed	5,00 [m/min]	Ø Pip half diameter	31 [µm]
		Inspected parcels	4 153 (4 153)	Ø Noise	1,69 [%]		
		Inspected area	0,500 [m <sup>2</sup> ]	X-Resolution	15 [µm]	Y-Resolution	40 [µm]
		Inspected length	42,527 [m]				
		Start	16/10/2009 13:02:25	Stop	16/10/2009 13:10:55	Duration	0:08:30

## Height distribution

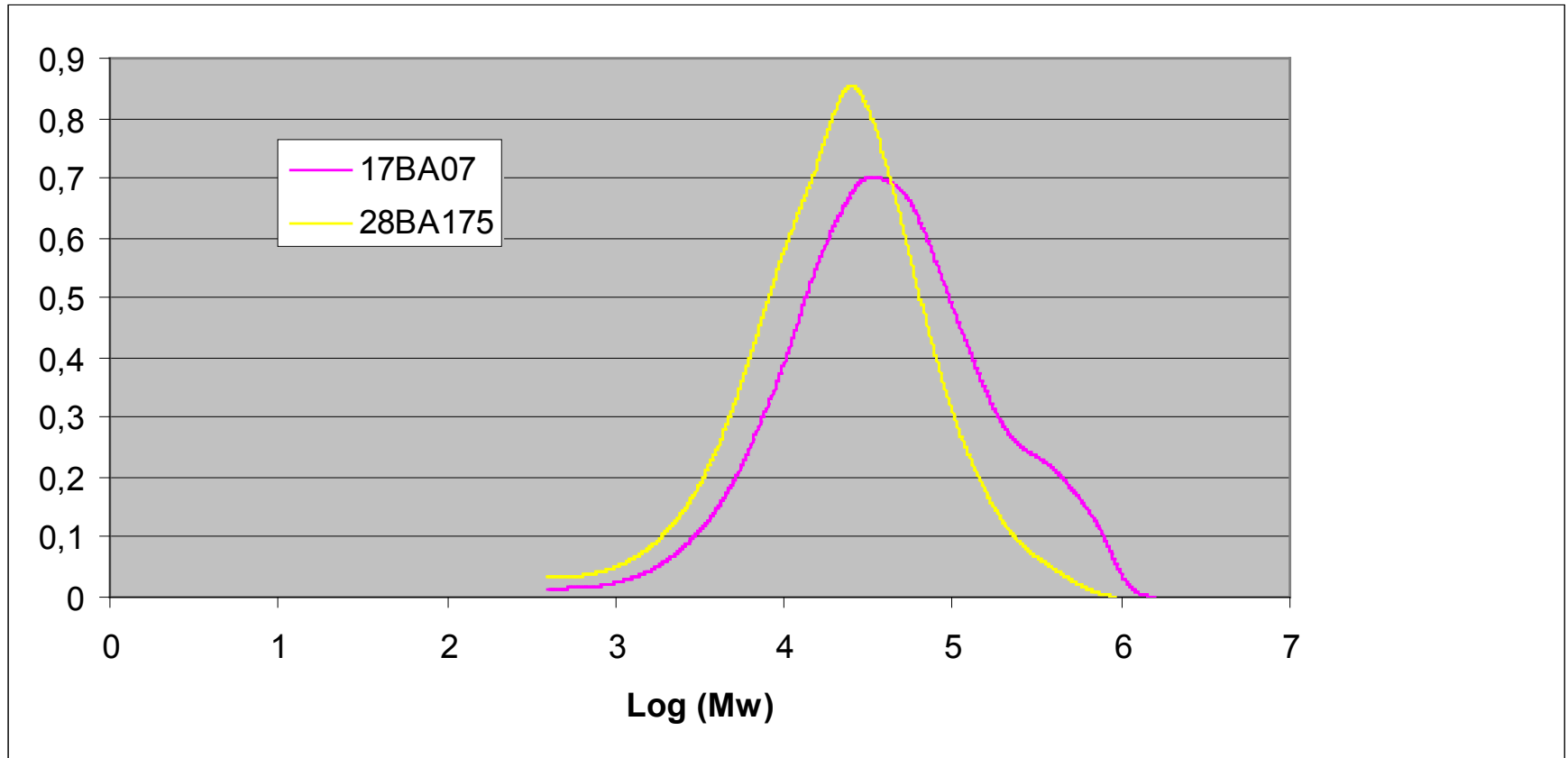


# 2/ Effect of Base Polymer Modification



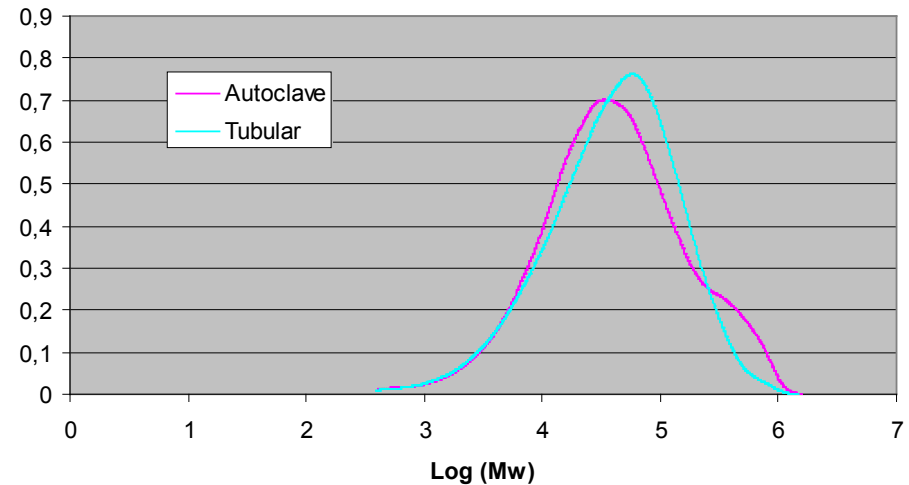
# 17BA07 + 28BA175: A Successful Blend!

---



# 17BA07 + 28BA175: A Successful Blend!

- Autoclave copolymers are known to give smoother surface than Tubular ones, thanks to a high Mw shoulder



- The particular combination of 17BA07 and 28BA175 molecular weight distribution may have a similar and enhanced effect
- The difference in melting temperature may also help the wetting and the dispersion of CB

# Conclusions

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Thanks to a dedicated semicon surface analyzer it was observed that the addition of a particular ethylene acrylate copolymer decreases the size and the number of protrusions by two folds. This technique appears more efficient than using a lubricant or other types of copolymers.