Market Trends, Opportunities and Latest Process Innovation in Vacuum Metallization – Introducing BOBST AluBond® Technology

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Presentation outline

- Introduction & background
  - Global market trends in vacuum metallizing
  - Metal adhesion evaluation
- AluBond® process & performance
  - Adhesion – EAA peel test
  - Adhesion – Laminate bond strength
  - Barrier performance
  - Metallizing defects – Optical microscopy
  - Dyne level and dyne level retention
- Summary and conclusions

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Introduction & background

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Global market trends in vacuum metallization

The challenges….

❶ Higher process performance

- High metal adhesion (examples: >2N/15mm PET/OPP, Increased metal adhesion on CPP & PE structures)
- High barrier metallization for increased shelf life (Al foil replacement, layer reduction, substrate down-gauging)
- Higher dyne level, better dyne level retention (metallized polyolefin substrates)

❷ Cost reduction (commodity)

- Down-gauging of substrates ⇨ Temperature/heat load management
- Metallization of more heat-sensitive substrates
- Increased output/ productivity/ reliability & reduced production cost
- Wide web metallization (movement: toll ⇨ convertor ⇨ film producer')

❸ Alternative & new process technologies (added value/ niche applications)

- Transparent inorganic barrier (SiO_x & AlO_x higher barrier single layer (dry and wet) and conversion solutions)
- Selective or partial Metallization (decorative, functional, security + barrier requirements)

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Global market trends in vacuum metallization

…BOBST solutions & innovations

❶ Higher process performance

- High barrier – DarkNight® & AluBond® process
- High adhesion – AluBond® process
- Defect reduction – Hawkeye pinhole detector (in-line defect detection & opacity control)
- Higher dyne and dyne level retention – AluBond® process or plasma post treatment

❷ Cost reduction

- Metallization of more heat sensitive substrates – K5 VISION & K5 EXPERT
- Metallization of down gauged materials – K5 VISION & K5 EXPERT
- Increased output/ productivity/ reliability – K5 VISION & K5 EXPERT/ K5 Wide Web

❸ Alternative & new process technologies (added value/ niche applications)

- Transparent inorganic barrier – SiO_x (PECVD), AlO_x (reactive PVD) & AlO_x conversion solutions
- Selective or partial metallisation – SelectMet® process

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Global market trends in vacuum metallization

Market available solutions for improving metal adhesion

Non-vacuum techniques

- *Chemical treatment/coating*
  - Cost Implications for the convertor
  - Production/ processability implications for the film producers
  - Potential detrimental barrier effects when combing with dry vacuum technology
- *Atmospheric plasma/ corona treatment*
  - Treatment consistency, uniformity & decay over time
- *Flame treatment*
  - Thermal implications (heat-sensitive & down-gauged materials)

In-vacuum techniques

- *Plasma treatment*
  - Limited adhesion (typically 1 – 2 N/(15 mm) for PET)
  - Special higher power or multiple treaters (levels of 2 – 3 N/(15 mm) for PET)
  - Limitation: Reliability/ consistency (process stability/ arcing/ electrode cleaning)
- *New **BOBST AluBond®** technology*

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Metal adhesion evaluation

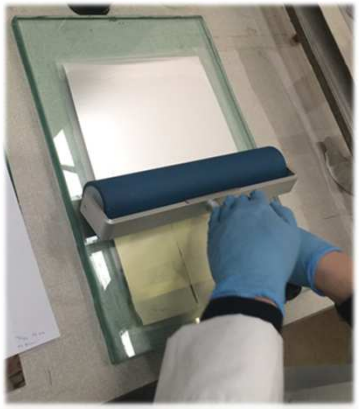
Techniques currently used in industry

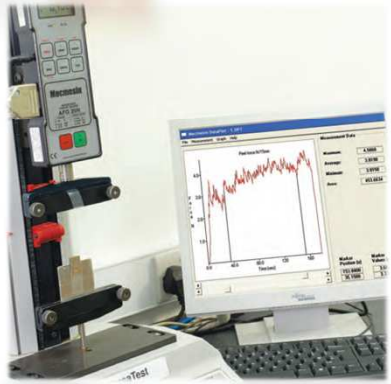
Tape test (AIMCAL TP-104-87)

- Instant result, no sample preparation
- Qualitative test method (pass/fail) ⇨ main limitation

EAA seal & peel test (AIMCAL TP-105-92, EMA seal test)

- Quantitative test method
- Sample preparation & specific equipment required
- Intrinsic strength of EAA film ⇨ main limitation





Laminate bond strength (ASTM F88, ISO 11339)

- Quantitative test method
- Time consuming & specific equipment required
- More representative of actual packaging application

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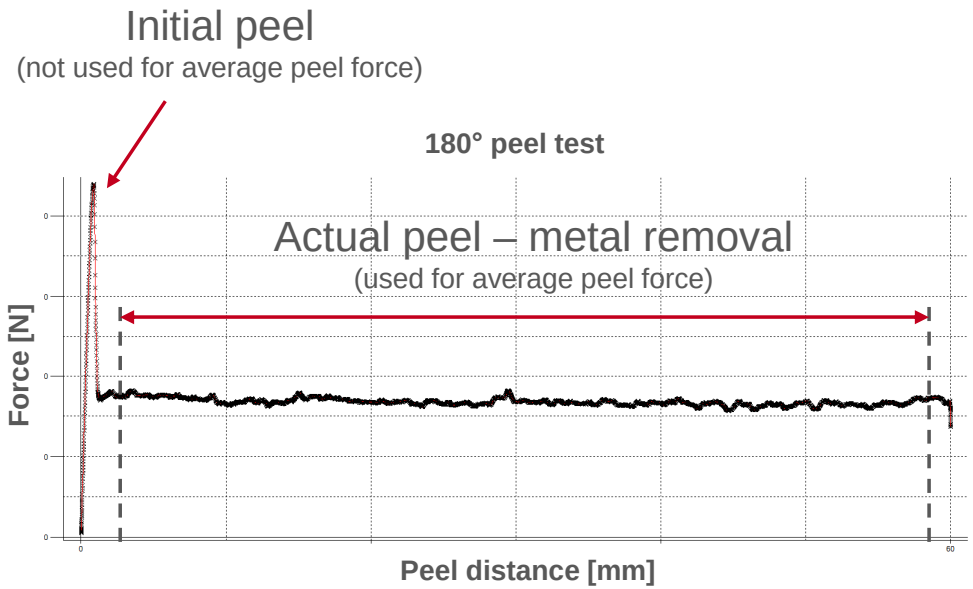
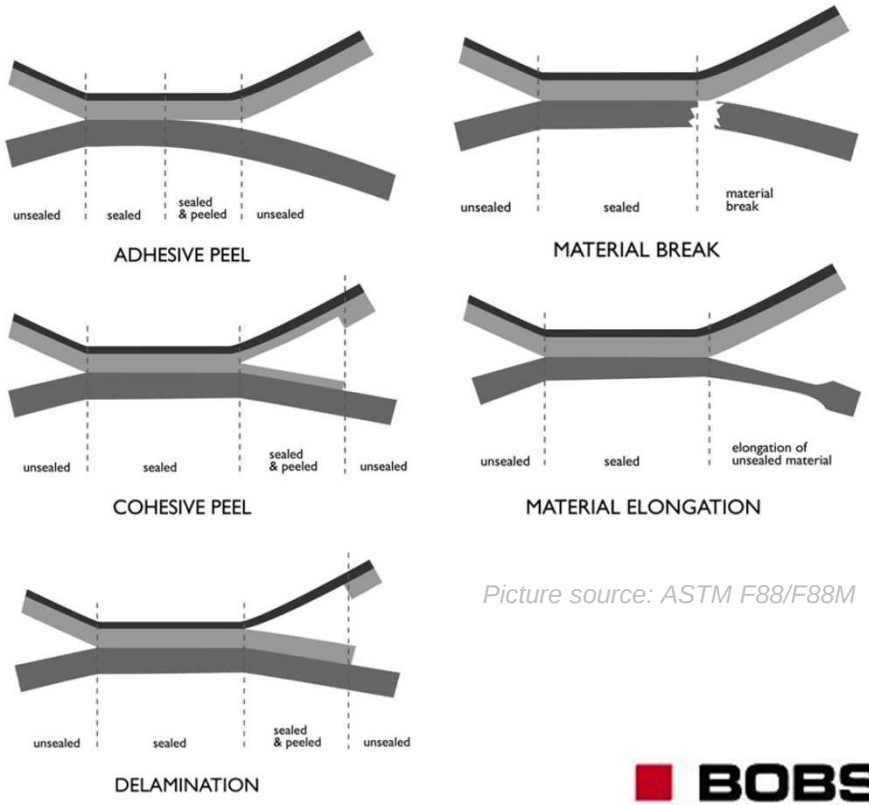
Metal adhesion evaluation

Interpreting and using quantitative adhesion results correctly

EAA peel test & laminate bond strength

- Different ***test setup*** ⇨ different results (peel ***speed***, peel ***angle***, sealant film ***thickness*** etc.)
- ***Test graph*** – Correct data extraction
- ***Failure mode*** – It's not just a number …





Picture source: ASTM F88/F88M

AluBond® process & performance

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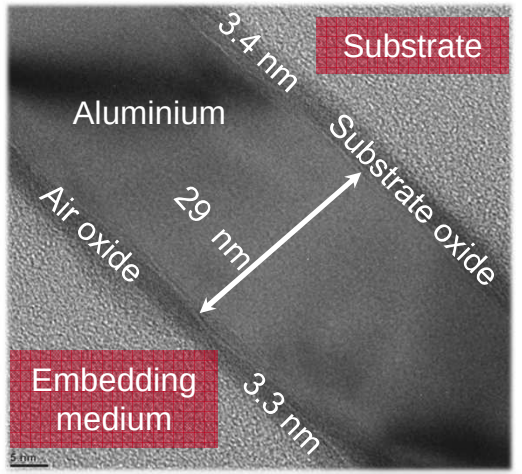
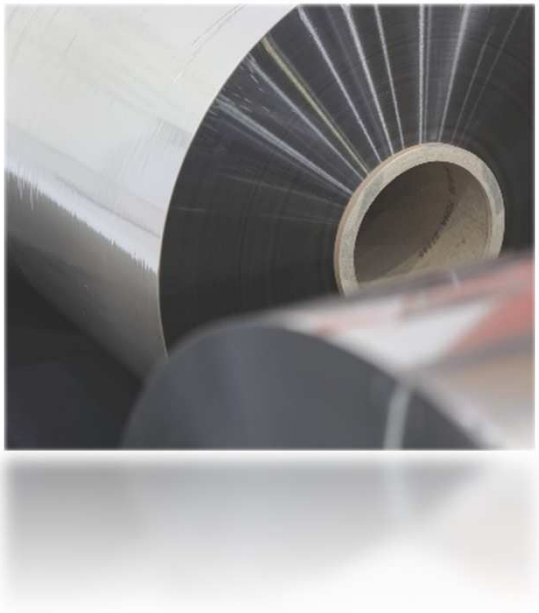
What is BOBST AluBond® Technology?

AluBond® – A **hybrid coating technology**

- Vastly improved *anchoring properties* to the base substrate
- *Tailored coating stoichiometry* (reactants (AluBond®) + products (Al)) created via a *uniquely designed coating gradient*



Picture source: 'Evaporated aluminum on polyester: optical and electrical properties as a function of thickness', McClure & Copeland, AIMCAL 2010



AluBond® – **Process performance**

- Improved *metal adhesion* between the metallised layer and the underlying base substrate to levels which conventional 'plasma' based systems have been unable to achieve (on barrier and sealant webs)
- Enhanced *dyne level & dyne retention*
- *Barrier* improvement obtained on all sealant webs tested

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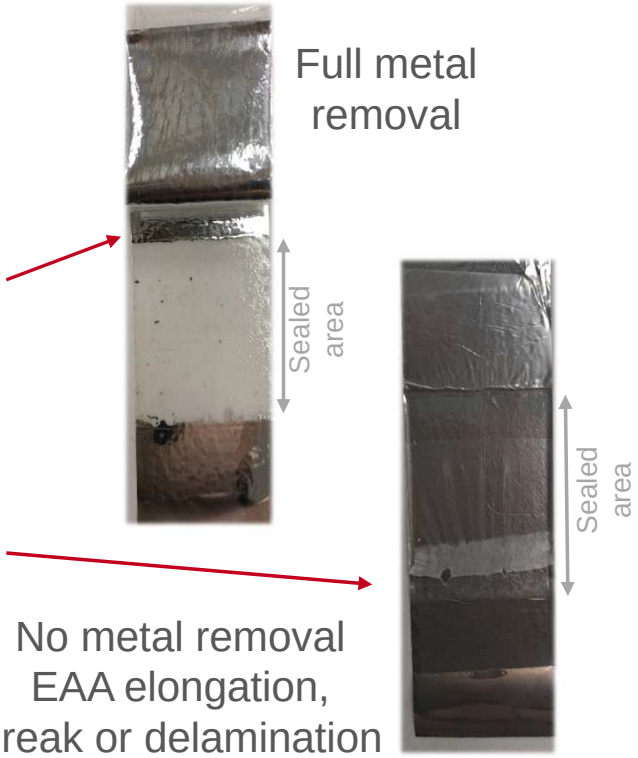
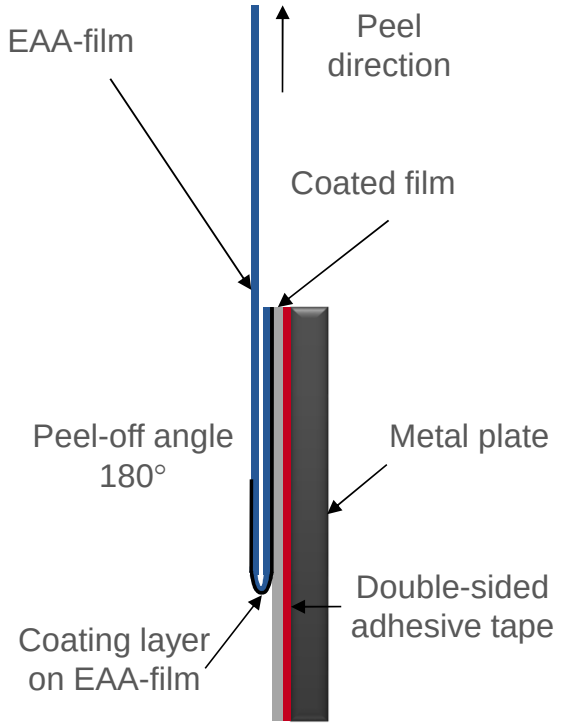
AluBond® process performance
Metal adhesion – EAA peel test

EAA peel test – *Metallized PET*

- Sealing: 105 °C, 4 bar, 20 s, speed: 50 mm/min

Structure	Description	Peel force N/(15 mm)
PET/Al 12 µm	Metal only	0.08 ± 0.02
	Low dosage plasma	0.38 ± 0.30
	Low dosage plasma + *AluBond®*	6.12 ± 0.21
	AluBond®	6.12 ± 0.28





EMA (European Metallizers Association) test procedure for metal adhesion (seal test)

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AluBond® process performance
Metal adhesion – EAA peel test

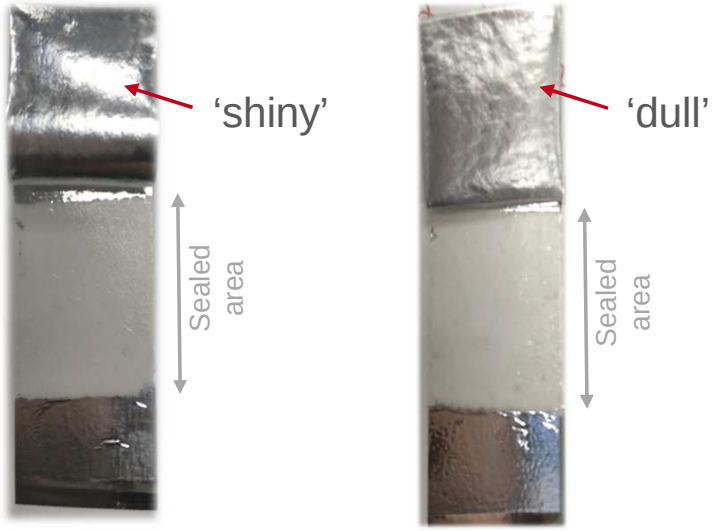
EAA peel test – *Metallized BOPP and CPP*

Structure	Description	Peel force N/(15 mm)
BOPP/Al 50 µm	Metal only	1.01 ± 0.23
	AluBond®	5.91 ± 0.25
BOPP/Al 20 µm	Metal only	0.52 ± 0.14
	AluBond®	4.47 ± 0.33
CPP/Al 25 µm	Metal only	0.89 ± 0.22
	AluBond®	3.12 ± 0.08

Non-AluBond® Full metal removal at *low peel force*

AluBond® partial/full metal removal at *high peel force*

Non-AluBond® *AluBond®*



Peeled-off EAA is shiny for non-AluBond® and dull for AluBond®

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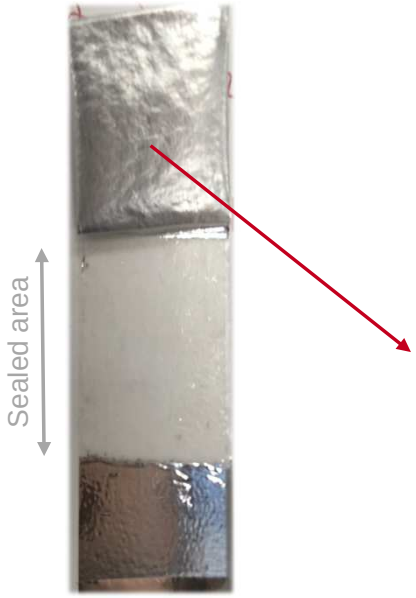
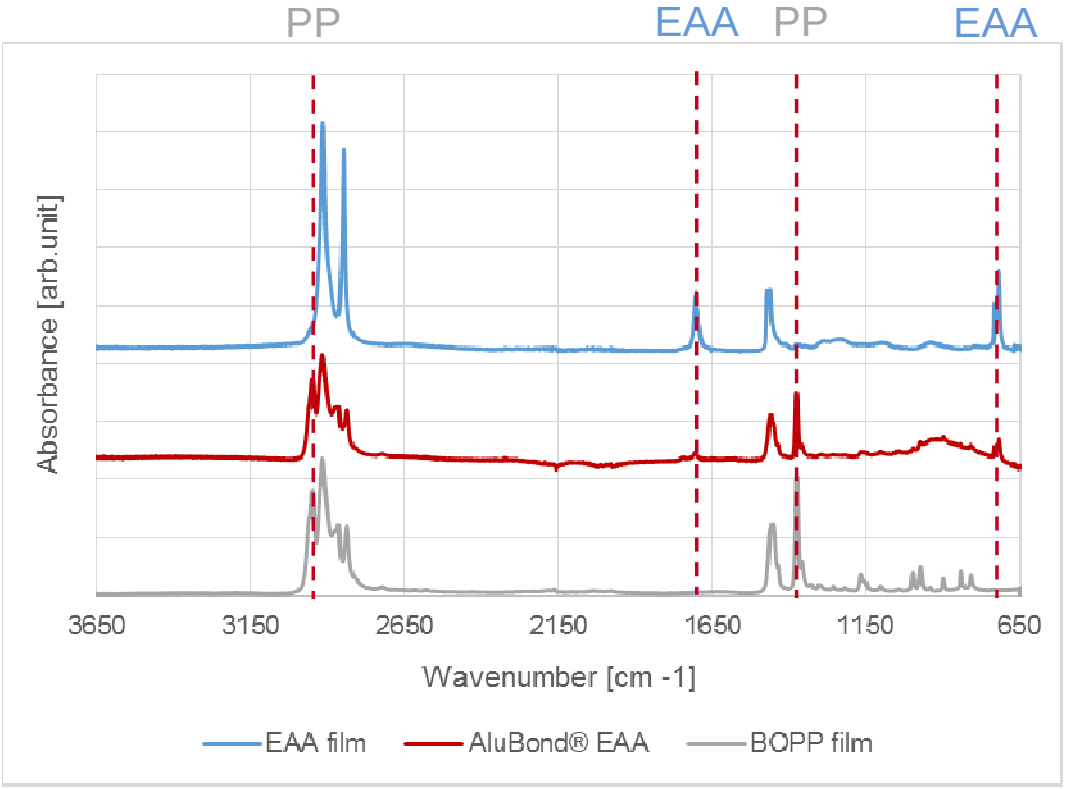
AluBond® process performance
Metal adhesion – FTIR analysis

EAA peel test – *Metallized BOPP and CPP*



AluBond®



AluBond® peel test sample shows clear PP and EAA peaks in FTIR analysis

⇨ BOPP/CPP skin layer peeled off along with AluBond ® metallization layer

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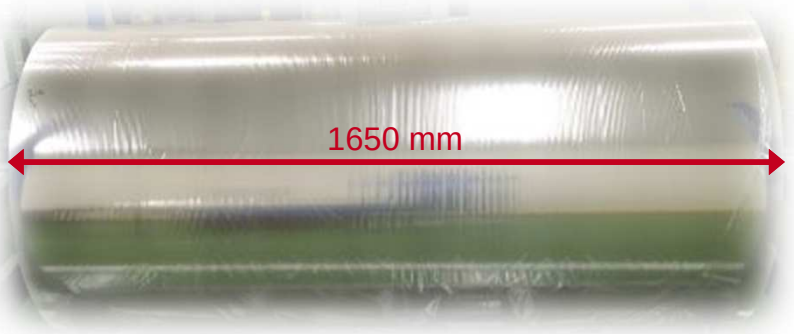
AluBond® process performance
Metal adhesion – Cross-web uniformity

EAA peel test – *AluBond® Metallized BOPP*

- Adhesion uniformity across web width & length
- Non-AluBond® adhesion: 0.52 N/(15 mm)
- 20 µm BOPP, 2.2 OD

AluBond® BOPP reel



Sample taken and measured every 100 mm

Adhesion Levels – Position from pump side of film

Position mm	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600
Adhesion N/(15 mm)	3.92	4.23	4.00	4.40	4.78	4.13	4.64	4.71	4.80	4.29	4.54	4.64	4.45	4.56	4.75	4.70
Failure mode	*Partial metal and BOPP skin layer removal*															

⇨ AluBond® adhesion shows very good cross-web uniformity

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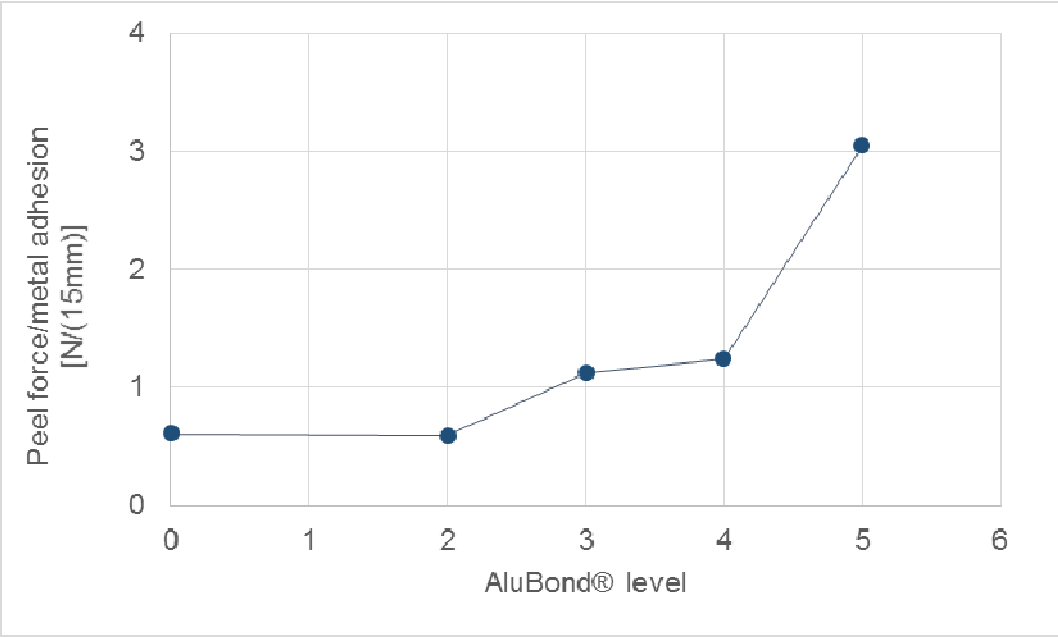
AluBond® process performance
Metal adhesion – Adjustment of AluBond® adhesion level

EAA peel test – *Metallized CPP* (example)



- ⇨ AluBond® adhesion level can be tuned to certain degree
- ⇨ No linear relationship
- ⇨ Significant step change typical for AluBond® level 5

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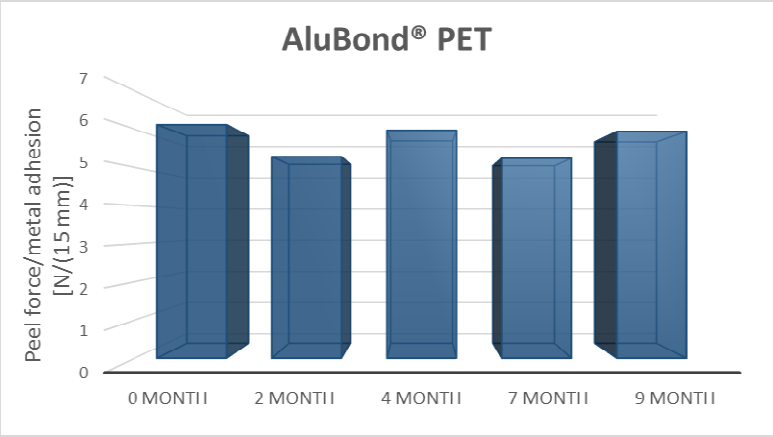
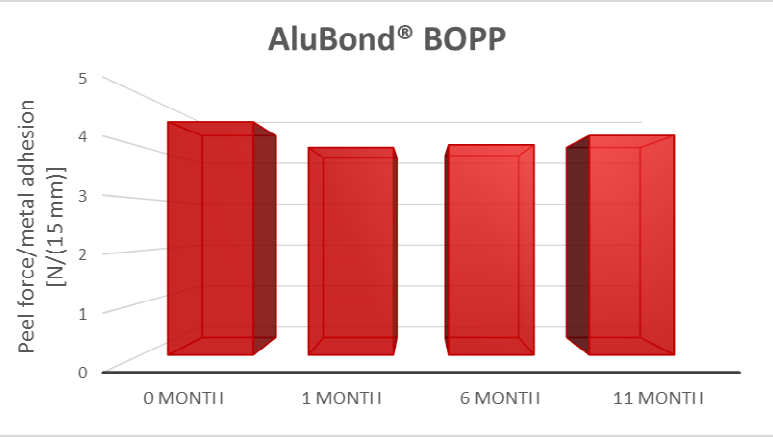
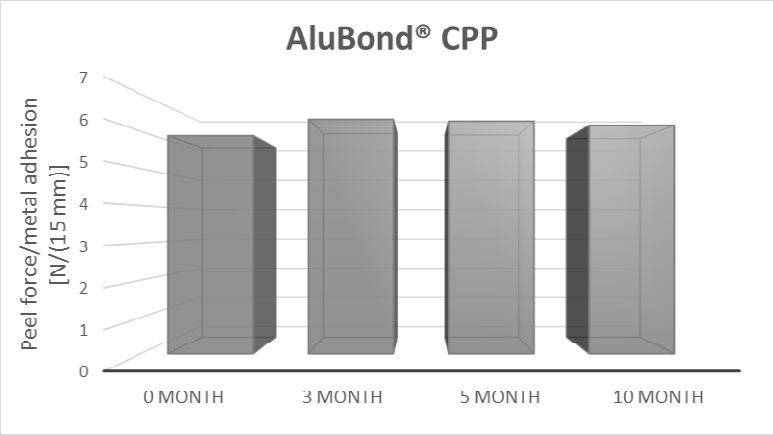
AluBond® process performance
Metal adhesion – Retention of AluBond® adhesion level







⇨ EAA peel test investigations

⇨ AluBond® adhesion level maintained over extended storage times

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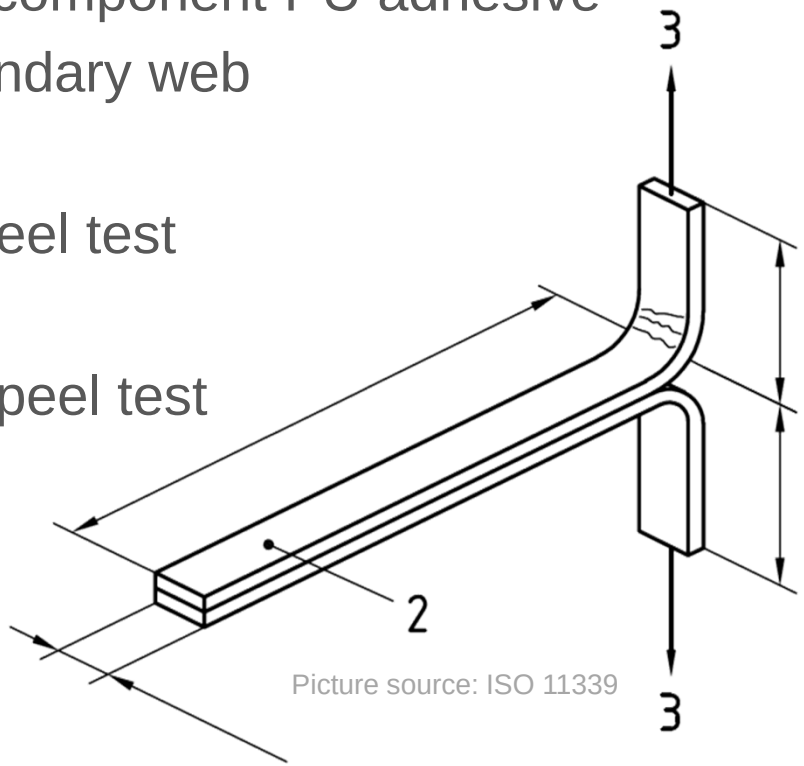
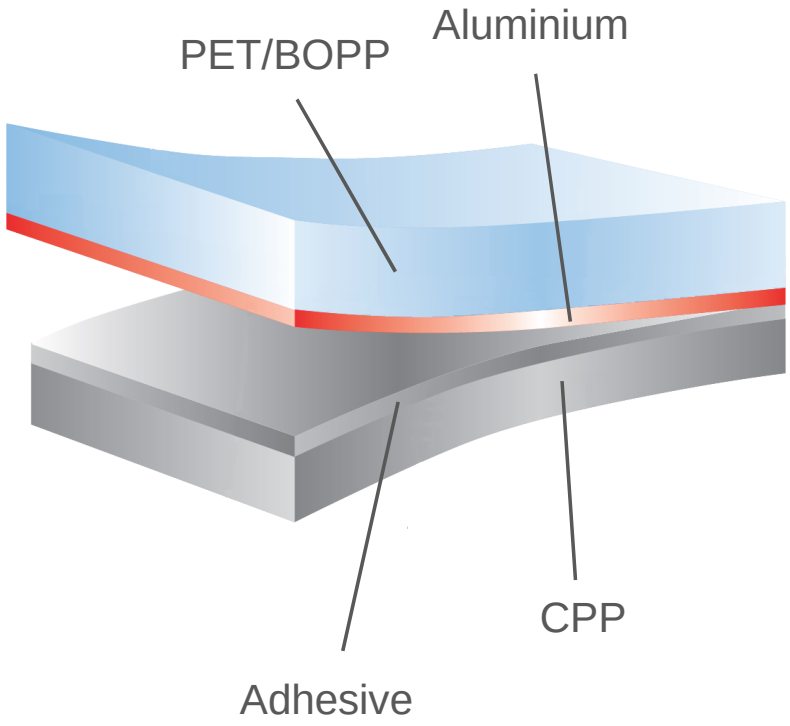
AluBond® process performance
Metal adhesion – Laminate bond strength

Laminate bond strength – *Metallized PET and BOPP*

- Laboratory lamination
- Solvent based 2-component PU adhesive
- 70 µm CPP secondary web (duplex laminate)
- 180º supported peel test at 50 mm/min
- 90º unsupported peel test at 100 mm/min



Picture source: ISO 11339



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AluBond® process performance
Metal adhesion – Laminate bond strength

Laminate bond strength – *Metallized PET and BOPP*

Structure	Test	Description	Peel force N/(15 mm)
PET/Al 12 µm	180º supported	Metal only	3.03 ± 0.26
		AluBond®	4.48 ± 0.49
	90º un-supported	Metal only	2.19 ± 0.29
		AluBond®	3.55 ± 0.34
BOPP/Al 20 µm	180º supported	Metal only	2.54 ± 0.08
		AluBond®	5.34 ± 0.22
	90º un-supported	Metal only	2.69 ± 0.08
		AluBond®	3.22 ± 0.27

- ⇨ *Full metal removal* for non-AluBond®
- ⇨ *Partial metal* removal for AluBond®
- ⇨ PET/BOPP *film break* for Alubond® in 90º unsupported T-peel test

AluBond®
BOPP
Partial metal removal & CPP delamination

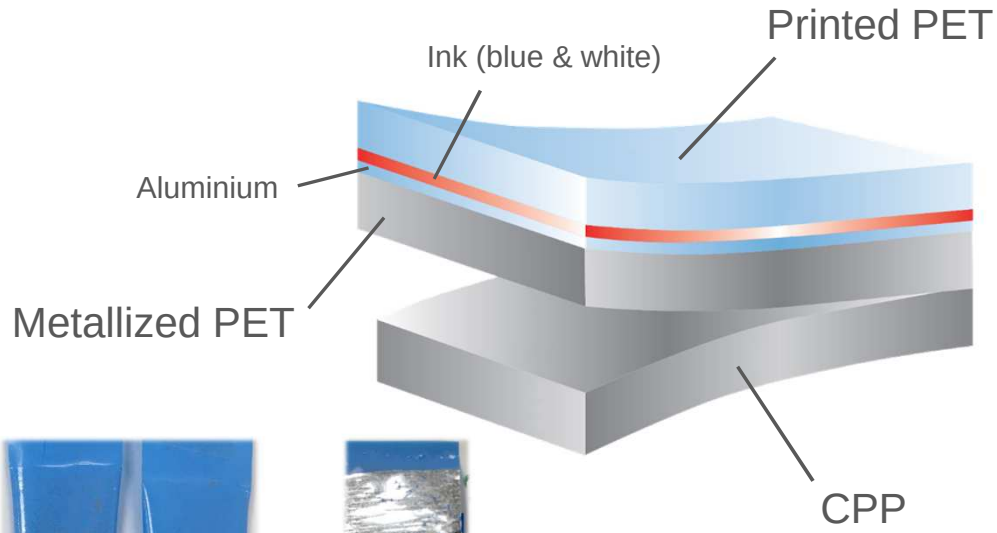
Non-AluBond ®
BOPP
Full metal removal

AluBond® process performance
Metal adhesion – Laminate bond strength

Laminate bond strength – *Metallized PET*

- Triplex laminate PETprint / metPET / CPP

Structure	Test	Description	Peel force N/(15 mm)
PET/Al 12 µm	180° supported	Metal only	0.70 ± 0.22
		AluBond®	3.62 ± 0.21
	90° un-supported	Metal only	0.51 ± 0.12
		AluBond®	3.91 ± 0.82



AluBond®

Very limited metal removal & delamination/break of printed PET

Non-AluBond ®

> 90 % metal removal

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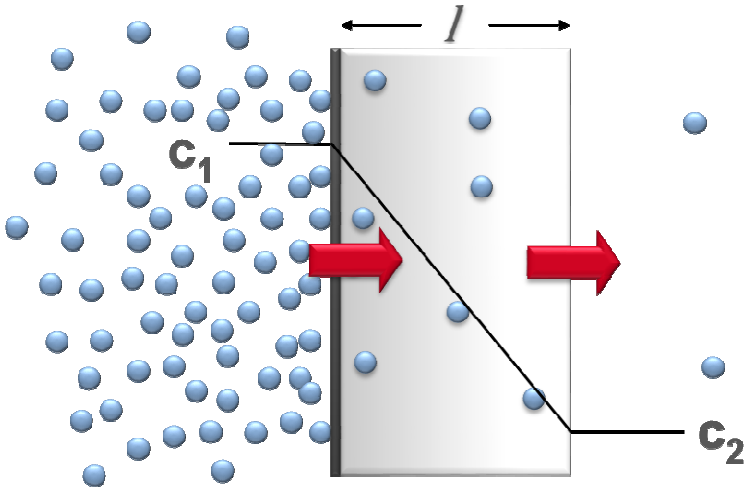
AluBond® process performance
Barrier properties

Barrier properties – *Metallized BOPP*

- Standard grade BOPP film
- 20 µm thickness, 3 layer coex-structure
- Corona treated

Description	OD	OTR	WVTR	Adhesion (EAA peel test)
		$cm^3/(m^2\ d)$	$g/(m^2\ d)$	N/(15 mm)
AluBond®	2.5	8.45 ± 0.08	0.06 ± 0.01	4.3 ± 0.2
AluBond®	2.8	5.12 ± 0.34	0.03 ± 0.00	4.1 ± 0.2
AluBond®	3.3	4.82 ± 0.57	0.03 ± 0.00	3.4 ± 0.5
Standard metal Datasheet information	2.5	50	0.4	1.1

*OTR 23 ℃, 50% RH
**WVTR 37.8 ℃, 90% RH



⇨ Significantly enhanced barrier performance for *Alubond®* metallized BOPP

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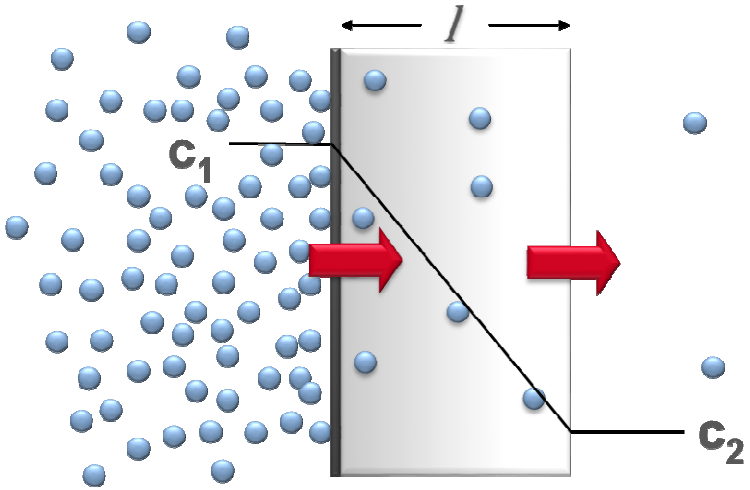
AluBond® process performance
Barrier properties

Barrier properties – *Metallized CPP*

- Standard grade CPP film
- 25 µm thickness, 3 layer coex-structure
- Corona treated

Description	OD	OTR	WVTR
		cm³/(m² d)	g/(m² d)
AluBond®	**2.3**	3.17 ± 0.42	0.05 ± 0.00
AluBond®	**2.7**	2.60 ± 0.09	0.04 ± 0.00
AluBond®	**3.3**	2.48 ± 0.21	0.03 ± 0.00
Standard metal Datasheet information	**2.5**	50	0.15

*OTR 23 ℃, 50% RH
**WVTR 37.8 ℃, 90% RH



⇨ Significantly enhanced barrier performance for *Alubond®* metallized CPP

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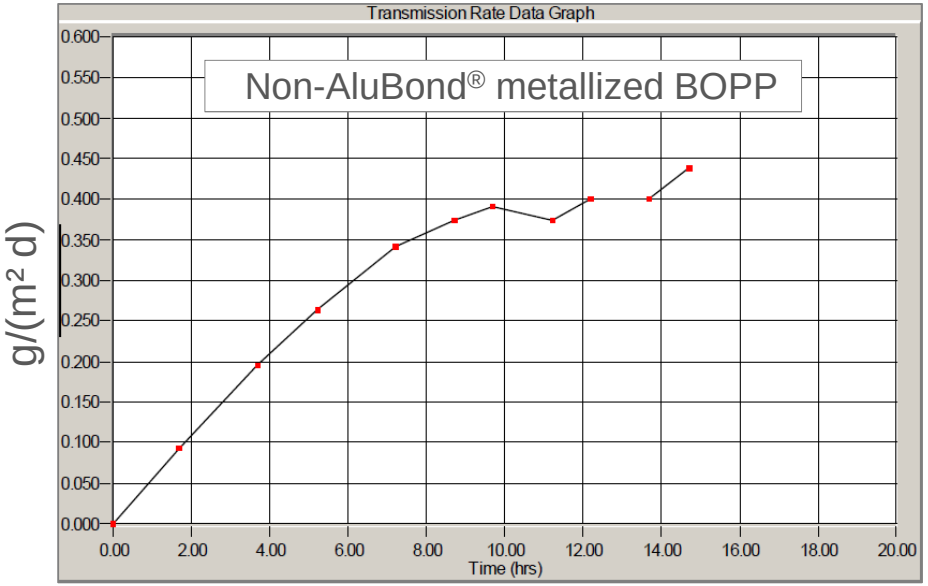
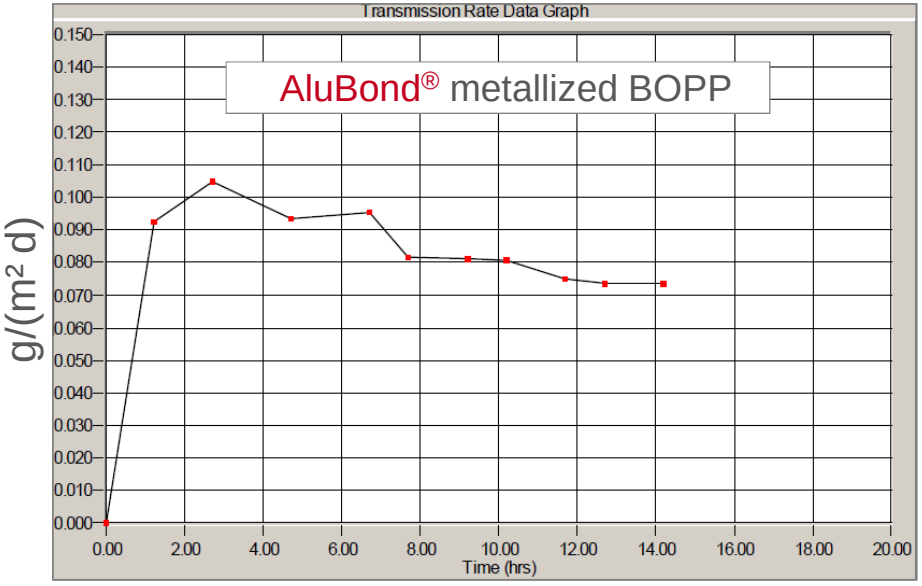
AluBond® process performance
Barrier properties

Barrier properties – *Metallized BOPP*

- WVTR behaviour during barrier measurement (37.8 °C, 90 % RH)





⇨ AluBond® shows *better moisture barrier* properties and *RH stability/corrosion resistance*

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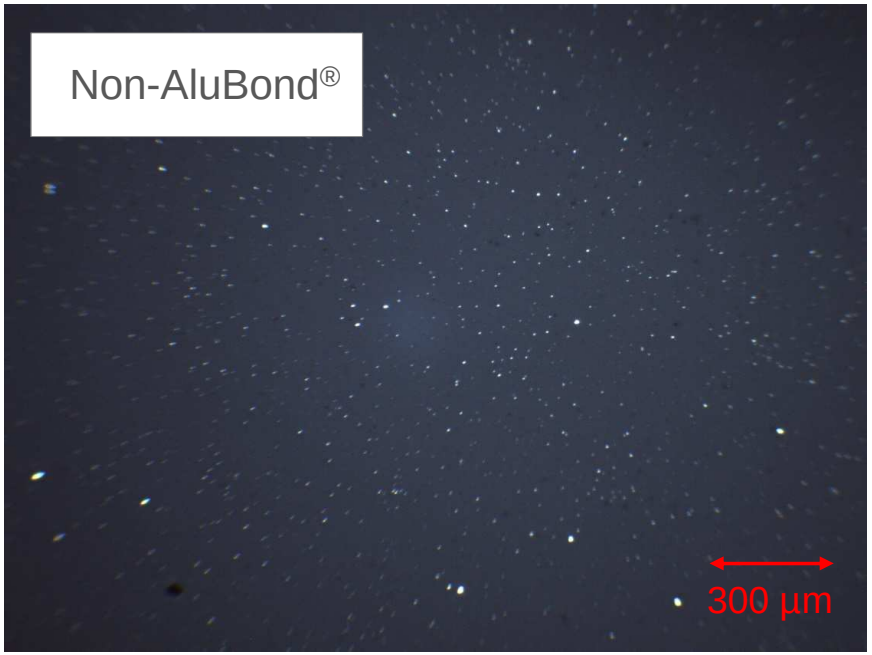
AluBond® process performance
Metallizing defects – Optical microscopy

Metallizing defects – *Metallized PET*



⇨ AluBond® shows a reduction in/elimination off *starry-night type defects*

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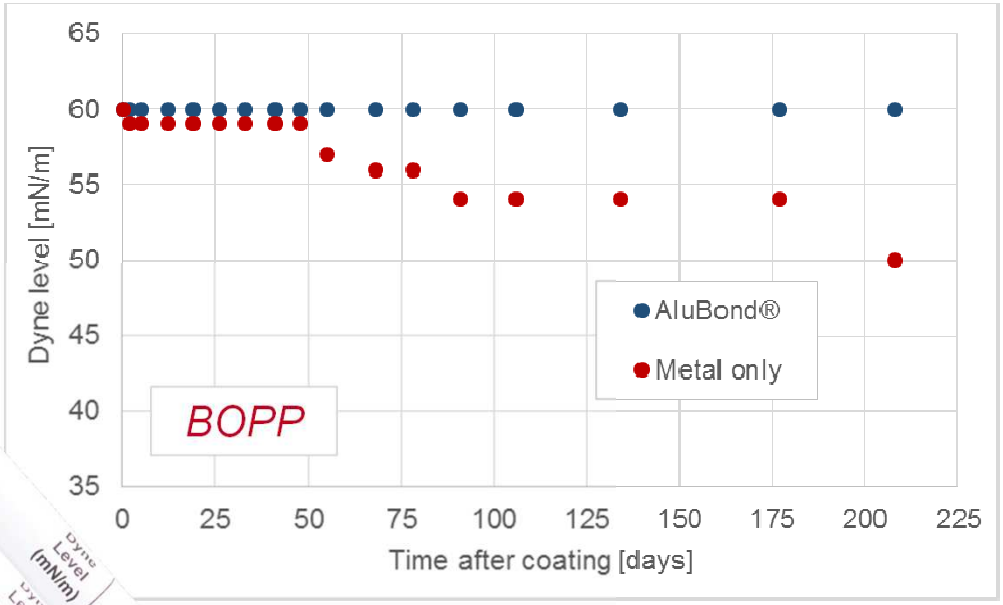
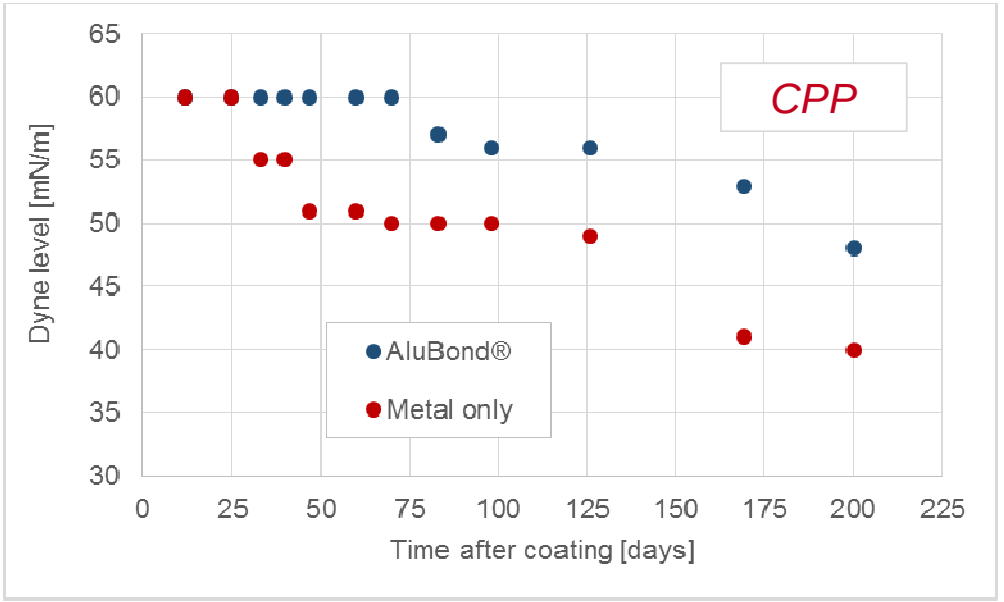
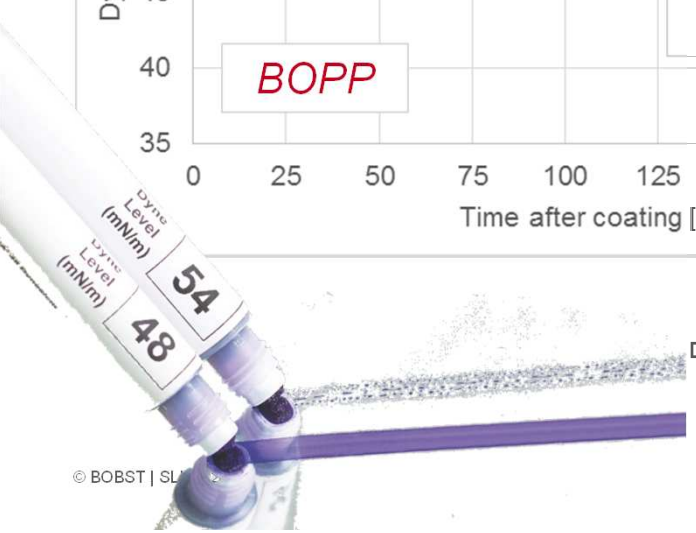
AluBond® process performance
Dyne level and dyne level retention

Dyne level retention – *Metallized BOPP and CPP*







⇨ AluBond® metallized films show improved *dyne level* and better *dyne level retention*

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Summary & conclusions

AluBond® delivers:

- Considerably higher *metal adhesion* compared to standard metallised film (EAA peel test, duplex & triplex laminates)
- Enhanced *barrier performance* for polyolefin substrates
- Enhanced *corrosion resistance* of aluminium layer
- Reduction in *metallizing defects*
- Higher *dyne level* and better *dyne level retention*

⇨ AluBond® addresses & satisfies current market trends for higher performance packaging materials

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THANK YOU