

2016 TAPPI PLACE CONFERENCE

FORT WORTH, TEXAS, APRIL 11-13, 2016

New Ultra Versatile Adhesive for Extrusion Lamination



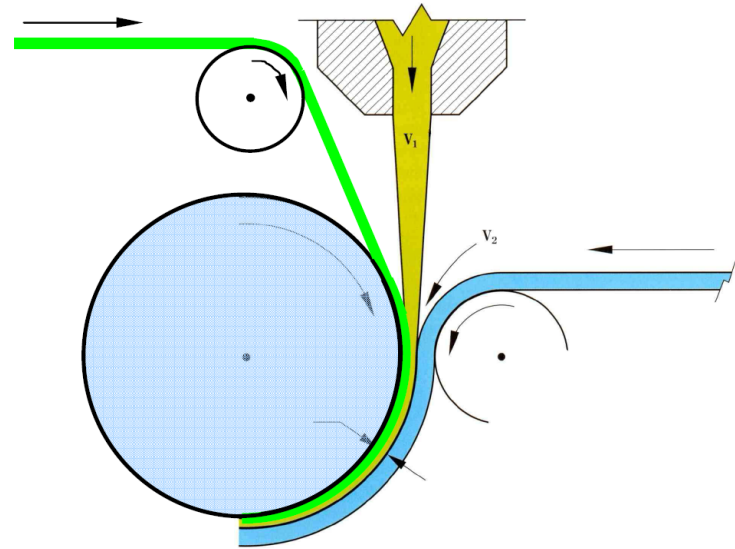
PRESENTED BY: NICK KHASAT

Extrusion Coating/Lamination & Packaging

- Productivity and quality
- Sophisticated structures in one pass
- Environmentally friendly
- No drying step
- No curing time to wait for
- High cost efficiency for large productions

➡ As long as bonding is really achieved

➡ Adhesion is a key parameter



New ultra versatile adhesive for extrusion lamination

Agenda:

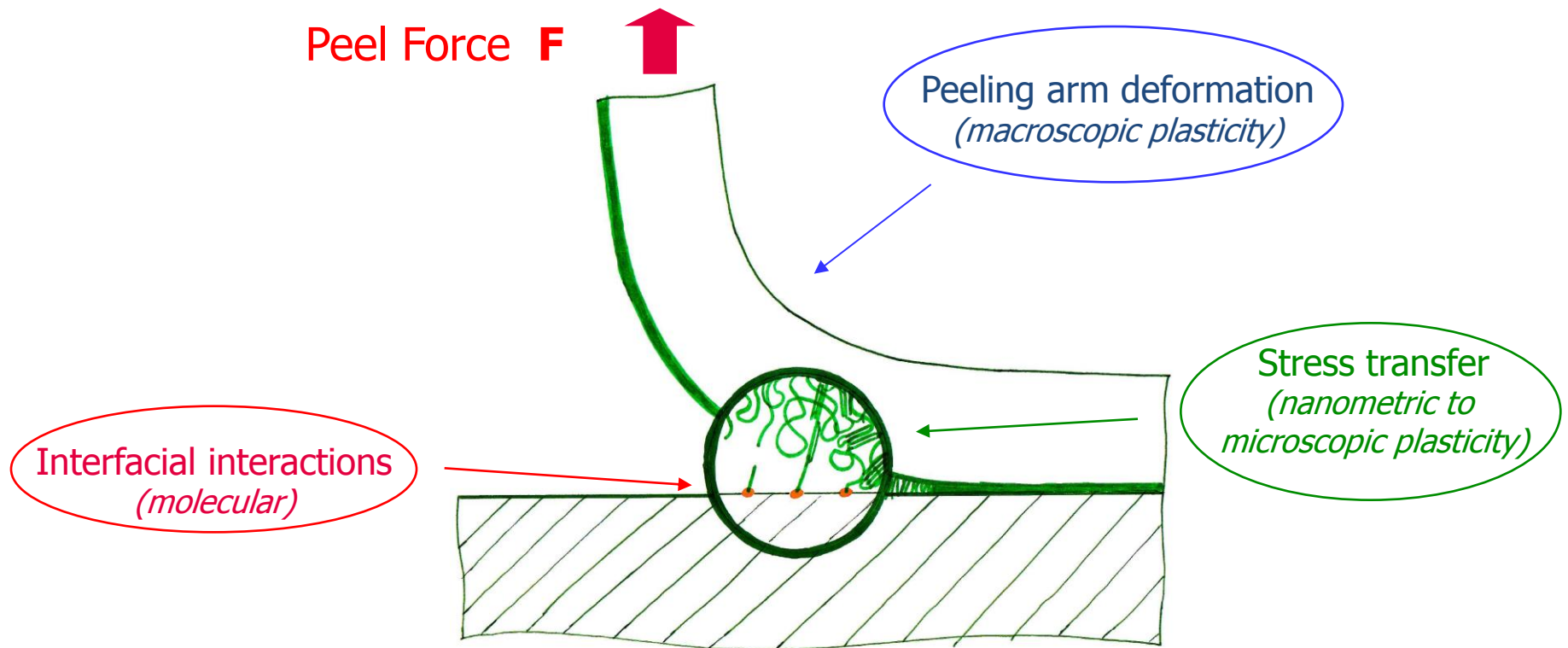
- 1/ Fundamentals about adhesion and its tricky development in extrusion lamination
- 2/ Adhesion mechanism depending on substrate type
- 3/ Ultra versatile new tie layer for extrusion lamination

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Adhesion: How do functional resins work ?



Peel Strength = Chemical Ties + Plasticity

Reactivity

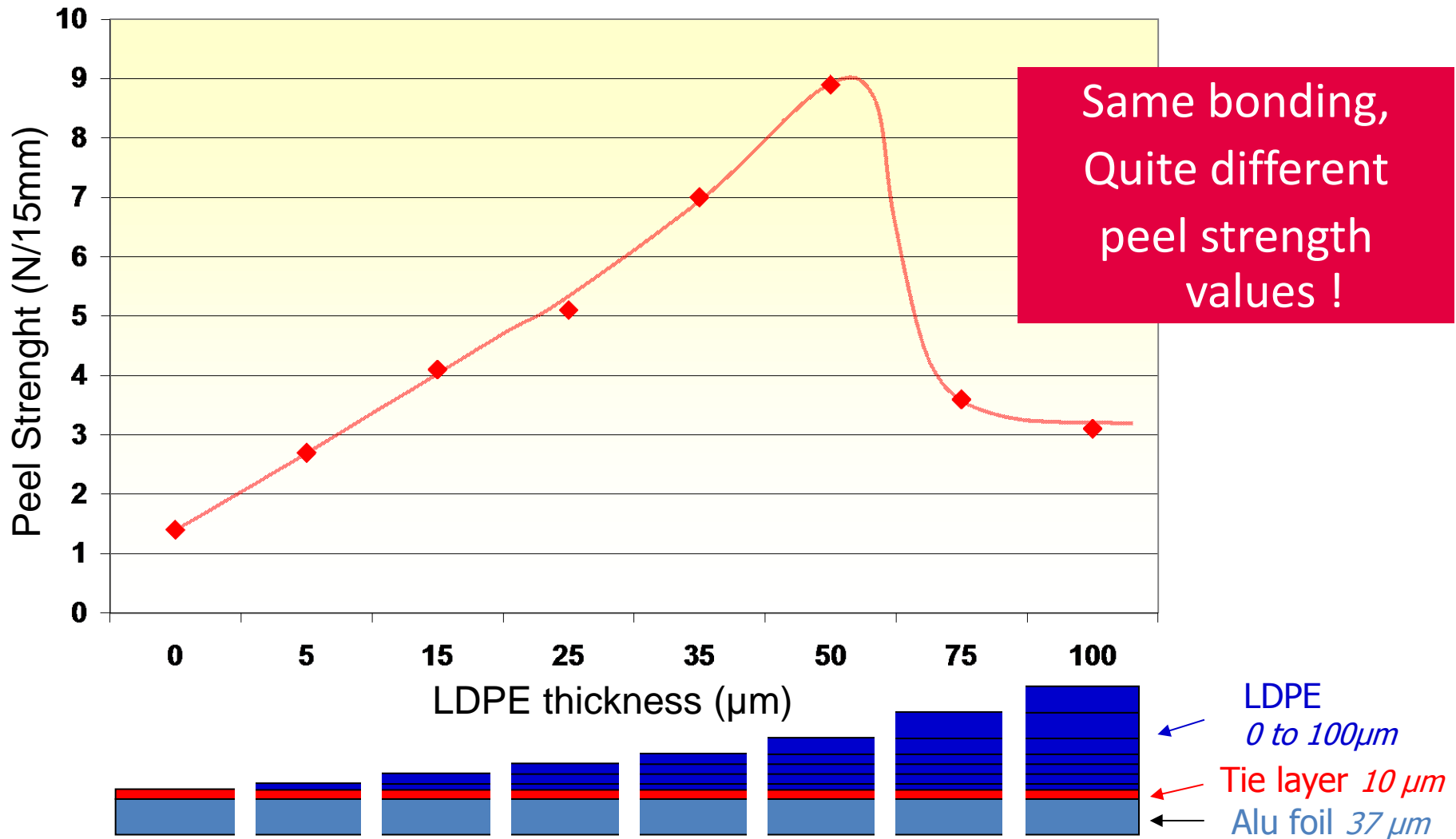
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Entanglement

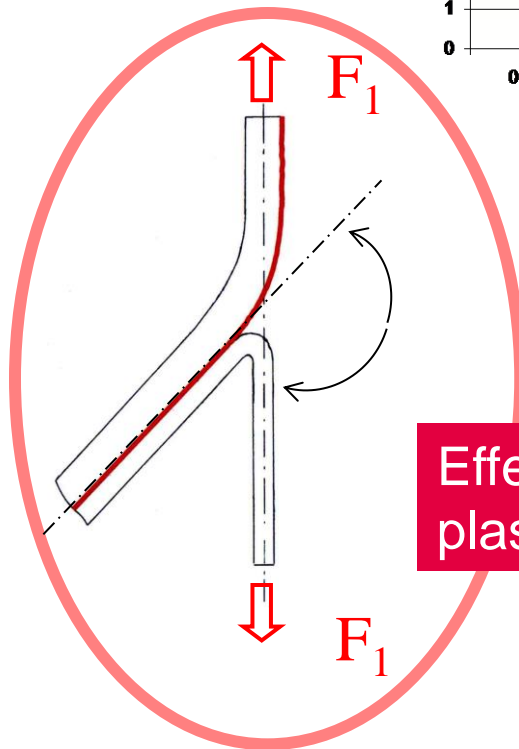
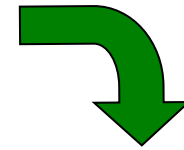
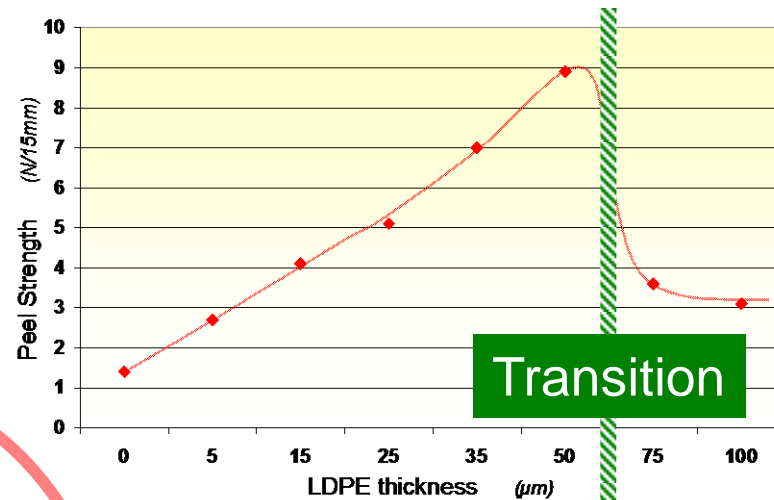
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Yield stress

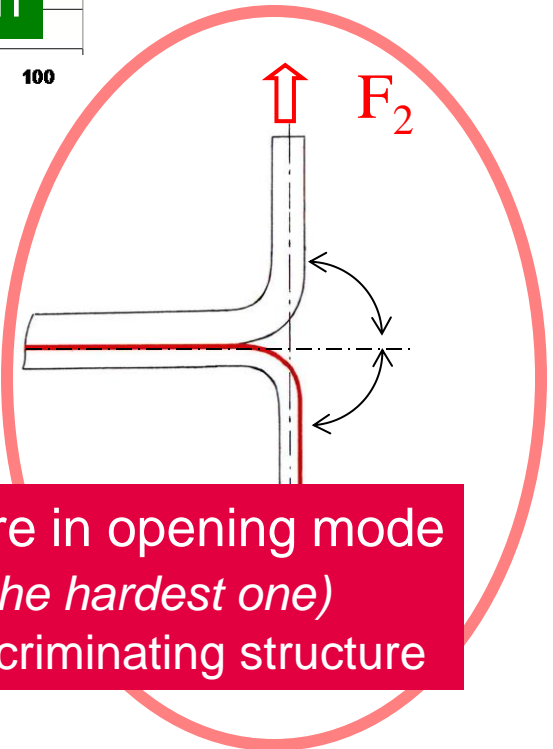
Mechanical effects in peel testing



Plasticity and fracture mechanics effects

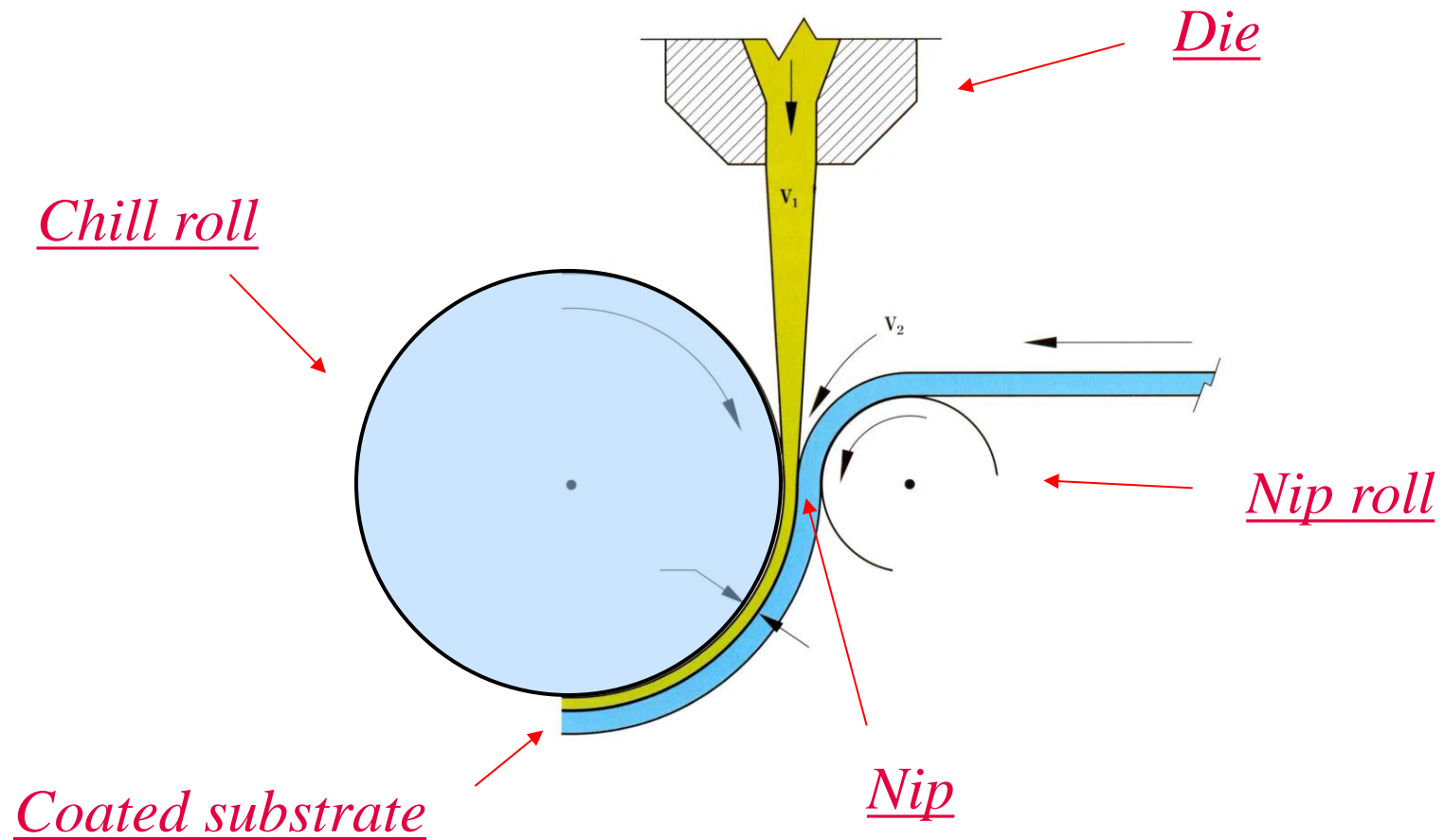


Effect of bulk plasticity

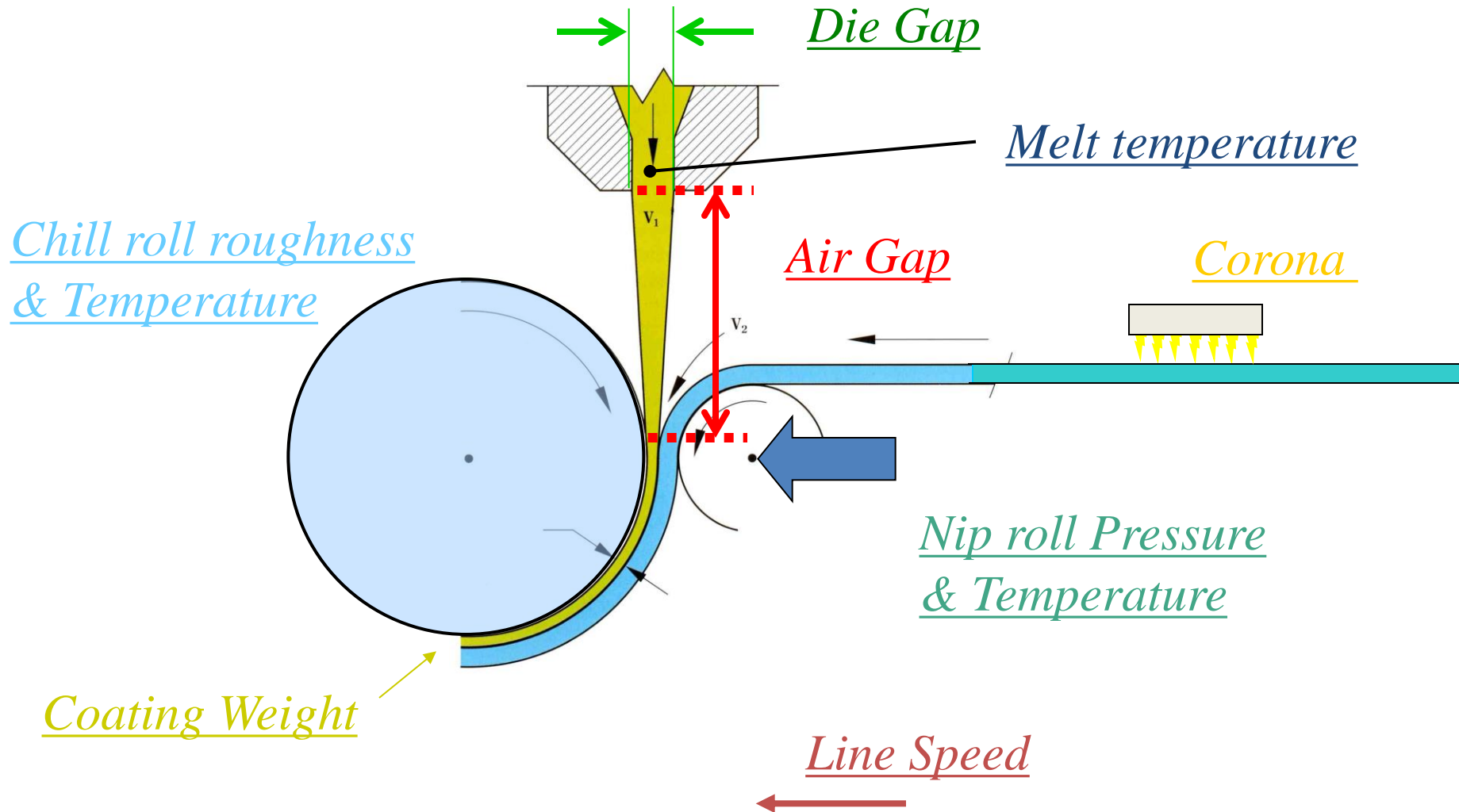


Fracture in opening mode
(the hardest one)
=> Discriminating structure

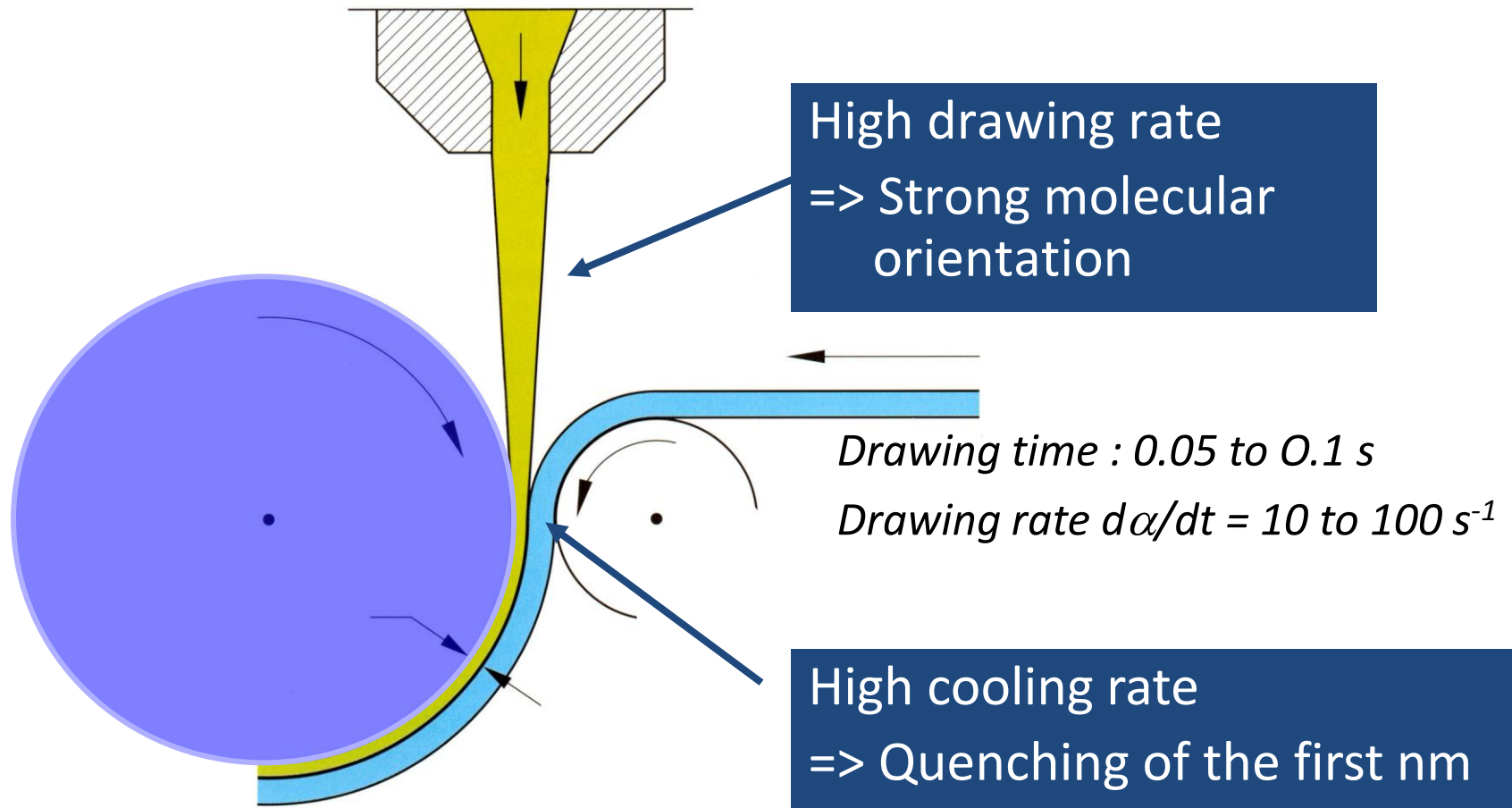
Extrusion Coating: only a few words to know...



...with a few processing parameters...

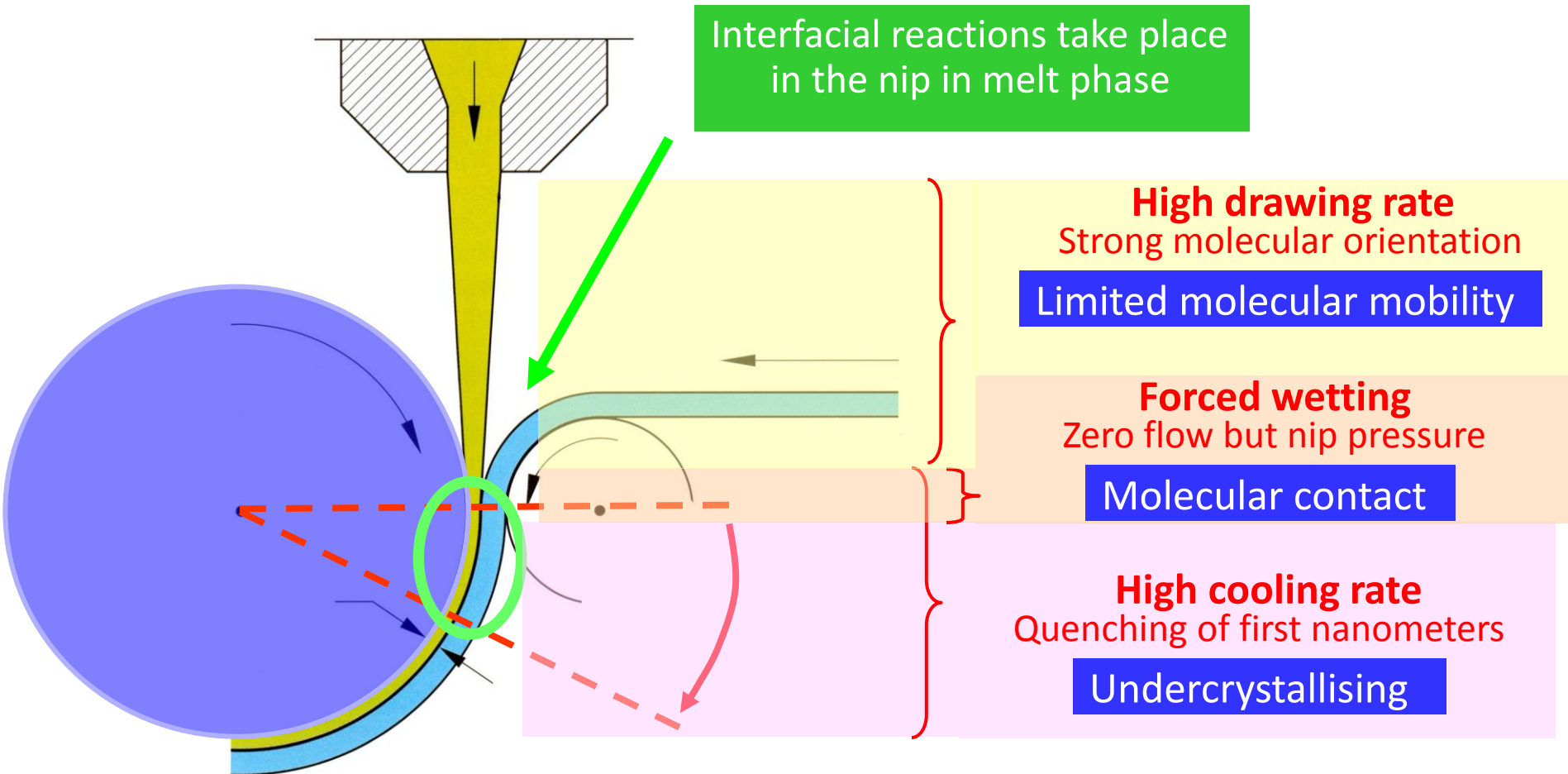


Two striking points in this type of process



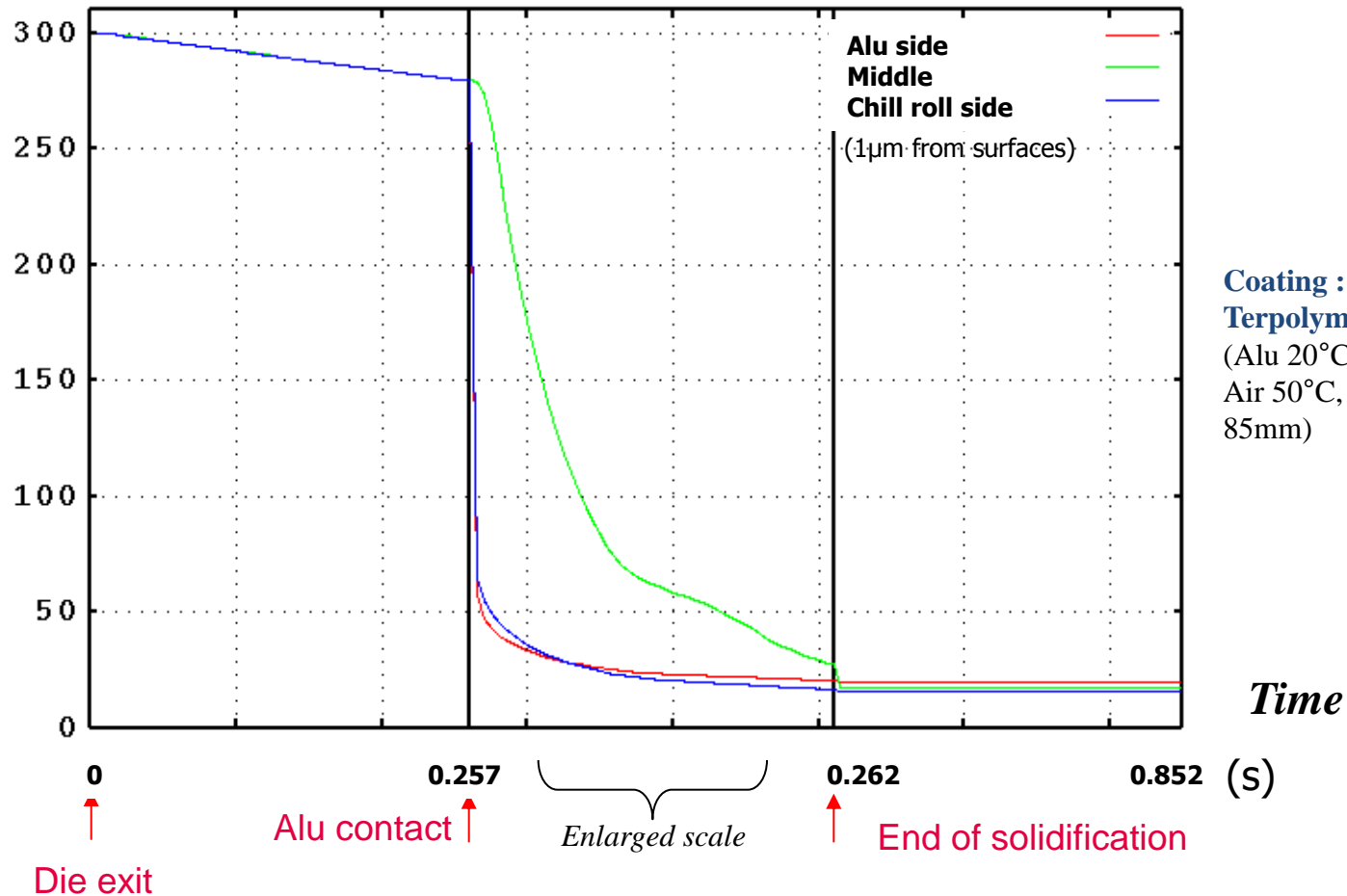
The laminator as a kind of bonding reactor

Energy available for bonding is \propto Mass and Temperature of extrudate



An example of cooling computation

Temperature (°C)



Time left for bonding : 5 ms

Adhesion & extrusion lamination: sum up

Process parameters influencing bonding ⇒ Actually, anything that affects

- Thermal input & exchanges
- Contact conditions of the melt onto the substrates

Product chemistry factors influencing bonding ⇒

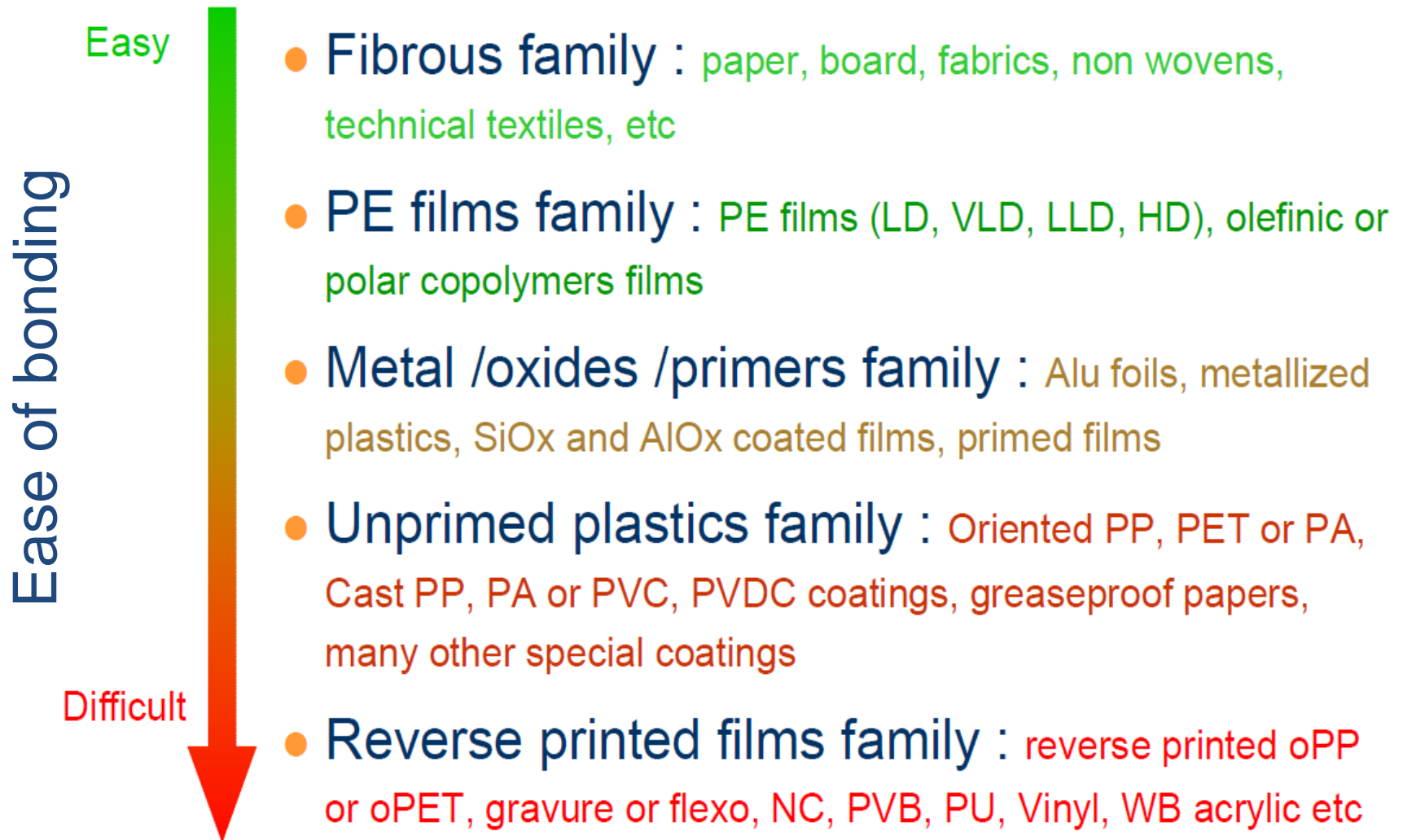
- Chemical functionality
- Concentration, distribution and availability of reactive groups close to the surface
- Temperature & crystallisation kinetics
- Physical properties E modulus & yield strength
- Viscosity
- High temperature mechanisms (oxidation)

New ultra versatile adhesive for extrusion lamination

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A wide range of substrates used in packaging



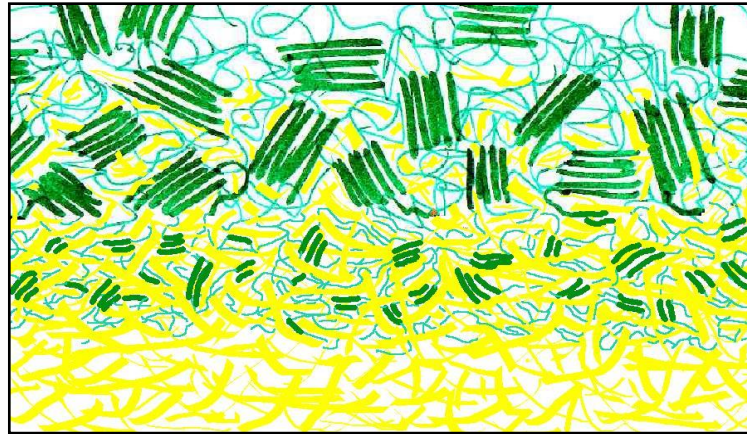
Bonding mechanism: fibrous family

Easy

Paper, board, fabrics, non wovens, technical textiles...

Coated resin
Semi-crystalline

Paper



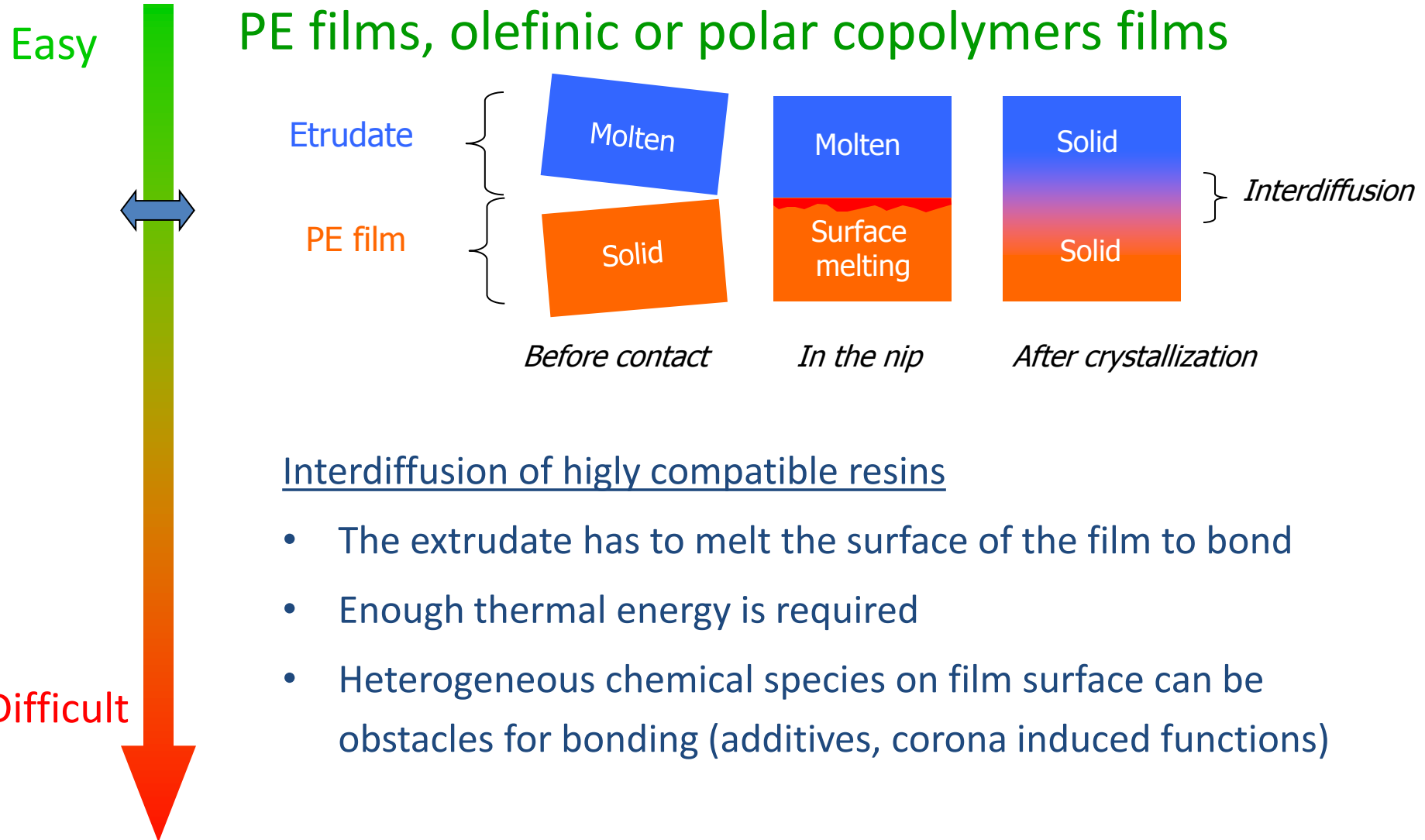
*Penetration of resin in
between the fibres*

Mechanical anchoring by resin penetration

- The extrudate has to be fluid (high thermal energy helps)
- Avoid time lag between contact and pressure in the nip
- Reactivity is not necessary, but more time is left before solidification with resins of low crystallisation temperature
- Burning surface micro-fibres can help

Difficult

Bonding mechanism: PE films family



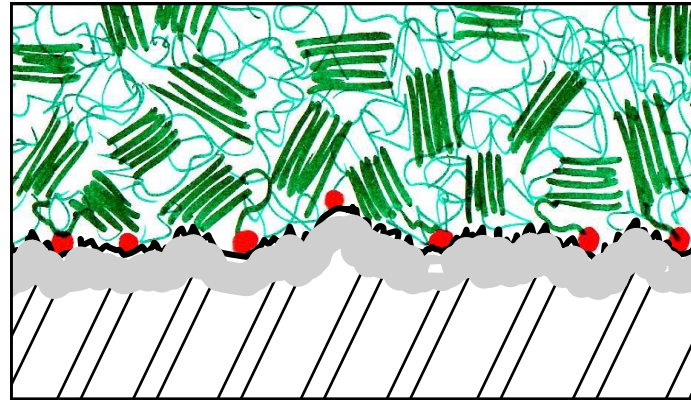
Bonding mechanism: metal, oxide, primers

Easy

Alu foils, metallized plastics, SiOx or AlOx coatings, primed films

Polymer
Semi-crystalline

Metal



} *Oxidized, hydroxylated, contaminated top layers*

- From hydrogen bonding to iono-covalent bonding
- Aluminium and metallized films: hydroxyl groups OH
- Wetting quality of aluminium is very important
- Corona treatment usually unnecessary
- PE-imine primers very widespread

Difficult

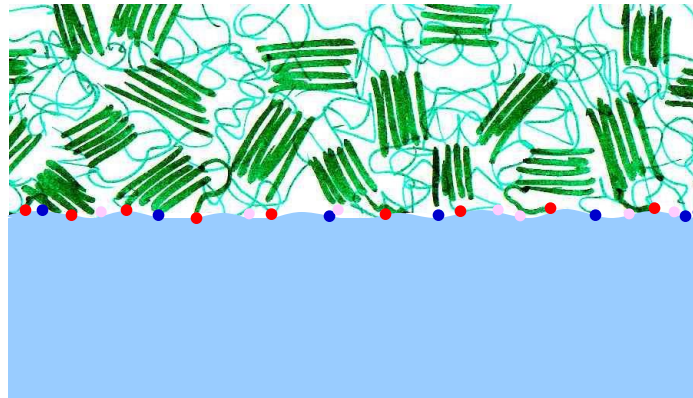
Bonding mechanism: other plastic films

Easy

Unprimed Oriented PP, PET, PA films, Cast PP, PA, PVC films, PVDC coatings, special coatings, greaseproof papers, etc...

Extruded resin
Semi-crystalline

Oriented film



Varied chemical interactions surface sites / polymer chains

- Requires a wide range of possible interactions
- Combined chemical functionalities are then necessary
- Surfaces often need to be corona or plasma functionalized
- No mechanism involving surface melting like with PE films
- Sensitivity to surface low masses (weak boundary layers)



Difficult



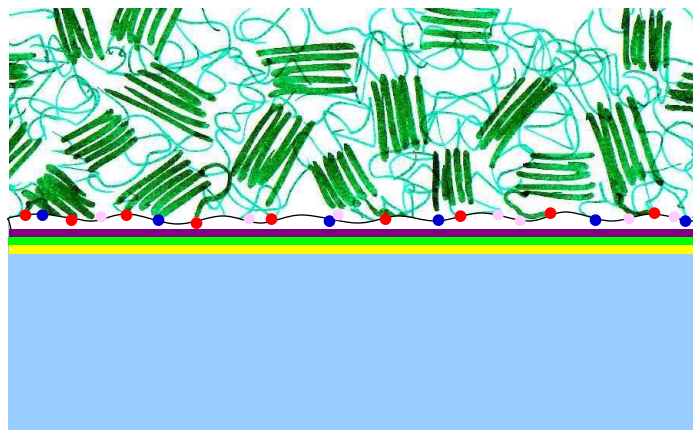
Bonding mechanism: reverse printed films

Easy

Reverse printed oPP or oPET - *Gravure or flexo printing - NC, PVB, PU or Vinyl binders for SB inks, acrylic WB, etc...*

Extruded resin
Semi-crystalline

Oriented film



White back layer

Ink layers

Compatibility and varied chemical interactions

- Requires an even wider range of possible interactions
- Ink layers become tie layers themselves → Additional failure possibilities: interlayer adhesion, ink cohesion, ink removal
- Corona usually damages bonding performance to inks
- Many additional parameters (Binder chemistry, co-resins, pigments, additives)

Difficult



New ultra versatile adhesive for extrusion lamination

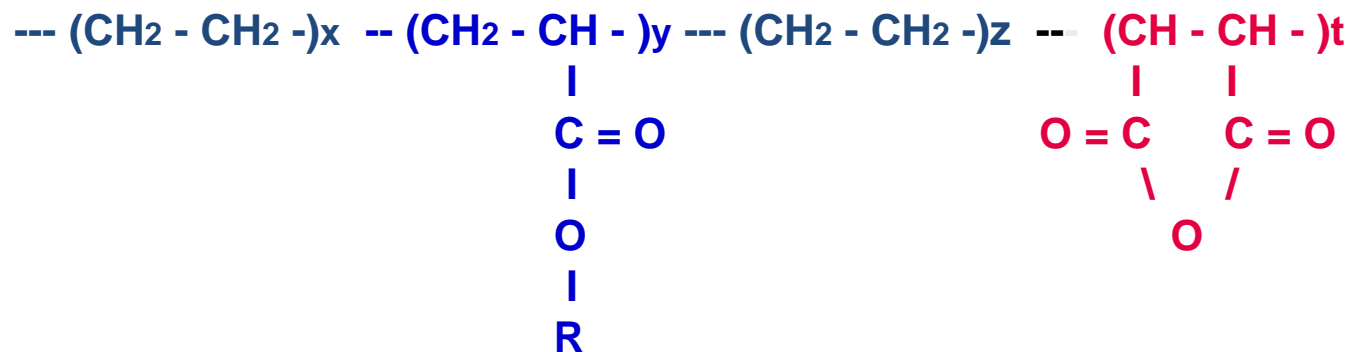
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Technical positioning & chemical structure of E-AE-MAH

E-AE-MAH are versatile adhesives to get direct bonding in extrusion lamination instead of using primers or other kinds of laminations with liquid glues.

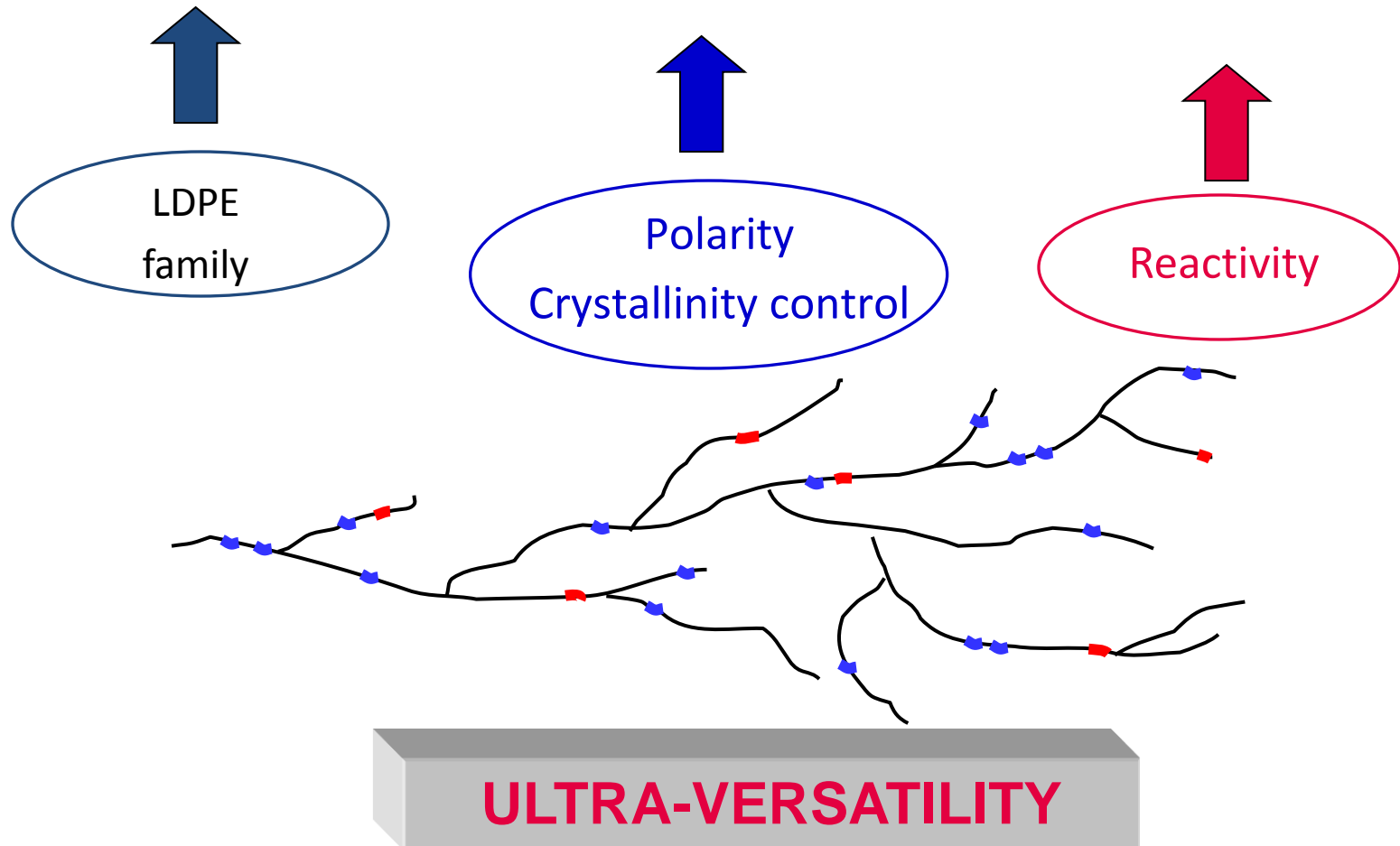
Ethylene – Acrylic Ester – Maleic Anhydride



Random ethylene terpolymers made by high pressure radical polymerisation

A chemistry tailor-made to develop adhesion

Ethylene – *Acrylic Ester* – *Maleic Anhydride*



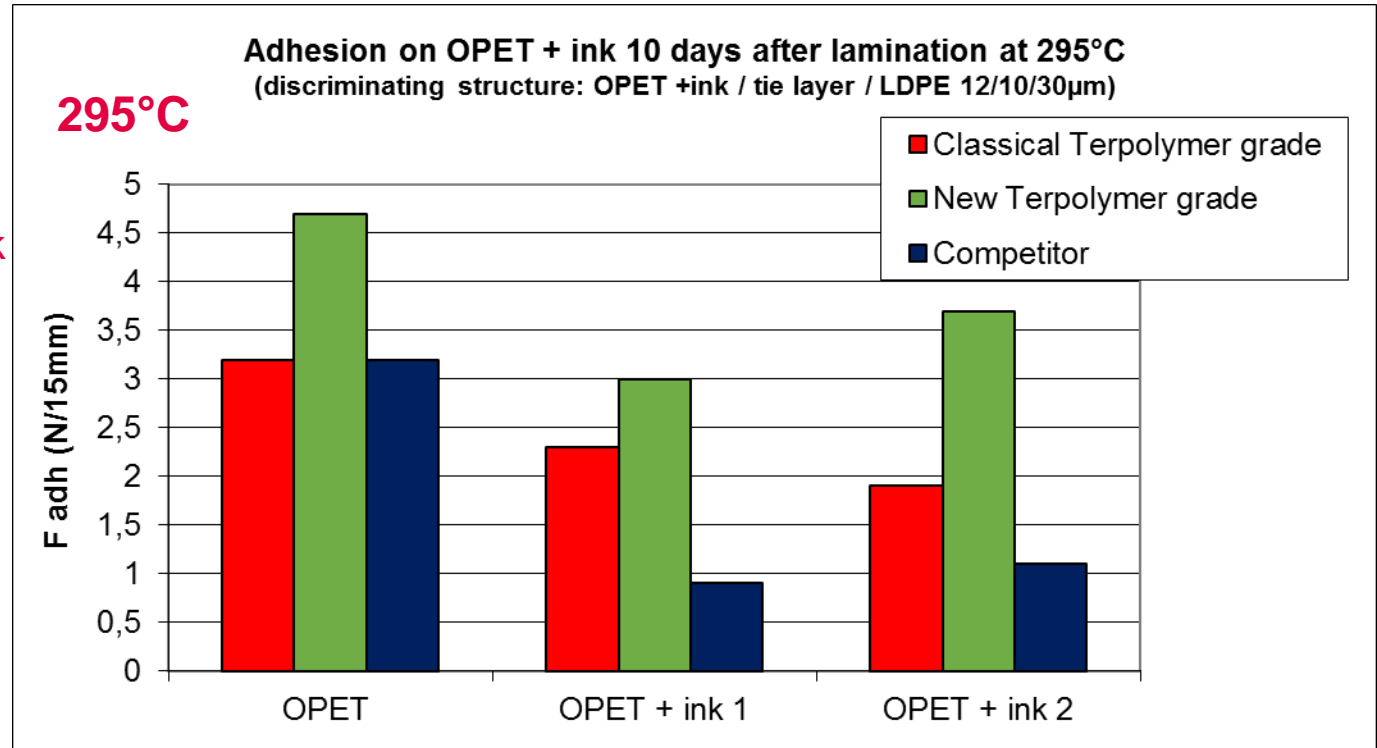
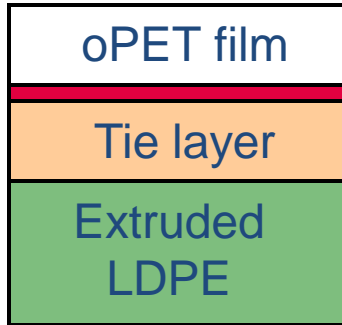
New ready to use ultra versatile tie layer

LOTADER® 4613

- Tailored for direct improved adhesion on different substrates type (**reverse printed oPP or oPET**, metallised plastics, woven PP, unprimed oriented PP or PET, alu foils ...)
- Rheology adapted for **coextrusion lamination**
- Non-corrosive, easy to purge and reduces transition
- **No need for primer**
- **Ready to use**
- Some examples on the following slides

Ultra versatile new tie layer → Examples

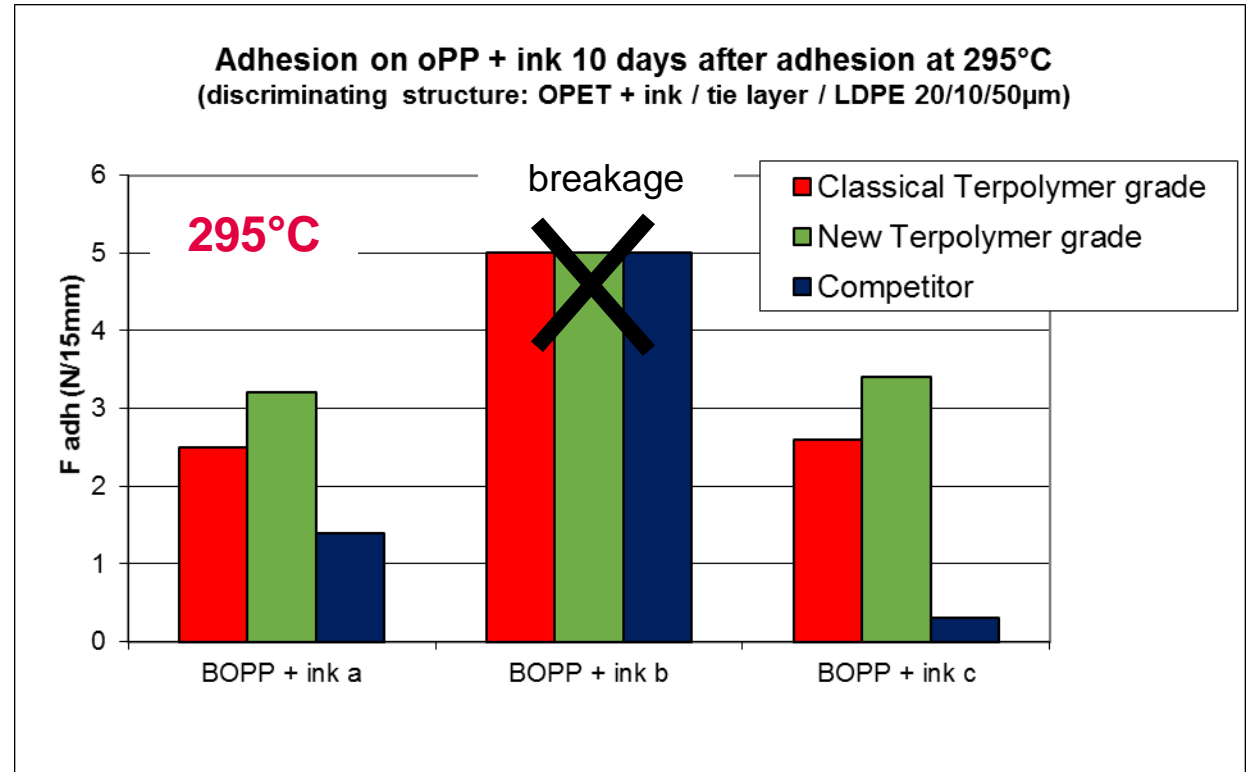
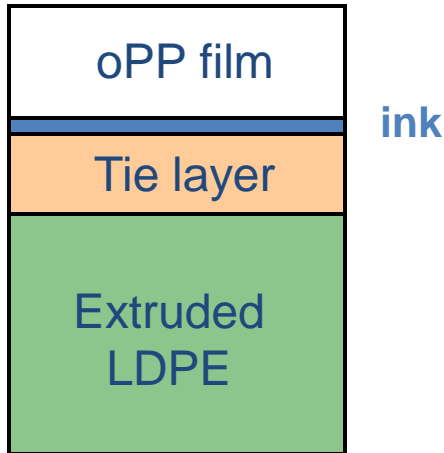
Adhesion on oPET with and without different ink systems =>



- Strong influence of ink formulation
- Ultra-versatility of the new formulation

Ultra versatile new tie layer → Examples

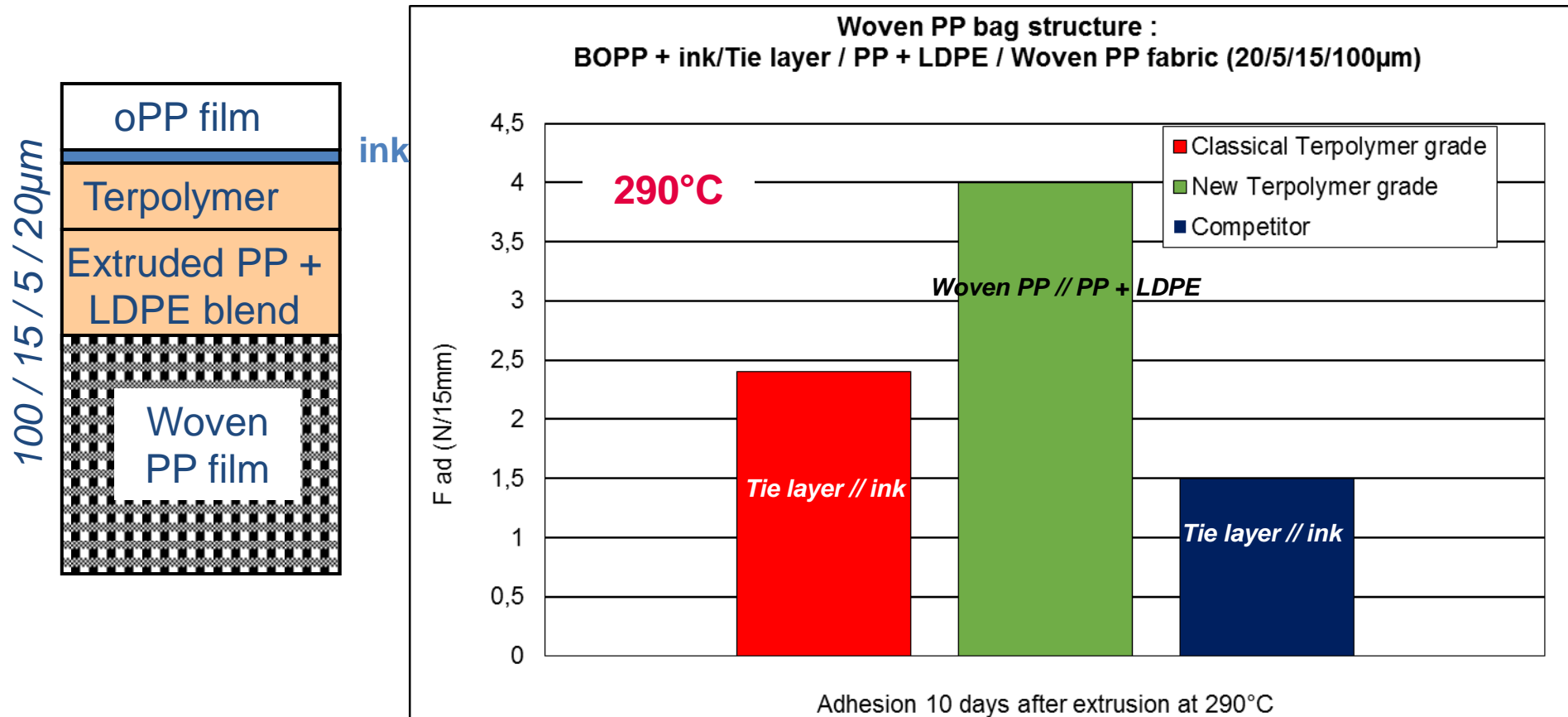
Adhesion on oPP with different ink systems =>



- Strong influence of ink formulation
- Ultra-versatility of the new formulation

Ultra versatile new tie layer → Examples

Adhesion on woven PP structure =>



- Strong influence of ink formulation regarding adhesion and failure interface
- Ultra-versatility of the new formulation

Sum Up

	EMA based competition	Classical E-AE-MAH	New E-AE-MAH
Adhesion on solid substrate			
Alu foil	-	+++	+++
Metallized films	-	+++	+++
PE (LD, LLD or HD)	+++	+++	+++
OPET	++++	++++	+++++
OPP	+++	+++	+++
OPA	++++	++++	++++
Ink PVB	+++	+++	++++
Ink PVC	+++	+++	++++
Ink PU	++	+++	++++
Ink NC	++	++	+++
Processability in extrusion coating & lamination			
Monolayer	-	++++	+
Coextrusion	++++	++++	++++

- Not recommended
 + Fair
 ++ Good
 +++ Very good
 ++++ Excellent

CONCLUSIONS

- Direct bonding is a key requirement to make extrusion lamination a very attractive technology
- Different bonding mechanisms have been reviewed depending on substrate families
- One of the most difficult substrates is reverse printed film and they need adhesives exhibiting a wide range of possible chemical interactions
- Our new ultra-versatile tie layer resin has been developed to get improved adhesion on ink

Acknowledgements

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THANK YOU FOR YOUR ATTENTION