TOWARD CLASS A SURFACE WITH THERMOPLASTIC COMPOSITE

A new material solution for lightweight design

RAMSPEC Milano 2018
Andreas Kolf

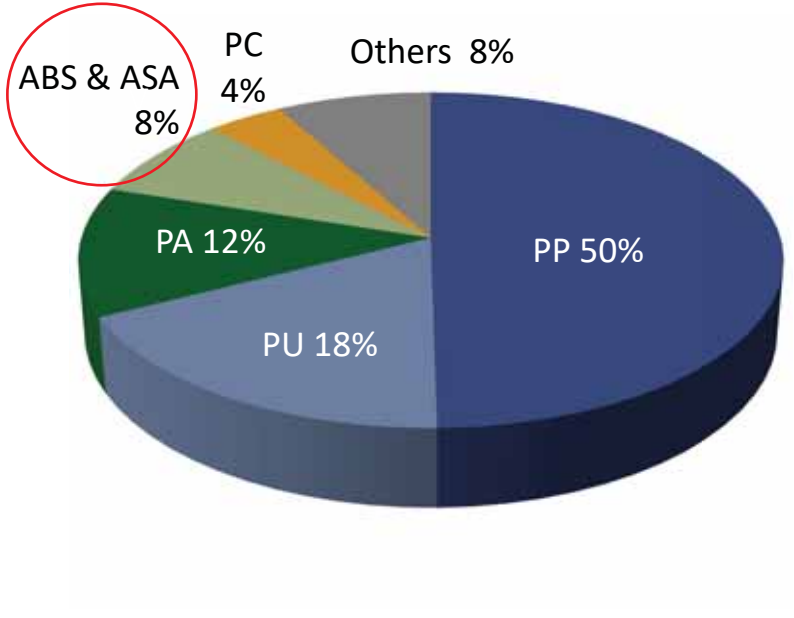
INEOS STYROLUTION

Driving Success. Together.

INEOS Styrolution at a glance

From thermoplastic to composites

Plastics used in automotive globally



Thermoplastic Composites

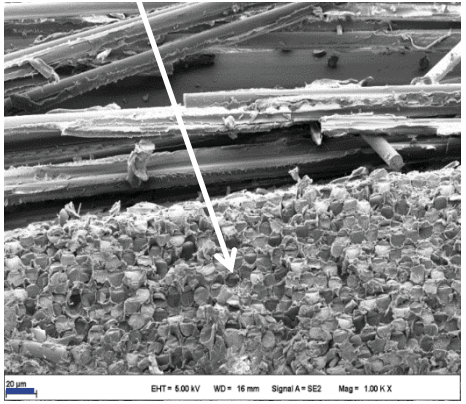
- ➡ **LFT, GMT, Organosheets, UD tapes**
- ➡ **RRIM, SRIM**
- ➡ **Organosheets, UD tapes**
- ➡ **StyLight®**
- ➡ **Organosheets, UD tapes**

Development of new matrix

Applicability of Styrenic Copolymer for thermoplastic composites

Sharp broken fibers (cutting edge) = good fiber matrix adhesion

200 µm



20 µm

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Modified SAN

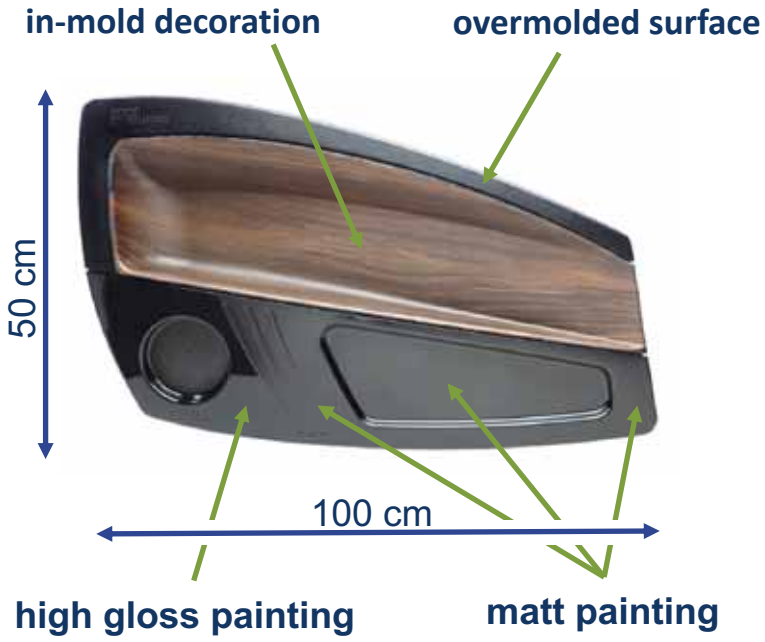
StyLight product portfolio

Material Description	Unit	StyLight Aesthetic S		StyLight Structural S	
		G290-1	C245-1	G580-1	G600-3
Fibers	-	Glass	Carbon	Glass	Glass
Textile	-	Fabric: Twill 2/2	Fabric: Twill 2/2	Fabric: Twill 2/2	Non Crimp Fabric: 0°/90°
Area weight	g/m²	290	245	580	600
Yarn	tex	204	3k	1200	1200/300
Weight rate	%	50/50	50/50	50/50	80/20

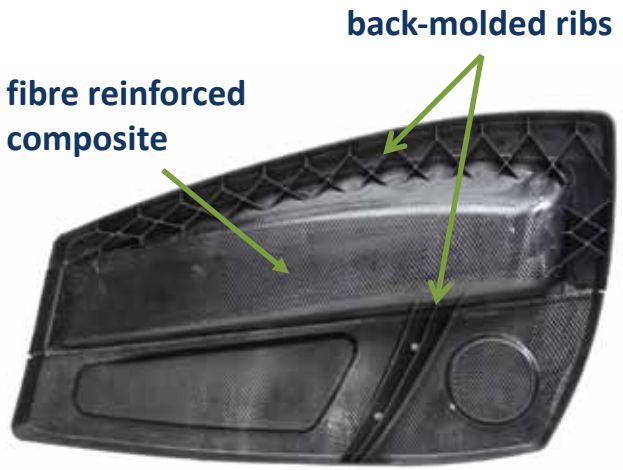
Materials for back injection	Standard	Unit	Novodur M203 G3 SL	Terblend N NG-04EF SL	Terblend N NG-06EF SL
Base resin	-	-	ABS GF	ABS/PA GF	ABS/PA GF
Fiber content	-	%	16	20	30
Melt Volume Rate 240 °C/10 kg	ISO 1133	cm^3/10 min	18	30	12
Tensile Modulus, 23°C	ISO 527	MPa	5600	5300	7500

StyLight demonstrator 2016

Decoration integration



Structural function integration



Key learnings

detected failures

Challenges

- Temperature management of the decorative foil
- Rib design and over molding
- Pressure distribution on the laminate
- Organosheet draping and shear stress in textile

New demonstrator project 2017/2018

Objectives

- Compare processing technologies for StyLight® industrialization
- Processing conditions for high surface quality and for foil decoration
- Validate process and structural simulation to forecast material behavior
- tool design and peripheral devices to optimize the cycle times

Demonstrator „Tray“

Neue Materialien Bayreuth

KRUMPHOLZ. FORMENBAU | KUNSTSTOFFTECHNIK

Neue Materialien Fürth

KURZ

esi get it right®

New demonstrator project 2017/2018: Overview

Material optimization	INEOS STYROLUTION	Identification of suitable material combination	
Compression molding	Neue Materialien Fürth	Process to obtain high-quality surfaces (2D)	Implement into 3D compression molding
Decoration	KURZ	Identification of suitable deco-foils	Partial In-Mold decoration
Injection molding	Neue Materialien Bayreuth KRUMPHOLZ. FORMENBAU | KUNSTSTOFFTECHNIK		Implement of expertise into 3D injection molding
Simulation	esi get it right®		Simulation of drape behavior of StyLight during processing

Description of “LiSA” equipment

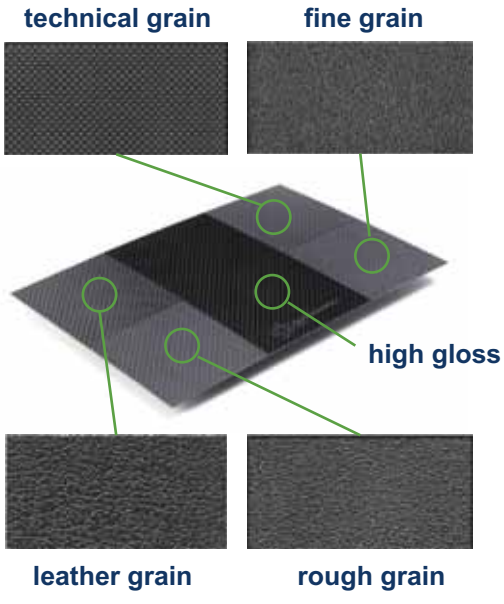
- Clamp force 100 - 2000 kN
- Isobaric and isochoric press operation
- Max. tool dimesions:
  1600mm x 1300mm x 700mm
- Conformal variothermal mold temperature up to 300 °C
- 3x IR heating area 500mm x 750mm
- Fully automated handling system, moveable in X- and Z-direction

Optimum processing with surface grains

Current status after approx. 50 different set-up trails

range of tested parameter	
Clamping pressure	60 - 125 bar
sheet temperature at heating	180 - 245 °C
mold closing speed	10 - 150 mm/s
mold temperature visible side	130 - 220 °C
mold temperature rear side	75 - 220°C

2D trial sample



technical grain / fine grain	
Clamping pressure	95 bar
sheet temperature at heating	195 °C
mold closing speed	150 mm/s
m	
m	

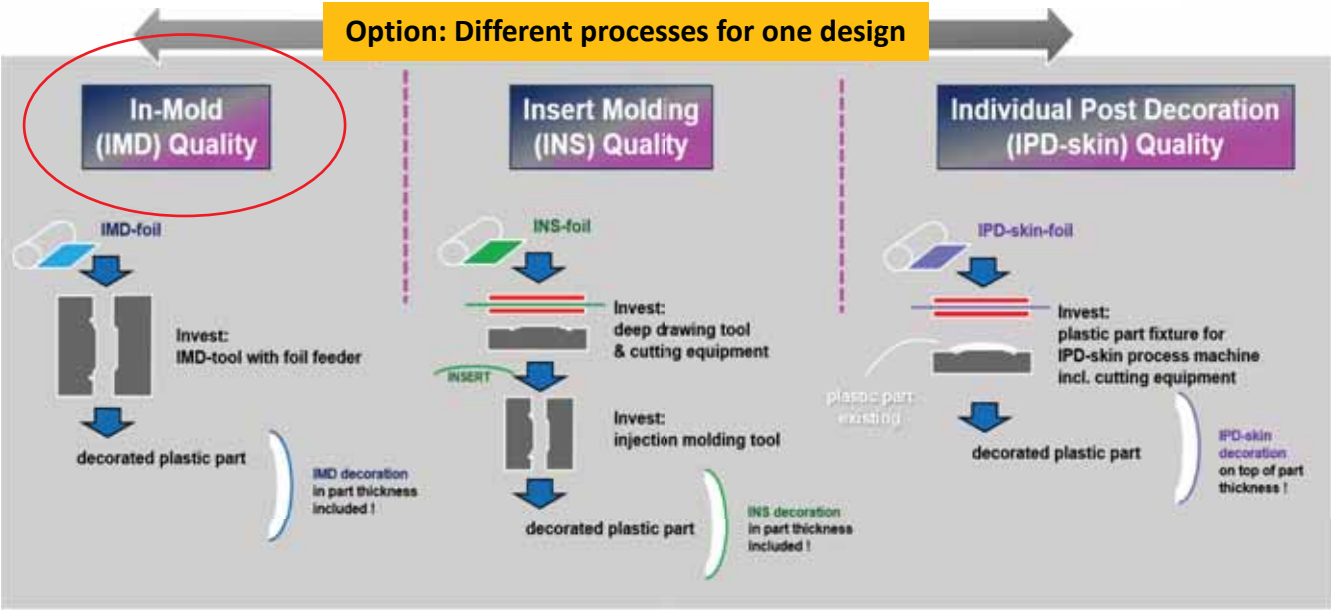
rough grain / high glossy surface	
Clamping pressure	125 bar
sheet temperature at heating	195 °C
mold closing speed	150 mm/s
mold temperature visible side	200 °C
m	

leather grain	
Clamping pressure	120 bar
sheet temperature at heating	235 °C
mold closing speed	10 mm/s
mold temperature visible side	200 °C
mold temperature rear side	190°C

Identification of suitable deco-foils

Design Possibility

Technology Options



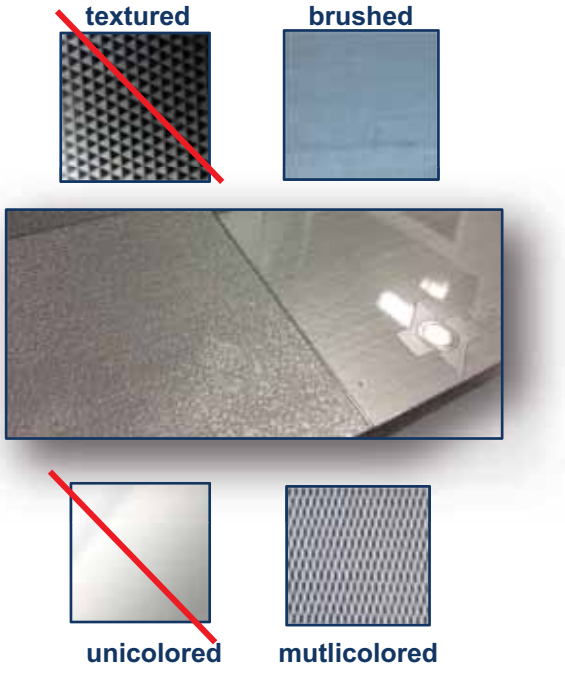
Optimum processing with decoration foils

Neue Materialien Fürth

Current status after approx. 70 different set-up trails

range of tested parameter	
Clamping pressure	20 - 120 bar
StyLight sheet temperature at heating	145 - 245 °C
Decoration foil temperature at heating	120 - 180 °C
mold closing speed	10 mm/s
mold temperature visible side	125 - 185 °C
mold temperature rear side	60 - 190°C

2D trial sample



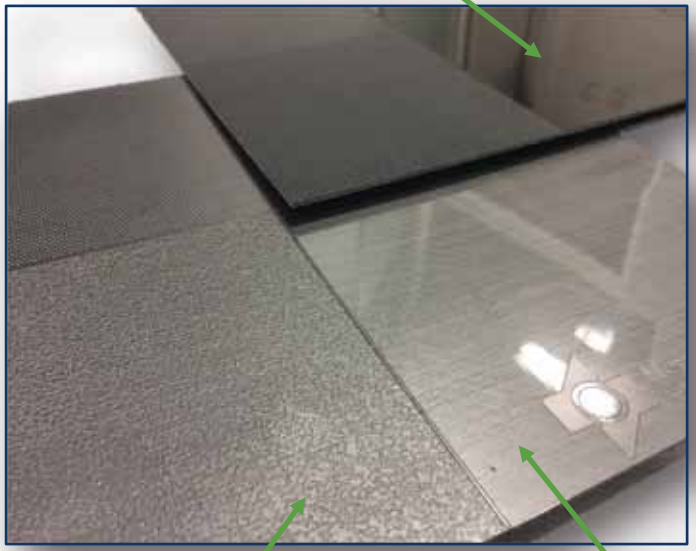
brushed metal decor	
Clamping pressure	120 bar
sheet temperature	230 °C
foil temperature	170 °C
mold temperature visible side	155 °C
mold temperature rear side	170°C

multicolored decor	
Clamping pressure	35 bar
sheet temperature	195 °C
foil temperature	140 °C
mold temperature visible side	140 °C
mold temperature rear side	160°C

Identification of suitable deco-foils

Results and key learnings of in-mold decoration with KURZ foils

Surface without decoration

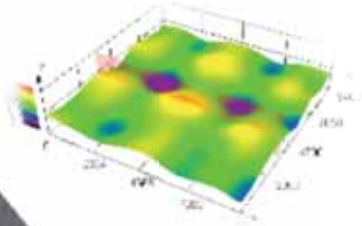


Brushed decoration foil on grained area

brushed foil on high-gloss area

- KURZ foils able to decorate SAN-based StyLight products
  ➔ design flexibility & valuable individualization
- Different mold structures being formed perfectly through package of decor foil and fiber-reinforced material
- Variothermal process setting
  ➔ homogeneous temperature distribution
  ➔ Higher mold temperature at part's backside

Wave measurement – LSM*



StyLight material	Press force [kN]	Mold temperature on visible side [°C]	Mold temperature on rear side [°C]	Surface waviness W_{Sz} [µm]
Thickness 1.0mm Carbon fabric	1500	220	220	2,47

*LSM = confocal Laser Scanning Microscopy / (Wavelength limit λ_c < 2,5mm und λ_f > 8,0mm)

Surface waviness measurement – LSM*

StyLight material	Press force [kN]	Mold temperature on visible side [°C]	Mold temperature on rear side [°C]	Surface waviness W_{Sz} [µm]	Decoration foil thickness [mm]	
Thickness 1.2mm Glass fabric with random glass fleece 	1200	200	80	2,81	/	various press forces
	1500			3,41	/	
	1600			4,38	/	
	1500	140	185	3,46	0,20	various foils
				1,95	0,30	
Thickness 1.0mm based on glass fabric	1500	200	80	2,87	/	various temp.
	1500	220	220	2,14	/	

*LSM = confocal Laser Scanning Microscopy / (Wavelength limit λ_c < 2,5mm und λ_f > 8,0mm)

Phase 2: Video of process at Neue Materialien Fürth

Neue Materialien Fürth

Injection molding of demonstrator “Tray”

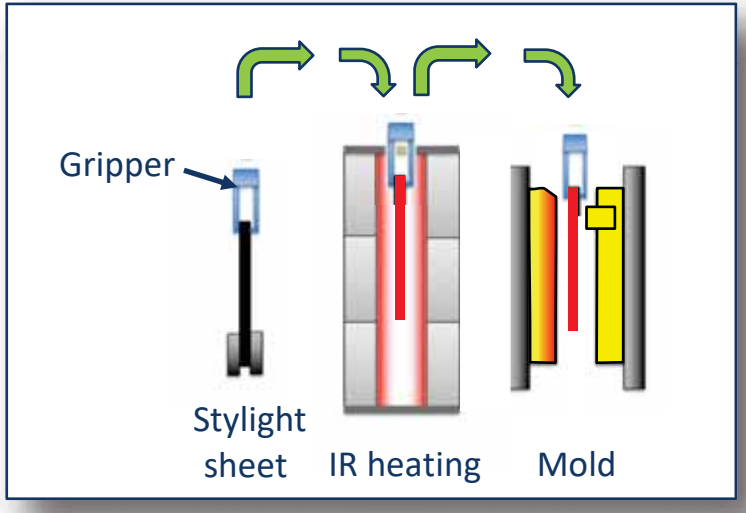
Neue Materialien Bayreuth
KRUMPHOLZ.
FORMENBAU | KUNSTSTOFFTECHNIK

Injection molding facility

- Engel duo 1350H / 1350M / 450 combi M
- Variothermal device - UniBell HeoCO II – Hot steam generator (max 250 °C)

Specific features

- Tree-axle portal robot with gripper unit
- Fully encased double-sided IR heating station (30 kW)
- One-sided variothermal heating of mold (weight 180kg)



Video of process at Neue Materialien Bayreuth

Neue Materialien Bayreuth

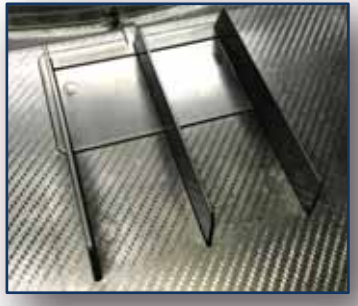
Results: Injection molding of demonstrator “Tray”

Neue Materialien Bayreuth

Back molded ribs / edge enclosure

- Terluran NG04 SL
- Novudur M203 G3 SL

Optimum processing conditions	
Clamping pressure	170 bar
Sheet temperature at heating	230 °C
Demolding temperature	10 mm/s
Mold temperature visible side	160 - 190 °C
Mold temperature rear side	90°C



Rip package

Technical challenges

- High flow material for optimal filled ribs
- Exact adjustment of pressure distribution
- Mold venting on the visible side to prevent air trap

New demonstrator project 2017/2018: technology comparison

Process requirements	 Press forming horizontal	 Injection molding vertical
Processing of glass fiber reinforced StyLight	✓	✓
Processing of carbon fiber reinforced StyLight	✓	Issue of backmolded cavity
Producing high glossy or grained surfaces	✓	✓
Full surface foil decoration	✓(PMD)	no
Partial foil decoration	✓	no
Back molded rib structures	no	✓
Cycle time	< 5 minutes	Depends on mold design / peripherique < 3min

Conclusion and outlook

Processing of StyLight of Class A surface applications

- Carbon fiber StyLight
  - Good results achieved with press forming
  - Clear coat validated
- Glass fiber StyLight
  - Suitable for structured surface of different grains
  - Color coating validated
- StyLight with decoration foils
  - Possible with optimum processing parameters
  - Limited type of foils suitable for in-mold decoration

Outlook for 2018/2019

- Demonstrator validation according to automotive interior specification
- Reduction of cycle time
- Modification of StyLight to further improve the surface quality and processing
- Correlation of the simulation results
- Post-mold foil decoration

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