NEW FRONTIERS FOR PLASTICS IN AUTOMOTIVE INTERIORS

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USA
OUTLINE

• “Innovate or die” – Peter Drucker
• “Innovation is the difference between the same perspective and an entirely new one...Invesco

• Interiors supply chain implications
• Innovation targets
• Paths to innovation
• Enablers/driving forces for interiors innovation
• Foams
• Acoustics
• Seating
• Soft touch
• Body/glazing seals
• Unique new materials
• Fiber reinforced plastics
• Luxury effect examples
THE INTERIOR PLASTICS SUPPLY CHAIN AND ITS INFLUENCES

**Government standards**
- Emissions
- CAFE standards
- Safety

**Changing fleet composition:**
- SUVs, PUTs, compacts, etc.

**The usual drivers:**
- Cost/performance
- Esthetics, haptic
- Quality/performance tier
- Environmental concerns
- Ergonomics
- VOC

**OEM req’ts:**
- Platform compatibility
- Branding/image
- DNA statement
- Globalization
- Specs, warranty concerns

**SOURCE:** ROBERT ELLER ASSOCIATES LLC, 2015
<table>
<thead>
<tr>
<th>INTERIOR TIER 1</th>
<th>2014 INTERIOR REVENUES, $Bn</th>
<th>ACQUIROR</th>
<th>NOTE/STATUS AS OF 041615</th>
</tr>
</thead>
</table>
| Magna          | 3.0(a)                      | Grupo Antolin    | - Pending agreement to sell $2.4BN out of estimated $3.0 BN interiors business.  
|                |                             |                  | - Excludes seating       |
| JCI Interiors  | 3.5                         | Yanfeng Auto     | - Completed (5/14) via non-cash transaction  
|                |                             |                  | - Excludes seating       |
| Visteon Interiors | 1.0                       | Cerberus Capital | - Completed → Reydel(Cerberus)  
|                |                             |                  | - Visteon sold 50% share in seating JV to partner Yanfeng Visteon Automotive Trim Systems in 2013 |
| Faurecia       | 5.0                         | None yet         | PSA owns 57% of Faurecia   |

Note:
- Emerge from overcapacity/low profitability  
- Increased purchase and pricing power

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2015
<table>
<thead>
<tr>
<th>TARGET</th>
<th>COMPONENT</th>
<th>PRIMARY OBJECTIVES</th>
<th>NOTE/CANDIDATES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seating</td>
<td>PU foam</td>
<td>Bio-components in foam chemistry</td>
<td>Started</td>
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<tr>
<td></td>
<td>Frame</td>
<td>- Thinner seat cross-section</td>
<td></td>
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<tr>
<td></td>
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<td>- Long glass/carbon fiber reinforced ETPs.</td>
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<tr>
<td>PP comp’ds</td>
<td>Panels/IP</td>
<td>- Thinner, low gloss, + grain</td>
<td>Improved: fillers, flow</td>
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<tr>
<td>- IP</td>
<td>substrate</td>
<td>- Increased structural, bio</td>
<td></td>
</tr>
<tr>
<td>- Door trim</td>
<td>Skins</td>
<td>Competition:</td>
<td></td>
</tr>
<tr>
<td>- Console</td>
<td></td>
<td>- Slush (PVC, TPU),</td>
<td>- Process cost reduction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- TPO sheet- o-TPV (recently)</td>
<td>- Avoid “cheap plastics” look</td>
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<tr>
<td></td>
<td></td>
<td>- Single/2 shot injection</td>
<td>- Soft touch</td>
</tr>
<tr>
<td>Acoustics</td>
<td>Floor, door,</td>
<td>- Get decibel level down without weight gain</td>
<td>- Foam, fiber, heavy layer combinations</td>
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<tr>
<td></td>
<td>firewall,</td>
<td></td>
<td>- PE/rigid constructions</td>
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<tr>
<td></td>
<td>headliner</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ductwork</td>
<td>- Headliner, IP</td>
<td>Reduce: BSR, weight</td>
<td>Polyolefin foams</td>
</tr>
</tbody>
</table>

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2015
SOFT TRIM PROCESS/MATERIALS OPTIONS

INJECTION

- CONV. INJECTION
- 2-SHOT
- OVERMOLD

SOFT TOUCH PAINT

- SEBS
- TPV
- TPU

BACK INJECTION

- COATED FABRIC
- FOILS
- UNCOATED FABRICS

SLUSH MOLD (CAST)

- TPU
- TPU BLENDS
- PVC
- TPO
- SEBS (TPE-S) (b)

VAC FORM FOILS

- TPO
- PVC
- TPU ALLOY SHEET

SKIN PROCESSES

COATED FABRICS (a)

- HAND WRAP(a)
- BACK INJECTION OR VAC FORM INJECTION

NOTE: (a) Polyurethane dispersion (PUD) coated fabrics gaining share
(b) Recently introduced

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2015
Pearlescent film
Application: 2015 Nissan Murano
Note: Pearlescent films are used in labels, decorative ribbon
Photo source: Wards Automotive
• **Extension of materials properties + efficient fabrication technology:**
  - Improved rheology o-TPVs + single shot injection

• **Extension/combination of capabilities:**
  - Borealis’ 20% long glass fiber grades utilizing integral foaming
  - Combining vibration damping TPEs with rigid plastic substrate → reduced BSR

• **Eliminating limitations:**
  - Reformulating slush PVC to eliminate fragmentation during airbag deployment
  - Colored long glass reinforced composites

• **Finding new paths:** Multiple sustainable, green solutions

• **Substitutions that solve problems:** (Weight save, BSR)
  - Substituting polyolefin foam for rigid ducting
EXAMPLE ENABLERS/DRIVERS FOR AUTO INTERIOR PLASTICS INNOVATION

ENABLERS

• Catalyst innovations
  - Metallocene EPDM
  - POEs

• Compounding: Broadening the performance envelope

• Plastic process technology improvement examples
  - Foaming improvements
  - Co-processing (co-blow, co-extrusion, co-injection)

• 3-D printing: Speeding prototype production and evaluation

DRIVERS

• Drive for “green” solutions: Driving bio-plastics and natural fiber substitution

• MPG regulations: Driving metal substitution, weight reduction
• Increased joining via bonding \(\rightarrow\) adhesives growth and functionalization of polyolefins

• Improving acoustics (acoustic barriers, seals for wind noise, buzz/squeak/rattle)

• EMF shielding via conductive fillers, back injection, films

• Weight save via:
  - thinwalling
  - metal substitution
  - lighter weight plastics
  - glass substitution (e.g. with polycarbonate)
  - filler substitution (e.g. with natural fibers or lighter fillers)

• Improved esthetics (eliminate “cheap plastics look”)

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2015
TWO EXAMPLES OF PLASTICS PROCESSING INNOVATIONS

• DYNAMIC VULCANIZATION

• FOAMING

• Both have had staying power:
  - Technology platforms for product and process development
  - Broad application range
  - Continuing evolution of applications
  - Basis for evolution of process variations
• Crosslinking elastomer “islands” in a plastic resin “sea” or matrix during extrusion

• Fundamental breakthrough was crosslinking of fine dispersion during extrusion

• Example of innovation driven by intensive investment and creative marketing to “shape” new markets

• The basis for:
  - olefinic TPVs (o-TPVs e.g. Santoprene from ExxonMobil) based on EPDM in PP
  - other island/sea, elastomer/plastic compositions

• Broad range of interiors applications:
  - skins, seals, hoses, body/glazing seals), boots/bellows

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2015
WHAT IS HAPPENING IN LONG FIBER REINFORCEMENT

• LGF PP:
  - reaching material property limits
  - innovation now design dependent

• Interior targets: door hardware modules, IP substrates, seat frames

• Growth of LGF - polyamides

• Flow enhancers → improved surface finish (Velocity® high flow grades from Plasticomp)

• Induction heating: (e.g. from RocTool) → improved surface finish

• Entry of long carbon fiber (LCF): performance and weight save advantage over LGF

• LGF/LCF hybrids: performance/cost stepping-stone
GLASS FIBER-CARBON FIBER HYBRID

• BALANCED PERFORMANCE
  – Glass fiber toughness
  – Carbon fiber strength

• PA66 20%GF 20%CF
  – Impact
    • 78% of glass fiber
    • 125% of carbon fiber
  – Strength
    • 124% of glass fiber
    • 96% of carbon fiber
  – Stiffness
    • 186% of glass fiber
    • 87% of carbon fiber

SOURCE: PLASTICOMP 2015
TECH. PLATFORM: PP/FIBER REINFORCED DOOR HARDWARE MODULE

CANDIDATE MATERIALS: PP REINFORCED WITH LONG GLASS FIBERS OR 40% CELLULOSE FIBERS

SOURCE: BROSE
CURRENT/PPOTENTIAL POLYOLEFIN FOAMS INTERIOR APPLICATIONS

HEADLINER

DUCTS IN HEADLINER

TRUNK COMPONENTS

INSTRUMENT PANEL SKINS

DOOR TRIM PANEL & MEDALLION

DOOR WATERSHIELD

FLOOR DUCTS

ACOUSTICS

INTERIOR PANELS WITH DECORATIVE SURFACES

Note:
(a) EPP bead foams

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2015
AIR DUCTS: TARGET FOR POLYOLEFIN FOAMS

OVER 10 AIR DUCTS PER CAR

EXAMPLE AIR DUCT
MATERIAL: PP FOAM
PROCESS: TWIN SHEET FORMING
SUPPLIER: SEKISUI ALVEO

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2015
INTERIOR TARGETS AND COMPETITORS

PKG TRAY/TRUNK LINER
NFIB/PP

WINDOW ENCAP
SEBS, o-TPV

SEALS: o-TPV, SEBS
PILLAR TRIM: PP, TPO

FOAM SUBSTRATE

IP: SKINS (TPO, SEBS?, TPU)

SEALS: o-TPV, SEBS

PKG TRAY/TRUNK LINER
NFIB/PP

ACOUSTIC BARRIER

SEAT TRIM (COATED FABRIC)

SEAT BACK(LGF/PA)

DOOR SEALS
o-TPV, SEBS

DOOR HARDWARE
MODULE, GF/PP

DOOR TRIM PANEL
NFIB/PP

DOOR TRIM
SKINS
SEBS, TPO

TARGETS: ROBERT ELLER ASSOCIATES LLC., 2015

PHOTO SOURCE: So.F.teR GROUP
AUTO ACOUSTICS CONTROL TECHNOLOGIES: ROLE FOR TPEs

AUTOMOTIVE ACOUSTICS SOLUTIONS

Body/glazing seals* (a)

Acoustic barrier and absorber constructions (b)*

Sound deadening carpet (d)

Acoustic glazing laminates

Foams injected into body hollow sections (c)

Improved engine mount isolation

Gasketing to control BSR (f)*

Noise cancellation Technology (e)

Parts re-design*

Note: *= current or potential TPE opportunities

(a) High growth application for SBC and o-TPVs

(b) Lightweight dash mats and heavy duty barriers (e.g. from Cascade Engineering).
    includes polyolefin foams

(c) For example Betafoam™ from Dow based on PU foams

(d) For example from IAC/Stankiewicz

(e) Becoming common via feedback microphones (e.g. Honda Accord and Chevrolet Impala)

(f) BSR= Buzz, squeak, rattle: opens opportunity for vibration damping TPE layer on plastic substrates

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2015
ACOUSTIC TARGETS FOR POLYOLEFINS/TPEs/FOAMS

DASH MAT
SUPPLIER: CASCADE ENGINEERING

FLAT ABSORBER FOR GEAR DRIVE
NOTE: WHITE AREAS ARE MICRO-PERFORATED POLYOLEFIN FOAMS

FOAM SUPPLIER: SEKISUI ALVEO

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2015
Ceramic cube:
50 micrometers per side, ultralight - mostly air
Strong, not brittle
Precise control of structure at nanoscale
- increased energy density of batteries with weight save
- space at nanoscale to precisely control flow of heat and light
- others?

SOURCE: MIT Technology Review, vol. 118 no. 2, Caltech
INNOVATION EXAMPLE: COMBINING MATERIALS TECHNOLOGIES → SYNERGY

HIGH STIFFNESS/LIGHTWEIGHT SHEET

Combination yields:
- high stiffness from graphene-like layers
- lightweight /thickness effect of PO foam
- easily molded

Target auto applications:
- sandwich structures
- battery
- electronics
- composites

PHOTO SOURCE: SEKISUI CHEMICAL CO., LTD

GRAPHENE

Scanning probe microscopic image of graphene, an allotropic form of carbon in a 2 dimensional, atomic scale hexagonal lattice.

One atom at each vertex → C-C bonding
- 100x stronger than steel
- efficient heat, electrical conductor
- nearly transparent
SUMMARY

- Globalized interiors supply chain is consolidating

- Interiors is a major innovation zone with many intermaterials/interprocess challengers to incumbents

- The major drivers/opportunity frontiers are:
  - acoustic improvement
  - weight save
  - luxury look and feel (haptics)
  - process improvement to replace outdated fabrication technology
  - active safety
  - electrical/electronic architecture

- The major challengers are
  - foams (several types)
  - fiber reinforced composites
  - thermoplastic elastomers (TPEs)
  - new generation fillers/reinforcements
  - improved conductive materials